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The Impact of Downward Nominal Wage Rigidity on the Unemployment Rate: Quantitative Evidence from Japan

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Abstract

To what extent does downward nominal wage rigidity (DNWR) raise the unemployment rate during periods of low inflation or deflation? To answer this question, we simulate the impact on the full-time male unemployment rate in Japan, by incorporating the DNWR of full-time male employees as estimated by Kuroda and Yamamoto (2003b) into the general equilibrium model of Akerlof, Dickens and Perry (1996). The simulation results show the followings. First, the DNWR estimated by Kuroda and Yamamoto (2003b) with Japanese longitudinal data from 1993-98 has a minor impact on the unemployment rate compared with the case of perfect DNWR. Nevertheless, this impact is not trivial in the sense that it raises the unemployment rate by as much as 1.8 percentage points under the baseline parameters adopted in this paper. Second, regarding the relationship with the rate of inflation, DNWR does not cause unemployment as long as the inflation rate is approximately 2.4 percent or higher, whereas its effects tend to increase gradually as the inflation rate falls below 2.4 percent. When inflation is below approximately 1 percent, however, the marginal increase in unemployment attributable to DNWR is small since DNWR is moderated by the adjustments to bonuses and extensive wage cuts observed in our Japanese data sets. Instead, under these conditions, it is the additional unemployment brought by labor market distortions that becomes the issue.

Keywords: Downward nominal wage rigidity; Unemployment rate; Inflation rate; Monetary policy; General equilibrium model with downward nominal wage rigidity
JEL classification: E24, E50, J64

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I. Introduction

Throughout the postwar period until the early 1990s, Japan's unemployment rate had been maintained at extremely low levels of around 1 to 2 percent. After the bubble economy burst at the start of the 1990s, however, the unemployment rate began to climb. It rose to the 3 percent level in 1995, then the 4 percent level in 1998, and has remained mired in the 5 percent range from the 2000s.

What can explain this persistent increase in unemployment? If the labor market's price adjustment mechanism is functioning, unemployment caused by insufficient effective demand should be eliminated through declines in the real wage. Using Japanese longitudinal data from 1993-98, however, Kuroda and Yamamoto (2003a, b) confirmed that Japanese nominal wages are downwardly rigid to some extent. Under low inflation or deflation, therefore, one may conclude that downward nominal wage rigidity (hereafter, DNWR) has damaged the labor market's price adjustment mechanism. If the sustained rise in the unemployment rate is attributed to DNWR, managing monetary policy by targeting a small but positive, rather than zero, inflation rate could create further room for real wage adjustments, which help reduce unemployment.

However, even if the existence of DNWR is confirmed, it would not be powerful enough to support monetary policy targeting a small but positive inflation, unless the actual impact of downward rigidity on unemployment is considered nontrivial.[1] In this regard, there has been a wealth of research quantifying the extent to which DNWR has caused unemployment, with the pioneering paper being Akerlof, Dickens and Perry (1996). Taking account of DNWR, Akerlof *et al.* (1996) suggest that a reduction in the inflation rate from 3 to zero percent would boost the unemployment rate from 5.8 to 7.6

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[1] Since the 1990s, there have been numerous empirical studies addressing the question of whether nominal wages are downwardly rigid. This research seems to have reached a consensus that DNWR does exist to some extent in Europe and the United States. Such research includes McLaughlin (1994, 1999, 2000), Lebow, Stockton and Wascher (1995), Kahn (1997), Card and Hyslop (1997), and Altonji and Devereux (1999). The existence of DNWR has also been confirmed in Japan by Kimura and Ueda (2001) and Kuroda and Yamamoto (2003a, b). Although Kimura and Ueda (2001) acknowledge DNWR until around 1998, they find no such rigidity when they extend the data until the first quarter of 2000. Furthermore, as described later, Kuroda and Yamamoto (2003a, b) find that under conditions requiring large wage cuts, it is in fact possible to lower nominal wages.

percent, and that 1 percent deflation would raise the unemployment rate to as high as 10.0 percent. The results of their paper are frequently cited in research arguing that the optimal rate of inflation should be small but positive rather than zero (see, for example, Fortin [1996], Bernanke *et al*. [1999] and Svensson [1999]).[2]

Furthermore, Lebow, Saks and Wilson (1999) estimate the Phillips curve using a parameter indicating DNWR, and find that the decline in the inflation rate in the 1990s caused an increase in the non-accelerating inflation rate of unemployment (NAIRU) in the United States. Meanwhile, Card and Hyslop (1997) use regional data to verify whether the slope of the Phillips curve differs between periods of high inflation and low inflation, and find no clear difference between the two. Fares and Hogan (2000) and Faruqui (2000) use data from Canada to estimate an employment adjustment function incorporating an index of DNWR. They find that DNWR has no significant impact on employment adjustments if they control for relevant shocks.[3]

In Japan, however, there has been virtually no analysis addressing this issue. Referring to the framework by Akerlof, Dickens and Perry (1996), therefore, this paper analyzes the impact on unemployment from DNWR confirmed by Kuroda and Yamamoto (2003b). We conduct Monte Carlo simulations on a general equilibrium model, focusing on the DNWR of full-time male employees and their unemployment rate.[4] The degree of DNWR is incorporated as "the extent to which nominal wage cuts are deferred (despite the fact that notional nominal wages should decline)." By altering

[2] In addition to DNWR, other factors supporting a small but positive rather than zero inflation rate include the impact on the financial system from debt deflation, the reduced effectiveness of monetary policy under the zero bound constraint on nominal interest rates, and the upward bias to price indices. For further details, see Shiratsuka (2001).

[3] The majority of prior research examining the relationship between DNWR and employment focuses on labor demand, but Altonji and Devereux (1999) focus on the impact on the labor supply. Kuroda and Yamamoto (2003c) also analyze whether workers leave their jobs less often if nominal wage cuts that should have occurred are deferred due to DNWR.

[4] In this paper, we only analyze DNWR of full-time male employees, and do not account for other types of workers such as full-time female employees or part-time workers. It would be preferable to define specific labor supply-demand functions for these different groups to consider different degrees of nominal wage rigidity and the substitution relationship between groups. Taking this into account would complicate the model, however, and greatly expand the amount of time required for simulation.

the degree of DNWR and the inflation rate, we confirm the changes in the simulated employee-based unemployment rate.[5]

We also show that in addition to DNWR there are other labor market distortions in the model of Akerlof, Dickens and Perry (1996), and these also cause unemployment. That is, in their model, the bargaining power of employees, the value of workers' time while unemployed, and wage inertia are incorporated as factors that could raise the steady-state level of nominal wages above the market clearing level even in the absence of DNWR. We therefore distinguish between the effects of DNWR and those of other labor market distortions, and focus on the extent to which increases in the unemployment rate brought by declines in the inflation rate can be attributed to DNWR.

A preliminary summary of our simulation results is as following. First, compared with the case of perfect downward rigidity, the DNWR estimated by Kuroda and Yamamoto (2003b) using longitudinal data from 1993-98 has only a minor impact on unemployment. Second, this impact is nonetheless nontrivial as it could raise the unemployment rate by as much as 1.8 percentage points. Third, as for the relation with the inflation rate, DNWR leads to unemployment when the inflation rate is roughly 2.4 percent or lower. On the other hand, if the inflation rate drops below approximately 1 percent or turns into deflation, there is no additional unemployment caused by DNWR, but rather it is labor market distortions that lead to additional unemployment.

This paper is organized as follows. In Section II, we review prior research analyzing the impact of DNWR on employment. We also explain briefly the findings of Kuroda and Yamamoto (2003b) that estimate the extent of downward rigidity in nominal wages via model estimation. In Section III, we provide an overview of a general equilibrium model incorporating DNWR and explain the simulation procedures used. In Section IV, we describe the simulation results. In Section V, we look at the policy implications suggested by our findings and describe additional issues for discussion.

[5] Since our model does not account for self-employed or those employed in family businesses, we use the employee-based unemployment rate, which is calculated by dividing the number of unemployed by the sum of employed and unemployed persons. This will be abbreviated to "unemployment rate" for the remainder of the paper.

II. DNWR in Japan

We incorporate the degree of DNWR estimated by Kuroda and Yamamoto (2003b) into the model from Akerlof, Dickens and Perry (1996). This warrants a brief overview of Kuroda and Yamamoto (2003b), as follows.

Kuroda and Yamamoto (2003b) use Japanese longitudinal data from the 1993-98 waves of *Japanese Panel Survey of Consumers* (JPSC) conducted by the Institute for Research on Household Economics (IRHE) to estimate the friction model shown below.

$$\tilde{w}_i - \tilde{w}_{i,-1} = \begin{cases} w_i^* - \tilde{w}_{i,-1} & if \quad 0 < w_i^* - \tilde{w}_{i,-1} \quad , \\ 0 & if \quad -\alpha < w_i^* - \tilde{w}_{i,-1} \le 0 \quad , \\ w_i^* - \tilde{w}_{i,-1} + \lambda & if \quad w_i^* - \tilde{w}_{i,-1} \le -\alpha \quad , \end{cases} \tag{1}$$

where $\tilde{w}_{i,-1}$ is the log of nominal wage in the previous period and $\tilde{w}_i$ is the log of nominal wage in the current period for each individual ($i = 1, \cdots, n$). w_i^* is the log of the notional wage expressed as a function of individual characteristics and a normally distributed error term. The model assumes that the observed nominal wage change can differ from the notional wage change when the notional wage change is less than zero. Specifically, if the notional wage change is between a certain negative threshold value and zero, the nominal wage change becomes zero, but under conditions where the notional wage change falls below this threshold value, the model allows a nominal wage cut to occur.

Parameter α is the threshold value that determines the range under which the observed nominal wage change is held to zero. If the estimated parameter α is significantly positive, nominal wage cuts do not occur as long as the notional wage change ranges from $-(\alpha \times 100)$ to zero percent. That is, there exists DNWR. Parameter λ determines the extent to which the nominal wage cut diverges from the notional wage cut when notional wage change falls below the threshold value. If the estimated parameter λ is significantly positive, it implies that the observed negative nominal wage change rates are still $(\lambda \times 100)$ percent higher than the notional ones, even when the notional wage change falls below the threshold. On the other hand, if λ is estimated negative, it is understood that nominal wage cuts are conducted by more than the amount that would be expected based on the notional wage.

