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Discussion Paper No. 2005-E-2

IMES

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IMES Discussion Paper Series 2005-E-2
March 2005

Wage Fluctuations in Japan after the Bursting of the Bubble Economy: Downward Nominal Wage Rigidity, Payroll, and the Unemployment Rate

Sachiko Kuroda† and Isamu Yamamoto‡

Abstract

In this paper, we investigate the existence and persistence of downward nominal wage rigidity (DNWR) for full-time employees based on the wage fluctuations observed in Japan, following the bursting of the bubble economy of the early 1990s. We also examine the extent to which DNWR has boosted firms' real payroll adjusted for labor productivity. We then estimate a version of the Phillips curve with DNWR to measure the impact of DNWR on Japan's unemployment rate. We summarize the results of this paper as follows. First, DNWR measured by the total annual earnings of full-time employees in Japan was observed from 1992 to 1997, but disappeared after 1998. Second, DNWR observed from 1992 to 1997 seemed to have raised firms' real payroll adjusted for labor productivity during a period in which both inflation and labor productivity growth were low. Third, our estimation results suggest that DNWR from 1992 to 1997 raised the unemployment rate by approximately 1 percentage point at the most, although it may overstate the effect of DNWR on unemployment.

Key words: Downward nominal wage rigidity, Inflation rate, Unemployment rate, Labor productivity, Phillips curve, Monetary policy

JEL classification: C30, E24, E50, J30, J60

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The authors would like to thank Kentaro Akashi of the University of Tokyo, Kazumi Asako of Hitotsubashi University, participants at the summer conference for the Financial Group of the Institute of Statistical Research, and the staff at the Institute for Monetary and Economic Studies (IMES), the Bank of Japan (BOJ), for their valuable comments. The views expressed in this paper are solely those of the authors, and do not necessarily reflect the official views of the BOJ or IMES. Whatever errors that may be contained herein are also solely those of the authors.

Contents

I. Introduction

This paper examines the downward rigidity of nominal wages by looking at how firms adjusted their payroll following the bursting of Japan's economic bubble of the early 1990s.

In previous analyses, Kuroda and Yamamoto (2003a, b) used longitudinal data from surveys of individual employees over the period from 1993 to 1998 to show that nominal wages for full-time employees in Japan were downwardly rigid. Applying these empirical results to simulation in a general equilibrium model, Kuroda and Yamamoto (2003c) showed the possibility of downward nominal wage rigidity (DNWR) raising the unemployment rate by a certain amount. Based on this simulation result, we tentatively concluded that it was desirable for monetary policymakers to target a small but positive rather than zero inflation rate, to prevent DNWR from becoming a binding constraint on wage-setting decisions.

Nevertheless, this tentative conclusion from Kuroda and Yamamoto (2003c) must be viewed with two reservations. The first is that even if there is DNWR, an increase in labor productivity could reduce firms' productivity-adjusted real payroll. [1] Second is that the empirical results from Kuroda and Yamamoto (2003a, b), obtained from the rather short-term period of 1993-98, do not tell us whether DNWR could be observed as a permanent phenomenon even under conditions of a deepening recession.

It is certainly the case that the DNWR observed at the individual employee level will not make it difficult for firms to adjust payroll if there is consistently high labor productivity growth. Moreover, even when DNWR is observed during periods of low labor productivity growth, monetary policymakers may not have to take DNWR fully into account, as long as the labor market's price adjustment mechanism works, over time, to bring nominal wages down and eliminate the damage caused by DNWR. On the basis of these possibilities, some monetary policymakers state that DNWR is only a

[1] In this paper, we define labor productivity as the quantity of goods and services produced by the input of one unit of labor, holding other conditions constant. Therefore, even though DNWR may make it difficult to reduce the payroll per employee, high labor productivity growth could reduce the cost of production per unit of product.

weak rationale for pursuing monetary policy that targets a small but positive rather than zero inflation rate (see Poole [1999]).

In this paper, we ask the following three questions. First, how long does DNWR persist under deflationary conditions where high labor productivity growth is unlikely? Second, to what extent does labor productivity growth actually alleviate the problems associated with DNWR? Third, what degree of negative impact would DNWR have on the economy before the nominal wage declines? If it takes time for nominal wages to decline and the damage that arises during this period is consequential or such damage prolongs the recession, it is conceivable that the constraints imposed by DNWR could at least be posited as a valid basis of pursuing a small but positive inflation rate for a central bank coping with the risk of deflation.

We begin by shedding light on the persistence of DNWR for full-time employees, through examination of published data from the mid-1980s in the *Basic Survey on Wage Structure* (Ministry of Health, Labor and Welfare). Next, we investigate the extent to which DNWR has raised the firms' productivity-adjusted real payroll, which is the total amount paid in wages adjusted for price level and labor productivity. We then estimate a version of the Phillips curve that takes account of DNWR to show empirically to what extent DNWR has raised Japan's unemployment rate.

Throughout the paper, we define nominal wages as the total nominal wages required for a firm to hire one full-time employee, including regular salaries, bonuses, and various allowances (such as overtime pay, assignment allowances, commuting allowances, and family allowances – which we refer to collectively as total annual earnings). In Kuroda and Yamamoto (2003a, b), we showed how the extent of DNWR varied depending on the type of employment and the type of nominal wage (total annual earnings or regular monthly salaries). As noted above, however, in order to understand the adjustments to nominal wages made by firms as a buffer against employment adjustment, we examine here the extent to which the total annual earnings per full-time employee are downwardly rigid, irrespective of the means used to make those adjustments.[2]

[2] For example, even if overtime pay and bonuses are adjusted with sufficient flexibility, when regular salaries increase during that time, it is conceivable that total annual earnings would become downwardly rigid and thus continue to put pressure on firms to make employment adjustments.

This paper is organized as follows. In Section II, we use published data from the 1980s until recently to examine both the existence and persistence of DNWR. Next, in Section III, we check for evidence of adjustments by Japanese firms to the productivity-adjusted real payroll when DNWR was present. In Section IV, we estimate a version of the Phillips curve that takes account of the DNWR observed in the 1990s to calculate to the extent to which DNWR has raised Japan's unemployment rate. In Section V, we discuss the implications of monetary policies based on our results.

II. DNWR: How Long Has It Persisted?

In this section, we examine the existence and persistence of DNWR after the late 1990s by investigating whether the nominal wage change distributions remained skewed to the right. We also evaluate whether the rightward skewness in the distribution is unique to periods of low inflation, since our data include the period in the 1980s when the inflation rate was relatively high.

We use published data from the *Basic Survey on Wage Structure* aggregated from data at the establishment level. Therefore, it is important to note that the data for nominal wage change may reflect measurement errors brought by sample changes in business establishments as well as by changes in the employee composition within each establishment. This kind of problem, specific to aggregate data, can be avoided by using longitudinal data on the same individual employee (or establishment), as was done in Kuroda and Yamamoto (2003a, b). In Japan, however, it is impossible to obtain such longitudinal data over an extended period. As a second-best solution for analyzing the 1980s and from 1999, we use the *Basic Survey on Wage Structure* for the analysis.

A. Analytical Framework

The specific framework for our analysis is as follows. We begin with the data on regular workers (full-time employees) from 1985 to 2001 published in the *Basic Survey on Wage Structure* disaggregated by prefecture, sex, firm size, and age group. Our purpose in disaggregating the data rather than using average values at the macro level is to minimize the above-noted disadvantages associated with aggregate data.[3]

Next, we calculate the year-on-year change in total annual earnings per employee by prefecture, sex, and firm size. In calculating the year-on-year change in total annual earnings, we control for changes in employee composition by age group (18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, and 60-64). Specifically, we calculate the year-on-year change in total annual earnings for each age group, and then take a weighted average based on the number of employees in each age group of the previous year. It is said that Japanese firms tend to adjust their payroll by restricting new hiring or by promoting early retirement during recessions. If such practices are taking place, it may impart an upward or downward bias on the average wage level, even when there are no nominal wage changes in any of the age groups. The above calculation excludes such biases caused by changes in the age structure of employees in the firm.

In detecting the existence of DNWR based on the nominal wage change distributions, we ascertain whether many nominal wages are left unchanged despite the need for a nominal wage cut. In other words, when the nominal wage change distribution is skewed to the right because of a large number of samples with close to zero change and a small number of samples with a negative change, we take this as evidence of downward rigidity in nominal wages, as in Kuroda and Yamamoto (2003a). In the recent literature, this is the most commonly used method for verifying the existence of DNWR.[4] This is because the average nominal wage changes at the macro

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[3] To eliminate the errors specific to aggregate data, one can further disaggregate the data on other characteristics in addition to prefecture, sex, firm size, and age group. Taking such an approach, however, would result in extremely small sample sizes for each category, and this in turn would magnify the errors caused by changes in the sample. With that in mind, we chose to disaggregate the data by prefecture, sex, firm size, and age group. However, we do not expect our analysis to produce much bias since Kuroda and Yamamoto (2003a) showed that controlling for other characteristics such as labor market experiences did not significantly change the results regarding the existence of DNWR.

[4] We believe the existence of a distribution of nominal wage changes reflects differences in nominal wage changes among sectors as well as the imperfect movement of labor stemming from labor market imperfections and the heterogeneity of employees.

level do not contain the information on whether nominal wage cuts were required based on economic conditions at the time.

B. Nominal Wage Change Distributions based on Data Disaggregated by Prefecture, Sex, Firm Size, and Age Group

Figure 1 shows the distribution of nominal wage change from 1985 through 2001.[5] The small triangle on the horizontal axis indicates the median nominal wage change.

Figure 1 shows that the DNWR constraint was not binding until 1991, because the nominal wage changes are high on average and only a small portion of the left tails of the distribution are in the negative region. In 1992-97, when the left tails of the distributions fall into the negative region, the distributions seem to be skewed to the right because of the fairly large number of samples with a change of near zero and the small number of samples with a negative change. This is evidence of DNWR. From 1998, however, DNWR seems to disappear because a large number of samples show negative nominal wage change and the distributions are not skewed to the right.

Note that the distributions for 1992-97 do not have an unusually large number of samples with near zero change, and that a greater number of the samples exhibit just under 1 percent of negative change. From this observation, one may consider that the degree of DNWR was not that great. However, two other possible causes for these numerous small nominal wage cuts should be noted, both of them due to the data characteristics. One possible cause is measurement errors from sample changes, and the other is firm-level adjustments of nominal wage per employee through such means as elimination of annual wage increases and the delay of promotions.[6]

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[5] In Figure 1, we showed the distributions pooled into two-year increments, except for 1985.

[6] For example, by eliminating annual wage increases, firms can reduce the nominal wages per employee if the workers' composition within the firm remains unchanged, even without lowering the nominal wages of each employee.

