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Abstract

This paper argues that estimation of the Phillips curve for Japan should take account of the geographic dispersion of labor-market conditions. We find evidence that the relationship between wage inflation and the unemployment rate is convex. With such convexity, wage inflation can occur when unemployment rates across regions become more disperse, even if the aggregate unemployment rate is unchanged. We show that controlling for the geographic dispersion of unemployment rates yields a flatter Phillips curve and a higher natural rate of unemployment.

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I. Introduction

Through the 1990s and beyond, the Japanese economy has experienced a period of low inflation accompanied by a steadily increasing unemployment rate (see Figure 1). Given its somewhat anomalous nature, there has been a great deal of debate regarding the effectiveness of monetary policy in this situation. In particular, a view held by many is that there is little-to-no tradeoff between inflation and unemployment at such low levels of inflation; i.e., the Japanese Phillips curve is non-linear and flattens out at low levels of inflation (See Nishizaki and Watanabe, 2000, for example). A relatively loose monetary policy would, therefore, yield little additional inflation while reducing unemployment substantially. Given this environment, it is not surprising that there has been renewed interest in the estimation of the Japanese Phillips curve (Nishizaki and Watanabe, 2000; Fukuda and Keida, 2001; Mio, 2001; Kuroda and Yamamoto, 2003c and 2005; Bank of Japan, 2003)

This paper presents new estimates of the Japanese Phillips curve following the approach suggested by Wall and Zoega (2004). They argue that if there is a convex relationship between the labor-market conditions and wage inflation, then differences in labor-market conditions across states or regions matter when estimating aggregate Phillips curves. The implication is that, when estimating the aggregate Phillips curve, it is not enough to include the aggregate level of slack in the labor market. One should also include a measure of the geographic dispersion of labor-market slack. When Wall and Zoega include such a measure in their empirical model of the U.S. Phillips curve, they find that doing so has a statistically significant effect. Their most important finding was that a decrease in the dispersion of state-level labor-market slack accounted for a two-percentage-point decrease in the U.S. natural rate of aggregate unemployment between 1982 and 2002. In addition, inclusion of their geographic-dispersion variable resulted in a flatter aggregate Phillips curve.

Regarding the Japanese Phillips curve, little attention has been paid previously to geographically disaggregated data.[1] Studies instead rely almost exclusively on aggregate variables, although some have also used industry disaggregates. Exceptions to this are Nishizaki and Watanabe (2000) and Kuroda and Yamamoto (2005), which use a panel-data approach with data for prefectures and regions, respectively. They harness the additional information provided by greater number of yearly observations to estimate the slope of the Japanese Phillips curve. They do not, however, take account of the dispersion of conditions across prefectures, which is the main point of our estimation.

When estimating the aggregate Phillips curve, the geographic dispersion of labor-market slack will matter under two conditions. The first condition is that there is a relationship between the aggregate business cycle and the dispersion of conditions across geographic entities—prefectures in the case of Japan. The second condition is that the relationship between wage inflation and labor-market conditions is convex. We address the first conditions for vacancy rates and unemployment rates below and the second condition in a separate section.

Figure 2 plots the aggregate unemployment rate and the dispersion of regional unemployment rates—as measured by their coefficient of variation—over the period 1983-2002. Note first that the aggregate unemployment rate does move somewhat with the business cycle, which indicate recessions in 1985-86, 1991-93, 1997-1999, and 2000-2002, even though the Japanese unemployment rate is famously much less

[1] See Fukuda and Keida (2001) for a review of the Japanese Phillips curve literature.

responsive than those of other countries.[2] Also note that the two series tended to move together over time, having a simple correlation of -0.74. In the 1980s, when the aggregate unemployment rate was low, the experience across regions was relatively disparate, but in the post-bubble era, regional unemployment rates became more similar to each other as aggregate unemployment rose nearly continuously throughout the period.[3]

The correlation between aggregate labor-market conditions and sub-national dispersion is not immediately obvious from the vacancy rate data, however. Figure 3 plots the yearly Japanese vacancy rate and the coefficient of variation of prefectural vacancy rates over the period 1983-2002.[4] The aggregate vacancy rate did not, however, move consistently in the same direction with the coefficient of variation of prefectural vacancy rates. During the bubble period of the late 1980s, aggregate vacancies rose dramatically while prefectural vacancy rates became more similar. Starting in the mid 1990s, however, prefectural vacancy rates became more similar in the face of a declining aggregate vacancy rate. The correlation coefficient between the two series is –0.24, which indicates a rather weak relationship.

Section II describes the theoretical implications of a convex relationship between wage inflation and labor-market conditions, while Section III tests for this. After the two conditions are established, Section IV estimates Phillips curves using aggregate data supplemented with a measure of the dispersion of regional

[2] For more-detailed explanations of trends in the Japanese labor market written in English, see Osawa et al (2002) and Fujiki, Nakada, and Tachibanaki (2001).

[3] This change over time is consistent with Wall (2007), who finds that regional business cycles became more similar to each other over the period 1976-2005.

[4] Vacancy data are not collected directly in Japan. Instead, the Japanese Ministry of Health, Labour and Welfare defines the number of vacancies in a period as the number of active openings minus the number of placements. The vacancy rate is the number of vacancies divided by the sum of vacancies and employment. Data on active openings and placements with prefectural breakdown are provided by the from various issues of *Report on Employment Service* issued by the Ministry of Health, Labour, and Welfare. Employment by prefecture can be obtained from the *Annual Report on Prefectural Accounts* issued by the Economic and Social Research Institute, Cabinet Office, Government of Japan.

unemployment rates. The implications of these findings for the natural rate are explored in Section V. Section VI concludes.