The results from this friction model estimated by Kuroda and Yamamoto (2003b) are summarized in Figure 1. The horizontal axis in Figure 1 is the notional wage change, the vertical axis is the observed nominal wage change, and the 45-degree line indicates where the two are equal. When the notional wage change is positive, the notional and observed nominal wage changes are assumed to be equal. When the notional wage change is zero or less, however, the observed nominal wage change is zero, thereby deviating from the 45-degree line and becoming horizontal. Kuroda and Yamamoto (2003b) estimate friction models for several types of wages, by employment status and sex. Among the results, we look here only at the results concerned with the regular wages (regular monthly wages) and annual earnings (total of regular wages, bonus, and overtime pay for the full year) of full-time male employees.[6]

As shown in Figure 1, the regular wages of full-time male employees are not actually reduced as long as the changes in notional wages do not drop below –7.7 percent. In other words, regular wages have downward rigidity within the –7.7 to zero percent range. Nevertheless, when the notional wage changes drop below the threshold value of –7.7 percent, the reductions tend to be substantially larger than those indicated by the decline in the notional wage changes since λ is estimated to be negative. Downward rigidity in annual earnings, on the other hand, exists when the notional change is in the range from –3.5 to zero percent, and when it drops below this range, actual annual earnings are reduced further than the notional wage change, just as with regular wages. The smaller threshold value for annual earnings relative to regular wages is consistent with prior research by Suruga (1987) and others who find that bonuses serve to increase the flexibility of nominal wages in Japan.

In the next section, we introduce a general equilibrium model that incorporates the DNWR derived from Kuroda and Yamamoto (2003b). As for measures of DNWR, we apply the estimates for α and λ for the regular wages and annual earnings of full-time male employees in the friction model.

[6] Figure 1 shows the results of Kuroda and Yamamoto (2003b) using a model that statistically takes into account measurement errors in reported nominal wages.

III. General equilibrium model incorporating DNWR

A. General equilibrium model and Japan's labor market

In this section, we explain the general equilibrium model and simulation procedures used for our analysis. The framework revolves around the model in Akerlof, Dickens and Perry (1996), hereafter the ADP model. We modify the model to reflect the characteristics of Japan's labor market.

1. The general equilibrium model from Akerlof, Dickens and Perry (1996)

The ADP model assumes a market structure with monopolistic competition in which each firm is faced with two types of heterogeneous shocks, one in the demand for their goods and the other in the real wages. Based on the assumption of monopolistic competition, the price of each firm's product is determined as a markup over the nominal cost of labor input (nominal wage), which is the only production input. The following assumptions are made regarding the setting of nominal wages. First, nominal wages, which are determined through bargaining between the employees and the firm, are consistently higher than the market clearing level. This is because of the employees' bargaining power and positive value of time while unemployed, and the slow adjustment of real and nominal wages from the previous period. Furthermore, to reflect DNWR, nominal wages are not reduced by more than 1 percent, except in the case of firms with two consecutive periods of losses.

The feature of slow adjustments to nominal wages can also be derived by incorporating staggered wage adjustments of the type described in Taylor (1979, 1980) or Calvo (1983). Accordingly, the ADP model can be interpreted as a standard general equilibrium model incorporating staggered wage adjustments with the additional constraint of DNWR.

2. Modification on the ADP model

In order to take into account the characteristics of Japan's labor market, we make the following two modifications to the ADP model. First, we incorporate partial downward rigidity in nominal wages to allow for nominal wage cuts once the notional wage changes drop below a negative threshold. Second, we distinguish between regular wages and bonuses.

These modifications are motivated by the results of Kuroda and Yamamoto (2003b). As explained in the previous section, Kuroda and Yamamoto (2003b) show that Japan's DNWR is imperfect in the sense that large cuts in nominal wages can occur. Also, according to Kuroda and Yamamoto (2003b), annual earnings including bonuses are less downwardly rigid than regular wages. These modifications are an attempt to reflect these characteristics of Japan's wage structure.

B. Model description

1. Goods market

In the goods market, we assume that monopolistically competitive firms indexed by $i\,(i=1,\cdots,n)$ face the following product demand function, consisting of aggregate demand and the demand for the individual firms' products.

$$D_i = \left(\frac{M}{\overline{P}}\right)\left(\frac{P_i}{\overline{P}}\right)^{-\beta} e^{\varepsilon_i}/n \quad , \tag{2}$$

where D_i is product demand, P_i is the price charged by each monopolistically competitive firm, $\overline{P}$ is the aggregate price level ($\overline{P} = n^{-1}\sum_{i=1}^{n} P_i$), M is the money supply, β is the price elasticity of product demand, and ε_i is the heterogeneous shock to product demand, which follows an AR (1) process as shown in equation (3).

$$\varepsilon_i = \rho_\varepsilon \varepsilon_{i,-1} + v_i^\varepsilon \quad , \quad v_i^\varepsilon \sim N(0,\sigma_\varepsilon^2) \quad , \tag{3}$$

where ρ_ε is the autocorrelation coefficient and v_i^ε is the normally distributed disturbance with mean zero and variance σ_ε^2. As shown in equation (4), each firm produces Q_i using labor input L_i.[7]

$$Q_i = L_i \quad . \tag{4}$$

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[7] In Japan, an amendment to the Labor Standards Act caused the number of scheduled working hours to fall rapidly from the late 1980s through the early 1990s. According to the *Basic Survey on Wage Structure* (Ministry of Health, Labor and Welfare), however, the number of regular hours actually worked by full-time workers had stopped declining by 1993. Therefore, we assume that reductions in scheduled working hours have no significant impact on the analyses herein.

Solving each firm's profit maximization problem, one can derive the following markup equation.

$$P_i = \frac{\beta}{\beta - 1} W_i \quad , \tag{5}$$

where W_i is the nominal wage.

2. Labor market

The unemployment rate u is defined by equation (6) as follows.

$$u = \max\left(\frac{L^f - L}{L^f}, \underline{u} \right) \quad , \tag{6}$$

where L is the aggregate labor input from each firm, and L^f is the labor force. We assume here that since the labor market is imperfect, at least ($\underline{u} \times 100$) percent of the labor force L^f are unemployed due to a mismatch between labor supply and demand. Accordingly, $\underline{u}$ represents the lower bound of the unemployment rate.[8]

a. The notional wage level

The nominal wage is derived as a solution of the following bargaining problem, where the firm and employees bargain over the nominal wage level W_i^n with bargaining power a ($0 \le a \le 1$).

$$\max_{W_i^n} \left[R_f^{1-a} R_l^a \right] = \max_{W_i^n} \left[\left(\frac{P_i D_i - f\overline{P} D_i - W_i^n L_i}{L_i} \right)^{1-a} \left(W_i^n - \left((1-u)\overline{W} + uc\overline{P} \right) \right)^a \right] \quad , \tag{7}$$

where R_f is the firm's surplus given by subtracting the fixed costs of production $f\overline{P}D_i$ (f is the fraction of fixed costs per unit of good) and total nominal wages paid $W_i^n L_i$ from revenue $P_i D_i$. On the other hand, R_l is the employee's surplus that is given by subtracting the employee's reservation wage from nominal wage. In this case, using the unemployment rate u as a weight, the reservation wage can be expressed as a weighted average of the average wage for employees when employed with another firm

[8] Once the unemployment rate reaches its lower bound, i.e., the frictional or structural unemployment rate, it becomes impossible to hire additional workers, such that even if the money supply increases, only prices and nominal wages increase.

$\overline{W}$ ($\overline{W} = n^{-1}\sum_{i=1}^{n} W_i$) and the income received when not working $c\overline{P}$ (e.g. unemployment insurance benefits).

Solving this problem, and further assuming that real wages are smoothed with the previous period based on the parameter z ($0 \le z \le 1$), and that the bargaining is subject to individual shocks η_i, one can derive the notional wage W_i^* divided by the aggregate price level as follows.

$$\frac{W_i^*}{\overline{P}} = (1-z)\left(\frac{W_{i,-1}}{\overline{P}_{-1}}\right) + z\{a[(P_i - f\overline{P})D_i / \overline{P}L_i] + (1-a)[(1-u)(\beta-1)/\beta + uc]\} + \eta_i \quad , \tag{8}$$

where the average real wage $\overline{W}/\overline{P}$ is expressed by $(\beta-1)/\beta$ from equation (5), and η_i is given by the following equation, with the autocorrelation coefficient ρ_ε and the normally distributed disturbance ν_i^ε with mean zero and variance σ_ε^2.

$$\eta_i = \rho_\eta \eta_{i,-1} + \nu_i^\eta \quad , \quad \nu_i^\eta \sim N(0, \sigma_\eta^2) \quad . \tag{9}$$

Note that the notional wage W_i^* here is the result of this bargaining and inertia when there is no DNWR.[9]

Also, as in equation (10) and (11), we suppose that the notional wage W_i^* determined in equation (8) consists of the notional regular wage S_i^* with the weight $(1-\theta^*)$ and the notional bonus B_i^* with a weight θ^*.[10]

$$S_i^* = (1-\theta^*)W_i^* \quad , \tag{10}$$

$$B_i^* = \theta^* W_i^* \quad . \tag{11}$$

This allows us to capture the wage structure in Japan wherein bonus payments can serve as a tool for nominal wage adjustment.

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[9] As explained later, since the notional wage is affected by labor market distortions, it is not necessarily the same as the equilibrium wage level that clears labor supply and demand.

