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Working Hours of Part-timers and the Measurement of Firm-level Productivity

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Working Hours of Part-timers and the Measurement of Firm-level Productivity*

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Abstract

This paper empirically quantifies what effect the data availability on part-timers' firm-level working hours may have on the accuracy of productivity measurement by using a data set on a large number of Japanese firms. Despite the practical importance of part-time workers in productivity measurement, this issue has not been considered seriously in past empirical studies. According to the analysis of this paper: (1) firm-level working hours of part-timers are quite heterogeneous even within the same industry; (2) when using industry average working hours, the bias of measured productivity is around 4% at the sample mean and from 1% to 2% at the sample median. The biases are especially large for service industries such as restaurant, hotel, and retail trade, where the part-time ratio is high; (3) however, the correlation between measured productivities using industry average working hours and those using firm-level hours is very high. This suggests there is only a small mismeasurement when using industry aggregate data in analyzing effects of firm characteristics or policy measures on productivity; (4) it is desirable to calculate full-time and part-time hours separately in productivity analyses covering service industries. In considering the importance of planning a valid economic growth strategy, enriching firm-level statistics is a cost-effective investment.

Key words: part-timer; working hours; productivity
JEL classifications: J01, D24, C81

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1. Introduction

Economic growth is the goal of long-term economic policy, and in advanced economies, productivity growth is the most important contributor to economic growth. Faced with an aging population and a decreasing labor force, Japan must now focus its economic policy on enhancing productivity, especially in the service sector. Against this background, numerous empirical studies on firm- or establishment-level productivity have been published. However, it is essential to measure outputs and inputs accurately in order to implement meaningful analyses of both labor productivity (LP) and total factor productivity (TFP).

Recently, the number of part-time workers is increasing rapidly in most advanced countries, and Japan is no exception. According to OECD statistics (http://stats.oecd.org), the ratio of part-time workers to total labor force in 2008 was around 16% in the OECD. This ratio exceeded 20% in the UK and Germany and was around 36% in the Netherlands. Among the factors behind the increasing number of part-time workers[1] are the female labor participation rate, population aging, change in industry structure, labor market reform, and social security systems. In Japan, according to the *Monthly Labor Survey*, the ratio of part-time employees to total regular employees was 27.3% in 2009, about an 8-percentage point increase over the figure in 1999 (19.5%).[2] By industry, the ratio is 13.9% in manufacturing, 42.3% in wholesale and retail trade, and 25.7% in service industries. Under the secular trend toward a service economy, the increase in the number of part-time workers is a challenge to the measurement of productivity in the non-manufacturing sector. The working hours of part-timers are heterogeneous by individuals and by employers. Even within the same industry, the working hours of part-timers are not so different from those of full-time workers in some firms or establishments, but part-time working hours are far shorter than full-time in other firms or establishments.[3] Diewert (2008), for example, states that using the number of persons employed is not an accurate

[1] See, for example, Buddelmeyer et al (2004), Euwals and Hogerbrugge (2006), and Guston and Kishi (2007).

[2] In the *Monthly Labor Survey* (Ministry of Health, Labor, and Welfare), "part-time employee" is defined as the person among regular employees 1) whose scheduled working hours per day is shorter than ordinary workers, or 2) whose number of working days per week is fewer than that of ordinary workers. This definition is basically the same as the definition of the *Basic Survey of Japanese Business Structure and Activities* used in this paper.

[3] Gaston and Kishi (2007) state that part-time workers holding jobs with full-time responsibilities are primarily manual workers, workers with service jobs, and professionals. In addition, service sector firms have been the main employers of part-time workers with full-time responsibilities.

measure of labor input due to the increase in the share of part-time workers. Although the working hours are also different among full-time workers, the heterogeneity is remarkable among part-time workers. There is therefore tremendous difficulty in measuring when analyzing firm- or establishment-level productivity.

It is a matter of course that total hours is a better measure of labor input than total employees. However, data on firm-level working hours are often unavailable. As a result, past studies generally use total employees as labor input or apply industry-level hours data in calculating firm-level working hours. Despite the practical importance of the treatment of part-time workers in productivity measurement, this issue has not been considered seriously in past empirical productivity analyses.

Establishment-level productivity studies for the U.S. manufacturing sector often use the *Census of Manufacturers* or the *Longitudinal Research Database* (Census Bureau). These studies generally calculate annual working hours of non-production workers as the plant's number of non-production workers multiplied by the average annual hours for non-production workers in the corresponding industry taken from the Current Population Survey (Bartelsman and Dhrymes, 1998; Syverson, 2004; Foster et al., 2008, among others). Studies for the UK manufacturing plants often use the *Annual Respondents Database* (Office of National Statistics). Disney et al. (2003), for example, use two-digit industry-level manual (non-production) hours to calculate plant-level labor input. Aghion et al (2009), instead, use total number of employees as labor input to calculate productivity.

The data limitation is more severe for studies on non-manufacturing industries. Foster et al. (2006), an important contribution in analyzing productivity of the U.S. retail sector, do not distinguish part-time workers from full-time workers and simply calculate labor input as the number of employees at establishments multiplied by the industry-level average hours. Morikawa (2010a), which analyzes productivity of personal service establishments in Japan, also uses the number of regular employees as the labor input measure.

In Japan, firm-level productivity studies frequently use micro data from the *Basic Survey of Japanese Business Structure and Activities* (Ministry of Economy, Trade, and Industry). However, as the Survey had not contained information about working hours until very recently, most studies calculate total hours as the number of regular employees, which includes both full-time and part-time employees, multiplied by the industry average working hours of regular workers taken from the *Monthly Labor Survey* (for example, Nishimura et al., 2005; Fukao and Kwon, 2006). By considering the fact that the ratio of part-time workers is different by companies even within the

same industry, Morikawa (2010b), for example, calculates labor input as the sum of full-time hours and part-time hours. However, although the numbers of full-time workers and part-time workers are available from the *Basic Survey of Japanese Business Structure and Activities*, working hours data for both full-time and part-time worker are taken from the *Monthly Labor Survey* at the industry level.[4]

The purpose of this paper is to quantify empirically what effect the available data on firm-level working hours of part-timers may have on the accuracy of productivity measurement. A recent version of the *Basic Survey of Japanese Business Structure and Activities* adds a questionnaire which can be used in calculating firm-level working hours of part-time workers. More specifically, the Survey asks "the full-time equivalent number of part-time workers" in the 2007 Survey.[5] By using this information, this paper calculates labor productivity (LP) and TFP at the firm-level and compares the results with those using industry-aggregated part-time hours data.