C. Testing for DNWR Using the Method from Kahn (1997)

1. Kahn's method for testing DNWR

In the previous subsection, looking at the distribution of nominal wage changes over time, we saw that (1) DNWR did not act as a constraint until 1991, (2) DNWR was observed in 1992-97, and (3) nominal wages were flexible from 1998. Below, we confirm these results through the statistical method developed by Kahn (1997).

Kahn's method is useful for examining the existence of DNWR because it does not require *ex ante* specification for the shape of the distribution of notional nominal wage changes when there is no DNWR and thus can avoid the arbitrary judgments of analysts.[7]

This method begins by estimating the shape of the distribution of notional nominal wage changes when DNWR does not exist, using information that includes periods when DNWR is not binding. Then, it is assumed that when DNWR does exist, a portion of the nominal wage change distribution in the negative region is thinned and built up in the near-zero region. Specifically, we use the following estimation model.

$$\begin{aligned} Prop_{1,t} &= \alpha_1 - \theta\alpha_1 DN_{1,t} + \left[\theta\left(\textstyle\sum_{r=2}^{m}\alpha_r\right)\right]DZ_{1,t} \quad , \\ Prop_{2,t} &= \alpha_2 - \theta\alpha_2 DN_{2,t} + \left[\theta\left(\textstyle\sum_{r=3}^{m}\alpha_r\right)\right]DZ_{2,t} \quad , \\ &\vdots \\ Prop_{m,t} &= \alpha_m - \theta\alpha_m DN_{m,t} \ . \end{aligned} \tag{1}$$

Here, $Prop_{r,t}$ is the proportion of samples with a nominal wage change from $(M-r)$ to $(M-r+1)$ percent in year *t*, with *M* the median of the nominal wage change. In other words, it indicates the height of the r^{th} bar ($r = 1,\ldots,m$) in a histogram depicting 1 percent increments from the median value to the left. $DN_{r,t}$ is a dummy variable that takes the value of one when $M-r+1<0$ (when the r^{th} bar is in the negative region), and $DZ_{r,t}$ is a dummy variable that takes the value of one when $M-r\le 0<M-r+1$ (when the r^{th} bar is in the region from zero to 1 percent). Both α_r and θ are

[7] Kahn's method has been used in many papers, including Lebow, Saks, and Wilson (2003) and Christofides and Leung (2003).

parameters to be estimated: α_r indicates the notional height of the r^{th} bar when there is no DNWR, and θ is a key parameter that indicates the proportion of samples when the nominal wage change is kept between zero and 1 percent due to DNWR (the proportion that is thinned when the r^{th} bar is in the negative region). We consider DNWR to be present when the parameter θ is significantly positive.

Figure 2 explains this estimation model. The figure shows a hypothetical distribution for nominal wage changes with a median value of 2 percent. α_1 is the notional height of the bar one unit to the left of the median. Since this bar is in the positive region, the actual height of the bar ($Prop_{1,t}$) is the same as α_1. In contrast, because the notional height of the second bar (α_2) includes zero, the actual height of the bar ($Prop_{2,t}$) is higher than α_2 by the sum of the fixed proportion (θ) of the height of those bars in the negative region. Furthermore, the notional heights of the bars three units or more to the left of the median (α_r) are all in the negative region, and thus the actual heights of those bars become $(1-\theta)\alpha_r$, which is to say lower than the median by the fixed proportion (θ).

2. Modifying the model

When applying the Kahn's method to the nominal wage change distributions in Japan, we make the following modifications in light of the data characteristics and the distribution shown in Figure 1.

First, even when the nominal wage change is negative, if it is in the range of –1 to zero percent, we assume that nominal wages are actually held to a zero percent change instead of being cut. This is because we need to consider the possibility that a large number of the minor changes in nominal wages were caused by the measurement errors associated with sample changes. For this modification, we assume that the bar in the nominal wage change distribution is shortened by $(\theta \times 100)$ percent when it is located to the left of –1 percent, and the two bars located at –1 to zero percent and at zero to 1 percent are heightened by an equal amount. [8]

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[8] Note that due to this modification we must assume that the small wage cuts achieved through elimination of annual wage increases and the delay of promotions cause no change in nominal wages. Consequently, our test should be interpreted as a test for whether nominal wage cuts of at least 1

Second, we set lower limit of the regions in which the bar is shortened by ($\theta \times 100$) percent at $-c$ percent. This modification is based on the results from Kuroda and Yamamoto (2003b), which showed that the extent of DNWR is not perfect and that nominal wage cuts do occur under conditions requiring a large cut.

Third, in estimating the height of each bar in the nominal wage change distribution, we include m bars to the right of the median as well as the left. This is because nominal wage change distributions in recent years have had negative median values.

Finally, we control for the variance of nominal wage changes. This takes into account that when the variance of the nominal wage change is large (small), the height of each bar in the notional distribution of the nominal wage change is low (high), irrespective of DNWR. Since the variance of nominal wage change is also affected by the existence of DNWR, however, we measure the variance of the nominal wage change by limiting samples to those above the median.

As a result of these modifications, we express the estimation model as follows.

$$
\begin{aligned}
Prop_{-m+1,t} &= (\alpha_{-m+1} + \beta VAR_t) - \theta(\alpha_{-m+1} + \beta VAR_t) N_{-m+1,t} + \left[\frac{1}{2}\theta \left(\sum_{r \in \{N_{r,t}=1\}} (\alpha_r + \beta VAR_t) \right) \right] Z_{-m+1,t} , \\
&\vdots \\
Prop_{0,t} &= (\alpha_0 + \beta VAR_t) - \theta(\alpha_0 + \beta VAR_t) N_{0,t} + \left[\frac{1}{2}\theta \left(\sum_{r \in \{N_{r,t}=1\}} (\alpha_r + \beta VAR_t) \right) \right] Z_{0,t} , \\
Prop_{1,t} &= (\alpha_1 + \beta VAR_t) - \theta(\alpha_1 + \beta VAR_t) N_{1,t} + \left[\frac{1}{2}\theta \left(\sum_{r \in \{N_{r,t}=1\}} (\alpha_r + \beta VAR_t) \right) \right] Z_{1,t} , \\
&\vdots \\
Prop_{m,t} &= (\alpha_m + \beta VAR_t) - \theta(\alpha_m + \beta VAR_t) N_{m,t} .
\end{aligned} \tag{2}
$$

Here $r = -m+1, \cdots, 0, 1, \cdots, m$. When $r > 0$, r is the r^{th} bar counting toward the left from the median, and when $r \le 0$, r is the $(r+1)^{\text{th}}$ bar counting toward the right from the median. $N_{r,t}$ is a dummy variable that takes the value of 1 when $-c \le M - r + 1 < -1$

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percent take place. When not modifying the model but instead applying Kahn's original method directly, we found no DNWR. Nevertheless, it is impossible from this result to know whether DNWR is not present owing to such factors as the elimination of annual wage increases and delay of promotions, or whether measurement errors caused a lot of small nominal wage declines.

(i.e., when the r^{th} bar is in the region of $-c$ to -1 percent), while $Z_{r,t}$ is a dummy variable that takes the value of one when $M - r - 1 \leq 0 < M - r + 1$ (i.e., when the r^{th} bar is in the region of –1 to 1 percent). VAR_t is the sample variance of nominal wage changes above the median at year t, and β is its coefficient. We set $m = 4$ and $c = 4.5$ for our estimation.[9]

3. Estimation results of nonlinear SUR

Using the same data as in the previous subsection, we estimate equation (2) by a nonlinear SUR (seemingly unrelated regression). To confirm the possibility that DNWR disappeared around 1998, we extend the end of the sample period successively from 1995 to 2001. The estimation results are shown in Table 1.

Looking at Table 1, one can see that the estimates of θ are significantly positive when we use the data up through 1997, indicating the existence of DNWR. For the estimates up through 1998, 1999, and 2000, however, θ is statistically insignificant. And, for the estimate ending with 2001, θ even becomes significantly negative. In Figure 3, we plotted the estimates of θ from 1995 to 2001. We see that approximately 45–60 percent of employees who should have received notional wage cuts until 1997 had their nominal wages left unchanged, but nominal wage cuts occurred roughly to the extent needed after 1997.

In light of these results, the last row in Table 1 shows the estimation result using data from the entire period 1985–2001, adding a time dummy variable to capture changes in θ from 1998. The time dummy variable is zero until 1997 and one from 1998, and by adding this to the term containing θ in equation (2), we identify the change in θ as the parameter θ_{98} for the time dummy variable.[10]

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[9] We set m = 4 because most of the nominal wage changes are within ±4 percent, as can be seen in Figure 1. We set the value of c based on the scope of DNWR (the threshold value in the friction model) estimated by Kuroda and Yamamoto (2003b). The results were robust to changes in the values of c of ±1%.

[10] As explained above, the observation of nominal wage change distributions suggests that there are three distinct periods: (1) 1985-91, when DNWR did not act as a constraint; (2) 1992-97, when DNWR was observed; and (3) 1998-2001, when DNWR was not observed. Accordingly, it is possible to define time dummy variables for θ that differ among the three periods. However,

Our estimation result shows that the estimate of θ is 0.548 until 1996, but drops to –0.106 (=0.548 – 0.654) from 1998. This says that nominal wages, as measured by the total annual earnings of full-time employees, were downwardly rigid until 1997, so that more than 50 percent of the required reduction in nominal wages was not made. From 1998, however, nominal wages were almost perfectly flexible, and the nominal wage cuts were actually 10 percent greater than when assuming no DNWR.[11]

4. The relationship between the nominal wage change gap and the inflation rate

Using the results from Table 1, we calculate the extent to which DNWR pushes up the average nominal wage change in the actual distribution. Assuming that the distribution of notional nominal wage change can be inferred from equation (2), we restore the height of the bar affected by DNWR to the notional height when the DNWR constraint is not binding. We then subtract the average of notional nominal wage change from the actual one, which we define as the "nominal wage change gap." This gap gets larger as DNWR raises the actual average nominal wage change relative to its notional value.

Figure 4 plots the nominal wage change gap for each year against the median of the actual nominal wage change, with the black circles representing data from 1985 to 1997 and the white circles representing data from 1998 to 2001.[12] This figure shows that during the 1985–97 period, the gap widened as the median nominal wage change got smaller, pushing up the actual nominal wage change by approximately 0.28 percentage point at its maximum.[13] During this period, the correlation coefficient

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during the period 1985-91 when the DNWR constraint was not binding, N and Z take the value of one in only three out of 56 samples. Therefore, defining time dummy variables for the three periods has virtually no impact on the results.

[11] These can be interpreted as pent-up nominal wage cuts from 1998 in response to the lack of nominal wage cuts in 1992-97 due to DNWR.

[12] We use the estimation result from the last row in Table 1 for the calculation of the nominal wage change gap.