[10] Although, in reality, the notional fraction of bonuses θ^* is determined endogenously, we take it as fixed for simplification. When wages are cut, however, the expost fraction θ obtained from the simulation declines during a recession, reflecting that bonuses cuts occur prior to regular wages cuts ($\alpha_s > \alpha_b$).

b. DNWR

Based on the friction model estimated by Kuroda and Yamamoto (2003b), we introduce the DNWR for both regular wages and bonuses as follows.

$$S_i = \begin{cases} S_i^* & \text{if} \quad S_{i,-1} < S_i^* \quad , \\ S_{i,-1} & \text{if} \quad S_{i,-1}e^{-\alpha_s} < S_i^* \le S_{i,-1} \quad , \\ S_i^* e^{\lambda_s} & \text{if} \quad S_i^* < S_{i,-1}e^{-\alpha_s} \quad , \end{cases} \tag{12}$$

$$B_i = \begin{cases} B_i^* & \text{if} \quad B_{i,-1} < B_i^* \quad , \\ B_{i,-1} & \text{if} \quad B_{i,-1}e^{-\alpha_b} < B_i^* \le B_{i,-1} \quad , \\ B_i^* e^{\lambda_b} & \text{if} \quad B_i^* < B_{i,-1}e^{-\alpha_b} \quad , \end{cases} \tag{13}$$

where α_s and α_b are parameters that indicate the threshold values until which nominal wages are not cut even if the notional wage changes are negative. Likewise, λ_s and λ_b are parameters that indicate the divergence of the nominal wage changes from the notional wage ones when nominal wage cuts do occur. Equations (12) and (13) indicate that DNWR is present when the notional wage change is between $-(\alpha \times 100)$ and zero percent, and the observed nominal wage cut is the notional wage change plus an additional change of $(\lambda \times 100)$ percent when the notional wage change is below $-(\alpha \times 100)$ percent. The observed nominal wage W_i is the total of the observed regular wage S_i and observed bonus B_i, as shown below.

$$W_i = S_i + B_i \quad , \tag{14}$$

As pointed out by Fehr and Götte (2000), we may not preclude the possibility that the threshold values (α_s and α_b) become smaller as the inflation rate becomes very low, causing DNWR to disappear. Kuroda and Yamamoto (2003b), however, did not find any changes in the threshold value attributable to the inflation rate in the estimated friction model for the regular wages and annual earnings of full-time male employees.[11] We therefore assume that the threshold values do not change with respect to either the inflation rate or time.

[11] This finding of Kuroda and Yamamoto (2003b) is limited to a narrow band of inflation rates from –1.17 to 2.19 percent, so the possibility of a change in the threshold value cannot be excluded when the inflation rate exceeds these bounds.

c. Labor market distortion other than DNWR

It is important to recognize that both the ADP and our models include the upward distortions to real and nominal notional wages caused by the employee's bargaining power a, real value of worker's time while unemployed c, and the inertia of real wages $(1-z)$ in equation (8). That is, when the parameters in equation (8) have values $0 < a \leq 1$, $0 < c$ and $0 < z \leq 1$, real and nominal notional wages are higher than the equilibrium level that clears excess supply and demand in the labor market ($a = 0$, $z = 1$, $c = 0$). We call these distortions labor market distortions.

As will be explained later, labor market distortions cause unemployment by increasing notional real and nominal wages above the market clearing level. We therefore distinguish the unemployment generated in this way from the unemployment caused either by a mismatch (at the lower bound of the unemployment rate) or by DNWR.

3. The relationship between DNWR and the rates of inflation and unemployment

The relationship between nominal wages and the money supply, inflation rate, and unemployment rate in the model can be explained as follows. Note that since aggregate demand is exogenously given and the money supply is a proxy variable for aggregate demand in our model, lowering the money supply corresponds to insufficient labor demand caused by a decline in effective demand.

a. A case without labor market distortions

To start with, we assume a case without labor market distortions ($a = 0$, $z = 1$ and $c = 0$). Suppose that nominal wages are perfectly flexible and the actual nominal wage and the notional wage in equations (12) and (13) are always equal (i.e., $S_i = S_i^*$ and $B_i = B_i^*$ regardless of the change in notional wages). Then, a π percent change in the money supply M results in a π percent change in prices, since nominal wages fully respond to the change in the money supply without affecting the unemployment rate. This means that, in a world of flexible nominal wages, the unemployment rate is independent of the rate of inflation. In other words, there is no correlation between the unemployment rate and the inflation rate.

On the other hand, assuming the existence of DNWR as in equations (12) and (13), we can see that the unemployment rate differs according to the rate of inflation.

When the growth rate of the money supply M declines, aggregate demand declines in accordance with equation (2). In this case, it is necessary to lower the nominal wage down to the level of the notional wage level W_i^* in order to keep the unemployment rate from increasing. Given that nominal wages are downwardly rigid in equations (12) and (13), however, even when the notional wage drops below the level of the previous period ($W_{i,-1} > W_i^*$), the nominal wage must be left unchanged. Firms facing those conditions have to pay out nominal wages higher than the notional level that would exist without downward rigidity ($W_i > W_i^*$). Then, in accordance with markup equation (5), the firm's product price P_i is also set higher than the level determined by the notional wage W_i^*. As a result, demand for that firm's product decreases in accordance with equation (2) and thus its labor input L_i must also decrease. If firms faced with DNWR continue to adjust their labor costs by reducing labor input instead of lowering nominal wages, the unemployment rate winds up increasing.

In the opposite scenario whereby the rate of growth in the money supply M increases, the inflation rate goes up, and product demand increases, there will be an overall increase in the notional wage of each firm. Under such a situation, a smaller number of firms will be bound by the constraint from DNWR in equations (12) and (13), and thus the unemployment rate can be kept low.

Therefore, in an economy where DNWR exists and cannot be eliminated for an extended period, the unemployment rate and the inflation rate are negatively correlated.[12]

b. A case with labor market distortions

Next we consider the case when the labor market distortions in equation (8) ($0 < a \leq 1$, $0 < c$, and $0 < z \leq 1$) are present. In this case, there is a negative correlation between the unemployment rate and the inflation rate, even when no DNWR exists. In other words, due to workers' bargaining power, real unemployment income, and wage inertia, the notional wage W_i^* is stuck higher than the labor market clearing level W_i^{**}. Since

[12] It has long been pointed out that when there is DNWR, there exists a negative correlation between the unemployment rate and the inflation rate even over the long run. For example, Tobin (1972) mentions that the long-run Phillips curve becomes horizontal in regions of high unemployment when there is DNWR, arguing against the claim of Friedman and others that the Phillips curve becomes vertical at the natural unemployment rate.

the notional wage W_i^* is determined by equation (8) in a way that it exceeds the labor market clearing level W_i^{**} by a fixed value rather than a fixed proportion, labor market distortions are non-neutral to the nominal price level. For example, the greater the decline in the labor market clearing wage W_i^{**} due to deflation, the larger in relative terms becomes the notional wage's deviation from the labor market clearing level due to labor market distortion, and this increases unemployment. Furthermore, since there is inertia in the notional wage W_i^*, during deflationary periods, the notional wage is pulled upward by the nominal wage level of the previous period. Therefore, the greater the extent of deflation, the more the unemployment rate rises.[13, 14]

It is important to note that the negative correlation between the unemployment rate and the inflation rate becomes even greater when the labor market distortions from equation (8) are present in addition to DNWR given by equations (12) and (13). For this reason, we distinguish between the unemployment caused by the labor market distortions in equation (8) and that caused by the DNWR in equations (12) and (13).

To see why there is a negative correlation between unemployment and inflation even in the absence of DNWR, we derive the labor input L^e from our model with a representative firm, perfectly flexible nominal wages, and no shocks to demand for goods or to real wages. This gives the following equation.

$$L^e = \frac{\pi M_{-1}}{z(1-a)\left(1-\dfrac{\beta}{\beta-1}c\right)\pi M_{-1} + \dfrac{\beta}{\beta-1}P_{-1}\{(1-a)c + a(1-f) + (1-z)W_{-1}\}} , \qquad (15)$$

where the inflation rate π enters the model exogenously as $M = \pi M_{-1}$. Taking the derivative of labor input with respect to the inflation rate yields

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[13] Since our simulation derives the steady-state rate of unemployment under the conditions in which prices increase or decrease at a constant rate, the inertia of wages can have an impact on not only the adjustment process but also on the steady state point itself.

[14] Graham and Snower (2003) derive a long-run negative correlation between the inflation rate and the unemployment rate without assuming perfect DNWR, by incorporating staggered wage adjustments in the new Keynesian macro model.

$$\frac{\partial L^e}{\partial \pi} = \frac{\frac{\beta}{\beta-1}P_{-1}\{(1-a)c+a(1-f)+(1-z)W_{-1}\}M_{-1}}{\left[z(1-a)\left(1-\frac{\beta}{\beta-1}c\right)\pi M_{-1}+\frac{\beta}{\beta-1}P_{-1}\{(1-a)c+a(1-f)+(1-z)W_{-1}\}\right]^2} > 0 \quad . \tag{16}$$

This shows that higher (lower) rates of inflation lead to increases (decreases) in labor input. Note that without labor market distortions ($a = 0$, $z = 1$, $c = 0$), the partial derivative in equation (16) becomes $\partial L^e / \partial \pi = 0$, and thus changes in the inflation rate do not cause changes in labor input.

c. Comparisons with the standard Phillips curve

The relationship between the inflation rate and the unemployment rate in our model is not comparable to that derived by standard Friedman-Phelps-type Phillips curve, since the underlying mechanisms are different.

In the standard Phillips curve, when changes in the money supply occur, a negative correlation is observed between inflation and unemployment for a temporary period. However, after prices and wages have completely absorbed the shock caused by changes in money supply, the unemployment rate returns to its original level (equivalent to the natural rate of unemployment or the NAIRU), which we often call the long-run (vertical) Phillips curve. Additionally, it is usual to assume that even if there are labor market distortions, those distortions are neutral relative to the nominal price level. Consequently, the amount of unemployment caused by labor market distortions is independent of the rate of inflation.

In contrast, our analysis is based on the assumption that neither DNWR nor labor market distortions disappear over the long run, and that those labor market distortions are non-neutral to nominal price levels. Therefore, our simulation aims to calculate the steady-state rate of unemployment under the condition that Japan's labor market structure, including DNWR and labor market distortions, is not changed permanently. Note that in this case the simulated unemployment rate is not uniquely determined for each inflation rate. Therefore, our model simulates a steady-state rate of unemployment for a given level of inflation rate. From here on, we will refer to this simulated unemployment rate as "the steady-state unemployment rate."

C. Simulation procedure

A brief explanation of the simulation procedure we use for our model is given below.

1. Setting target values

First, to ensure that our model consistently replicates Japan's labor market, we simulate the model so as to hit the target values derived from actual data. We use four targets as in Akerlof, Dickens and Perry (1996): the standard deviation of nominal wage changes, the rate of job creation, the rate of job destruction, and the steady-state unemployment rate.

We set a target value of 5 percent for the standard deviation of nominal wage changes, based on the *Basic Survey on Wage Structure* (Ministry of Health, Labour and Welfare).[15] Our target values for the job creation rate and the job destruction rate[16] are 8 percent for each, based on the estimates from Higuchi and Shinpo (1998) and Genda (1998).[17] The steady-state unemployment rate target value is 3.01 percent when the inflation rate is 2 percent (its value in 1985). This value is estimated by using flow data on employment and unemployment.[18]

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[15] We use the weighted standard deviation of the year-on-year change in total annual earnings for males, broken down by industry, company size, age group and education level. The weights are the number of workers in each category.