II. Theoretical implications

If, at a disaggregated level, the relationship between labor-market slack and wage inflation is convex, cross-prefecture differences in slack over the business cycle can matter when estimating the link between the aggregate price level and the labor market. One form of this convexity is downward nominal wage rigidity, which often is said to arise because managers are hesitant to cut wages because of considerations about worker morale (Bewley, 1999; Kawaguchi and Ohtake, 2004). Wage cuts are likely to introduce personnel and incentive problems beyond the intended effect on turnover. Indeed, there is strong evidence of downward nominal wage rigidity in Japan (Kimura and Ueda, 2001; and Kuroda and Yamamoto, 2003a, 2003b), which is in line with similar evidence for the United States (Card and Hyslop, 1997; McLaughlin, 1999; and Bewley, 1999).[5] More recently, however, Kuroda and Yamamoto (2005) find that downward nominal wage rigidity did not hold in Japan after 1997.

In general, as described in the classic Phelps (1968) paper outlining the expectations-augmented Phillips curve, convexity can arise when it is more difficult to reduce the nominal wage relative to expectations than it is to increase it. If this is true, then there might be a role for using geographically disaggregated information to estimate aggregate inflation. In Phelps (1968), wage inflation persists because firms cannot adjust instantaneously to changes in conditions. For a given vacancy rate, wage inflation is decreasing in the unemployment rate, which indicates the size of the

[5] Because the evidence regarding downwardly rigid wages points to a flat Phillips curve at very low inflation, much of the discussion in Japan has centered on whether or not to adopt an inflation target not insignificantly above zero. See Otake (2001), for example. According to Kuroda and Yamamoto (2003c), for example, the extent of downward nominal wage rigidity in Japan warrants an inflation target of at least 2.4 percent.

available labor force. Actual wage inflation equals expected wage inflation at a critical unemployment rate $\bar{u}$. For unemployment rates above $\bar{u}$, there is unexpected wage deflation. Conversely, for unemployment rates below $\bar{u}$, there is unexpected wage inflation. If firms are more reluctant to cut expected wages than to raise them—as the evidence suggests—the slope of the relationship between wage inflation and the unemployment rate is flatter above $\bar{u}$ than it is below $\bar{u}$. In this model, therefore, the convexity of the relationship between wage inflation and the unemployment rate arises because of the different slopes above and below $\bar{u}$. A similar argument can be used to model possible convexity between wage inflation and the vacancy rate.

The potential importance of this convexity for aggregate inflation can be illustrated as follows: Consider two equally sized regions with the same unemployment rate. Now consider equal but opposite-signed changes in the regions' unemployment rates (i.e., the changes are mean-preserving). As this occurs, one region experiences wage inflation while the other experiences wage deflation. Because of the convexity between wage inflation and the unemployment rate, the wage inflation experienced by one region is greater in absolute terms than the wage deflation experienced by the other. In this example, therefore, there is wage inflation at the aggregate level even though there was no change in the aggregate unemployment rate. In general, then, with a strictly convex relationship between wage inflation and the unemployment rate, for any given aggregate unemployment rate, an increase in the dispersion of regional unemployment rates will mean higher aggregate wage inflation. Similarly, with a strictly convex relationship between wage inflation and the vacancy rate, aggregate wage-inflation rates should be increasing in the dispersion of regional vacancy rates.

III. Testing for convexity

Our next step is to test the hypothesis that the relationship between wage inflation and labor-market conditions is convex. In the spirit of Phelps (1968), we consider both the vacancy rate and the unemployment rate, as do Wall and Zoega (2004). We use a prefecture-level panel and the following regression equation:

$$\frac{\dot{w}_{it}}{w_{it}} = \alpha_0 + \alpha_i + \tau + \beta_1 v_{it} + \beta_2 v_{it}^2 + \lambda_1 u_{jt} + \lambda_2 u_{jt}^2 + \omega\pi_{j,t-1} + \varepsilon_{it}, \quad (1)$$

where a subscript t indicates time and subscripts i and j indicate prefecture and region, respectively.[6] In equation (1), w denotes the wage, α_0 is the common intercept, α_i is the prefectural fixed effect, τ is the time trend, $\dot{w}$ denotes the change in the wage, v denotes the vacancy rate, u is the unemployment rate, and π is the CPI inflation rate, which is lagged to control for inflation expectations. Note that because unemployment data are available at the prefecture level beginning only in 1997, we used unemployment data at the regional level instead. Also note that, because wage inflation should reflect changes in consumer prices regardless of the source of the change, we have not adjusted the CPI series to account for the change in the consumption tax rate in 1997. With 20 years of observations (1983-2002) and 47 prefectures, we have 940 observations.[7]

In estimating equation (1), we use four different hourly wage measures derived from data provided by the *Basic Survey on Wage Structure* conducted by Ministry of Health, Labour, and Welfare. From this survey we use the data for full-time male employees in major industries on scheduled hours worked, overtime hours

[6] The null hypothesis that $\beta_1, \beta_2, \lambda_1$, and λ_2 are the same across prefectures is rejected, which is not surprising given that we have only 20 observations per prefecture.
[7] See the appendix for the assignment of prefectures to regions.

worked, contractual cash earnings,[8] and annual special cash earnings including bonus and term-end allowance paid in the previous year.[9] From these series, we construct our four wage measures: total wages per hour, total manufacturing wages per hour, contractual wages per hour, and contractual manufacturing wages per hour.[10] We used several different wage measures because there is some debate about which wage is appropriate. For example, some studies, including Toyoda (1987), suggest that relevant wage measure should not include bonus payments (special cash earnings) because the wage changes in the Springtime Wage Increase focus on contractual cash earnings.

Because of data constraints, our wage measures the most favorable ones for our case. We use full-time male wages because it is the most reliable series that is available at the prefecture level. However, full-time males are likely to have the most rigid wages relative to other subgroups, especially part-time women, whose share of the workforce has been increasing over time. An alternative wage measure that includes wages of all worker categories is available from *Monthly Labor Survey, Prefectural Survey* conducted by Ministry of Health, Labour, and Welfare. It is not useful for our purposes, however, because the firms from which the survey is drawn is resampled periodically. While adjustments for this resampling are provided for national data, they are not provided for prefectural data.