[13] Note that the aggregate data used in this section are subject to measurement errors caused by changes in the sample of establishments as noted above. If these measurement errors are large, we should recognize that the estimated degree of DNWR and size of the nominal wage change gap could be understated relative to the true values.

between the median nominal wage change and the gap was –0.74. The same trend can be seen in the relationship between the inflation rate and the nominal wage change gap with the correlation coefficient –0.42 in the 1985–97 period. In other words, the impact from DNWR tends to be greater as the inflation rate declines.

Meanwhile, from 1998, when DNWR was no longer observed, the nominal wage change gap turned negative, and the more negative the median value of the nominal wage change, the more negative became the gap. [14] As for the finding that DNWR was not observed from 1998, there are the two alternative interpretations: one is that the current experience with deflation has freed the Japanese economy from the DNWR constraint at least for the time being. The other is that these nominal wage cuts observed from 1998 were only a one-time, large-scale adjustment in response to a major shock. According to the latter interpretation, just because nominal wages were adjusted downward from 1998, it does not necessarily follow that nominal wages in Japan will respond flexibly and adjust downward every time there is a recession.

III. Labor Cost Adjustments by Japanese Firms: The Relationship between DNWR, the Inflation Rate, and Labor Productivity Growth

In the previous section, we used aggregate data to confirm the existence of downward rigidity in the nominal wages of full-time employees at the macro level, at least until 1997. This evidence implies that flexible adjustments to payroll were not carried out during this period.

Even when assuming the existence of downward rigidity, however, when the inflation rate and labor productivity growth are high, the payroll may be flexibly adjusted on a real, productivity-adjusted basis. With this in mind, in this section we examine how Japanese firms adjusted their productivity-adjusted real payroll on an

[14] Kuroda and Yamamoto (2003b) applied a friction model to nominal wage changes at the employee level and found a nominal wage structure in which DNWR does exist, but under conditions where large cuts are required, nominal wage cuts are brought down below their notional level. The results in this section are consistent with the nominal wage structure found in Kuroda and Yamamoto (2003b), in the sense that although nominal wages were downwardly rigid until 1997, the declines in nominal wages from 1998 were greater than necessary.

aggregate basis over the past 20 years, taking into consideration the inflation rate, labor productivity growth, and the existence of DNWR.[15, 16]

A. Analytical Framework

As our measure of firms' payroll, we use the productivity-adjusted real wage per employee ω multiplied by the number of employees L, which we term the productivity-adjusted real payroll J. The productivity-adjusted real wage per employee ω is defined as $W/(Pe)$, the nominal wage W divided by price P and labor productivity e, and can be interpreted as the total annual earnings per employee after adjusting for prices and labor productivity.

Furthermore, we decompose changes in the productivity-adjusted real payroll into two components: (1) the contribution from changes in the productivity-adjusted real wage holding constant the total number and age composition of employees; and (2) the contribution from changes in the number of employees holding constant the average productivity-adjusted real wage and the age profile (productivity-adjusted real wage curve). By holding constant not only the number of employees and the level of productivity-adjusted real wages but also the age composition, it is possible to distinguish changes in the productivity-adjusted real payroll caused by changes in the age composition of employees, which are quantity (employment) adjustments, from those caused by changes in the wage profile, which are price (productivity-adjusted real wage) adjustments. When there is a decrease in the proportion of younger (older) employees, who are paid lower (higher) wages, through a decrease in hiring (encouragement of early retirement), the productivity-adjusted real payroll decreases

[15] This paper looks only at the payroll of full-time employees (wages per employee times the number of employees). We do not analyze here the cost of labor for part-time employees or non-wage costs such as employee benefits.

[16] Our analysis assumes that capital and labor are not perfect substitutes. If capital and labor were perfect substitutes, factor demand would shift toward capital when labor becomes overvalued due to the existence of DNWR, and thus the payroll would not remain high. Nevertheless, in the real world, as evidenced by the phenomenon of labor hoarding during recessions, capital and labor are not perfect substitutes. It is therefore likely that DNWR will drive up firms' payroll. We confirm this possibility in this section.

(increases). However, as with the analysis in Section 2, we identify this change not as a price adjustment but as quantity adjustment achieved through changes in the age composition of employees.

Changes in the productivity-adjusted real payroll can be decomposed as follows,

$$\begin{aligned} \Delta J &= \sum_A \left(\omega^A + \Delta\omega^A\right)\left(L^A + \Delta L^A\right) - \sum_A \omega^A L^A \\ &= \underbrace{\sum_A \Delta\omega^A L^A}_{\substack{\text{(1) Contribution from changes in} \\ \text{the productivity-adjusted real wage}}} + \underbrace{\sum_A \Delta L^A \omega^A}_{\substack{\text{(2) Contribution from changes in} \\ \text{the number of employees}}} + \underbrace{\sum_A \Delta\omega^A \Delta L^A}_{\text{Cross-terms}} , \end{aligned} \tag{3}$$

where A denotes the age group (17 and under, 18-19, 20-24,25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65 and over). ω^A denotes the productivity-adjusted real wage per employee of age group A, and L^A denotes the number of employees of age group A.

The data sources and variable definitions are as follows. First, the nominal wage W is from the *Basic Survey on Wage Structure* and indicates total annual earnings as in Section II. Price P is the *Consumer Price Index* (CPI, from the Ministry of Internal Affairs and Communications), adjusted for the introduction of the consumption tax in April 1989 and the increase in the consumption tax rate in April 1997. Labor productivity e is the real GDP per employee, calculated from the *National Accounts* (Cabinet Office) and The *Labour Force Survey* (Ministry of Internal Affairs and Communications).[17] Lastly, for number of employees, we calculate the number of full-time employees using both the *Labour Force Survey* and the *Special Survey of the Labour Force Survey* (Ministry of Internal Affairs and Communications).

[17] Our consideration of labor productivity here is aimed at understanding how exogenous changes in labor productivity cause changes in the productivity-adjusted real payroll when the number of employees is held constant. Hence, when dividing real GDP by the number of employees, we use a five-year backward-moving average to eliminate the endogenous changes in labor productivity brought by changes in the number of employees.

B. Labor Cost Adjustments over Time

1. Factor decomposition of the productivity-adjusted real payroll

Figure 5 decomposes the changes in the productivity-adjusted real payroll J from 1975–2001, based on equation (3).[18] Although the solid line, which shows the rate of change in the productivity-adjusted real payroll – the change in the productivity-adjusted real wage multiplied by the number of full-time employees – was held fairly low from the mid 1970s to the early 1980s and the period of recession caused by yen appreciation in the mid-1980s,[19] it remained high from 1992 and did not become significantly negative until 1996 and after.

Were these movements in the productivity-adjusted real payroll made through adjustments to price (productivity-adjusted real wage) or to quantity (employment)? Looking at the contributions from each factor shown in the bar graph, we see the following.

First, until about 1991, the productivity-adjusted real wage had a negative impact on the productivity-adjusted real payroll during economic recessions, and the necessary adjustments seemed to be made. In contrast, changes in the number of employees consistently had a positive impact on the productivity-adjusted real payroll of approximately zero to 2 percent, indicating that adjustments were not made on the quantity side.

Second, looking at the period of bubble collapse around 1992–95, the productivity-adjusted real wage grew at the high rate of approximately 2 percent. Moreover, the contribution from changes in the number of employees during this period was in the range of zero to 1.5 percent. Therefore, we can understand that a high productivity-adjusted real payroll resulted from both the high productivity-adjusted real wage and slow employment adjustments.

A more detailed look at changes in the number of employees shows that while the productivity-adjusted real wage was growing by approximately 2 percent, employment growth declined to zero percent in 1995. This may indicate that

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18 Since the contribution from the cross-terms is negligible, it is not included in the figure.

19 The productivity-adjusted real payroll rose to a relatively high level in 1983, however.

persistently high productivity-adjusted real wages had a downward effect on employment growth. A comparison of changes in the productivity-adjusted real wage and the employment level suggests a tendency for employment growth to weaken during periods when the productivity-adjusted real wage is rising. In fact, the correlation coefficient between growth in the productivity-adjusted real wage and differences in employment growth since 1990 was –0.39, indicating a significantly negative correlation. Hence, it is likely that increases in the productivity-adjusted real wage cause an increase in unemployment by lowering employment growth.

Third, both the productivity-adjusted real wage and the number of employees had a near zero or negative impact on the productivity-adjusted real payroll from 1996. One particularly large difference with previous recessions is that labor cost adjustments from 1996 were achieved not only by productivity-adjusted real wage cuts but also by reducing employment.

2. Factor decomposition of the productivity-adjusted real wage

Next, to understand what caused the changes in the productivity-adjusted real wage shown in Figure 5, in Figure 6 we decompose the changes in the productivity-adjusted real wage into three factors: nominal wage changes, CPI changes, and labor productivity changes.

Figure 6 shows that most of the adjustments to the productivity-adjusted real wage in 1975–91 were achieved by holding nominal wage growth below the sum of inflation and labor productivity growth. In contrast, beginning in 1992, the decline in inflation and labor productivity made it necessary to lower the nominal wage to adjust the productivity-adjusted real wage. Nevertheless, as we confirmed in Section II, because nominal wages were downwardly rigid until 1997, no reductions in nominal wages were observed until 1998. This suggests that one of the factors that kept the productivity-adjusted real wage high in 1992–95 was the existence of DNWR. On the other hand, it should be noted that there have been adjustments to the productivity-adjusted real payroll, through a rise in labor productivity in 1996, 1997, and 2000 and through nominal wage cuts in 1998–99.

3. Adjustments to the nominal payroll since the 1990s

Finally, we examine how firms adjusted their payroll in the 1990s by taking a closer look at the changes in nominal wages and employment, both of which are key to understanding the adjustments to the productivity-adjusted real payroll during that period.

Figures 7 and 8 plot the contributions to the productivity-adjusted real payroll from nominal wage changes and employment changes, respectively, to visualize how firms timed their various adjustments. In both figures, an arrow points to the first year of adjustment in which the contribution to the productivity-adjusted real payroll was negative for at least two consecutive years. The contribution from nominal wage changes to changes in the productivity-adjusted real payroll shown in Figure 7 is the same as that in Figure 6, but the contribution from employment change in Figure 8 is the difference between the change in employment and the change in population. By eliminating the change in employment level brought by population change, we identify the effects from the reduction of hiring and the increase of early retirement.[20]

Looking at Figure 7, we can understand the following points in regard to the adjustment of overtime pay, bonuses, and regular salaries.[21] First, during the period soon after the bursting of the bubble economy, the initial stage of adjustment began with adjustments to overtime pay, followed later by adjustments to bonuses.[22] Nevertheless, regular salaries were growing during this period, and it was not until 1998 that nominal wage adjustments making an overall negative contribution occurred. Around 1998,

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[20] Employment growth can be negative when the labor force itself is declining due to the effects of lower birth rates. Therefore, by measuring the extent to which employment in each age group has changed relative to the change in population, we have eliminated population-related factors from employment growth. Ideally, the impact on employment growth from other labor supply factors should also be eliminated, but we have not made such an adjustment here.