[16] The job creation rate Δ^c and the job destruction rate Δ^d are defined as follows.

$$\Delta^c = \sum_{i \in \{L_i - L_{i,-1} > 0\}} \left(\frac{L_i - L_{i,-1}}{L_{i,-1}} \times 100 \right) \quad , \quad \Delta^d = -\sum_{i \in \{L_i - L_{i,-1} < 0\}} \left(\frac{L_i - L_{i,-1}}{L_{i,-1}} \times 100 \right) \quad .$$

[17] Higuchi and Shinpo (1998) estimate the job creation rate and the job destruction rate as 7.4 percent and 7.9 percent. This estimate, however, does not include firms with less than five employees. Genda (1998) finds that in firms with less than five employees, the job creation and job destruction rates are both higher than in larger firms. Based on this finding, we use a rate of 8 percent, a slightly higher figure than the estimates from Higuchi and Shinpo (1998).

[18] We compute the transition matrix for males with two states – employed and unemployed, from the Ministry of Labour (2000 and other years). We then estimate the steady-state unemployment rate for males, by assuming this transition matrix to be an ergodic Markov one. The estimated steady-state unemployment rate is 3.01 percent in 1985, 2.08 percent in 1990, 3.41 percent in 1995, 5.74 percent in 1999 and 5.91 percent in 2000. For the details of computations for the steady-state unemployment rate using flow data, see Kuhn and Schuetze (2001) and Kuroda (2003).

2. Setting the parameters

Our model contains 16 parameters. For the number of firms n, we use 10,000.[19] The model's exogenously assigned lower bound on the unemployment rate $\underline{u}$ is assumed as 2.65 percent, which is approximately 90 percent of the steady-state unemployment rate in 1985.[20] For the parameters related to DNWR, we adopt the estimates from Kuroda and Yamamoto (2003b) noted in Section II, $\alpha_s = 0.077$ and $\lambda_s = -0.029$ for regular wages and $\alpha_b = 0.035$ and $\lambda_b = -0.027$ for bonuses.[21] For the relative shares of notional regular wages and bonuses, we compute the fraction of total cash wages accounted for by annual bonuses for male employees in 1985, which corresponds to $\theta^* = 0.31$.[22]

For the parameters regarding labor market distortion, we use $a = 0.10$, $z = 0.80$, and $c = 0.30$, consistent with Akerlof, Dickens and Perry (1996). To do sensitivity analysis, we also check both lower ($a = 0.05$, $z = 0.90$, $c = 0.25$) and higher ($a = 0.15$, $z = 0.70$, $c = 0.35$) levels of labor market distortion.

For the other parameters, we check possible combinations of the parameters within the ranges below, following Akerlof, Dickens and Perry (1996): $\beta = [4.0, 6.0]$, $\rho_\varepsilon = [0.1, 0.9]$, $\rho_\eta = [0.1, 0.9]$, $\sigma_\varepsilon = [0.01, 0.10]$, $\sigma_\eta = [0.01, 0.10]$, $f = [0.0, 0.25]$. We then

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[19] We set the number of firms by referencing the sample sizes in frequently cited surveys of Japanese firms (including the *Business and Investment Survey of Incorporated Enterprises* [Cabinet Office], *Quarterly Survey of Japanese Business Activities* [Ministry of Economy, Trade and Industry], and the *Tankan Short-Term Economic Survey of Enterprises in Japan* [Bank of Japan]). The number of firms does not alter the simulation results to a great extent.

[20] The Ministry of Health, Labour and Welfare (2001) reports that the frictional and structural unemployment rate is 2.26 percent in the first quarter of 1985, which amounts to 88 percent of the official unemployment rate at that time. For our model, we set 2.65 percent as the lower bound of the unemployment rate, by applying this 88 percent factor to the steady-state unemployment rate for 1985.

[21] The bonus parameters are set under the assumption that bonuses will be cut prior to regular wages if wages are going to be cut, and thus we use the parameter for downward rigidity of annual earnings estimated by Kuroda and Yamamoto (2003b). It should be noted that the data used for estimation by Kuroda and Yamamoto (2003b) include overtime pay in annual earnings. Therefore, it is important to keep in mind that the less downward rigidity of annual earnings than regular wages is reflecting the adjustments through overtime pay as well as bonuses.

[22] Under periods of high inflation when DNWR is unlikely to bind, we believe that the observed fraction of bonuses approaches the notional one. This is why we use the value from 1985.

choose those parameters that bring us closest to the target values using the procedures outlined below.[23, 24]

3. Simulation procedures

In choosing the parameters, we first set the inflation rate[25] at 2 percent and then choose the parameter combinations that achieve the mean squared errors from the four target values that fall within given ranges for each. Next, we simulate the steady-state unemployment rates with zero inflation, using every possible combination of those parameters, and then choose the parameter combination that gives the median value steady-state unemployment rate. Armed with the parameters chosen in this way, we simulate the steady-state unemployment rates corresponding to other inflation rates, and use these results as our baseline. For each simulation, the number of repetition is 300.[26]

Unlike Akerlof, Dickens and Perry (1996), our analysis focuses on how the steady-state unemployment rate changes in response to changes in the extent of DNWR. That is, Akerlof, Dickens and Perry (1996) look at how the steady-state unemployment rate increases from pushing the inflation rate below 3 percent. In contrast, we look at how the steady-state unemployment rate changes depending on the parameters that describe the extent of DNWR. We believe the larger (smaller) the threshold values (α_s

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[23] For the price elasticity of product demand, we set a range of parameter values from $\beta = 5.16$, which is computed based on the average labor share over the 1980s and 1990s. Since labor share is given by $\overline{W}L/\overline{P}\,D = \overline{W}/\overline{P} = (\beta - 1)/\beta$ in our model (D is the aggregated product demand for each monopolistically competitive firm, where $D = L$ in equilibrium), it is possible to compute β once we know labor share. We compute the labor share with data from *Financial Statements Statistics of Corporation by Industry* (Ministry of Finance) in the 1980s and 1990s.

[24] Within the given ranges, we set the parameters in each 0.25 interval for β , 0.1 for ρ_ε and ρ_η, 0.05 for f , and 0.001 for σ_ε and σ_η.

[25] In our simulation, we assume that the inflation rate would change as much as the exogenous rate of change in the money supply *M*. However, when the rate of change in the money supply *M* is lowered, the aggregate price level moves higher relative to the case with no downward rigidity, since firms that defer nominal wage cuts also defer changes in their product price using the markup formula. As a result, strictly speaking, the inflation rate is not going to be exactly the same as the rate of change in money supply *M*. Looking at the simulation results, however, the inflation rate is virtually unaffected by firms constrained by DNWR, and thus it is nearly the same as the rate of change in money supply *M*. For this reason, our model treats the inflation rate as being the same as the change in the money supply.

[26] In each simulation, we generate the individual shocks (ν_i^ε and ν_i^η) from a normal distribution, and then iteratively calculate the value of each variable.

and α_b) in equations (12) and (13), the greater (smaller) the number of firms affected by DNWR and the higher (lower) the steady-state unemployment rate.

To see this, we change the parameters for DNWR (α_s and α_b), as well as the inflation rate, to simulate the steady-state unemployment rate that corresponds to each set of values.

IV. Simulation Results

A. The impact of DNWR on the steady-state unemployment rate

The parameters chosen through the process explained in the previous section are as follows: $\alpha_s = 0.077$, $\lambda_s = -0.029$, $\alpha_b = 0.035$, $\lambda_b = -0.027$, $\beta = 4.75$, $\theta = 0.31$, c=0.30, ρ_ε=0.10, $\rho_\eta = 0.60$, σ_ε=0.013, σ_η=0.035, $z = 0.80$, $a = 0.10$ and $f = 0.15$.

The simulation result is shown in Figure 2 [1]. The thick solid line with black squares shows the relationship between the inflation rate and the simulated steady-state unemployment rate. Hereafter, we refer to this baseline result as case A. Based on these parameters, inflation of 2 percent produces a steady-state unemployment rate of 3.12 percent. This corresponds to point *i* in Figure 2 [1]. Likewise, with 1 percent inflation, the steady-state unemployment rate is 4.60 percent, and with zero percent inflation it is 5.95 percent, plotted in Figure 2 [1] as points *ii* and *iii*, respectively. Since we set a floor on the steady-state unemployment rate, the relationship between the inflation rate and the steady-state unemployment rate becomes vertical at 2.65 percent. It is also important to note that at an inflation rate zero percent, the range within one standard deviation of the simulated steady-state unemployment rate under different parameter combinations is 5.58 to 6.33 percent. Thus, changing the parameter combinations does not change to a substantial degree the steady-state unemployment rate.[27]

Next, we simulate the effect of the changes in the extent of DNWR (α_s and α_b) on the steady-state unemployment rate. The solid line with empty squares in Figure 2 [1] shows the relationship between inflation and the simulated steady-state

[27] Although we assume in our model a notional fraction of the bonus relative to regular wage θ of 0.31, changing this parameter value does not change the steady-state unemployment rate to a great extent.

unemployment rate when we set the extent of downward rigidities at extremely large values for α_s and α_b ($\alpha_s = 1{,}000$ and $\alpha_b = 1{,}000$). We call this result case B (the perfect downward rigidity model).[28] We can see that under perfect DNWR, the steady-state unemployment rates are considerably higher than in case A. In other words, the extent of DNWR for full-time male employees represented by $\alpha_s = 0.077$ and $\alpha_b = 0.035$ has less of an impact on the steady-state unemployment rate compared with the case of perfect downward rigidity.

We look next at the opposite case, when there is no DNWR. We plot case C (the no downward rigidity model), which assumes complete flexibility in nominal wages and sets $\alpha_s = \alpha_b = \lambda_s = \lambda_b = 0$, as the solid line with empty triangles in Figure 2 [1].

It should be noted in case C that the steady-state unemployment rate departs from its lower bound of 2.65 percent and incrementally increases, despite the complete lack of DNWR. This shows, as explained in the previous section, how the labor market distortions in equation (8) push up the steady-state unemployment rate as the inflation rate declines. Under case C, the steady-state unemployment rate is not affected by DNWR. Therefore, the gap between the steady-state unemployment rate under case C and the steady-state unemployment rate under baseline case A represents the net increase in the steady-state unemployment rate due to DNWR.