The results of our four estimations are summarized in Table 1. Note first that the marginal effects of all of our right-hand-side variables always have the expected

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[8] Contractual cash earnings mean before-tax wages paid to employees, for the surveyed month of June, specified in advance in labor contracts, labor agreements, and/or working rules of establishments.
[9] Special wages including bonus and term-end allowance including (l) wages which are paid for temporary or unexpected reasons, not based upon agreements or rules established in advance and (2) wages paid in accordance with payment conditions and calculation methods already determined in labor agreements or working rules but paid based on a calculation period exceeding three months. They also include (3) wages paid under reason which are uncertain and (4) wages in back pay under a new labor agreement.
[10] Total wages include contractual cash earnings and annual special earnings, while total hours worked includes scheduled hours and overtime hours.

signs and are almost always statistically different from zero: In all four cases, wage inflation is positively related to the vacancy rate and negatively related to the unemployment rate. Further, wage inflation is positively related to inflation expectations in all cases, and for three cases there is a positive time trend in wage inflation, capturing a positive trend in productivity.

Because for all cases the estimated coefficient on squared unemployment is negative and statistically significant, we conclude that there is strong evidence of a convex relationship between wage inflation and the unemployment rate. On the other hand, although the sign of our estimates of the coefficient on the vacancy rate squared has the right sign to indicate convexity, for none of the cases is the coefficient statistically different from zero.

We should note that our above estimation is similar to the regional Phillips curve estimation of Kuroda and Yamamoto (2005), who found that a cubic specification of the relationship between wage inflation and unemployment is appropriate. The key differences between our estimation and theirs is that, following Phelps (1968), we include the vacancy rate and a variable to control for inflation expectations. They assume that the latter of these is controlled for by the combination of fixed effects and time dummies. If we eliminate these two variables from our estimation, we also find support for a cubic specification.

IV. The Japanese Phillips curve

Our results in the previous section indicate that there is a convex relationship between wage inflation and the unemployment rate, but not between wage inflation and the vacancy rate. This evidence, along with our earlier evidence (see Figure 2) regarding the relationship over time between the aggregate unemployment rate and the dispersion of regional unemployment rates, suggests that the estimation of the aggregate Japanese Phillips curve might be improved by taking account of the regional dispersion of unemployment rates.

To test this supposition, we estimate a fairly standard Phillips curve:

$$\pi_t = \alpha + f(y_t) + \rho\pi_t^e + \boldsymbol{\delta}'\mathbf{Z_t} + \varepsilon_t, \qquad (2)$$

where π_t is the average CPI inflation rate for years t and t+1, y_t is a measure of labor-market slack, π_t^e is the expected inflation rate, **Z** is vector of variables to control for shocks, and ε is an error term. We use both the unemployment rate and the active opening ratio as our labor-market slack variable. Although the unemployment rate was the slack variable of choice in early studies of the Japanese Phillips curve (Toyoda, 1972 and 1987), this was not the case in later studies because the labor hoarding resulting from Japanese long-term employment meant that the unemployment rate did not fluctuate much over the business cycle.[11] As a result, more-recent studies have used the active opening ratio as their labor-market slack variable.

Consistent with most studies, we measure expected inflation with lagged inflation, which we average over years t-1 and t-2.[12] Our shock variables include the rate of depreciation of the yen against the dollar (averaged over years t and t+1) and trend productivity growth (trend growth of real GDP per employee). These variables are denoted, respectively, by $\dot{E}_t$ and $Pr\dot{o}d_t$. Our innovation is to include the coefficient

[11] Kurosaka and Hamada (1982) and Hamada and Kurosaka (1984) also show that the Japanese Okun coefficient was high and unstable due to the labor hoarding based on Japanese long-term employment. Their conclusion still holds in the 1990s. For example, Fujiki, Kuroda, and Tachibanaki (2001) showed the ordinary least square regression of the annual log employment rate computed from the official unemployment rate on a constant term, a time trend, and log GDP yields estimates of Okun coefficients ranging from 7.3 to 10 using the sample period of 1981-1999. See also Yoshikawa (2000) for review on Okun's law in Japan.

[12] Toyoda (1987) used results of the Consumer Confidence Survey to control for expected inflation. In the survey, respondents are asked to evaluate on a scale of one to five what they consider the prospects for the five subjects over the next six months. Toyoda (1987) applies the method proposed by Carlson and Parkin (1975) to these survey data. See the explanation of this survey at: http://www.esri.cao.go.jp/en/stat/shouhi/qshohi_kaisetu-e.html.

of variation of regional unemployment rates, CV_t, as an additional shock variable to explain changes in the rate of aggregate inflation. Whereas the other shock variables control for the movement of the macroeconomy, CV_t measures the dispersion of regional unemployment rates. This variable controls for the possibility that, because of convexity and non-uniform changes in regional unemployment rates, there is a misreading of the link between the aggregate conditions and the aggregate price level (see Section II).

Our specification is therefore

$$\pi_t = \alpha + f(y_t) + \rho\pi_t^e + \delta_1\dot{E}_t + \delta_2 Pr\dot{o}d_t + \delta_3 CV_t + \varepsilon_t, \quad (3)$$

which we estimate using, in turn, the unemployment rate and the active opening ratio as our slack variable y_t. For each case we also use linear and quadratic functional forms for $f(y_t)$. Finally, for each variable and each functional form, we estimate (3) first under the restriction that $\delta_3 = 0$ (i.e., that CV_t does not matter) and then without this restriction.

A problem when estimating the Phillips curve for Japan—and to a slightly lesser extent, the United States—is the pooling of periods of very high inflation (the 1970s) and very low inflation (the 1990s). An oft-used solution for the case of Japan is the use of dummy variables for the high-inflation years of the 1970s and early 1980s. While such a solution can handle difference in the intercept, it still assumes that the coefficient on the slack variable is the same across the periods. Nishizaki and Watanabe (2000), on the other hand, are interested in potential non-linearities in the Phillips curve, so their innovative solution is to allow for a kink, which they find to occur most plausibly at around 3 percent. Our solution is simply to restrict our analysis to the post-1982 period, during which inflation ranged between –0.7 and 3.3 percent. Because the period includes only one year of inflation above 3 percent, we need not be concerned with the severe non-linearities that Nishizaki and Watanabe were controlling for.