[21] We calculated the amount of overtime pay by subtracting bonuses and regular salaries from total annual earnings. As noted earlier, total annual earnings include commuting and other allowances in addition to bonuses, regular salaries, and overtime pay. Due to data availability, however, we assume that the commuting and other allowances are relatively small.

[22] Although the figures are not shown here, for middle-aged workers in the 45-54 age group, a relatively greater proportion of the adjustments was achieved through cuts in overtime pay and bonuses.

reflecting an increase in the number of firms that suspended pay raises in response to the deepening economic recession, the growth of regular salaries dropped to nearly zero. Then in 1999 and 2000, with the economy slowing further, the firms that had already made adjustments using overtime pay and bonuses began to eliminate annual wage hikes and reduce regular salaries, to the extent that even the average growth rate in regular salaries turned negative.

In contrast, looking at employment adjustments shown in Figure 8, it was not until 1997 that the contribution from employment changes adjusted for population factors turned negative for all age groups in total. During this period, growth in the number of younger employees aged 24 and under turned negative in the mid-1990s, suggesting that firms began restricting the hiring of younger workers. Around 1996, the rate of growth in employment of older workers aged 55 and above turned negative, suggesting that older workers were encouraged to take early retirement (or were simply laid off).

Summarizing these observations from Figures 7 and 8, labor cost adjustments made by firms following the bursting of the economic bubble were generally carried out in the following order: overtime pay, bonuses, employment adjustments including restriction of hiring younger employees and promotion of early retirement programs, and finally elimination of annual wage increases and reductions to regular salaries.[23]

4. Summary

We obtain two results in this subsection. First, firms' adjustments of the productivity-adjusted real payroll for full-time employees seem to have been achieved through price (productivity-adjusted real wage) adjustment rather than quantity (employment) adjustment until approximately 1991. Around 1992–95, adjustments were insufficient both in terms of quantity and price, and it was not until 1996 and after

[23] We found the following regarding payroll adjustments during the period from the late 1970s to the 1980s, when inflation was relatively high. First, with the exception of 1986 when there was a slight decrease in overtime pay, nominal wages grew every year. Second, the number of employees aged 24 and under and 55 and over grew at roughly the same pace relative to the population. Hence, we can understand that the labor cost adjustments in the latter half of the 1990s that focused on overtime pay and bonuses were of an unprecedented scope.

that such adjustments were made. Second, a more detailed examination of the price adjustment shows that, until 1991, adjustments to the productivity-adjusted real wage were made by holding growth in nominal wages below the sum of the inflation rate and labor productivity growth. Nevertheless, from 1992, when both inflation and labor productivity were extremely low, DNWR kept productivity-adjusted real wages high. From 1998, however, firms were able to adjust productivity-adjusted real wages by lowering the nominal wage and through labor productivity improvements. Looking further at changes in the nominal wage from the 1990s, although overtime pay and bonuses were adjusted relatively early, it was not until around 1997 that these adjustments were extended to include regular salaries.

IV. The Relationship between DNWR and Unemployment: Empirical Evidence from the Estimated Phillips Curve

Section III showed that the DNWR for full-time employees found in Section II put pressure on the productivity-adjusted real payroll of Japanese firms when both inflation and labor productivity growth were low in the mid-1990s. In this section, we estimate a version of the Phillips curve to examine the extent to which DNWR has affected the unemployment rate in Japan.

A. DNWR and the Shape of the Phillips Curve

The shape of the Phillips curve, which shows the trade-off relationship between unemployment and price or wage inflation, will differ depending on the existence of DNWR. This has long been noted in the literature. For an example of this, we summarize the argument of Tobin (1972, 1997): the unemployment rate increases rapidly under low inflation due to the presence of DNWR and the slope of the Phillips curve becomes less steep. Nevertheless, during periods when the unemployment rate stays high under low inflation, DNWR gradually disappears and nominal wage cuts become possible. Hence, there is a nonlinear relationship between the unemployment rate and the price or wage inflation rate, which makes the short-run Phillips curve S-shaped.

Tobin's arguments are consistent with the results from the preceding section, which showed that DNWR was observed for full-time employees up through 1997 but then disappeared from 1998 under the prolonged recession. If this is the case, then Japan's Phillips curve must be S-shaped, becoming less steep under low inflation but resuming a steeper slope as the high unemployment rate persists.[24]

To confirm this, we plot a Phillips curve using regional data from 1985–2001 in Figure 9. The vertical axis is the regional inflation rate and the horizontal axis the regional unemployment rate. In both cases, we take the deviation from the sample average for each region. This is to control for the regional fixed effects, that is, both variables' regional differences at average levels.[25] The plots with diamond symbols are for 1992–97 (when DNWR was observed), and those with triangle symbols for the period up until 1991 (when the DNWR constraint was not binding) and from 1998 (when no DNWR was observed). The regions comprise – Hokkaido, Tohoku, Kanto, Hokuriku, Chubu, Kinki, Chugoku, Shikoku, and Kyushu. The data on regional inflation rates are from the *Consumer Price Index* and those on regional unemployment rates are from the *Labour Force Survey*.[26]

The Phillips curve in Figure 9 is downward sloping, indicating a negative correlation between the inflation rate on the vertical axis and the unemployment rate on the horizontal axis. Comparing the slope of the Phillips curve among periods of different inflation rates, one may see a tendency that the slope to be steeper during periods of a relatively high inflation rate on the vertical axis, flatten out as the inflation

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[24] Recent literature using aggregate data from Japan, including Nishizaki and Watanabe (2000) and Kimura and Ueda (2001), noted the possibility that the slope of the Phillips curve for Japan flattened under the low inflation and economic stagnation of the 1990s.

[25] Since the sample averages of inflation rate by each region are all close to zero, the actual inflation rate and the deviation from the sample average do not vary considerably. Therefore, we assume it is possible to observe the existence of DNWR based on Figure 9. The reason for using regional data is to increase the degree of freedom. It would be preferable to use data disaggregated by prefecture for consistency with Section II. Due to data availability, however, we use regional data for the analysis in this section.

[26] As in Section III, we use CPI data after adjusting for the effects from the launch of the consumption tax and the increase in the consumption tax rate. Because the *Consumer Price Index* and the *Labour Force Survey* have slightly different regional classifications, we took weighted averages based on either the size of the labor force or the population.

rate on the vertical axis becomes lower, and becomes slightly steep when the inflation rate on the vertical axis turns substantially negative. This observation seems to suggest a nonlinear relationship between inflation and unemployment.

This nonlinear relationship can be also confirmed by estimating the regional Phillips curve. Specifically, we regress the first to third moment of the actual regional unemployment rates on the actual regional inflation rates, by using two-way fixed-effect models. We assume here that other factors such as expected inflation and supply shocks are absorbed into the fixed effects of each region and each year.

The estimation results are shown in Table 2. In the first model, which uses only the first moment of the unemployment rate as an explanatory variable, its coefficient is significantly negative. In the second model, which adds the second moment of the unemployment rate, the coefficient of the second moment is not significantly different from zero. In the third model, which also includes the third moment of the unemployment rate, the coefficient of the first moment is negative, that of the second moment is positive, and the third moment is negative at the one percent significance level. These results suggest that Japan's Phillips curve is nonlinear and S-shaped.[27]

It should be noted, however, that these findings do not tell us the extent to which DNWR raises the unemployment rate or the extent to which unemployment decreases due to the disappearance of DNWR. Taken a step further, the additional increases in unemployment from 1998 when DNWR was no longer present seem to suggest a need to consider factors other than DNWR.

To quantify the impact of DNWR on the unemployment rate, we calculate the extent to which DNWR raised unemployment by incorporating the nominal wage change gap into the Phillips curve.

[27] Based on the *F*-value for the fixed effects, a fixed-effect model can be justified under all cases. We also used the Hausman test where applicable to decide between a random-effect or fixed-effect model, and in every case the fixed-effect model was chosen.

B. Estimating a Regional Phillips Curve with DNWR

1. Deriving the estimation model

In the absence of DNWR, the nominal wage change in region i and year t ($\dot{W}_{it}^{nr}$) depends on the expected inflation rate ($\dot{P}_{it}^{e}$), labor market conditions ($u_{it} - u_{it}^{*}$: where u_{it} is the observed unemployment rate and u_{it}^{*} the equilibrium unemployment rate), the labor productivity growth rate ($\dot{e}_{it}$), and an error term (ε_{it}), as shown in equation (4) below.

$$\dot{W}_{it}^{nr} = \dot{P}_{it}^{e} + b(u_{it} - u_{it}^{*}) + \dot{e}_{it} + \varepsilon_{it} \ , \ \varepsilon_{it} \overset{i.i.d.}{\sim} N(0, \sigma_{\varepsilon}^{2}) \ . \tag{4}$$

Assuming a constant markup rate over the long run, the inflation rate is equivalent to the nominal wage change minus labor productivity growth ($\dot{P}_{it}^{nr} = \dot{W}_{it}^{nr} - \dot{e}_{it}$). Accordingly, we can rewrite equation (4) as a regional price Phillips curve:

$$\dot{P}_{it}^{nr} = \dot{P}_{it}^{e} + b(u_{it} - u_{it}^{*}) + \varepsilon_{it} \ . \tag{5}$$

In the presence of DNWR, the actually observed nominal wage change ($\dot{W}_{it}^{r}$) is raised relative to the nominal wage change assuming no DNWR ($\dot{W}_{it}^{nr}$) by the amount of the nominal wage change gap (gap_{it}), as shown in Section II ($\dot{W}_{it}^{r} = \dot{W}_{it}^{nr} + gap_{it}$). Taking into account the possibility that there are different degrees of stickiness in prices and in nominal wages over the short run, the inflation rate with DNWR is expressed by $\dot{P}_{it}^{r} = \dot{W}_{it}^{r} - \dot{e}_{it} + \dot{M}_{it}$, with $\dot{M}_{it}$ the change in the markup rate.

The relationship among these variables can be written $\dot{W}_{it}^{r} - \dot{W}_{it}^{nr} = \dot{P}_{it}^{r} - \dot{P}_{it}^{nr} - \dot{M}_{it}$ $= gap_{it}$, and plugging this into equation (5), the regional Phillips curve with DNWR is given by the following equation.

$$\dot{P}_{it}^{r} = \dot{P}_{it}^{e} + \dot{M}_{it} + b(u_{it} - u_{it}^{*}) + gap_{it} + \varepsilon_{it} \ . \tag{6}$$

Note that when $\dot{P}_{it}^{r} = \dot{P}_{it}^{e}$ and $\dot{M}_{it} = gap_{it} = \varepsilon_{it} = 0$, the unemployment rate u_{it} becomes its equilibrium value u_{it}^{*}.