This comparison of cases A and C shows that the steady-state unemployment rate tends to be held down to a maximum of 1.8 percentage points when there is no DNWR. In other words, if the degree of DNWR were considerably lower than that measured by Kuroda and Yamamoto (2003b), the steady-state unemployment rate should also have been lower by approximately 1.8 percentage point. For the rest of the paper, we will refer to the steady-state unemployment rate attributable purely to DNWR as "the steady-state unemployment rate induced by DNWR."

Figure 2 [2] plots the difference between the steady-state unemployment rates under cases A and C to focus on how the steady-state unemployment rate induced by DNWR increases as the inflation rate declines (case A-d). The figure indicates that

[28] When there is perfect DNWR, the lower the rate of change in M, the greater the number of firms constrained by downward rigidity; therefore the divergence between the rate of change in M and the inflation rate becomes large. Accordingly, it is important to note that under the perfect DNWR of case B, actual results should plot higher and to the right.

when the inflation rate is above 2.4 percent, even in the presence of DNWR, the steady-state unemployment rate induced by DNWR does not increase at all.[29]

Next, when the inflation rate drops below 2.4 percent, the effects of DNWR come into play and the steady-state unemployment rate gradually increases. For example, when the inflation rate declines from 2 to 1 percent, the steady-state unemployment rate induced by DNWR moves from 0.47 to 1.77 percent, an increase of 1.30 percentage points.

Further declines in the inflation rate below 1 percent, however, have almost no effect on the steady-state unemployment rate induced by DNWR. For example, a decrease in the inflation rate from 1 to –1 percent only increases the steady-state unemployment rate induced by DNWR by 0.1 percentage point.

Finally, it may be interesting to note that when the inflation rate further declines below –1 percent, the steady-state unemployment rate induced by downward rigidity begins to decline and reaches zero when the inflation rate drops to approximately –6 percent.[30]

B. The impact of DNWR on the steady-state unemployment rate under low inflation or deflation

Our finding that declines in the inflation rate below 1 percent have almost no upward impact on the steady-state unemployment rate induced by DNWR is not necessarily consistent with Akerlof, Dickens and Perry (1996). Recall that Akerlof *et al.* argue that dropping the inflation rate from 3 to zero percent increases the steady-state unemployment rate in the United States from 5.9 to 7.6 percent, and 1 percent deflation

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[29] Nevertheless, it should be noted that the lower bound on the inflation rate (2.4 percent), required to ensure that the steady-state unemployment rate is unaffected by DNWR, depends on the target inflation rate and the lower bound on the steady-state unemployment rate. For our simulation, we have chosen parameters that give a steady-state unemployment rate of 3.01 percent when inflation is at 2 percent and we do not allow the steady-state unemployment rate to drop below 2.65 percent. For this reason, the gap between cases A and C gradually disappears as the inflation rate moves above 2 percent and the two cases yield the same results when the inflation rate reaches 2.4 percent. However, if the target rate of inflation is set higher or the lower bound on the steady-state unemployment rate is set lower, the rate of inflation at which cases A and C are equalized moves higher. Accordingly, the lower bound on the inflation rate required to ensure that DNWR has no effect can vary depending on how these values are set.

[30] We believe this is because the change in notional wages on average drops below the threshold level under extreme deflation, and thus the constraints from DNWR effectively disappear.

raises the unemployment rate to as high as 10 percent because of the existence of DNWR. Hence, it is interesting to investigate the possible explanations of why there is so little upward impact on the steady-state unemployment rate induced by DNWR with inflation below 1 percent in our simulation, which is geared toward Japan's labor market. To answer that question, we will engage in further simulations by changing the parameters describing DNWR.

1. The effects of bonuses

As explained in Section III.A, our model differs from the ADP model in that it includes bonuses. Hence, we now look at how the presence of bonuses affects the steady-state unemployment rate.

Case D (no bonus) shown in Figure 3 [1] alters the baseline case A in Figure 2 [1] by setting parameter θ^* to zero and assuming no bonus, i.e., all of nominal wages are paid out as regular wages. Accordingly, a comparison of the steady-state unemployment rate between case D (no bonus) and case A makes it possible to identify the degree to which the bonus payment weakens DNWR and to which unemployment could be avoided as a result.

Figure 3 [1] shows that the steady-state unemployment rate in case D (no bonus) is higher by 0.94 percentage point with 1 percent inflation and by 1.25 percentage points with 1 percent deflation than in the baseline case A. Therefore, the simulation results can be interpreted as showing that bonus payments have lowered the steady-state unemployment rate by approximately 1 percentage point.

To examine more closely how the presence of bonuses affects the steady-state unemployment rate induced by DNWR, we plot the difference between case D and case C as case D-d in Figure 3 [2]. Case A-d (baseline) includes the bonus, which is the same as in Figure 2 [2]. As noted earlier, in case A-d, reducing the inflation rate below 1 percent has almost no effect on the steady-state unemployment rate induced by DNWR, meaning that under low inflation or deflation, the curve is nearly vertical.

However, in case D-d when there is no bonus, the curve is slightly downward sloping even if the inflation rate is below 1 percent. For example, lowering the inflation rate from 1 to –1 percent causes an additional 0.4 percentage point increase in the steady-state unemployment rate induced by downward rigidity. It follows from this result that when inflation is low or negative, bonuses serve to suppress, albeit only slightly, increases in the steady-state unemployment rate induced by DNWR.

2. Changes in the steady-state unemployment rate due to λ

As explained in section II.B, the results of Kuroda and Yamamoto (2003b) show that, although nominal wages in Japan do have some degree of downward rigidity, once a certain threshold is exceeded, the nominal wage tends to be cut considerably more than does the notional wage. This is another difference between our model and the ADP model, represented in our model by a negative value of λ.

To see the effect of λ, Figure 3 [1] also shows the simulation results when λ_s is set to zero with no bonus, which we designate as case E (no bonus and λ_s = 0). Comparing case E with case D (no bonus), the steady-state unemployment rate is higher in case E by approximately 0.5 percentage point with a 1 percent inflation rate and by 1.25 percentage points with 1 percent deflation. Compared with the baseline case A, it is higher by approximately 1.5 percentage points with a 1 percent inflation rate and 3.57 percentage points with 1 percent deflation. That is, the presence of bonuses and the λ_s parameter weakens the degree of downward rigidity in the nominal wages of full-time male employees in Japan, and thereby suppresses growth in the steady-state unemployment rate by approximately 1.50 to 3.57 percentage points.

Furthermore, under case E (no bonus and λ_s = 0), the larger the decline in the inflation rate, the greater tends to be the difference in the steady-state unemployment rate with case C. For example, looking at the difference between case E and case C, plotted as case E-d (no bonus and λ_s = 0) in Figure 3 [2], the curve is slightly downward sloping even with inflation below 1 percent. In other words, with no bonus and λ_s = 0, when the inflation rate declines, the steady-state unemployment rate induced by DNWR tends to continue rising. This tendency is not observed in baseline case A-d, and somewhat observable in case D-d (no bonus). In case E-d (no bonus and λ_s = 0), when inflation declines from 1 to –1 percent, the steady-state unemployment rate induced by DNWR increases by an additional 1.1 percentage points. Taking into account that the additional increase in the steady-state unemployment rate from not having a bonus is approximately 0.4 percentage point, this indicates that setting λ_s to zero has a net impact of approximately 0.7 percentage point.

To summarize the results from Section IV. B. 1 and B. 2, it is possible to conclude that although DNWR is present to some extent, the increase in the steady-state unemployment rate induced by DNWR is constrained in Japan under low inflation or deflation. This feature is brought mainly by nominal wage adjustments through bonuses and wage cuts, when they do occur, being larger than those indicated by the decline in the notional wage.

C. International comparisons

Next, we simulate our model by assuming that the extent of DNWR is the same as that estimated for other countries in prior research. Specifically, we use the estimation results of Altonji and Devereux (1999) and Fehr and Götte (2000), which estimate a friction model as in Kuroda and Yamamoto (2003b) by using longitudinal data from the United States and Switzerland, respectively. The DNWR parameters they found are $\alpha_s = \alpha_b = 0.654$ and $\lambda_s = \lambda_b = 0.044$ for the United States, and $\alpha_s = \alpha_b = 0.312$ and $\lambda_s = \lambda_b = -0.078$ for Switzerland. The simulation results using these parameters are shown in Figure 3 [1] as case F (international comparison).

Case F plots out as a single line because of the overlap in results obtained from applying the U.S. and Swiss parameters. Moreover, the simulated steady-state unemployment rate in case F also overlaps with case B, which is the case of perfect downward rigidity. Therefore, one may interpret these findings as showing that the impact of DNWR on the steady-state unemployment rate is extremely small in Japan compared with countries such as the United States and Switzerland, where there is nearly perfect DNWR.

D. The impact of labor market distortions on the steady-state unemployment rate: robustness check

It is important to see how the parameters of labor market distortion ($a = 0.10$, $z = 0.80$, $c = 0.30$) in equation (8) change the results, since the simulated steady-state unemployment rate in our model is affected not only by nominal wage rigidity but also by other labor market distortions. We therefore check the robustness of our simulation results by changing the parameters in equation (8) that describe labor market distortions. We use two sets of parameters: one indicating a small presence of labor market distortions ($a = 0.05$, $z = 0.90$, $c = 0.25$) and the other indicating a large presence ($a = 0.15$, $z = 0.70$, $c = 0.35$). The simulation results are summarized in Figure 4 [1]a for small labor market distortions and in Figure 4 [1]b for large labor market distortions.

Looking first at the case of small labor market distortions in Figure 4 [1]a, it is clear that the steady-state unemployment rates generated by the model, cases A′ (baseline), B′ (perfect DNWR) and C′ (no DNWR), are smaller than the standard cases in Figure 2 [1]. In contrast, the cases of large labor market distortions in Figure 4 [1]b, cases A″ (baseline), B″ (perfect DNWR) and C″ (no DNWR), generate a higher steady-state unemployment rates than the standard cases in Figure 2 [1].

Next, we plot the difference between the baseline (cases A, A′ and A″) and the no downward rigidity model (cases C, C′ and C″) to see the relationship between the inflation rate and the steady-state unemployment rate induced by DNWR. The comparison shows that the labor market distortions also have an effect on the steady-state unemployment rate induced by DNWR. For example, when the inflation rate is 1 percent, the steady-state unemployment rate induced by DNWR is less than 1.5 percent with the small labor market distortions, but approximately 2.5 percent with the large labor market distortions.