A. Phillips Curve I: Unemployment Rate

Our estimates of the Phillips curve using the unemployment rate as the slack variable are presented in Table 2. For both specifications that do not include the CV_t variable, the estimation works well in the sense that all estimated coefficients have the expected signs and are almost always statistically significant. The quadratic specification performs the best in terms of goodness of fit, although both perform respectably by this standard.

For both specifications, inclusion of the CV_t variable has the expected effects: The estimated effect of an increase in the dispersion of regional unemployment rates is positive and the Phillips curve is flatter than otherwise. A likelihood-ratio test rejects the null that the restriction that the effect of the quadratic term is zero does not affect the overall estimation (i.e., the quadratic specification is preferred). Finally, in the preferred quadratic specification the estimated coefficient on CV_t statistically different from zero, although a likelihood-ratio test does not reject the hypothesis that inclusion of CV_t has no effect on the overall estimation.

Figure 4 illustrates the difference between the Phillips curve with and without CV_t. The two Phillips curves are derived by substituting the 2002 values for all variables except for the unemployment rate into (3) using the respective coefficient estimates from the quadratic specification in Table 2. As mentioned above, inclusion of CV_t results in a flatter Phillips curve, particularly at high rates of unemployment, and indicates a higher zero-inflation unemployment rate (i.e., a higher "natural" rate of unemployment). This latter point is explored in more detail in Section V.

B. Phillips Curve II: Active Opening Rate

As mentioned above, most early studies of the Japanese Phillips curve do not use the unemployment rate as the slack variable. This is because the Phillips curve usually "doesn't work" when the unemployment rate is used, a result that is attributed to the fact that the unemployment rate in Japan is not nearly as sensitive to the business cycle as it is in other countries. The active opening rate—the ratio of active job openings to active applications—shows more movement over the business cycle than does the unemployment rate. It is, therefore, typically used instead of the unemployment rate when labor-market slack is of most interest, as it is presently. Even though our estimates using the unemployment rate work fairly well for the traditional variables, we perform the same exercise using the active opening rate.

Our results using the active opening rate are presented in Table 3. For both specifications that do not include the CV_t variable, the estimated coefficients have the expected signs. All are statistically significant, except for those in the quadratic specification. Further, the linear specification of the active opening rate performs the best in terms of goodness of fit. For both specifications, inclusion of the CV_t variable flattens the Phillips curve, as it did in the previous case using the unemployment rate as the slack variable. Also, the estimated effect of an increase in the dispersion of prefectural vacancy rates is positive and statistically significant. For both specifications a log-likelihood test rejects the hypothesis that inclusion of CV_t has no effect on the overall estimation.

In sum, the specifications of the Phillips curve that include CV_t are preferred statistically to those that do not, and inclusion of CV_t leads to a somewhat flatter Phillips curve. This is illustrated by Figure 5, in which the Phillips curves with and without CV_t are derived in the same manner as those in Figure 4. Note also that, at least for 2002, the "natural" active opening rate (the active opening rate that is consistent with zero inflation) is slightly higher when CV_t is included, indicating less inflationary pressure than does the alternative.

V. "Natural" Rates

We showed in the previous section that a model of the Phillips curve that controls for the dispersion of unemployment rates across regions is preferred statistically to an otherwise identical model that does not. In this section, we will demonstrate the economic significance of the dispersion of regional unemployment rates in terms of its effect on the "natural" rate of unemployment (NRU) the "natural" active opening rate (NAOR). Because natural rates are useful benchmarks for determining whether or not the situation in labor markets is inflationary, our results have implications for monetary policy.

A. Natural Rate of Unemployment

Solve (3) for when $\pi_t = \pi_t^e = 0$, y_t is the unemployment rate, and $f(y_t) = \theta_1 y_t + \theta_2 y_t^2$ to obtain NRU_t, the time-varying trend natural rate of unemployment:

$$\text{NRU}_t = \frac{-\theta_1 \pm \sqrt{\theta_1^2 - 4\theta_2(\alpha + \delta_1 \dot{E}_t + \delta_2 Pr\dot{o}d_t + \delta_3 CV_t)}}{2\theta_2}. \quad (4)$$

We calculate (4) using the relevant coefficients from Table 2 and the trend values for $\dot{E}_t$, $Pr\dot{o}d_t$, and CV_t. Of course, this yields two distinct series, one of which we rule out on the grounds that it is consistently above the highest actual unemployment in the sample. Figure 6 illustrates the movement of estimated trend NRU during 1983-2002 when CV_t is included and when it is not.[13] The thick black line is the trend NRU from the model that includes CV_t and the thick gray line is the trend NRU when CV_t is not included. For reference, the figure also includes the actual unemployment rate as a dashed gray line.

As mentioned previously, the model that includes CV_t yields a slightly higher raw NRU for 2002 than does the model without CV_t. This is apparent in Figure 6 which shows that the difference in trend NRU between the two versions of the model in 2002 (3.4 versus 3.2) is the smallest for all of the years in our sample. In the earliest years of the sample, the difference was around a full percentage point. Over time, the difference between the two estimates of NRU fell along with the dispersion of labor-market conditions across regions (see Figure 2). In terms of the monetary policy implications, our findings consistently indicate a less-inflationary environment when the geographic dispersion of unemployment rates is controlled for.