Regarding the changes in expected inflation, the markup rate, and the equilibrium unemployment rate, we break down each variable into the factors common among regions, the factors common across time, and the others, as below.

$$\dot{P}_{it}^{e} = \dot{P}_{i}^{e} + \dot{P}_{t}^{e} + v_{it} \ , \qquad v_{it} \overset{i.i.d.}{\sim} N(0,\sigma_{v}^{2}) \ , \tag{7}$$

$$\dot{M}_{it} = \dot{M}_{i} + \dot{M}_{t} + m_{it} \ , \qquad m_{it} \overset{i.i.d.}{\sim} N(0,\sigma_{m}^{2}) \ , \tag{8}$$

$$u_{it}^{*} = u_{i}^{*} + u_{t}^{*} + \eta_{it} \ , \qquad \eta_{it} \overset{i.i.d.}{\sim} N(0,\sigma_{\eta}^{2}) \ . \tag{9}$$

Here, we assume that v_{it} , m_{it} , and η_{it} are stochastic variables with normal distributions, uncorrelated with the unemployment rate and other variables.

Substituting equation (6) into equations (7) – (9), we can derive the following equation to be estimated.

$$\dot{P}_{it}^{r} = a_{i} + n_{t} + bu_{it} + gap_{it} + \varphi_{it} \ , \tag{10}$$

where $a_{i} = \dot{P}_{i}^{e} + \dot{M}_{i} - bu_{i}^{*}$, $n_{t} = \dot{P}_{t}^{e} + \dot{M}_{t} - bu_{t}^{*}$, and $\varphi_{it} = v_{it} + m_{it} - b\eta_{it} + \varepsilon_{it}$.

As noted in Section IV.A, if it is DNWR that flattens the Phillips curve under low inflation, the second and third moments of the unemployment rate become less significant or insignificant in equation (10), since the equation uses the gap_{it} variable to explain the degree of DNWR. Therefore, in estimating (10) using a two-way fixed-effect model, we add the second and third moments of the unemployment rate to the explanatory variables as in Section IV.A.[28]

2. Estimation results

We use the same regional data from 1985–2001 as above. To calculate the nominal wage change gap of region *i* and year *t* (gap_{it}), we first take weighted averages of the nominal wage change by prefecture using the number of employees as a weight to derive the average actual nominal wage change of region *i* and year *t*. We then match

[28] Since the lower the inflation rate, the larger the nominal wage change gap, there is a simultaneous equation bias between $\dot{P}_{it}^{r}$ and the gap_{it} variable. Therefore, we restrict the coefficient of the gap_{it} variable to value 1 without testing the validity of the constraint.

them with the hypothetical average nominal wage changes that were constructed from the hypothetical nominal wage change distributions based on the estimation results in Section II. Finally, subtracting the average hypothetical nominal wage change from the average actual nominal wage change by region i and year t, we obtain the nominal wage change gap (gap_{it}).

The estimation results are listed in Table 3. Looking at model 3 of Table 3, one can find that the *p*-values of the second and third moments of the unemployment rate are 7 to 9 percent. Therefore the statistical significance of nonlinearity is lower than that of Table 2, which does not account for DNWR. This shows that DNWR is indeed one of the factors that make the Phillips curve nonlinear. Nevertheless, it is important to note that even when we explicitly take DNWR into account, the nonlinearity of the Phillips curve does not completely disappear.

It is likely that the nominal wage change gap used for the estimation is being underestimated, since it includes measurement errors caused by changes in the establishment samples as explained in Section II. Hence, if the true nominal wage change gap were large, the second and third moments of the unemployment rates might become totally insignificant, and the relationship between unemployment and inflation might be described with a near-linear function.

Alternatively, the nonlinearity of the Phillips curve after taking DNWR into account would suggest that the increase in unemployment observed during the low inflation of the 1990s was caused not only by DNWR, as stated by Tobin (1997), but also by other factors. Conceivable factors other than DNWR include the following: (1) labor market distortions other than DNWR that cause unemployment (higher real wages due to real wage inertia or the bargaining power of employees) are amplified under low inflation or deflation;[29] (2) a one-time structural change that occurred around the collapse of the bubble flattened the Phillips curve; and (3) gradual and persistent structural changes that brought about unemployment occurred together with low inflation/deflation and shifted the Phillips curve rightward.[30]

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29 For details, see Kuroda and Yamamoto (2003c).

30 We assume that the structural changes are absorbed by the fixed effect of each year in estimating equation (10). However, it is possible that the structural changes that occurred in the 1990s cannot be captured by the fixed effect. Thus, we also estimated the Phillips curve by incorporating several

3. The impact of DNWR on the unemployment rate

We use model 3 of Table 3 to investigate the extent to which DNWR raised the unemployment rate. Specifically, we first calculate an estimated value for the unemployment rate in 1997, when the upward shift in the nominal wage change from DNWR was at its greatest. Next, after subtracting the term of the nominal wage change gap, we calculate an estimated value for the unemployment rate in the absence of DNWR. We then identify the upward impact on the unemployment rate from DNWR by taking the difference between these two values.

The results of our calculations show an upward impact on the unemployment rate from DNWR of approximately 1.1 percentage points in 1997. Since the unemployment rate was 3.4% in 1997, approximately one-third of the unemployment was caused by DNWR.

Our finding that a nominal wage change gap of only approximately 0.3 percent raised the unemployment rate by 1.1 percentage points in 1997 may overstate the effect of DNWR on unemployment. Thus, the estimation results here should be taken with reservations. However, one may interpret that a nominal wage change gap was created under conditions in which the Phillips curve was flattened by factors other than DNWR, and this wound up magnifying the increase in the unemployment rate due to DNWR. In other words, as indicated by the estimation results in Table 3, the Phillips curve had a nonlinear shape even when taking account of DNWR. Consequently, in 1997 the slope of the Phillips curve became extremely small, such that a minor upward shift in the Phillips curve due to DNWR could bring about a substantial increase in the unemployment rate. Observe that given a flattened slope in the Phillips curve, there will be a certain impact on unemployment even if the upward shift of nominal wage change from DNWR is small.

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other explanatory variables (e.g., the ratio of part-time employees to total employees or the female participation rate by region), but those attempts did not affect our estimation result.

4. Context for the increase in unemployment from 1998

Finally, we calculate how the unemployment rate was pushed down when the nominal wage change gap turned negative in 1998 using the same method as above. Our results suggest that the negative nominal wage change gap had a downward impact on the unemployment rate of approximately 0.7 percentage point in 1998.

The actual unemployment rate continued to rise from 1998, however. How should we interpret this rise in unemployment even after DNWR disappeared? There are several conceivable reasons for this. One possibility is that the employment adjustment due to DNWR occurred with a lag. In Japan, it is said that labor hoarding is likely to occur because of the high cost of employment adjustments. It follows that when a firm needs to adjust employment as a result of a DNWR-induced increase in payroll, it could take several years to accomplish the necessary adjustment. The analysis above did not take this possibility into account, and thus assumed that the nominal wage change gap until 1997 would not raise the unemployment rate after 1997. When we use the two-year backward-moving average of the nominal wage change gap to estimate equation (10), however, we obtain the result that DNWR raised the unemployment rate by 0.25 percentage point even in 1998.[31] Another possibility is that DNWR until 1997 raised mismatch unemployment.[32] It may have been difficult for the workers who became unemployed due to DNWR to find new jobs because of the undeveloped external labor market in Japan, making it likely that those workers remained stuck in the unemployment pool. Finally, another possibility is that the increase in the unemployment rate from 1998 was caused by factors other than DNWR, such as the labor market distortions and structural changes noted above.

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[31] In addition, when we take a three- or four-year backward-moving average of the nominal wage change gap, we obtain the result that DNWR raised the unemployment rate until 1999 or 2000, respectively.

[32] Mismatch unemployment includes the unemployment caused by the mismatch of skills (human capital) and that caused by regional segmentation of the labor market.

V. Concluding Remarks

We now summarize the results of this paper. First, downward rigidity of nominal wages, as measured by the total annual earnings of full-time employees calculated from aggregate data, was observed in Japan in the period 1992–97, but disappeared from 1998, when Japan's recession deepened. This finding suggests that DNWR has been observed but is not a permanent phenomenon. Second, when both inflation and labor productivity were low in 1992–97, DNWR pushed up firms' productivity-adjusted real payroll and damaged their profitability. Third, because DNWR had become a binding constraint on firms' ability to adjust nominal wages in 1992–97, they had to reduce employment to reduce their payroll. This led to an increase in unemployment of approximately 1 percentage point at the most until 1997. Furthermore, given the slow employment adjustment of Japanese firms, DNWR observed until 1997 may have increased unemployment even after 1997. However, it should be noted that there were also other factors that raised the unemployment rate in the 1990s, including structural changes and labor market distortions other than DNWR.

We would like to conclude by briefly discussing the implications of these results for monetary policy.

Our analysis has shown that nominal wages in Japan are not permanently downwardly rigid, and that nominal wage cuts do occur after a certain amount of time passes. In other words, it is possible to argue that Japan's monetary policy does not have to take DNWR into account, because even if DNWR is observed under conditions of low inflation or deflation, nominal wages will be cut after a certain period and this could dissipate the damage brought by DNWR.

The timing of the nominal wage cuts may require monetary policy to address DNWR, however. If DNWR disappears relatively quickly, there is no need to use monetary policy to target a small but positive inflation rate as mentioned above. It is important to realize, however, that it was not until 1998 that the nominal wages of full-time employees in Japan began to decline, seven to eight years after the bursting of Japan's economic bubble. During this period, firms' profits continued to deteriorate and the unemployment rate increased by approximately 1 percentage point due to DNWR. There is also a possibility that DNWR until 1997 had delayed effects on unemployment thereafter. Furthermore, in countries such as Japan, where the external labor market is not fully developed, workers who have lost their job cannot easily find a new one, and this makes it likely that the unemployment pool will become larger.

In light of this, any consideration of monetary policy options should take adequate account of not only the damages directly caused by DNWR, but also of the possibility that such damages will linger even after DNWR has disappeared.