Of course, there are numerous practical difficulties in precisely measuring productivity, such as the quality of labor and capital; deflation of output; the measurement of quality change; and the treatment of new products and services. Furthermore, various estimation issues, such as economies of scale, assumption of perfect competition, and the choice of functional forms, have been discussed for a long time. The analysis of this paper deals with only a small part of the productivity measurement issues. Hulten (2001), Diewert and Nakamura (2007), Diewert（2008）, and Syverson (2010) are good surveys on the measurement of productivity.

Major results of the analysis in this paper can be summarized as follows:

(1) Firm-level working hours of part-timers are quite heterogeneous even within the same industry.

(2) When using industry average working hours, the bias of measured productivity is around 4% at the sample mean and from 1% to 2% at the sample median. The biases are especially large for service industries such as hotel, restaurant, retail trade, and entertainment where the part-time ratio is high.

(3) However, the correlation between measured productivities using industry average working hours and those using firm-level hours is very high, which suggests there is no serious mismeasurement of productivity when using industry aggregate data in analyzing effects of firm characteristics or policy measures, especially when the

[4] The *Monthly Labor Survey* covers all industries and these are classified into 36 industries of which 23 are manufacturing.

[5] The annual figures (sales, costs, etc.) of the 2007 Survey are for the fiscal year 2006.

sample is manufacturing firms.
(4) Even when firm-level working hours data are unavailable, it is desirable to calculate full-time and part-time hours separately in productivity analyses covering service industries.

The rest of this paper is organized as follows. Section 2 explains the data used and the method of analysis. Section 3 reports and interprets the results and Section 4 concludes.

2. Data and Methods

The data used in this paper is the 2006 firm-level cross-sectional data drawn from the *Basic Survey of Japanese Business Structure and Activities* (Ministry of Economy, Trade, and Industry). [6] The number of the sample firms is 27,917. The *Basic Survey of Japanese Business Structure and Activities*, an annual survey that was begun in 1991, accumulates representative statistics on Japanese firms with 50 or more regular employees, including those engaged in mining, manufacturing, electricity and gas, wholesale, retail, and several service industries. Over 25,000 firms are surveyed every year. The purpose of this Survey is to capture a comprehensive picture of Japanese firms, including their basic financial information (sales, costs, profits, book value of capital, number of employees, etc.), composition of businesses, R&D activities, IT usage, and foreign direct investments. The Survey is vigorously used for firm-level productivity analyses in Japan.

The Survey, from its beginning, asked about the number of part-time employees as part of the number of regular employees. In the 2007 Survey (for the fiscal year 2006), an important survey item was added—the full-time equivalent number of part-time workers. This information can be used in calculating firm-level working hours of part-time workers *relative to those of the full-time workers* by dividing the full-time equivalent number of part-time workers by the raw number of part-time workers. It is important to note that the Survey does not collect information about the working hours of full-time workers. Although the working hours of full-time workers by company are not available, heterogeneity of full-time working hours is normally smaller than that of part-time working hours. Someone may wonder that the ratio of part-time working

[6] The Survey for the fiscal year 2006 was conducted in 2007.

hours to full-time workers may be affected by the business cycle. Normally, working hours (overtime) increase during boom periods and decrease in recessions. However, as indicated in Figure 1, the cyclical movements of full-time hours and part-time hours are quite similar.[7]

This paper first calculates several distributional characteristics, such as mean and median, of the firm-level working hours of part-timers, and observes the difference among industries. The industry classification of the Survey is three-digits (about 150 industries). For convenience, we classify industries into six large industries: manufacturing, electricity and gas, wholesale trade, retail trade, service, and other industries.[8]

Then we calculate labor productivity（LP）and TFP of the sample firms by different measures of total hours. The first measure（total hours 1）is the number of total full-time equivalent workers multiplied by the industry-level full-time hours. This measure is supposed to be the most accurate calculation based upon currently available data. The second measure（total hours 2）is calculated as the number of full-time workers multiplied by the industry-level full-time hours plus the number of part-time workers multiplied by the industry-level part-time hours. The third measure（total hours 3）is calculated as the number of regular workers（full-time plus part-time）multiplied by the industry-level hours for regular workers. This measure is the most commonly used in the past studies, but the measure does not distinguish full-time and part-time. To summarize, the three measures of firm i can be written as follows:

Total hours 1 ($L1_i$) = $(E^f_i + E^p_i/(H^p_i/H^f_i)) * H^r$

Total hours 2 ($L2_i$) = $E^f_i * H^f + E^p_i * H^p$

Total hours 3 ($L3_i$) = $E^r_i * H^r$

Where E^f_i, E^p_i, and E^r_i denote the number of full-time, part-time, and regular workers for firm i, respectively, and H^f, H^p, and H^r denote the industry-level average working hours of full-time, part-time, and regular workers (full-time + part-time), respectively. (H^p_i/H^f_i) is the part-time hours relative to the full-time workers of the firm.

After calculating these total hours by firms, we compare the three productivity estimators（$\ln LP1_i$, $\ln LP2_i$, $\ln LP3_i$, $\ln TFP1_i$, $\ln TFP2_i$, $\ln TFP3_i$）by using these alternative measures of total hours as labor inputs ($L1_i$ $L2_i$ $L3_i$). Specifically, we

[7] The data are taken from the *Monthly Labor Survey*.