In addition, when focusing on how much the steady-state unemployment rate induced by DNWR would increase from lowering the inflation rate, we see that every line is nearly vertical with the inflation rate under 1 percent. This implies that the choice of parameters describing labor market distortions does not seem to affect the tendency of the steady-state unemployment rate induced by DNWR to not increase very much under low inflation.

It is also possible to take these robustness checks as indicative of the degree to which the steady-state unemployment rate would change under structural changes – specifically changes to the real value of workers' time while unemployed such as unemployment insurance benefits (parameter c) and the workers' bargaining power (parameter a). Nevertheless, it is important to keep in mind that when evaluating policies that promote such structural changes, we should account not only for changes in the steady-state unemployment rate, but also for changes in social welfare brought about by the policy change. That is, even if lowering unemployment benefits (lowering parameter c) causes a reduction in the steady-state unemployment rate, it may not be the case that this policy change improves social welfare, since the utility level of unemployment declines. Additionally, when evaluating policies from a welfare perspective, we should account for the fact that the source of funds for unemployment benefits is not explicitly built into our model.[31]

V. Concluding Remarks: Policy Implications and remarks

A. Summary and policy implications

This paper examines the impact of downward nominal wage rigidity (DNWR) on the unemployment rate. Under low inflation or deflation, when nominal wages are not fully adjusted due to downward rigidity, firms may make quantitative adjustments to their labor input, and this may cause an increase in the aggregate unemployment rate. By running a simulation using a general equilibrium model with DNWR, we estimate the impact of downward rigidity on the steady-state unemployment rate for full-time male employees.

Our model represents the extent of DNWR as the range where required nominal wage cuts are deferred. By changing this range in various ways, we compare how the simulated steady-state unemployment rates differ. The levels of DNWR we try include: (1) the baseline case from estimates by Kuroda and Yamamoto (2003b) using Japanese longitudinal data; (2) under perfect DNWR; (3) when no DNWR is present; (4) when there is a greater degree of DNWR due to the lack of bonuses; (5) when the extent of actual nominal wage cuts is less than under the baseline case; and (6) using the estimates from other countries in prior research.

The simulation results indicate that the impact of DNWR for full-time male employees in Japan in the 1990s estimated by Kuroda and Yamamoto (2003b) is

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[31] Regarding the desirable level of unemployment insurance benefits, there is a wealth of prior research analyzing the level of benefits that optimizes social welfare using a general equilibrium model, including Hansen and Imrohoroglu (1992) and Acemoglu and Shimer (1999). This prior research takes a comprehensive accounting of the effect of raising unemployment insurance benefits on consumption smoothing, the impacts of the employees' moral hazard on unemployment, and the distortionary effects on workers' consumption brought by the tax increases needed to finance the increase in benefits.

considerably less than in the case of perfect DNWR. This impact is not trivial, however, and under the baseline parameters assumed for our model, it increases the steady-state unemployment rate by as much as approximately 1.8 percentage points.

Looking next at how this impact changes in accordance with the inflation rate, we find the following. First, when the inflation rate is approximately 2.4 percent or higher, there is no increase in the steady-state unemployment rate. Second, as the inflation rate drops below 2.4 percent, the steady-state unemployment rate gradually increases. Third, under low inflation of less than approximately 1 percent or deflation, the increase in the steady-state unemployment rate caused by DNWR disappears, and additional unemployment no longer occurs. This can be attributed to the wage structure of Japan, which is characterized by nominal wage adjustments through bonuses and greater cuts in nominal wages. Fourth, when the inflation rate becomes substantially negative and reaches approximately –6 percent, the steady-state unemployment rate attributable to DNWR disappears.

The result that serious increases in the steady-state unemployment rate are avoided through bonuses and wage cuts signifies a certain degree of flexibility in Japan's labor market. In other words, when considering monetary policy in a deflationary environment, even if the central bank is successful in raising the inflation rate to approximately 1 percent as a way to reduce unemployment, it is unlikely that the unemployment resulting from DNWR will disappear. Therefore, under low inflation or mild deflation, there is little that monetary policy can contribute toward the reduction of unemployment induced by DNWR.

On the other hand, our simulation results indicate that DNWR has no effect on the steady-state unemployment rate when the rate of inflation is approximately 2.4 percent or higher. Considering this, one may conclude that the central bank should target an inflation rate of at least 2.4 percent.[32]

In addition, our simulation shows that even the steady-state unemployment rate induced by labor market distortions apart from DNWR becomes higher as the inflation

[32] Given that the steady-state unemployment rate induced by DNWR also disappears when the inflation rate drops to approximately –6 percent, a mechanical interpretation of the results would suggest that setting the inflation target at –6 percent would be another policy option. As explained below, however, it is important to keep in mind that when considering the optimal rate of inflation, it is necessary to take a comprehensive look at the social costs and benefits of inflation and deflation.

rate drops below 1 percent. Accordingly, given these labor market distortions, if monetary policy should aim to reduce the steady-state unemployment rate caused by them, it makes sense to pursue a monetary policy that targets an inflation rate of 2.4 percent or higher. In this case, monetary policy may contribute toward minimizing the damages brought by distortions in the labor market arising from structural factors.

However, one may insist that the rise in the unemployment rate induced by labor market distortions should be solved through structural policies minimizing the labor market distortions themselves, rather than through monetary policy. From this standpoint, it may be important to make proposals that also address the optimal arrangements to reduce unemployment such as unemployment insurance and other labor market institutions.

B. Remarks

Given some limitations in our analysis such as the period of time covered and the assumptions made, further analysis is required prior to concluding that monetary policy should target a small but positive inflation rate. In the paragraphs that follow, we offer some remarks on our model and suggestions for further analysis.

The first remark is the possibility that the parameter α has been getting smaller during the last several years of persistent and mild deflation. The simulated steady-state unemployment rate with inflation at –1 percent under the baseline case A in Figure 2 (1) is 7.15 percent, considerably above the actual steady-state unemployment rate of less than 6 percent observed since 2000, when deflation has been approximately 1 percent.[33] This implies that we may not be able to accurately simulate the steady-state unemployment rate of the recent deflationary period using the same DNWR parameters estimated by Kuroda and Yamamoto (2003b).

As noted earlier, Kuroda and Yamamoto (2003b) confirm that during the period 1993-98, the threshold value α indicating the extent of DNWR does not vary with the inflation rate. Looking at changes in the inflation rate as measured by the Consumer Price Index, however, the rate has remained negative since 1999. This points to the possibility that the degree of DNWR has decreased following the period analyzed.

[33] Here we are comparing the simulated steady-state unemployment rate with the estimated value of the steady-state unemployment rate explained in Footnote 18.

Kimura and Ueda (2001), who use time-series data by industry from the *Basic Survey on Wage Structure* (Ministry of Health, Labor and Welfare), confirm the existence of DNWR in Japan when using data until 1998. But they also report that the DNWR disappears when extending the period of analysis until the first quarter of 2000 using time-series data from the *Monthly Labour Survey* (Ministry of Health, Labour and Welfare).[34]

Accordingly, an issue remaining for further research is whether the DNWR found in Kuroda and Yamamoto (2003b) persists even during periods of sustained mild deflation, as argued by Akerlof, Dickens and Perry (1996).

Our second remark concerns the settings used for our model. The general equilibrium model in this paper is useful for clarifying the impact of DNWR on the unemployment rate and for debating the role monetary policy can play. As noted above, however, our model does not account for different types of workers such as full-time and part-time. As shown by Kuroda and Yamamoto (2003a, b), the extent of DNWR varies greatly with the type of nominal wage. Consequently, to get a more accurate handle on DNWR's impact on the unemployment rate, it is preferable to expand the model by incorporating separate labor supply/demand functions for full-time and part-time workers and then consider the substitution relationship between workers' types. Additionally, in our model, the only way firms can adjust their labor costs is by changing either nominal wages or the labor input. In reality, however, firms are able to adjust labor costs through a variety of means, including by modifying the seniority wage system and retirement system, eliminating annual wage accrual (*teisho*),[35] cutting nonwage benefits, conducting job rotation within the firm (*haiten*), temporarily transferring employees to other firms (*shukko*), replacing full-time workers with part-time workers, and outsourcing. Considering these alternative ways to cut labor costs,

[34] Caution is required in interpreting these results, given that the data used for the estimates through the first quarter of 2000 comes from a different source than the analysis through 1998, and may also include workers with different employment status. Kimura and Ueda (2001) point to a number of possible reasons why they find no DNWR when they extend the estimation period to 2000. Those include the possibility that structural changes through modifications of the seniority pay system reduced downward rigidity, as well as the possibility that a large negative shock led to emergency cuts in nominal wages.

[35] By eliminating *teisho*, firms can reduce the total amounts of nominal wages if the workers' composition within the firm remains unchanged.

the results of our simulation might overestimate the impact of DNWR on unemployment.

Other remarks include (1) aggregate demand is given exogenously in our model, and a decrease in aggregate demand indicates a decrease in the money supply; (2) changes in the money supply and in prices ultimately occur on nearly a one-to-one basis; (3) the transmission of monetary policy is a black box and taken as being insensitive to the inflation rate; (4) the model does not deal explicitly with two specific problems currently germane to Japan (the zero bound constraint on nominal interest rates and the problem of non-performing loans); and (5) there is no adjustment in the capital stock and no consideration of major supply-side structural changes.

Third, it is important to note that our model deals only with the impact of DNWR on employment. DNWR can affect other aspects of the economy besides unemployment, such as consumption and income. When deriving the implications for monetary policy, it is necessary to take a broader view that encompasses aspects of the economy outside of employment issues.

Fourth, it is important to realize that our analysis applies estimates from a short period of longitudinal data into a general equilibrium model that abstracts from many of the problems in Japan's economy outside of DNWR. Consideration of the optimal rate of inflation requires adequate treatment of numerous other factors besides DNWR. Those factors include the presence of "shoe leather" costs, the non-neutrality of taxes with respect to inflation, the income transfer from debtors to creditors and the effects of debt deflation on the financial system, and the possibility that the zero bound constraint on nominal interest rates reduces the effectiveness of monetary policy. Additional research in this area is crucial to enable a proper cost/benefit analysis of inflation and deflation aimed at identifying the optimal rate of inflation.