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Table 1 Estimation Results for Nonlinear SUR

	Sub-sample (1985-)							All sample
	-95	-96	-97	-98	-99	-00	-01	1985-01
θ	0.606	0.480	0.453	0.010	0.013	-0.013	-0.055	0.548
	(8.908)	(9.314)	(6.472)	(0.392)	(0.494)	(-0.524)	(-2.099)	(7.311)
θ_{98}	-	-	-	-	-	-	-	-0.654
	-	-	-	-	-	-	-	(-8.591)
α_{-3}	0.017	0.032	0.047	0.045	0.045	0.041	0.039	0.044
	(3.658)	(6.718)	(7.594)	(7.819)	(8.182)	(7.990)	(8.016)	(8.842)
α_{-2}	0.039	0.059	0.072	0.073	0.074	0.071	0.068	0.073
	(6.089)	(8.820)	(10.402)	(11.209)	(12.067)	(12.200)	(12.357)	(12.936)
α_{-1}	0.115	0.132	0.139	0.142	0.140	0.140	0.139	0.145
	(14.579)	(19.414)	(20.372)	(20.596)	(20.721)	(20.204)	(20.374)	(20.456)
α_0	0.186	0.211	0.217	0.211	0.211	0.209	0.207	0.214
	(14.065)	(18.074)	(20.117)	(18.989)	(20.298)	(21.548)	(22.735)	(24.757)
α_1	0.227	0.241	0.253	0.257	0.254	0.250	0.242	0.241
	(20.351)	(23.637)	(25.016)	(28.681)	(28.124)	(28.908)	(25.115)	(24.273)
α_2	0.140	0.141	0.147	0.153	0.154	0.153	0.150	0.147
	(20.873)	(18.350)	(18.521)	(18.918)	(20.314)	(21.265)	(22.140)	(23.203)
α_3	0.048	0.065	0.075	0.070	0.070	0.068	0.066	0.077
	(6.358)	(9.751)	(9.555)	(10.419)	(11.209)	(11.642)	(11.997)	(11.771)
α_4	-0.006	0.019	0.030	0.026	0.030	0.028	0.028	0.038
	(-4.417)	(6.731)	(9.413)	(9.333)	(6.276)	(6.329)	(6.092)	(7.898)
β	0.009	0.002	-0.002	-0.002	-0.002	-0.001	0.000	-0.002
	(64.852)	(7.386)	(-4.094)	(-4.286)	(-5.337)	(-2.608)	(-0.253)	(-4.277)
Number of observations	88	96	104	112	120	128	136	136

Notes: 1. Numbers in parentheses are *t*-values.
2. θ_{98} is the coefficient for the dummy variable, which takes the value of one from 1998 and after.

Table 2 Panel Estimation Results for the Regional Phillips Curve: Assuming No DNWR

	Model 1	Model 2	Model 3
Unemployment rate	-0.271	-0.381	-1.558
	(-3.186)	(-2.097)	(-3.141)
	[0.002]	[0.038]	[0.002]
(Unemployment rate)^2		0.013	0.363
		(0.686)	(2.614)
		[0.494]	[0.010]
(Unemployment rate)^3			-0.032
			(-2.542)
			[0.012]
Constant term	2.713	2.908	4.122
	(10.837)	(7.677)	(6.818)
	[0.000]	[0.000]	[0.000]
Adjusted R^2			
Within	0.952	0.953	0.955
Between	0.124	0.131	0.106
Overall	0.935	0.933	0.932
F-value	2.713	2.752	3.276
	[0.009]	[0.008]	[0.002]
Number of observations	153	153	153

Notes: 1. Numbers in parentheses are *t*-values. Numbers in brackets are *p*-values.
2. *F*-values are the *F*-statistics for the fixed effects.

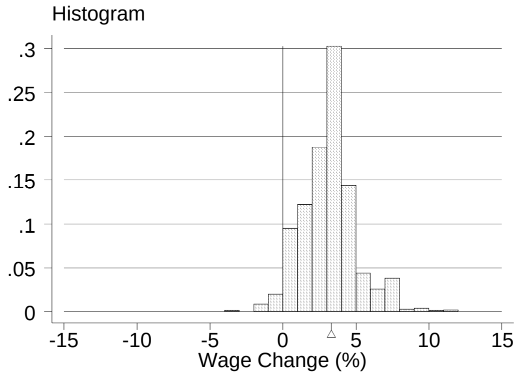
Table 3 Panel Estimation Results for the Regional Phillips Curve: Assuming DNWR

	Model 1	Model 2	Model 3
Unemployment rate	-0.223	-0.357	-1.258
	(-2.365)	(-1.776)	(-2.257)
	[0.020]	[0.078]	[0.026]
(Unemployment rate)^2		0.016	0.284
		(0.757)	(1.818)
		[0.451]	[0.071]
(Unemployment rate)^3			-0.024
			(-1.731)
			[0.086]
Nominal wage change gap	1.00	1.00	1.00
	-	-	-
Constant term	2.572	2.811	3.739
	(9.263)	(6.692)	(5.504)
	[0.000]	[0.000]	[0.000]
Adjusted R^2			
Within	0.941	0.942	0.943
Between	0.247	0.256	0.222
Overall	0.931	0.929	0.928
F-value	1.964	1.994	2.267
	[0.056]	[0.052]	[0.027]
Number of observations	153	153	153

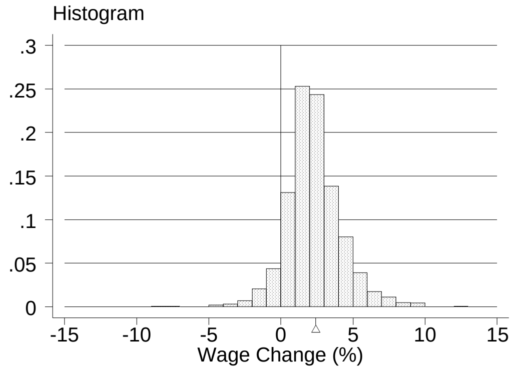
Notes: 1. Numbers in parentheses are t-values. Numbers in brackets are p-values.
2. F-values are the F-statistics for the fixed effects.

Figure 1 Nominal Wage Change Distributions

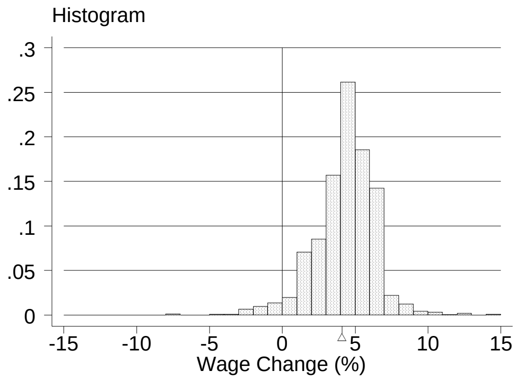
[1] 1985



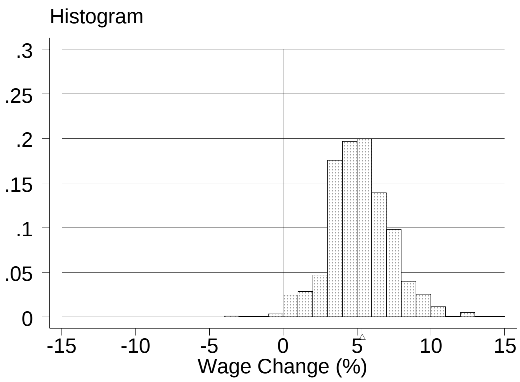
[2] 1986–87



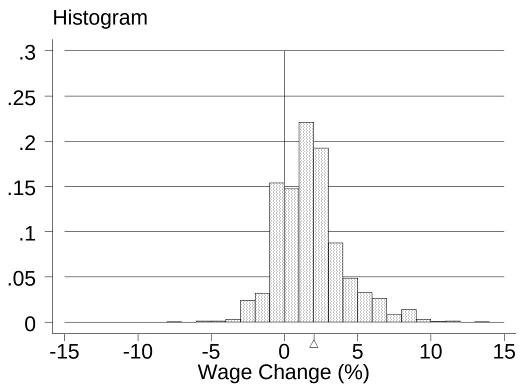
[3] 1988–89



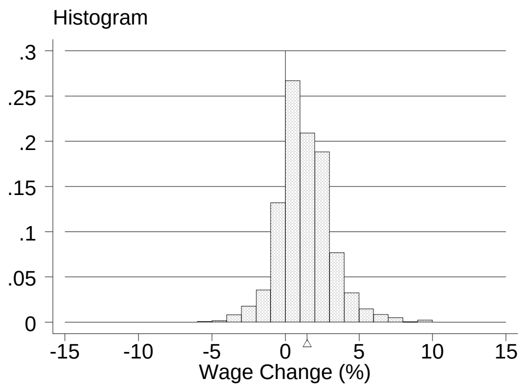
[4] 1990–91



[5] 1992–93

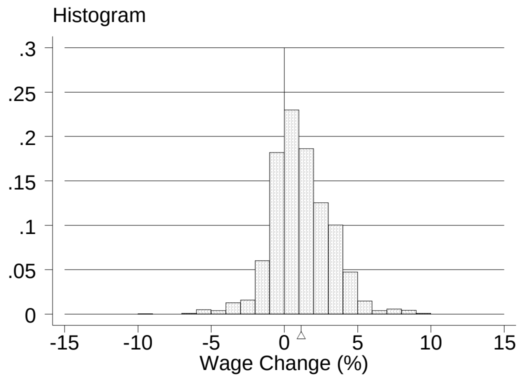


[6] 1994–95

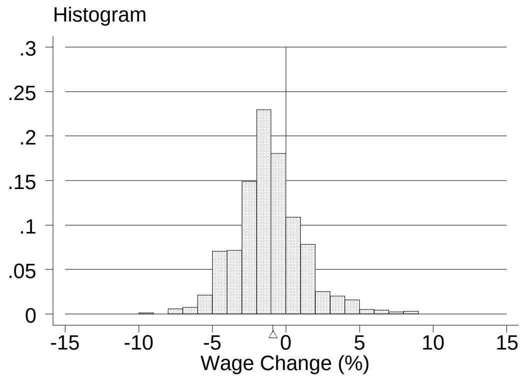


Note: The small triangle (Δ) on the horizontal axis indicates the median.