[8] The service industry includes restaurant, hotel, research, cleaning, entertainment, advertising software, etc.

calculate the absolute deviations between $\ln LP1_i$ and $\ln LP2_i$, $\ln TFP1_i$ and $\ln TFP2_i$, $\ln LP1_i$ and $\ln LP3_i$, and $\ln TFP1_i$ and $\ln TFP3_i$ ($|\ln LP1_i - \ln LP2_i|$, $|\ln TFP1_i - \ln TFP2_i|$, $|\ln LP1_i - \ln LP3_i|$, $|\ln TFP1_i - \ln TFP3_i|$). $LP1_i$ and $TFP1_i$ are assumed to be the "correct" productivities here. The deviation from $LP1_i$ or $TFP1_i$ means the firm-level measurement error caused by inaccurate labor input data. The summary measures of the mismeasurements are the mean and the median of these firm-level absolute deviations. These summary measures are converted and expressed in percentage terms.[9]

Labor productivity is the value added (Y_i) per total working hour. Value added is the sum of the operating profit, rent, wage, depreciation, and paid tax. All of these variables are directly available in the *Basic Survey of Japanese Business Structure and Activities*. We calculate TFP in two different ways. The first TFP (TFPa) is cost-share-based TFP index number, which is calculated in a nonparametric manner that uses a hypothetical representative firm as the reference (see, for example, Nishimura et al. 2005; Fukao and Kwon 2006). The input and output of a hypothetical representative firm are calculated as the geometric means of the input and output of all firms, and the cost shares of labor and capital are calculated as arithmetic means. The TFP for each firm is calculated relative to the hypothetical representative firm.[10] The second TFP (TFPb) is estimated as a residual by using a Cobb-Douglas production function without imposing constant returns to scale restrictions. In calculating TFPb, three-digit industry dummies are added as independent variables ($\ln Y_i = a + ß\ln L_i + \gamma \ln K_i + \delta_i$ industry dummies $+ u_i$). The TFPa has the advantage of avoiding problems of using restrictive functional forms, but it assumes constant returns to scale. The TFPb uses a restrictive functional form, but has the merit that economies of scale can be incorporated.

3. Results

[9] When the log deviation is d, the percent term can be calculated as exp（d）-1.

[10] Past studies using the *Basic Survey of Japanese Business Structure and Activities* often estimate TFP in a non-parametric manner (Nishimura et al., 2005; Fukao and Kwon, 2006; Morikawa, 2010, among others). The formula for calculating the TFP level of firm i is as follows.

$$\ln TFP_i = (\ln Y_i - \mathit{lnY}) - (1/2)\Sigma_j(W^j_i + \mathit{W^j})(\ln X^j_i - \mathit{lnX^j})$$

Y_i denotes the output of firm i and X^j_i is the input of factor j at firm i. W^j_i is the cost share of input j. *Italics* means the sample average value.

Part-time working hours relative to full-time workers as percentage terms are reported in Table 1. The average of all sample firms is 84% and the median is 100%. These figures indicate that for the majority of firms part-time hours are similar to full-time. To see the figures by industry, part-time hours are shorter in retail trade and service industries on average. Standard deviations of part-time hours are around 0.2（20%）in every industry. The part-time hours figure at the 10 percentile（P10）of all sample firms is around 50% and at the 5 percentile（P5）is 44%. In some firms, average part-time working hours are less than half of full-time hours. Part-time working hours is quite heterogeneous among firms and this is prominent for retail trade and service industries. The results for all three-digit industries are shown in Appendix 1.

Then, we assess measurement error by using estimated firm-level productivity. As described in the previous section, the summary measure used here is the sample mean and the median of the absolute deviations（$|\ln LP1_i - \ln LP2_i|$, $|\ln TFP1_i - \ln TFP2_i|$）. The results, as expressed percentage terms, are shown in Table 2. Average mismeasurements are found to be 4.6% for labor productivity, 3.8% for TFPa, and 4.7% for TFPb, respectively. At the median, mismeasurements are 0.8% for LP, 1.8% for TFPa, and 2.0% for TFPb. By industry, the mismeasurements are large for retail trade firms, where mean mismeasurements are 10.3% (LP), 7.3% (TFPa), and 9.5% (TFPb) and those at the median are 4.3% (LP), 2.8% (TFPa), and 5.0% (TFPb). The reason is because the ratio of part-time workers is higher and also the dispersion of part-time hours among firms is larger in retail trade. Service industries' mismeasurement is also large in comparison with manufacturing industries'. The result suggests the importance of using part-time hours data at firms in order to obtain accurate firm-level productivity estimates, especially when the sample includes firms operating in retail trade or service.

Table 3 shows the number of firms of which the measured LP and TFP are revised upward and downward when using firm-level part-time hours data. As for the LP, downward revision is more prevalent than upward revision, because in the large number of sample firms the part-time hours is longer than the industry-aggregate part-time hours taken from the *Monthly Labor Survey*. As a result, total labor input becomes larger for the large number of firms. On the other hand, the majority of firms' TFP is revised upward, although the figure is sensitive to the method of calculating TFP. The reason for the difference between TFP and LP is that the measured TFP is, by definition, the deviation from the "average" of the sample, irrespective of the methods of calculation.

Table 4 shows the three-digit industries where the mismeasurements at the industry median are large. The results for every three-digit industry are indicated in Appendix 2. The measurement error of productivity is larger for restaurants, hotels, entertainment service, food retailers, etc. In analyzing the productivity of these industries, it is extremely important to use firm-level part-time hours data.

As discussed in the introduction, some of the past firm-level productivity studies do not distinguish full-time and part-time workers. In these studies, the total number of regular employees, which includes both full-time and part-time employees, multiplied by the industry average working hours of regular workers is used as labor input. In these cases, the mismeasurement of productivity might be more serious. Table 5 shows the summary measure of productivity mismeasurement ($|\ln LP1_i - \ln LP3_i|$, $|\ln TFP1_i - \ln TFP3_i|$). The mean mismeasurements are twice as large as the results presented in Table 2. Although the median of the mismeasurement is smaller than the mean, the figures are more than twice in comparison with the figures in Table 2. Especially, the median absolute deviations for wholesale and retail are from 10% to 20%. The figure of LP for service industries is also large and more than 10%. Under the secular trend of increasing part-time workers, mismeasurement of labor input by ignoring the difference in part-time ratio among firms (simply using the number of total workers and their average hours) causes serious bias in regard to measured productivity. In such calculation, the labor input will be overestimated and the productivity will be underestimated for a firm whose part-time ratio is increasing.