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Figure 1. Relation between the Notional Wage Change and the Observed Nominal Wage Change

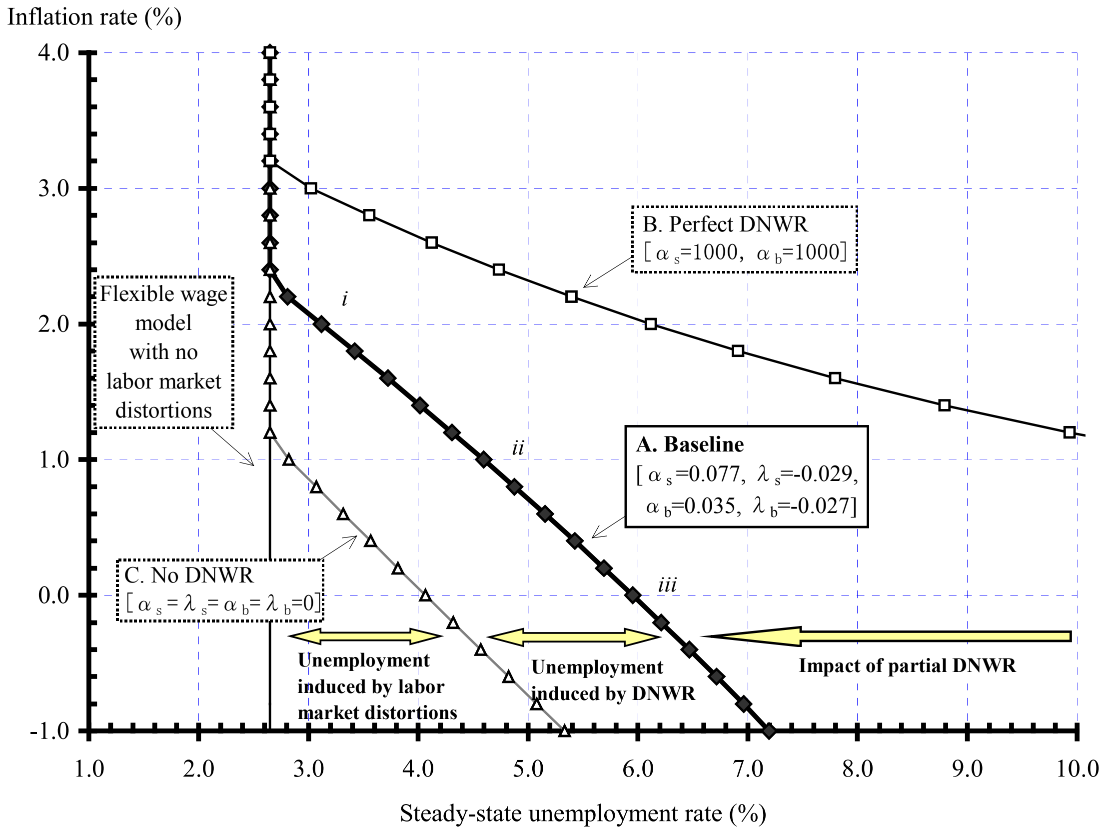
[1] Regular Monthly Salaries of Full-Time Male Employees

[2] Annual Earnings of Full-Time Male Employees

Source: From Kuroda and Yamamoto (2003b), taking account of measurement errors.

Figure 2. Simulation Result 1: Relationship between Inflation Rate and Steady-State Unemployment Rate

[1] Relationship between Inflation Rate and Steady-State Unemployment Rate



Notes: 1. Simulation results of general equilibrium model with DNWR.

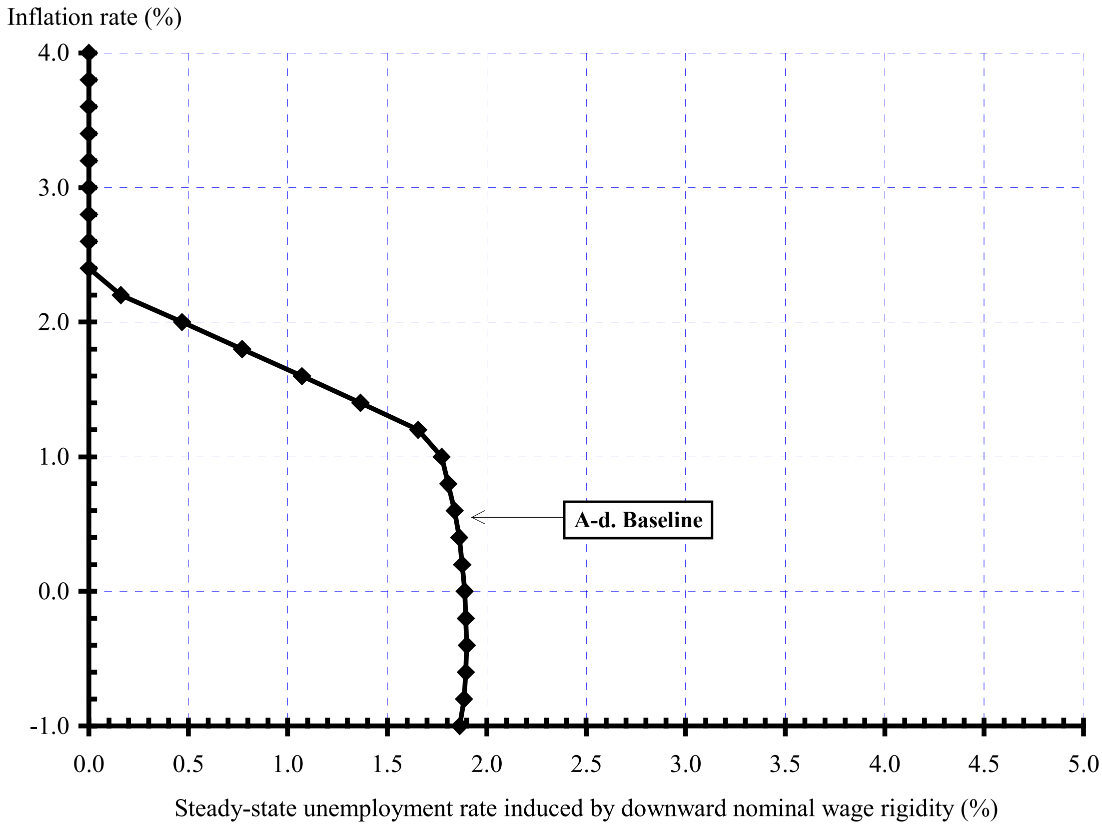
2. The baseline parameters for α_s and α_b are from the estimates of friction models in Kuroda and Yamamoto (2003b) for the regular wages and annual earnings of full-time male employees.

3. Due to the existence of DNWR, the steady-state unemployment rate is not uniquely determined but rather variant with the inflation rate. Therefore, each plot represents the steady-state unemployment rate simulated under the corresponding inflation rate.

4. Since our model assumes the lower bound of the steady-state unemployment rate at 2.65 percent, the relationship between the steady-state unemployment rate and the inflation rate becomes vertical at that point.

Figure 2. Simulation Result 1: Relationship between Inflation Rate and Steady-State Unemployment Rate (continued)

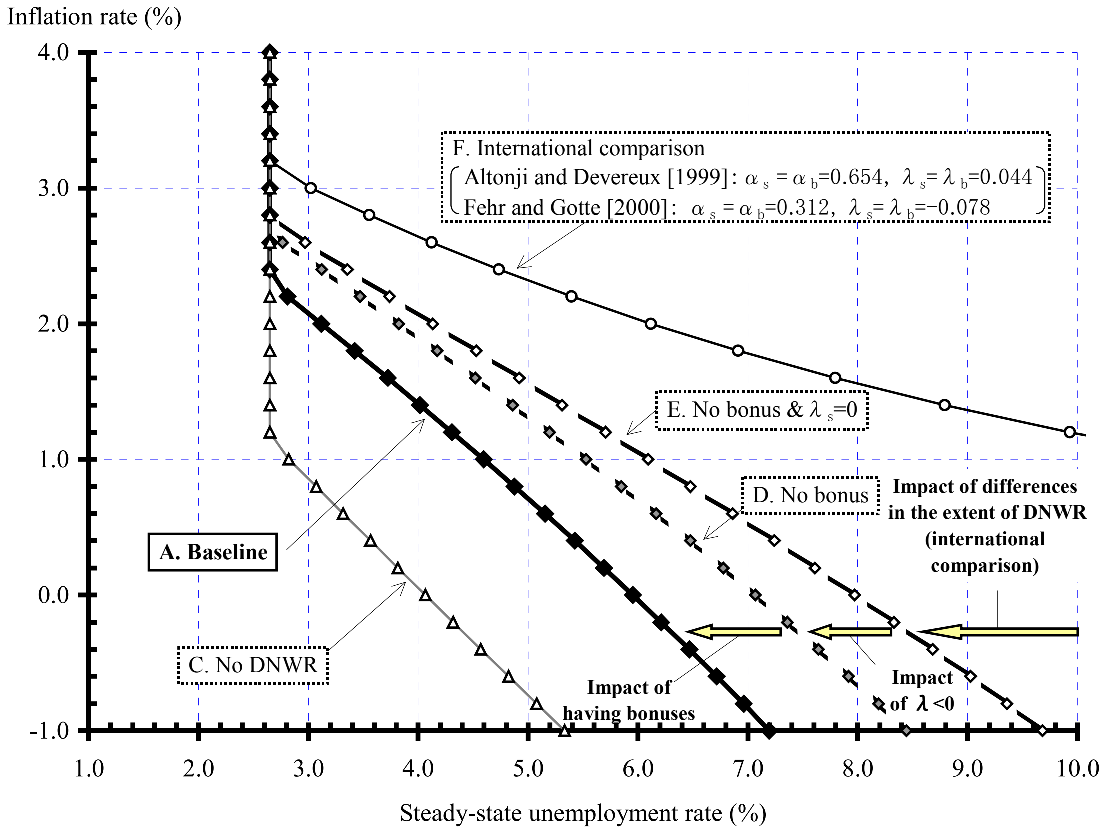
[2] Relationship between Inflation Rate and Steady-State Unemployment Rate induced by DNWR



Note: Simulation results of general equilibrium model with DNWR.

Figure 3. Simulation Result 2: Relationship between Inflation Rate and Steady-State Unemployment Rate

[1] Relationship between inflation rate and steady-state unemployment rate



Notes: 1. Simulation results of general equilibrium model with DNWR.