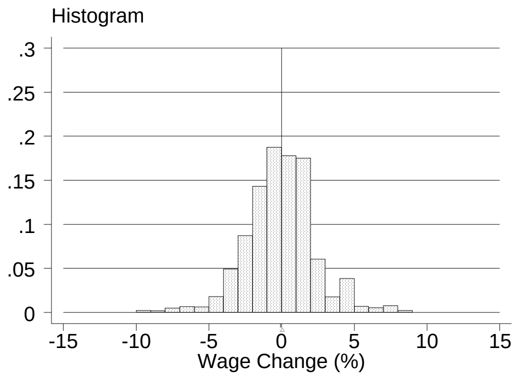
[7] 1996–97



[8] 1998–99

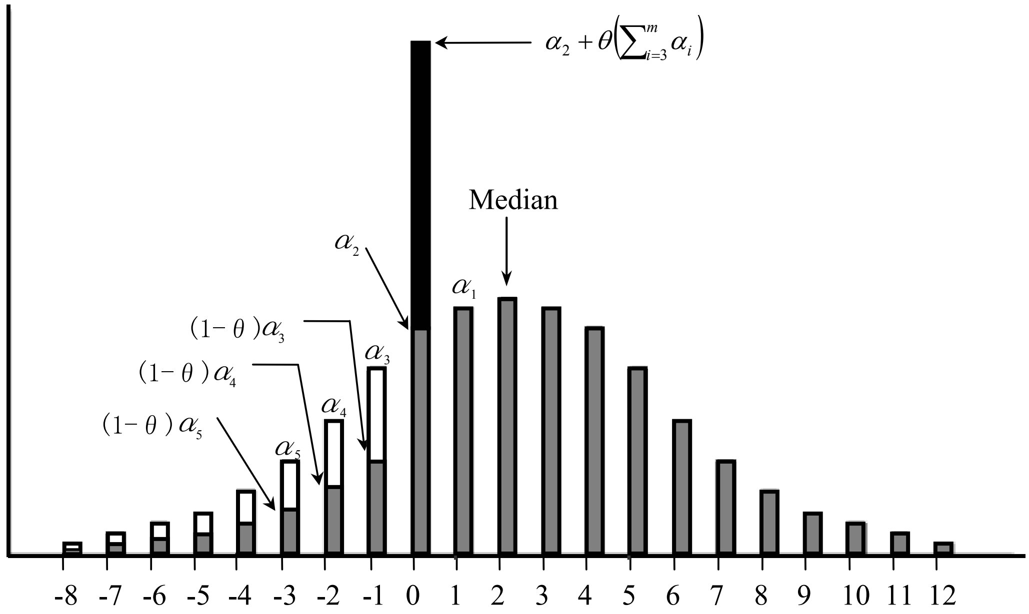


[9] 2000–01



Note: The small triangle (Δ) on the horizontal axis indicates the median.

Figure 2 Kahn's Method of Testing for DNWR



Note: Based on Lebow *et al.* (2003).

Figure 3 Estimates of θ over Time

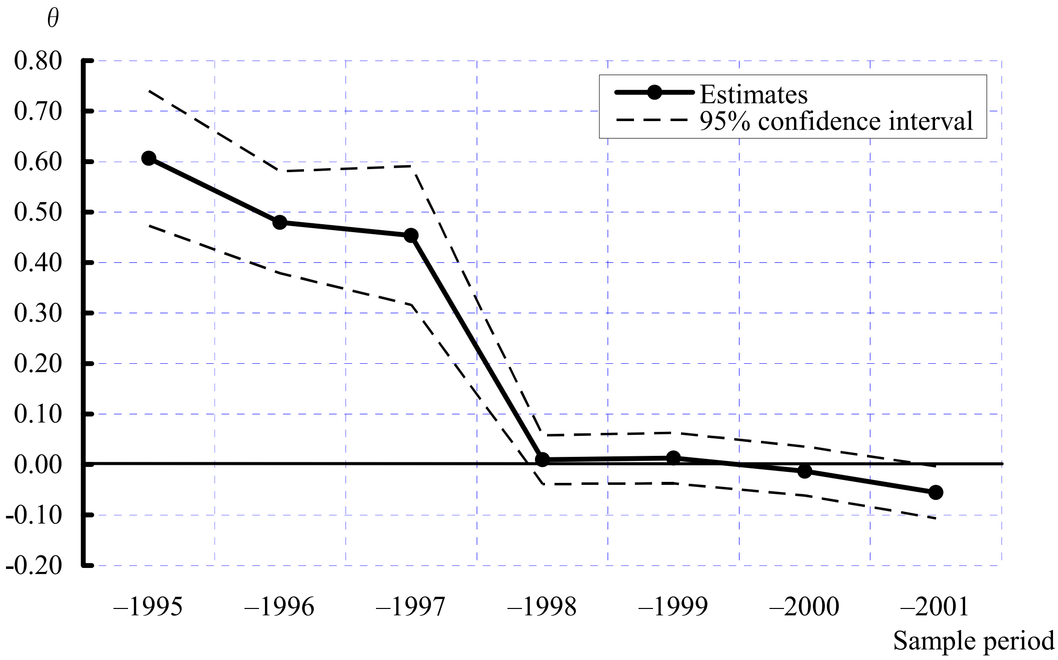


Figure 4 Nominal Wage Change Gap

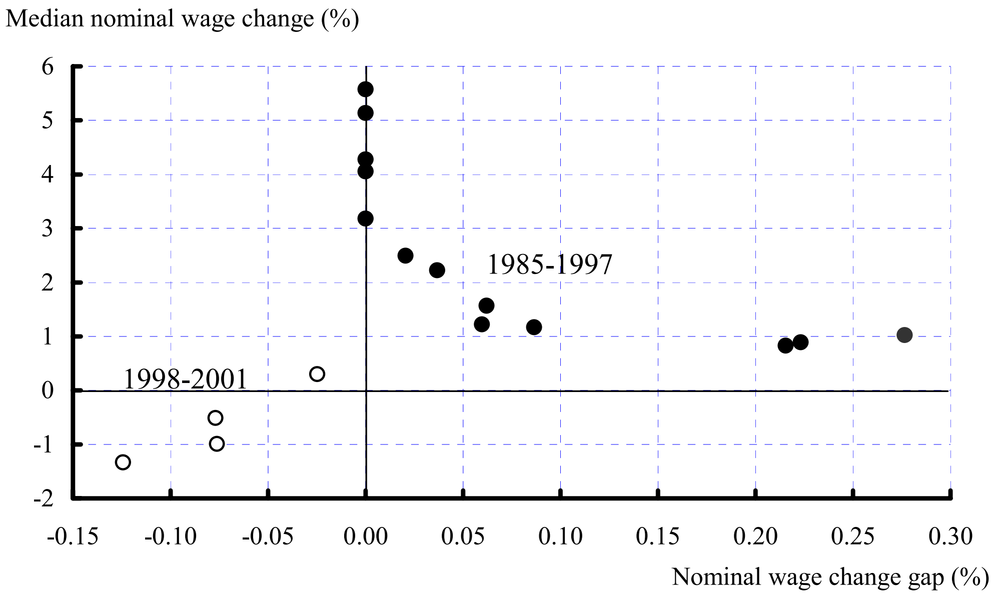


Figure 5 Factor Decomposition of Changes in the Productivity-Adjusted Real Payroll

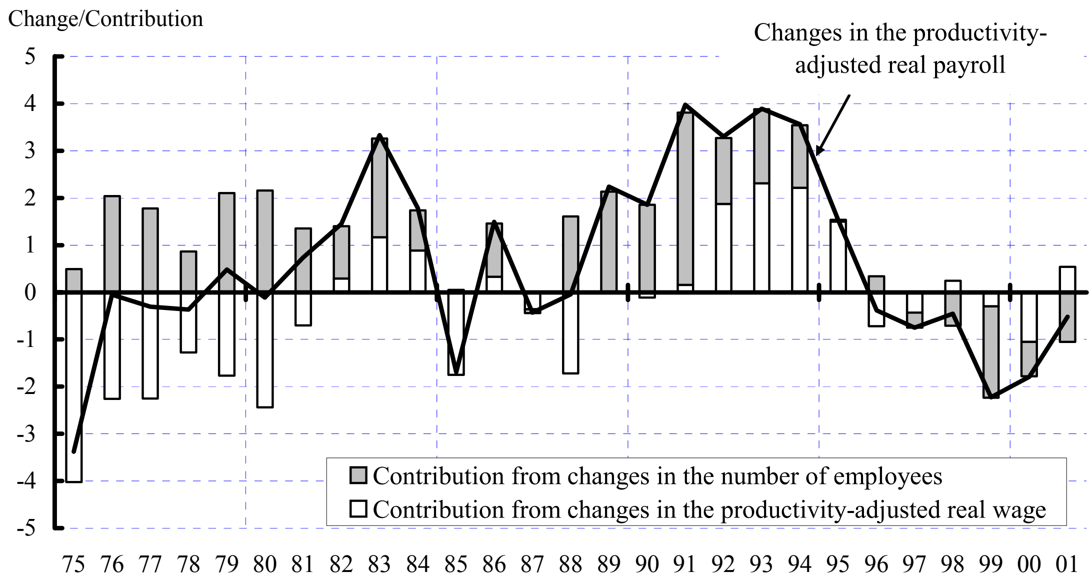


Figure 6 Factor Decomposition of Contribution from Changes in the Productivity-Adjusted Real Wage

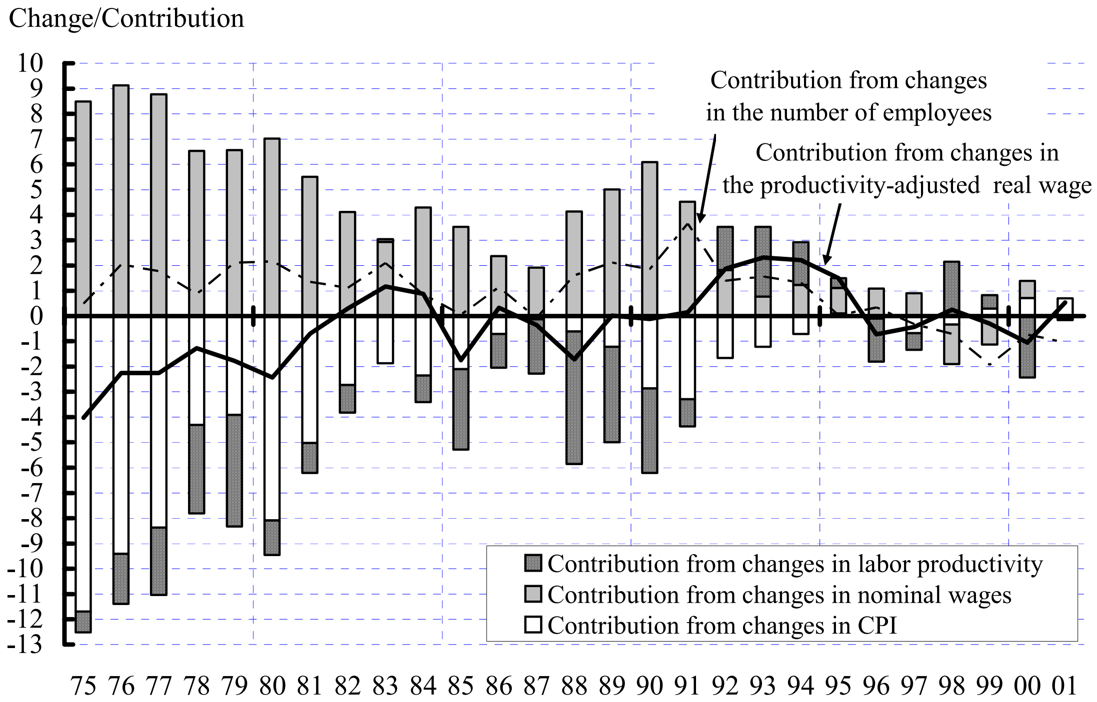
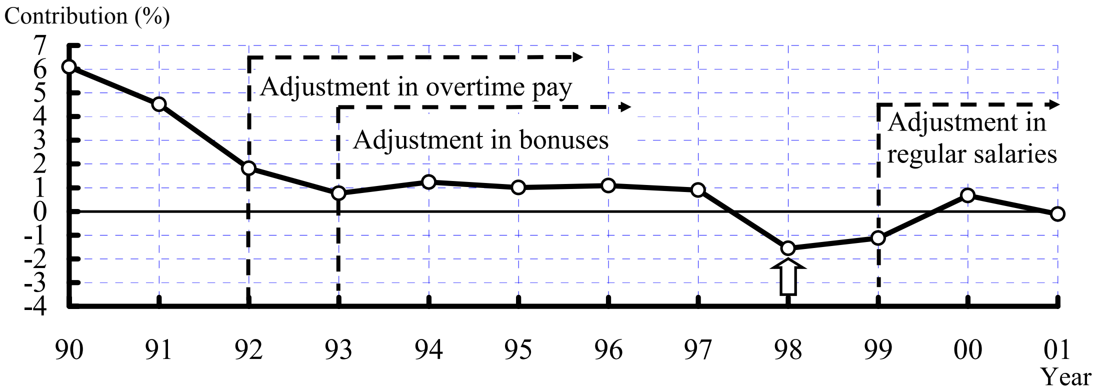
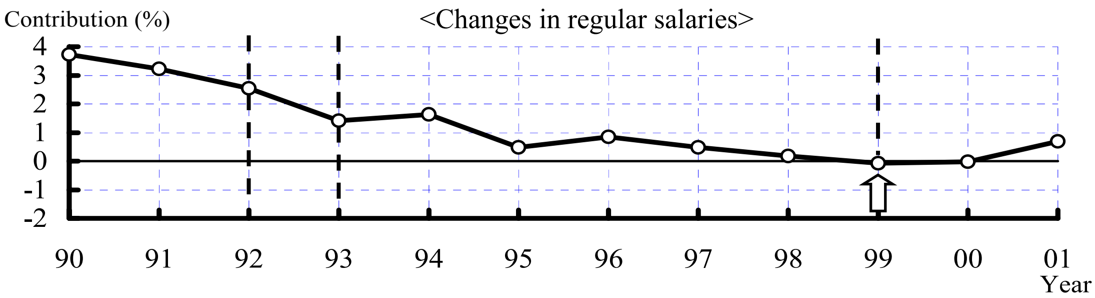