Our model indicates also that the NRU has been falling over time, whereas the alternative model suggests that it has been rising along with the actual unemployment rate.[14] Our results in this regard are contrary to what most observers of the Japanese economy, who do not account for geographic dispersion, believe has been happening. To understand our result, assume that the economy starts at the aggregate NRU, meaning that inflation is zero. If, during the next period, prefectural unemployment rates converge without there being an increase in aggregate unemployment, inflation would fall below zero (due to convexity). Thus, because of this convergence effect, the new NRU must be lower than the old one. Our finding is that the trend NRU has been

[13] We obtain trend levels by applying a Hodrick-Prescott filter to the raw series.
[14] For example, Chart 27 in White Paper on Labor Economy, Japanese Ministry of Health, Labour, and Welfare 2005 shows a series of NRU estimated from U-V analyses. The NRU estimated in that way increased between the middle of the 1990s and 2003.

falling over time because the convergence effect has been dominating other factors that may have been working to raise the NRU.

B. Natural Active Opening Rate

Solve (3) for when $\pi_t = \pi_t^e = 0$, y_t is the active opening rate, and $f(y_t) = \theta_1 y_t$. This yields NAOR_t, the time-varying natural active opening rate:

$$\text{NAOR}_t = -(\alpha + \delta_1 \dot{E}_t + \delta_2 Pr\dot{o}d_t + \delta_3 CV_t)/\theta_1. \qquad (5)$$

We calculate (5) using the relevant coefficients from Table 3 and the trend values for $\dot{E}_t$, $Pr\dot{o}d_t$, and CV_t. When the actual active opening rate is above NAOR the economy faces inflationary pressures. Figure 7 illustrates the movement over 1983-2002 of estimated trend NAOR with and without accounting for CV_t. The thick black line is the trend NAOR from the model that includes CV_t and the thick gray line is trend NAOR from the model that does not include CV_t. For reference, the figure also includes the actual active opening rate (AOR) as a dashed gray line.

Note that the trend NAOR that controls for CV_t rises throughout our sample period, indicating an increasingly less-inflationary environment for any given actual active opening rate, much as we found when we used the unemployment rate as the slack variable. For 2002, because the actual opening rate is below either trend NAOR, there is deflationary pressure, which clearer from the trend NAOR that controls for CV_t.

VI. Conclusions

The central point of this paper is that studies of the Phillips curve for Japan should take account of changes in the geographic dispersion of labor-market slack. Our first evidence of this is from our prefecture-level panel estimation in which we show that there is a convex relationship between wage inflation and the unemployment rate.

We then show that controlling for the dispersion of regional unemployment rates yields a flatter Phillips curve and a higher natural rate than we obtain when we ignore regional dispersion.

Appendix: Japanese Regions and Their Prefectures

Hokkaido
- **1** Hokkaido

Tohoku
- **2** Aomori
- **3** Iwate
- **4** Akita
- **5** Miyagi
- **6** Yamagata
- **7** Fukushima

Northern Kanto
- **8** Ibaraki
- **9** Tochigi
- **10** Gumma
- **18** Nagano
- **21** Yamanashi

Southern Kanto
- **11** Chiba
- **12** Saitama
- **13** Tokyo
- **14** Kanagawa

Hokuriku
- **15** Niigata
- **16** Toyama
- **17** Ishikawa
- **20** Fukui

Tokai
- **19** Gifu
- **22** Shizuoka
- **23** Aichi
- **27** Mie

Kinki
- **24** Shiga
- **25** Kyoto
- **26** Hyogo
- **28** Nara
- **29** Osaka
- **30** Wakayama

Chugoku
- **31** Tottori
- **32** Shimane
- **33** Okayama
- **34** Hiroshima
- **35** Yamaguchi

Shikoku
- **36** Kagawa
- **37** Tokushima
- **38** Ehime
- **39** Kochi

Kyushu
- **40** Fukuoka
- **41** Saga
- **42** Nagasaki
- **43** Oita
- **44** Kumamoto
- **45** Miyazaki
- **46** Kagoshima
- **47** Okinawa