To summarize, in estimating firm-level productivity, 1) it is better to treat full-time and part-time workers separately even when using industry-aggregated hours data; 2) it is desirable to use part-time hours data at firm-level, if available. These treatments are especially important when the sample includes wholesale, retail, and service firms.

Table 6 shows the correlation coefficients among measured LPs and TFPs by using three different total hours data. Column 1 shows the correlation coefficients between LP1 and LP2, and columns 2 and 3 show the correlation coefficients between TFP1 and TFP2. The correlation coefficients are between 0.98 and 0.99 for all industries irrespective of the productivity measures. This means the rankings or relative positions of firms' productivity are not much affected by the measurement of part-time hours. Columns 4-6 show correlations between LP1 and LP3（TFP1 and TFP3）, which are lower than the figures in columns 1-3, but still around 0.98 for all industries. This result confirms the previous finding that it is better to treat full-time and part-time workers separately. By industry, the correlations for retail trade are lower than those of

other industries, but still between 0.92 and 0.99. When comparing the estimation methods, non-parametric index number TFP is relatively robust against the measurement of part-time hours.

These results suggest that in analyzing the effects of firm characteristics or policy measures on productivity, the use of industry-aggregated part-time hours do not fundamentally affect the conclusions qualitatively. This is particularly true for the analysis using only manufacturing firms as samples. This is good news for the past empirical studies, but in future, the number of part-time workers and their working hours at the firm level should be used, once the data are available.

4. Conclusion

This paper empirically quantifies what effect the available data on firm-level working hours of part-timers may have on the accuracy of productivity measurement, using cross-sectional data from the *Basic Survey of Japanese Business Structure and Activities* in 2006. Past empirical studies on firm- or establishment-level productivity were often forced to use industry-aggregate hours data due to the lack of micro-level hours data, but such treatment may cause a large mismeasurement of productivity. The motivation behind this study is the rapidly increasing number of nonstandard workers in most of the advanced countries including Japan, and the importance of accurately measuring part-time working hours as labor input in implementing firm-level productivity analysis. Past empirical studies have overlooked this practically important issue.

According to the analysis: (1) Firm-level working hours of part-timers are quite heterogeneous even within the same industry. (2) When using industry average working hours, the bias of measured productivity is around 4% at the sample mean and from 1% to 2% at the sample median; the biases are especially large for service industries such as hotel and restaurant, retail trade, and entertainment, where the part-time ratio is high. (3) The correlation between measured productivities using industry average working hours and those using firm-level hours is very high, which suggests there will be a small mismeasurement when using industry aggregate data in analyzing effects of firm characteristics or policy measures. (4) Even when firm-level working hours data are unavailable, it is desirable to calculate full-time and part-time hours separately in productivity analyses, especially when the analysis covers service industries.

The analysis in this paper uses industry-aggregated working hours data for full-time workers, which are taken from the *Monthly Labor Survey*. In reality, the working hours of full-time workers are also different among firms, even though the magnitude is smaller than part-time hours. Although the *Basic Survey of Japanese Business Structure and Activities* started to collect information about the full-time equivalent number of part-time workers, information on full-time working hours is still unavailable. Therefore, the effect of the heterogeneity of full-time hours among firms on measured productivity is beyond the scope of this paper. In order to address this issue, we hope to obtain firm- or establishment-level statistics to collect detailed hours data. Linking the micro data of firm or establishment statistics with the individual-level data of labor statistics to construct employer-employee matched data sets may be another approach.[11]

At the time of writing this paper, only the 2006 cross-sectional data are available. As a result, this study analyzes productivity *level* and does not deal with productivity *growth*. If firm-level part-time hours are stable throughout the period of analysis, the bias stemming from using industry-level hours data in regard to productivity growth may not be serious. For similar reason, panel-data analysis controlling for the firm fixed-effect may be relatively robust despite the lack of part-time hours at firm-level. However, for the medium- to long-term productivity analysis, the stability assumption seems to be too strong. Furthermore, the mismeasurement is becoming more serious with the rapid increase in the number of part-time workers and the change in industrial structure toward the service economy. Future research will focus on analysis of productivity growth.

Economic growth strategy is an important policy agenda in most advanced countries including Japan. In order to plan valid growth strategy, it is essential to evaluate quantitatively what types of firm characteristics—such as R&D, IT investment, intangible assets, management, and organizations—produce higher productivity. There are various issues in accurately measuring productivity. The analysis of this paper deals with only a small part of the measurement issues, but the result sheds light on the importance of the detailed data on labor input. The recent addition of the survey item on the full-time equivalent number of part-time workers in the *Basic Survey of Japanese Business Structure and Activities* is an important step toward a better productivity measurement. In considering the necessity of planning a valid economic

[11] Abowd and Kramarz (1999) is a representative survey of the analysis using matched employer-employee data.

growth strategy, enriching firm-level statistics is a cost-effective investment.

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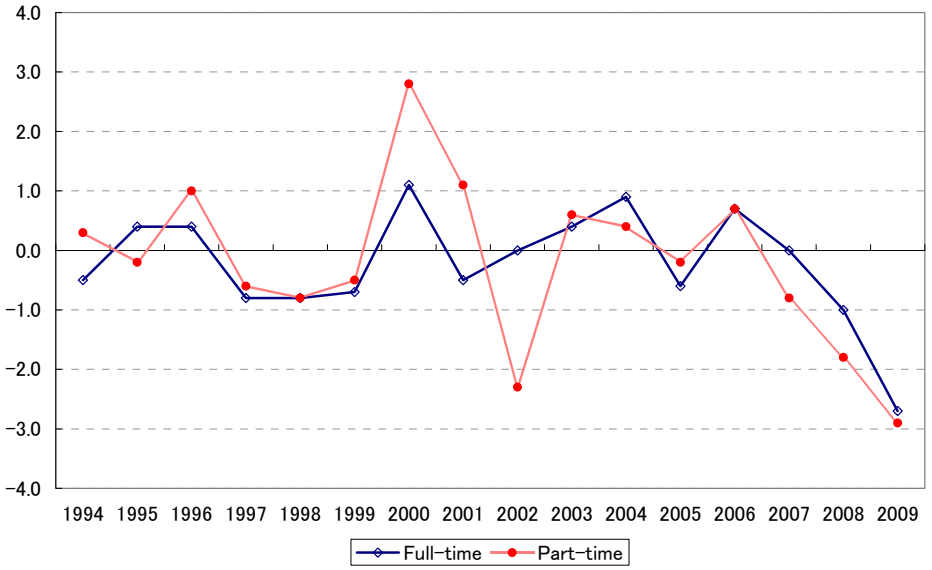
Figure 1 Hours of full-time and part-time workers（changes from the previous year, %）