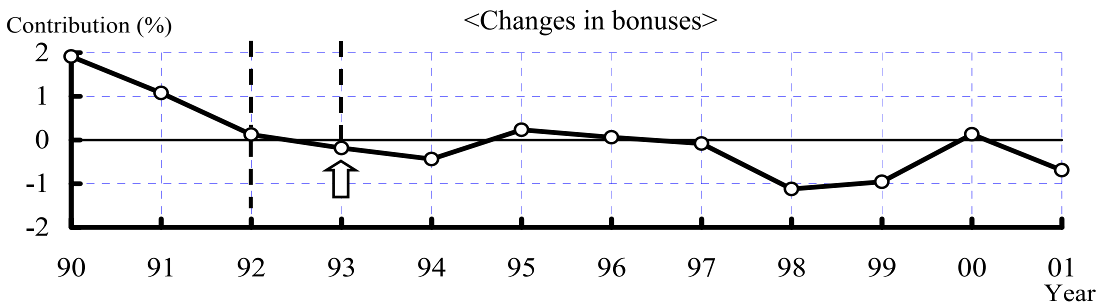
Figure 7 Decomposition of Nominal Wage Changes and the Timing of Adjustments

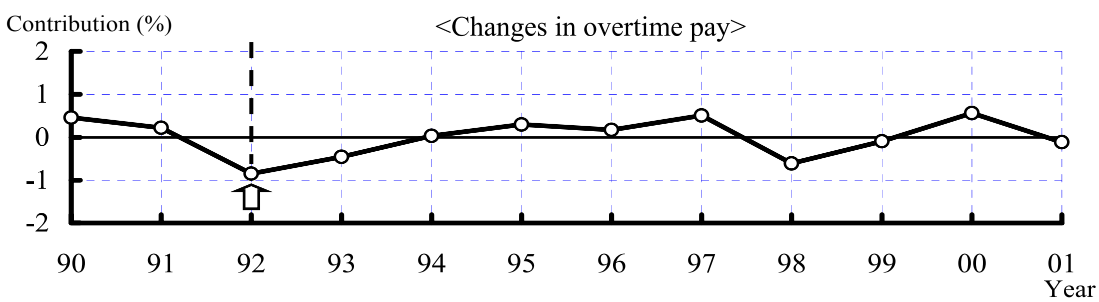
[1] Contribution from nominal wage changes to changes in the productivity-adjusted real payroll



[2] Decomposition



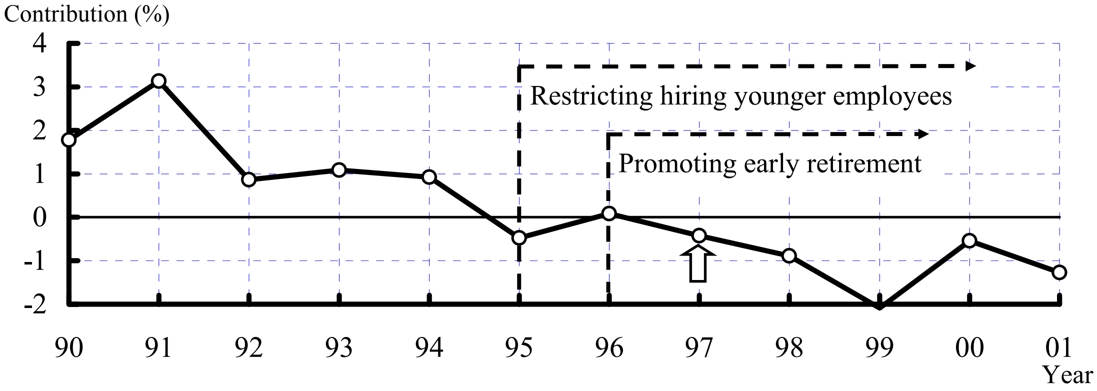




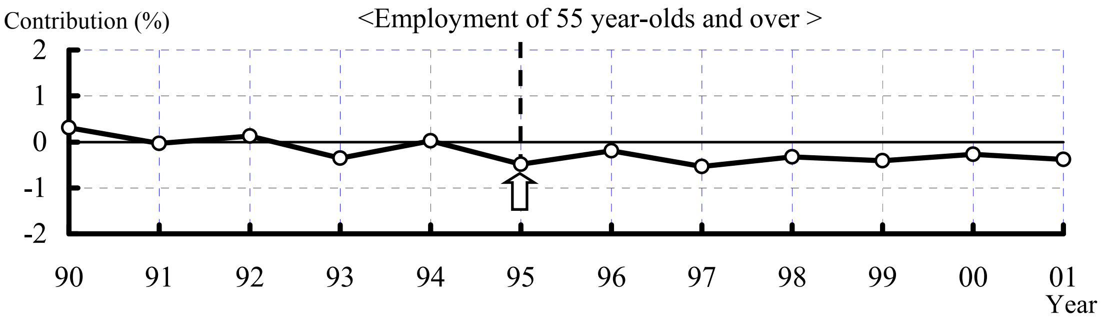
Note: Upward-pointing arrows indicate the first year of a two-consecutive-year period of negative contribution.

Figure 8 Decomposition of Employment Changes and the Timing of Adjustments

[1] Contribution from employment changes to changes in the productivity-adjusted real payroll



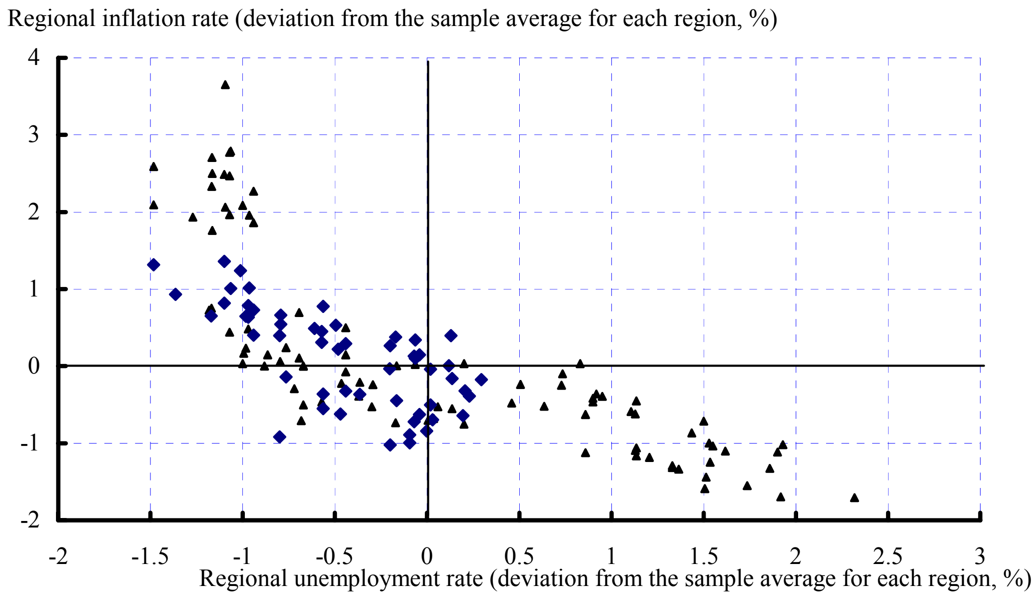
[2] Decomposition



Note: 1. Upward-pointing arrows indicate the first year of a two-consecutive-year period of negative contribution.

2. Contribution of employment changes is the actual contribution from employment changes minus the contribution from employment change caused by population growth.

Figure 9 Regional Phillips Curve



Note: 1. Because the *Consumer Price Index* and the *Labour Force Survey* have slightly different regional classifications, we took weighted averages based on either the size of the labor force or the population.

2. Each region is defined as follows.

Hokkaido : Hokkaido.
Tohoku : Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima.
Kanto : Saitama, Chiba, Tokyo, Kanagawa, Ibaraki, Tochigi, Gumma, Yamanashi, Nagano.
Hokuriku : Niigata, Toyama, Ishikawa, Fukui.
Chubu : Gifu, Shizuoka, Aichi, Mie.
Kinki : Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama.
Chugoku : Tottori, Shimane, Okayama, Hiroshima, Yamaguchi.
Shikoku : Tokushima, Kagawa. Ehime, Kochi.
Kyushu : Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima, Okinawa.

Sources: *Consumer Price Index* and *Labour Force Survey* (Ministry of Internal Affairs and Communications).