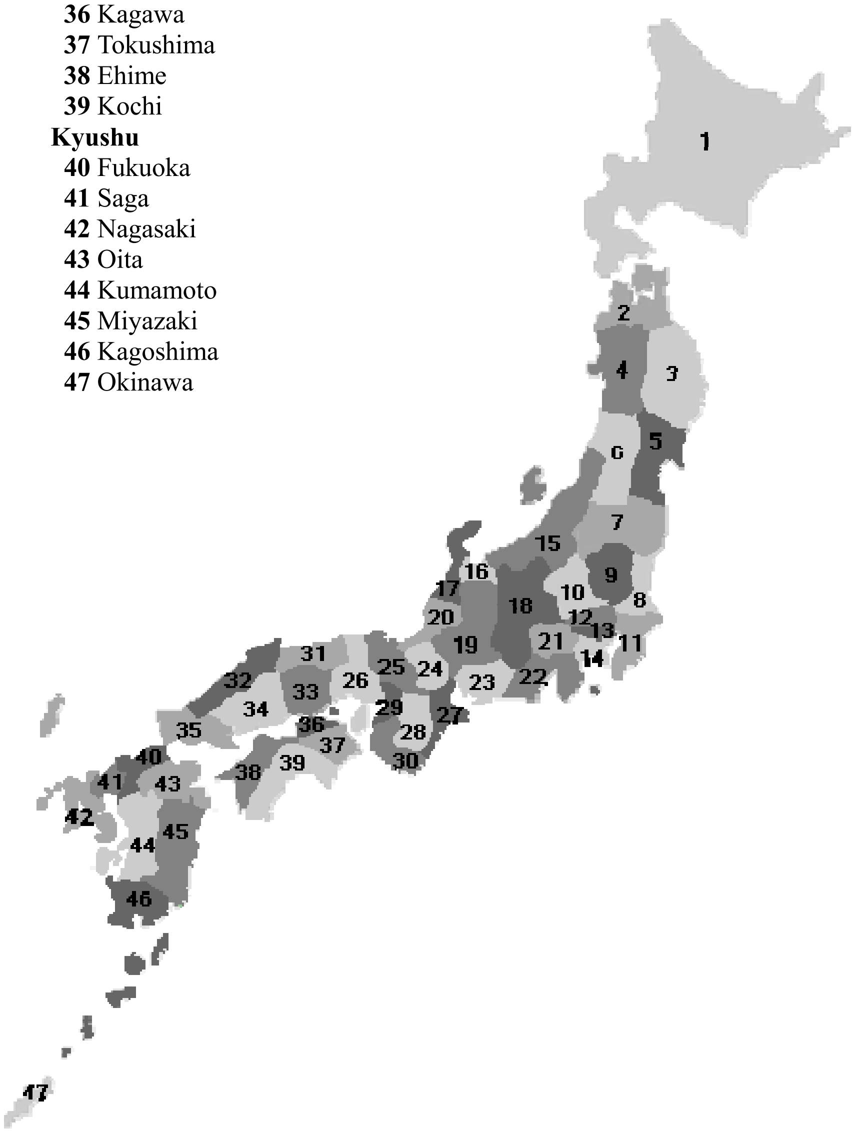

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Table 1. Testing for Convexity with a Panel of Prefectures

	Growth of total wages per hour	Growth of manufacturing wages per hour	Growth of contractual wages per hour	Growth of contractual manufacturing wages per hour
Prefectural vacancy rate (β_1)	1.167* [0.582] (2.01)	1.119* [0.727] (1.54)	0.559 [0.620] (0.90)	0.542 [0.780] (0.69)
Prefectural vacancy rate squared (β_2)	0.089 [0.109] (0.82)	0.122 [0.136] (0.90)	0.100 [0.116] (0.86)	0.089 [0.146] (0.61)
Regional unemployment rate (λ_1)	-1.937* [0.460] (4.21)	-1.789* [0.574] (3.12)	-1.864* [0.489] (3.81)	-1.638* [0.616] (2.66)
Regional unemployment rate squared (λ_2)	0.155* [0.052] (3.00)	0.135* [0.064] (2.10)	0.123* [0.055] (2.24)	0.114* [0.069] (1.64)
Lagged regional inflation rate (ω)	0.529* [0.085] (6.24)	0.606* [0.106] (5.73)	0.682* [0.090] (7.55)	0.894* [0.114] (7.86)
Trend (τ)	-0.006 [0.018] (0.35)	0.053* [0.022] (2.41)	0.041* [0.019] (2.20)	0.087* [0.024] (3.70)
Common intercept (α_0)	3.507* [1.417] (2.47)	2.508 [1.769] (1.42)	4.353* [1.509] (2.88)	3.138* [1.900] (1.65)
R^2 within	0.519	0.379	0.448	0.305
R^2 between	0.128	0.007	0.116	0.009
R^2 total	0.403	0.271	0.362	0.245
F(6,887)	159.27	90.38	119.97	64.72

Least squares estimation with prefectural fixed effects. Each regression uses 940 observations from 47 prefectures over 20 years (1983-2002). Numbers in brackets are standard errors while those in parentheses are absolute *t*-statistics. A "*" indicates statistical significance at the 10% level.

Table 2. The Japanese Phillips Curve I: Slack Variable = Unemployment Rate

	Linear		Quadratic	
Unemployment rate (θ_1)	-0.720* [0.184] (3.91)	-0.644* [0.184] (3.50)	-2.936* [1.016] (2.89)	-2.992* [0.917] (3.26)
Unemployment rate squared (θ_2)	-	-	0.295* [0.136] (2.18)	0.316* [0.123] (2.57)
Inflation expectations (ρ)	0.217* [0.094] (2.31)	0.198* [0.090] (2.20)	0.205* [0.082] (2.50)	0.180* [0.095] (0.189)
Yen depreciation (δ_1)	0.062* [0.010] (6.04)	0.061* [0.010] (6.23)	0.060* [0.009] (6.66)	0.059* [0.009] (6.72)
Trend productivity growth (δ_2)	0.753* [0.283] (2.66)	0.224 [0.566] (0.40)	0.566* [0.266] (2.13)	-0.122 [0.445] (0.27)
CV of regional unemployment rates (δ_3)	–	7.069 [5.139] (1.38)	–	9.023* [4.247] (2.12)
Intercept (α)	1.767 [1.029] (1.72)	0.875 [1.027] (0.85)	5.892* [1.905] (3.09)	5.038* [1.687] (2.99)
R^2	0.841	0.850	0.883	0.897
Root MSE	0.526	0.529	0.467	0.454
Log likelihood	-12.636	-12.071	-9.574	-8.298
Likelihood ratio[a]	1.130		2.552	

White-corrected standard errors are in brackets and absolute *t*-statistics are in parentheses. An '*' indicates statistical significance at the 10 percent level. Each regression has 20 observations for 1983-2002.

[a] The null hypothesis is that a zero restriction on the coefficient on the CV of regional unemployment rates does not affect the other coefficient estimates. This is cannot be rejected for either specifications. The critical value at the 10 percent level is 2.71.

Table 3. The Japanese Phillips Curve II: Slack Variable = Active Opening Rate

	Linear		Quadratic	
Active opening rate (θ_1)	1.990* [0.342] (5.83)	1.852* [0.326] (5.68)	1.602 [3.186] (0.50)	1.047 [3.074] (0.34)
Active opening rate squared (θ_2)	-	-	0.200 [1.630] (0.12)	0.414 [1.591] (0.26)
Inflation expectations (ρ)	0.485* [0.075] (6.43)	0.400* [0.072] (5.57)	0.486* [0.076] (6.38)	0.401* [0.069] (5.80)
Yen depreciation (δ_1)	0.060* [0.010] (5.94)	0.057* [0.009] (6.29)	0.060* [0.011] (5.66)	0.057* [0.009] (6.40)
Trend productivity growth (δ_2)	0.943* [0.211] (4.47)	0.033 [0.427] (0.08)	0.952* [0.246] (3.87)	0.044* [0.446] (0.10)
CV of regional unemployment rates (δ_3)	–	11.038* [4.125] (2.68)	–	11.143* [4.186] (2.72)
Intercept (α)	-2.791* [0.405] (6.89)	-3.476* [0.476] (7.31)	-2.643* [1.179] (2.24)	-3.176* [1.166] (2.72)
R^2	0.880	0.904	0.880	0.904
Root MSE	0.458	0.423	0.473	0.438
Log likelihood	-9.865	-7.623	-9.856	-7.577
Likelihood ratio[a]	4.484*		4.558*	

White-corrected standard errors are in brackets and absolute *t*-statistics are in parentheses. An '*' indicates statistical significance at the 10 percent level. Each regression has 20 observations for 1983-2002.