（Source）*Monthly Labor Survey*（Ministry of Health, Labor, and Welfare）. Establishments with 30 employees or more.

Table 1 Part-time working hours relative to full-time workers by industry

	mean	median	P25	P10	P5
Manufacturing	86.0%	100.0%	75.0%	57.1%	50.0%
Electricity and Gas	87.3%	100.0%	75.0%	57.2%	50.0%
Wholesale	85.9%	100.0%	74.4%	55.1%	50.0%
Retail	80.1%	88.8%	62.5%	49.9%	40.0%
Service	81.4%	100.0%	63.6%	47.1%	33.3%
Other	84.8%	100.0%	72.1%	50.0%	40.0%
All industries	84.4%	100.0%	71.4%	50.0%	44.0%

Table 2 Measurement error of productivity by using industry-aggregated part-time hours（expressed in percentage terms）

	mean			median		
Industry	LP	TFPa	TFPb	LP	TFPa	TFPb
Manufacturing	2.5%	2.6%	2.9%	0.6%	1.8%	1.5%
Electricity and Gas	1.1%	1.4%	2.3%	0.0%	1.3%	1.7%
Wholesale	3.6%	3.1%	3.8%	0.9%	1.9%	2.2%
Retail	10.3%	7.3%	9.5%	4.3%	2.8%	5.0%
Service	8.1%	6.4%	8.0%	0.7%	2.0%	3.1%
Other	3.0%	2.8%	3.5%	0.4%	1.8%	1.8%
All industries	4.6%	3.8%	4.7%	0.8%	1.8%	2.0%

(Note) TFPa is the cost-share-based index numbers. TFPb is the residual of estimated production function.

Table 3 The number of firms where measured productivity is revised upward and downward

	LP	TFPa	TFPb
Upward revision	4,076	18,797	14,147
Downward revision	14,707	7,094	11,742

(Note) TFPa is the cost-share-based index numbers. TFPb is the residual of estimated production functions.

Table 4 Three-digit industries which exhibit large measurement errors of productivity at the median

LP		TFPa		TFPb	
Industry	median deviation	Industry	median deviation	Industry	median deviation
Bowling alleys	42.1%	Bowling alleys	24.2%	Movie theater	27.1%
Movie theater	30.5%	Ordinary restaurants	15.7%	Private lesson	25.5%
Ordinary restaurants	23.4%	Movie theater	13.4%	Bowling alleys	22.0%
Private lesson	18.5%	Other restaurants	11.1%	Ordinary restaurants	19.1%
Other restaurants	15.6%	Private lesson	10.6%	Other restaurants	18.8%
Education service	14.5%	Photo studio	10.3%	Education service	15.5%
Amusement park	14.3%	Education service	9.8%	Telemarketing	14.3%
Photo studio	13.8%	Sports stadiums	9.5%	Miscellaneous personal services	13.1%
Hotels	13.6%	Food retail	9.2%	Hotels	12.1%
Entertainment services	13.4%	Entertainment services	8.1%	Photo studio	12.0%

Table 5 Measurement errors of productivity by not distinguishing part-time and full-time（expressed in percentage terms）

	mean			median		
Industry	LP	TFPa	TFPb	LP	TFPa	TFPb
Manufacturing	3.3%	4.3%	2.8%	1.9%	3.2%	1.4%
Electricity and Gas	1.4%	3.3%	1.6%	0.8%	2.8%	1.1%
Wholesale	18.2%	9.7%	3.4%	19.8%	10.3%	1.9%
Retail	19.0%	11.4%	11.2%	19.8%	9.9%	8.4%
Service	13.0%	7.8%	7.7%	13.2%	5.0%	2.2%
Other	3.2%	4.0%	2.8%	2.6%	3.4%	1.2%
All industries	9.6%	6.8%	4.7%	5.1%	4.1%	1.8%

(Note) TFPa is the cost-share-based index numbers. TFPb is the residual of estimated production function.

Table 6 Correlation coefficients of productivity estimates by using different hours data

	LP1 and LP2, TFP1and TFP2			LP1and LP3, TFP1 and TFP3		
	(1)	(2)	(3)	(4)	(5)	(6)
	LP	TFPa	TFPb	LP	TFPa	TFPb
Manufacturing	0.994	0.995	0.991	0.992	0.993	0.990
Electricity and Gas	1.000	0.999	0.998	0.999	0.998	0.999
Wholesale	0.991	0.995	0.991	0.990	0.995	0.990
Retail	0.937	0.970	0.936	0.920	0.957	0.924
Service	0.972	0.984	0.965	0.967	0.982	0.961
Other	0.995	0.997	0.994	0.995	0.997	0.994
All industries	0.984	0.990	0.981	0.976	0.985	0.978

(Note) TFPa is the cost-share-based index numbers. TFPb is the residual of estimated production function.