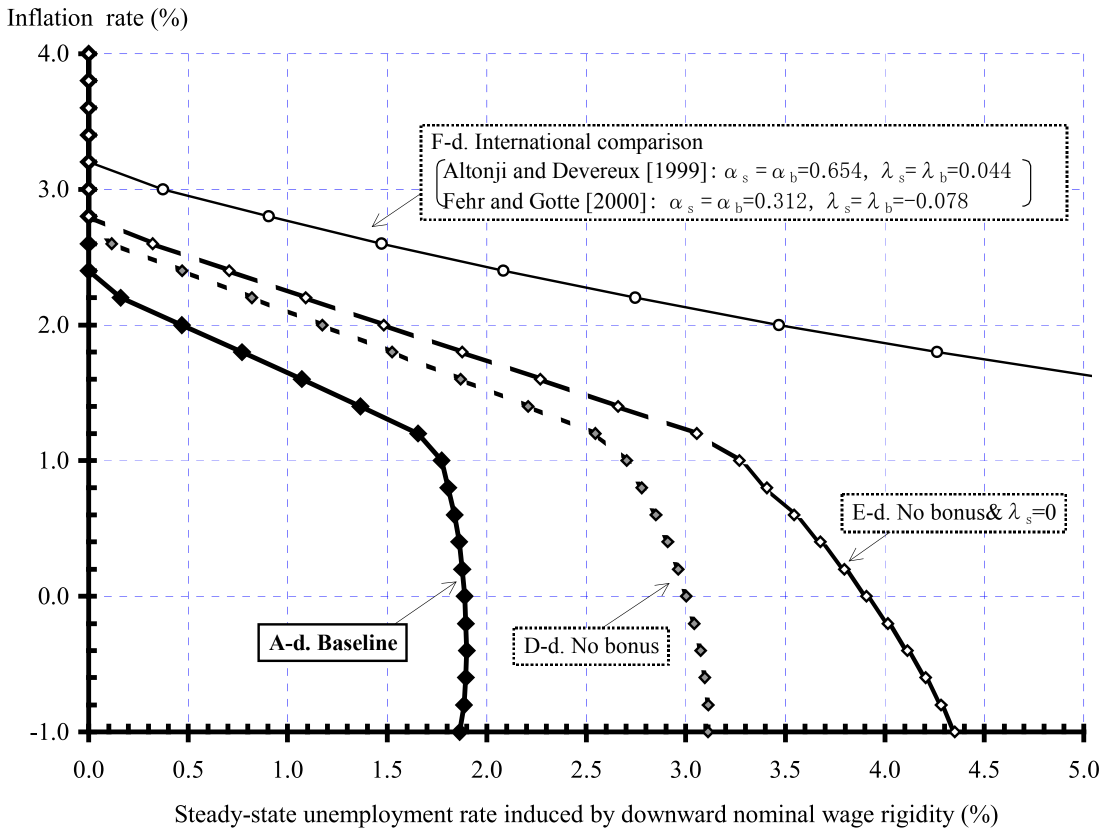
2. The baseline parameters for α_s and α_b are from the estimates of friction models in Kuroda and Yamamoto (2003b) for the regular wages and annual earnings of full-time male employees.

3. Due to the existence of DNWR, the steady-state unemployment rate is not uniquely determined but rather variant with the inflation rate. Therefore, each plot represents the steady-state unemployment rate simulated under the corresponding inflation rate.

4. Since our model assumes the lower bound of the steady-state unemployment rate at 2.65 percent, the relationship between the steady-state unemployment rate and the inflation rate becomes vertical at that point.

Figure 3. Simulation Result 2: Relationship between Inflation Rate and Steady-State Unemployment Rate (continued)

[2] Relationship between Inflation Rate and Steady-State Unemployment Rate induced by DNWR

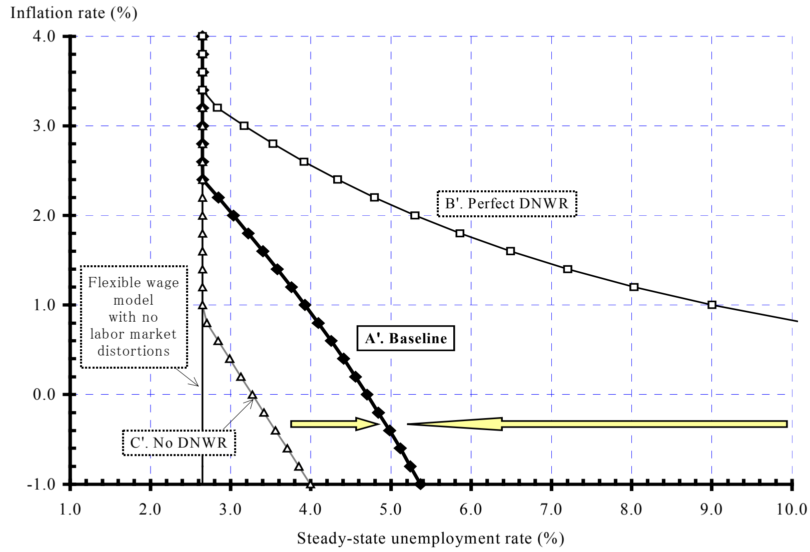


Note: Simulation results of general equilibrium model with DNWR.

Figure 4. Simulation Result 3: Robustness of Parameters Indicating Labor Market Distortions

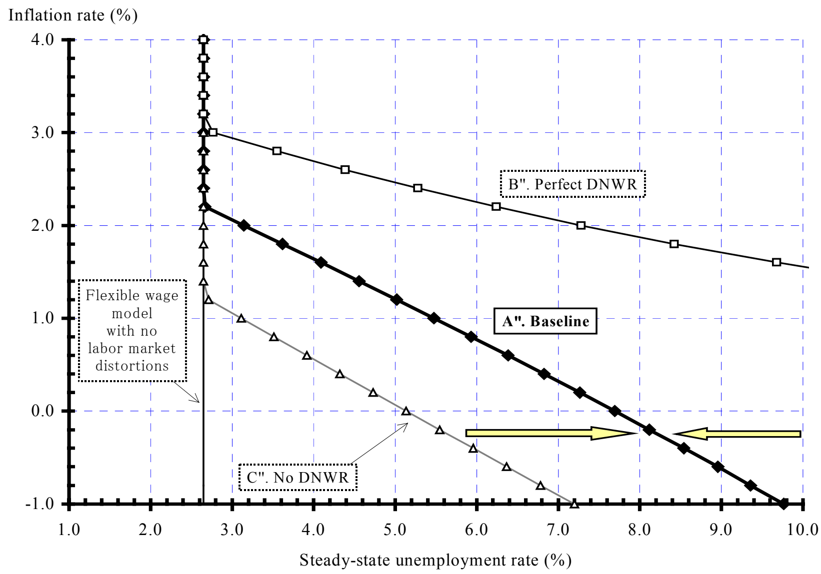
[1] Relationship between inflation rate and steady-state unemployment rate

a. *When labor market distortions are small*



Note: With parameters set at $c=0.25$, $a=0.05$, $z=0.90$ (Figures 2 and 3, parameters are set at $c=0.30$, $a=0.10$, $z=0.80$).

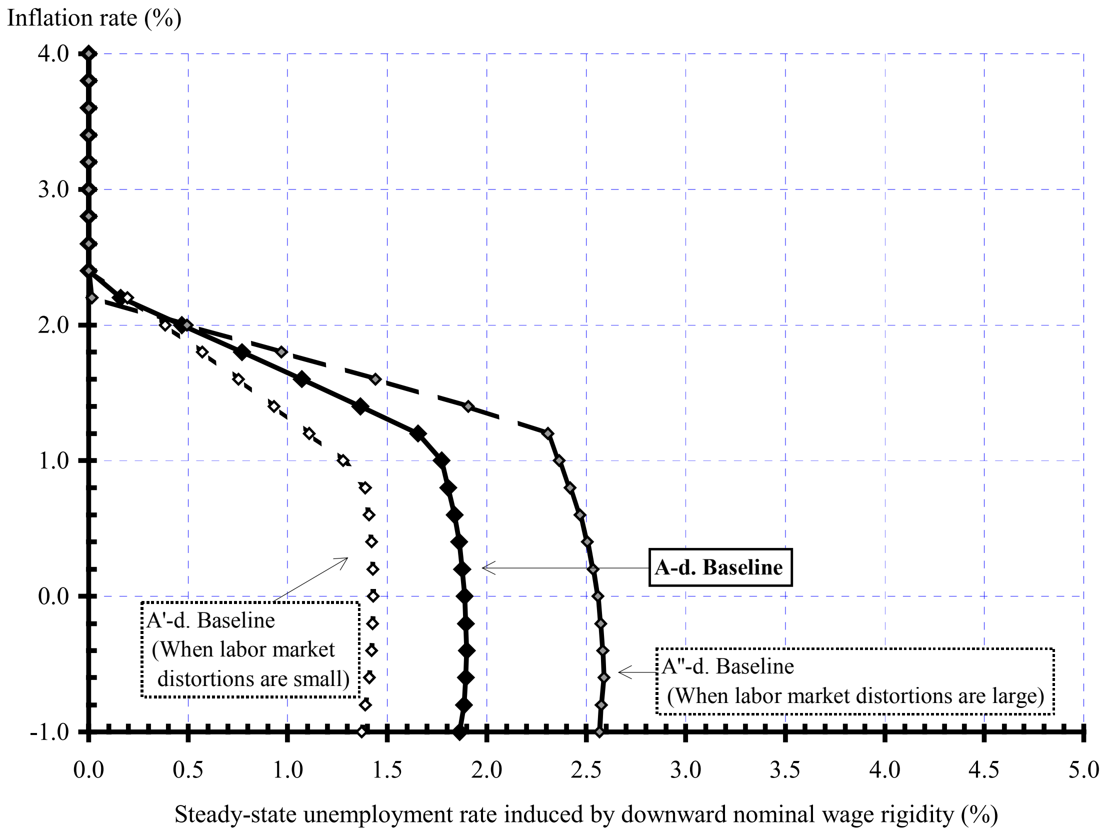
b. *When labor market distortions are large*



Note: With parameters set at $c=0.35$, $a=0.15$, $z=0.70$ (Figures 2 and 3, parameters are set at $c=0.30$, $a=0.10$, $z=0.80$).

Figure 4. Simulation Result 3: Robustness of Parameters Indicating Labor Market Distortions (continued)

[2] Relationship between Inflation Rate and Steady-State Unemployment Rate induced by DNWR



Note: Simulation results of general equilibrium model with downward nominal wage rigidity (DNWR).