[a] The null hypothesis is that a zero restriction on the coefficient on the CV of regional unemployment rates does not affect the other coefficient estimates. This is rejected for both specifications. The critical value at the 10 percent level is 2.71.

Figure 1: Inflation/Unemployment Plot, 1983-2002

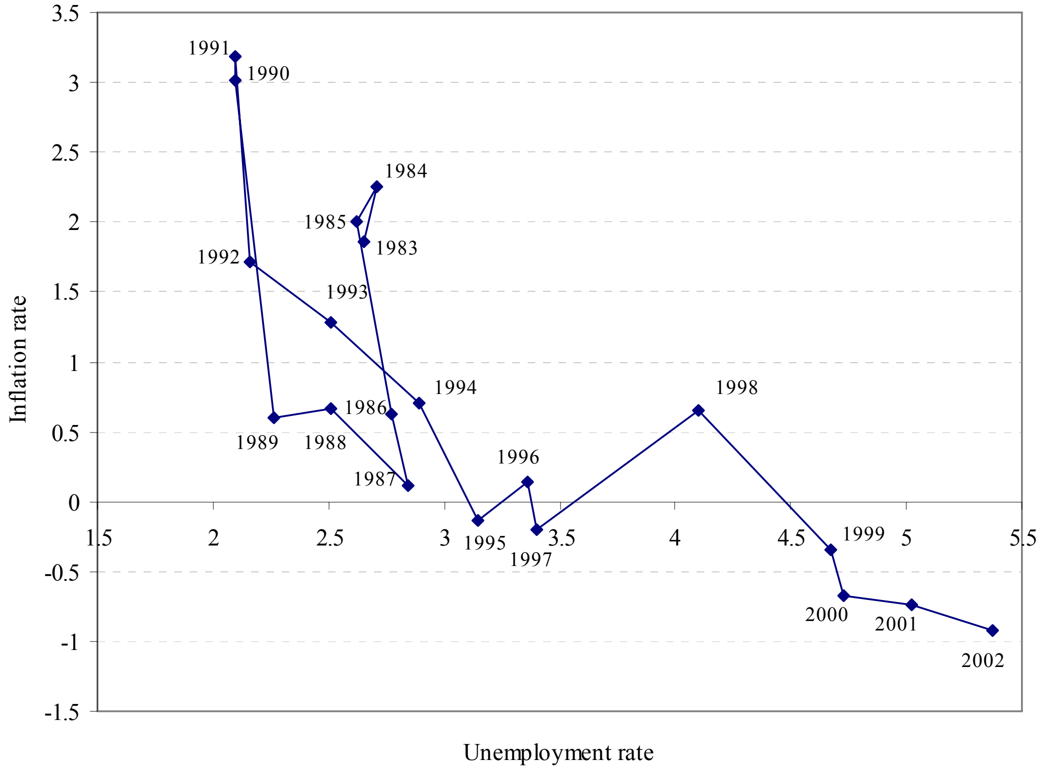

Figure 2. Unemployment and the Regional Coefficient of Variation