Appendix 1 Part-time working hours relative to full-time workers (by three-digit industries, in percentage terms)

Industry	mean	median	P10
Agriculture	76.4%	87.5%	14.3%
Mining	89.4%	100.0%	60.0%
Construction	88.0%	100.0%	62.2%
Livestock products	82.0%	93.2%	50.0%
Seafood products	83.6%	100.0%	57.1%
Flour and grain mill products	86.4%	100.0%	53.2%
Miscellaneous foods and related products	81.2%	88.9%	50.0%
Manufacturing of beverages, tea and tobacco	82.2%	100.0%	45.5%
Animal food and organic fertilizers	85.3%	100.0%	61.1%
Textile mill products	81.3%	82.5%	45.5%
Woven fabric mills	85.2%	100.0%	60.0%
Dyed and finished textiles	85.1%	100.0%	50.0%
Miscellaneous textile goods	84.2%	100.0%	53.8%
Knitted garments, clothing	86.1%	100.0%	57.1%
Miscellaneous textile products	86.2%	87.9%	66.7%
Lumber and wood products	83.6%	100.0%	50.0%
Miscellaneous wood products	87.3%	100.0%	50.0%
Furniture and fixtures	88.1%	100.0%	66.7%
Pulp and paper	89.6%	100.0%	56.3%
Paper products	84.2%	100.0%	50.0%
Printing and allied industries	86.7%	100.0%	58.3%
Chemical fertilizers and inorganic chemicals	87.7%	100.0%	50.0%
Organic chemicals	85.7%	100.0%	54.3%
Chemical fibers	95.2%	100.0%	68.4%
Oil and fat products, soaps	88.6%	100.0%	63.6%
Drugs and medicines	89.3%	100.0%	64.3%
Miscellaneous chemical products	89.5%	100.0%	66.7%
Petroleum and refining	96.2%	100.0%	77.3%
Miscellaneous petroleum and coal products	93.2%	100.0%	72.7%
Plastic products	84.3%	100.0%	56.4%
Tires and inner tubes	88.1%	94.2%	66.7%
Miscellaneous rubber products	88.5%	100.0%	62.5%
Leather products and fur skins	88.7%	100.0%	63.2%
Glass and its products	85.5%	100.0%	54.5%
Cement and its products	87.1%	100.0%	50.0%
Miscellanous ceramic, stone and clay products	84.5%	100.0%	50.0%
Iron and steel	86.8%	100.0%	50.0%
Miscellaneous iron and steel products	83.7%	100.0%	50.0%
Smelting and refining of non-ferrous metals	90.7%	100.0%	60.0%
Non-ferous metal products	88.4%	100.0%	66.7%
Constructional and architectural metal products	87.5%	100.0%	60.0%
Miscellaneous fabricated metal products	86.5%	100.0%	50.0%
Metalworking machinery	85.9%	100.0%	53.8%
Special Industry machinery	88.6%	100.0%	55.6%
Business and service machinery	84.2%	98.8%	50.0%
Miscellaneous machinery and machine parts	85.9%	100.0%	57.1%
Industrial electrical apparatus	84.4%	91.7%	62.7%
Household electric appliances	86.6%	100.0%	63.6%
Electronic equipment	87.3%	100.0%	65.6%
Miscellaneous electrical machinery equipment	88.4%	100.0%	65.0%

Industry	mean	median	P10
Communication equipment	88.3%	100.0%	63.6%
Computer	89.7%	100.0%	69.0%
Electronic parts, devices, and electronic circuits	87.1%	100.0%	62.4%
Motor vehicles, parts and accessories	88.0%	100.0%	61.5%
Miscellaneous transportation equipment	87.9%	100.0%	55.3%
Medical instruments and apparatus	89.8%	100.0%	66.7%
Optical instruments and lenses	85.3%	88.9%	63.6%
Watches, clocks and parts	78.6%	100.0%	40.0%
Miscellaneous precision machinary	87.4%	100.0%	62.5%
Miscellaneous manufacturing industries	84.6%	100.0%	50.0%
Electricity	93.4%	100.0%	75.0%
Gas	85.4%	100.0%	50.0%
Communications	89.6%	100.0%	50.0%
Broadcasting	94.1%	100.0%	70.5%
Software	88.8%	100.0%	53.8%
Data processing and information services	86.9%	100.0%	50.0%
Internet based services	87.6%	100.0%	60.0%
Video picture, sound information	90.4%	100.0%	50.0%
Newspaper publishers	77.2%	78.6%	42.9%
Publishers	84.7%	100.0%	46.7%
Miscellaneous information services	90.2%	100.0%	60.0%
Road transport	82.0%	95.0%	49.0%
Warehousing	91.6%	100.0%	75.0%
Miscellaneous transport	80.8%	100.0%	40.0%
Wholesale (textile)	87.4%	100.0%	66.7%
Wholesale (apparel)	84.7%	100.0%	57.8%
Wholesale (Agricultural products)	81.8%	93.1%	50.0%
Wholesale (food and beverages)	81.6%	87.3%	51.7%
Wholesale (building materials)	89.3%	100.0%	60.0%
Wholesale (chemical products)	86.8%	100.0%	52.9%
Wholesale (mineral, metal products)	87.0%	100.0%	51.8%
Wholesale (Recycled material)	83.9%	100.0%	50.0%
Wholesale (machinery and equipment)	90.0%	100.0%	60.0%
Wholesale (Motor vehicles)	87.0%	100.0%	53.8%
Wholesale (Electrical machinery)	89.8%	100.0%	66.7%
Wholesale (Miscellaneous machinery and equipment)	87.0%	100.0%	57.1%
Wholesale (Furniture and fixtures)	87.2%	100.0%	50.0%
Wholesale (Drugs and toiletries)	85.5%	100.0%	52.9%
Miscellaneous wholesale trade	85.5%	100.0%	56.6%
Retail (apparel)	83.4%	94.1%	53.4%
Retail (food and beverage)	74.5%	74.4%	48.3%
Retail (Motor vehicles and bycicles)	88.2%	100.0%	55.6%
Retail (Furniture, household utensil)	80.0%	83.2%	50.0%
Retail (machinery and equipment)	83.1%	100.0%	50.0%
Retail (Drug and toiletry stores)	74.2%	75.0%	42.3%
Fuel stores	79.3%	90.8%	47.4%
Miscellaneous retailers	80.2%	88.9%	49.5%
Finance and insurance	75.2%	80.0%	50.0%
Credit card and money lending business	81.8%	93.7%	53.1%
Real estate trade	79.4%	87.8%	48.4%

	mean	median	P10
Real estate lessors and managers	76.6%	94.7%	38.2%
Automobile parking	82.4%	82.4%	64.7%
restaurants	72.1%	74.8%	38.1%
Miscellaneous eating and drinking places	75.8%	82.1%	46.1%
Hotels	78.9%	100.0%	37.5%
Medical, health care, and welfare	72.6%	70.3%	48.6%
Education	69.8%	74.1%	21.6%
Instruction services	74.4%	74.0%	41.8%
Architectural services	88.2%	100.0%	62.5%
Design services	87.9%	100.0%	50.0%
Photographic studios	78.8%	100.0%	40.8%
Engineering	88.3%	100.0%	60.0%
Miscellaneous technical services	86.2%	100.0%	50.0%
Scientific and development research institutes	79.9%	80.0%	50.0%
Laundry	76.4%	76.5%	50.0%
Miscellaneous public bathhouses	59.9%	62.5%	49.5%
Miscellaneous laundry, beauty and bath services	78.9%	92.3%	37.1%
Travel agency	86.0%	100.0%	55.3%
Ceremonial services	79.8%	100.0%	46.3%
Film developing and finishing	84.0%	100.0%	20.0%
Other personal services	71.5%	72.2%	63.6%
Miscellaneous personal services	69.7%	63.9%	50.0%
Cinemas	73.6%	75.0%	44.4%
Golf courses	77.6%	93.5%	37.5%
Sports facilities	65.7%	61.7%	29.5%
Amusement parks, theme parks	83.5%	100.0%	50.0%
Bowling alleys	86.9%	100.0%	34.4%
Miscellaneous amusement and recreation services	80.0%	87.4%	48.7%
Waste disposal business	76.8%	86.0%	47.4%
Automobile maintenance services	69.3%	75.7%	11.1%
Machine repair services	88.6%	100.0%	60.0%
Industrial equipment and machinery leasing	91.2%	100.0%	70.4%
Office machinery leasing	91.8%	100.0%	66.8%
Automobile leasing	85.3%	100.0%	46.2%
Miscellaneous goods leasing	83.1%	100.0%	52.5%
Rental	82.4%	100.0%	50.0%
Advertising	86.3%	100.0%	50.0%
Commodity inspection services	74.7%	75.0%	33.3%
Surveyor certification	79.3%	75.6%	50.0%
Building maintenance services	71.3%	75.0%	36.6%
Employment services	86.3%	100.0%	57.3%
Guard services	75.3%	97.5%	13.4%
Display services	91.7%	100.0%	66.7%
Worker dispatching services	85.6%	100.0%	50.0%
Telemarketing	78.3%	81.9%	48.6%
Miscellaneous business services	82.2%	97.1%	50.0%
All industries	84.4%	100.0%	50.0%

(Note) The list excludes industries of which the number of sample firms are less than 4.

Appendix 2 Measurement error of productivity at the median by three-digit industries

Industry	LP	TFPa	TFPb
Agriculture	3.7%	2.2%	2.7%
Fisheries	0.0%	1.9%	0.9%
Mining	0.1%	1.4%	0.6%
Construction	0.4%	1.8%	1.4%
Livestock products	2.7%	2.3%	2.9%
Seafood products	1.8%	1.9%	2.9%
Flour and grain mill products	1.1%	1.7%	1.0%
Miscellaneous foods and related products	4.6%	3.1%	4.1%
Manufacturing of beverages, tea and tobacco	0.7%	1.7%	1.6%
Animal food and organic fertilizers	0.3%	1.6%	1.1%
Textile mill products	0.7%	1.6%	2.1%
Woven fabric mills	0.6%	1.8%	1.5%
Dyed and finished textiles	0.3%	1.7%	1.1%
Miscellaneous textile goods	1.1%	1.8%	1.6%
Knitted garments, clothing	1.2%	2.0%	2.0%
Miscellaneous textile products	1.8%	2.0%	3.3%
Lumber and wood products	0.3%	1.8%	1.0%
Miscellaneous wood products	0.7%	1.8%	1.7%
Furniture and fixtures	0.5%	1.7%	1.1%
Pulp and paper	0.3%	1.6%	1.2%
Paper products	1.1%	1.7%	1.3%
Printing and allied industries	0.7%	1.7%	1.3%
Chemical fertilizers and inorganic chemicals	0.3%	1.5%	0.9%
Organic chemicals	0.0%	1.6%	1.3%
Chemical fibers	0.7%	1.5%	0.6%
Oil and fat products, soaps	0.5%	1.6%	1.2%
Drugs and medicines	0.5%	1.7%	1.9%
Miscellaneous chemical products	0.6%	1.6%	1.5%
Petroleum and refining	0.0%	1.4%	1.4%
Miscellaneous petroleum and coal products	0.2%	1.6%	1.0%
Plastic products	1.1%	1.7%	1.7%
Tires and inner tubes	0.7%	1.4%	2.4%
Miscellaneous rubber products	0.6%	1.8%	1.5%
Leather products and fur skins	2.3%	2.1%	2.5%
Glass and its products	0.4%	1.7%	1.3%
Cement and its products	0.1%	1.7%	1.0%
Miscellanous ceramic, stone and clay products	0.3%	1.7%	1.4%
Iron and steel	0.2%	1.6%	1.2%
Miscellaneous iron and steel products	0.2%	1.7%	1.0%
Smelting and refining of non-ferrous metals	0.3%	1.6%	1.0%
Non-ferous metal products	0.5%	1.7%	1.3%
Constructional and architectural metal products	0.4%	1.8%	1.0%
Miscellaneous fabricated metal products	0.8%	1.7%	1.4%
Metalworking machinery	0.6%	1.7%	1.1%
Special Industry machinery	0.3%	1.8%	1.2%
Business and service machinery	0.6%	1.8%	1.8%
Miscellaneous machinery and machine parts	0.5%	1.8%	1.1%
Industrial electrical apparatus	0.7%	1.9%	1.5%
Household electric appliances	0.8%	1.8%	1.7%
Electronic equipment	0.4%	1.8%	1.8%

	LP	TFP	TFPb
Miscellaneous electrical machinery equipment	0.7%	1.8%	1.8%
Communication equipment	0.3%	1.8%	1.4%
Computer	0.2%	1.8%	1.7%
Electronic parts, devices, and electronic circuits	0.3%	1.7%	1.7%
Motor vehicles, parts and accessories	0.5%	1.7%	1.5%
Miscellaneous transportation equipment	0.3%	1.8%	1.4%
Medical instruments and apparatus	2.1%	1.7%	2.4%
Optical instruments and lenses	0.8%	1.8%	1.9%
Watches, clocks and parts	2.4%	1.8%	2.4%
Miscellaneous precision machinary	0.8%	1.8%	1.4%
Miscellaneous manufacturing industries	0.9%	1.8%	1.9%
Electricity	0.0%	1.2%	2.9%
Gas	0.3%	1.4%	1.2%
Heat supply	0.0%	1.1%	0.4%
Communications	0.0%	1.7%	2.8%
Broadcasting	0.1%	1.7%	3.4%
Software	0.0%	2.0%	1.3%
Data processing and information services	0.3%	1.9%	2.0%
Internet based services	0.0%	1.8%	2.2%
Video picture, sound information	0.0%	1.9%	1.2%
Newspaper publishers	0.3%	1.8%	1.3%
Publishers	0.4%	1.9%	1.8%
Miscellaneous information services	0.7%	1.8%	2.5%
Road transport	3.6%	2.1%	4.9%
Warehousing	2.6%	1.5%	7.1%
Miscellaneous transport	1.0%	1.6%	2.5%
Wholesale (textile)	0.3%	1.9%	2.0%
Wholesale (apparel)	2.3%	1.9%	4.2%
Wholesale (Agricultural products)	4.1%	2.1%	4.2%
Wholesale (food and beverages)	3.4%	2.0%	3.7%
Wholesale (building materials)	0.4%	1.7%	1.1%
Wholesale (chemical products)	0.3%	1.8%	1.4%
Wholesale (mineral, metal products)	0.4%	1.8%	1.5%
Wholesale (Recycled material)	1.1%	1.7%	2.4%
Wholesale (machinery and equipment)	0.0%	1.9%	1.2%
Wholesale (Motor vehicles)	0.8%	1.8%	1.9%
Wholesale (Electrical machinery)	0.3%	1.9%	1.7%
Wholesale (Miscellaneous machinery and equipment)	0.5%	1.8%	1.2%
Wholesale (Furniture and fixtures)	2.5%	1.9%	3.3%
Wholesale (Drugs and toiletries)	2.2%	1.9%	2.5%
Miscellaneous wholesale trade	1.5%	1.9%	2.9%
Retail (apparel)	8.1%	4.1%	7.0%
Retail (food and beverage)	12.5%	9.2%	11.9%
Retail (Motor vehicles and bycicles)	0.6%	1.6%	1.2%
Retail (Furniture, household utensil)	6.4%	3.1%	6.1%
Retail (machinery and equipment)	0.7%	1.9%	3.3%
Retail (Drug and toiletry stores)	7.9%	5.6%	7.9%
Fuel stores	3.6%	2.7%	4.5%
Miscellaneous retailers	5.7%	3.4%	5.9%
Finance and insurance	1.4%	1.6%	2.2%

	LP	TFP	TFPb
Credit card and money lending business	0.9%	1.9%	3.5%
Real estate trade	4.8%	1.9%	6.4%
Real estate lessors and managers	5.5%	3.2%	5.9%
restaurants	23.4%	15.7%	19.1%
Miscellaneous eating and drinking places	15.6%	11.1%	18.8%
Hotels	13.6%	8.0%	12.1%
Medical, health care, and welfare	8.1%	4.6%	9.3%
Education	14.5%	9.8%	15.5%
Instruction services	18.5%	10.6%	25.5%
Architectural services	2.1%	1.6%	3.2%
Design services	0.0%	2.0%	1.4%
Photographic studios	13.8%	10.3%	12.0%
Engineering	0.1%	1.9%	1.8%
Miscellaneous technical services	0.4%	1.9%	2.1%
Scientific and development research institutes	0.1%	1.8%	2.3%
Laundry	11.4%	8.0%	10.0%
Miscellaneous laundry, beauty and bath services	1.6%	1.7%	3.2%
Travel agency	1.2%	1.9%	5.5%
Ceremonial services	6.0%	3.3%	7.2%
Film developing and finishing	12.1%	7.5%	9.6%
Other personal services	3.3%	1.9%	4.6%
Miscellaneous personal services	3.4%	4.9%	13.1%
Cinemas	30.5%	13.4%	27.1%
Golf courses	8.0%	4.5%	6.9%
Sports facilities	12.1%	9.5%	10.4%
Amusement parks, theme parks	14.3%	8.1%	9.9%
Bowling alleys	42.1%	24.2%	22.0%
Miscellaneous amusement and recreation services	13.4%	8.1%	11.3%
Waste disposal business	1.0%	1.9%	3.1%
Automobile maintenance services	1.4%	1.9%	3.3%
Machine repair services	0.6%	1.8%	2.1%
Industrial equipment and machinery leasing	0.2%	1.1%	1.4%
Office machinery leasing	0.0%	1.6%	2.4%
Automobile leasing	0.5%	1.3%	2.8%
Miscellaneous goods leasing	3.4%	1.8%	4.4%
Rental	2.2%	1.6%	3.2%
Advertising	0.0%	1.9%	2.2%
Commodity inspection services	0.7%	2.0%	0.9%
Surveyor certification	1.2%	1.8%	4.0%
Building maintenance services	4.0%	3.1%	7.3%
Employment services	0.7%	1.8%	5.8%
Guard services	2.7%	1.5%	2.7%
Display services	0.3%	1.7%	0.6%
Worker dispatching services	0.2%	2.1%	4.0%
Telemarketing	6.5%	4.1%	14.3%
Miscellaneous business services	1.4%	2.0%	5.4%
All industries	0.8%	1.8%	2.0%

(Notes) The list excludes industries of which the number of sample firms are less than 4.