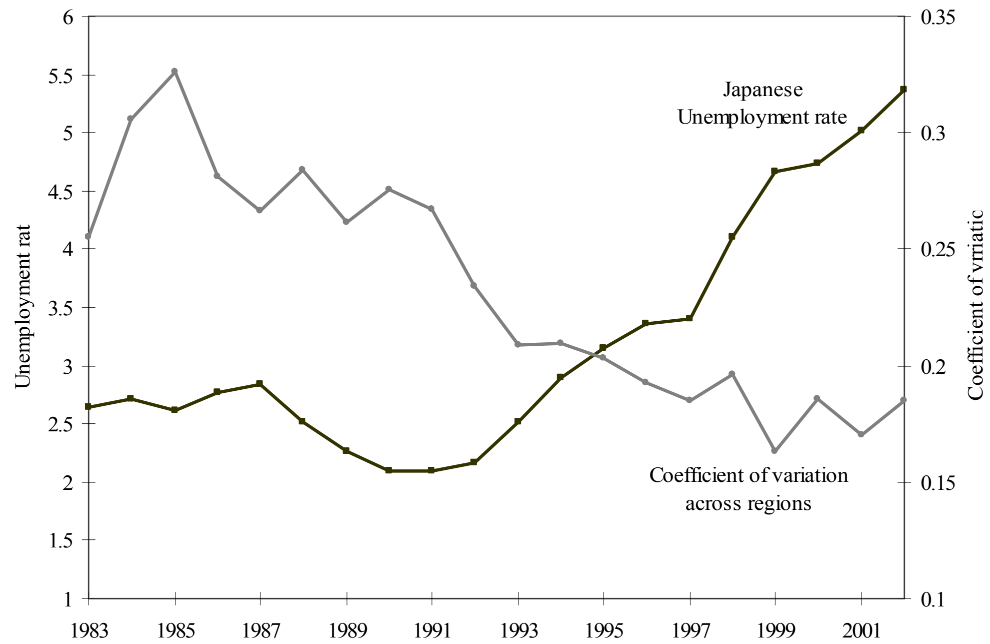

Figure 3. Vacancy rate and the prefectural coefficient of variation

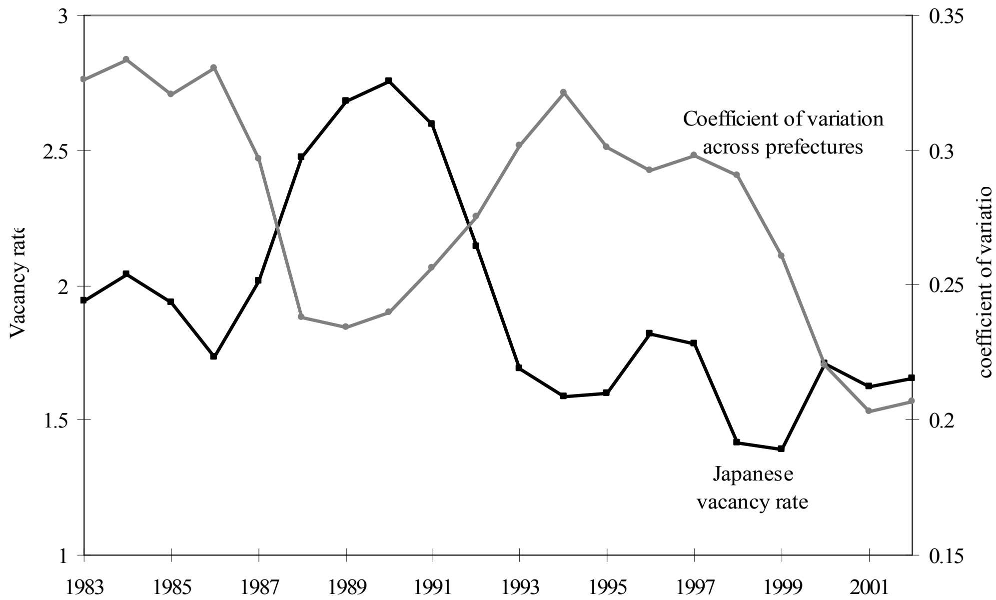

Figure 4. Phillips Curve with Quadratic Specification of Unemployment

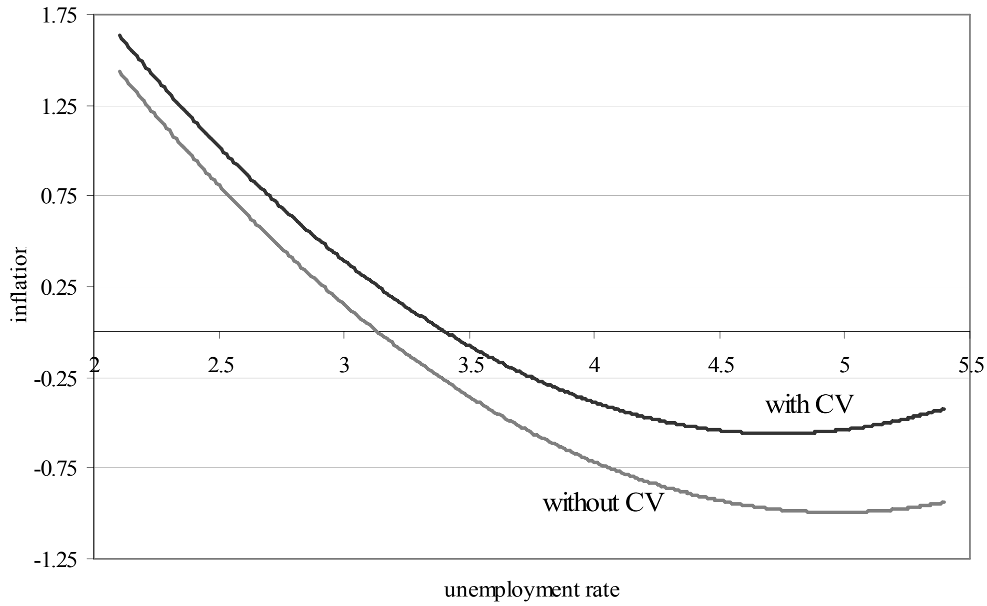

Figure 5. Phillips Curve with Linear Specification of AOR

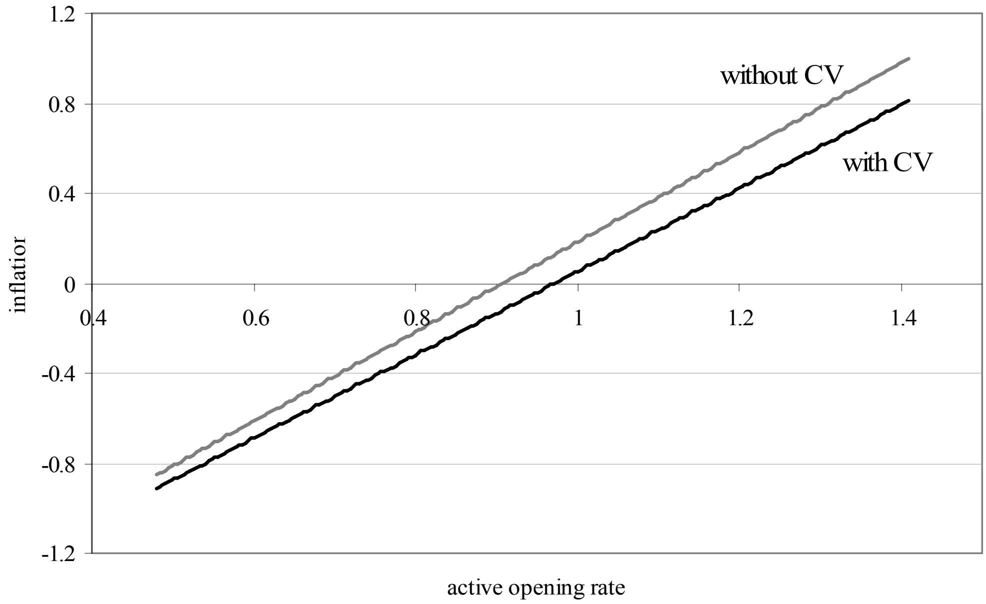

Figure 6. The Natural Rate of Unemployment, 1983-2002

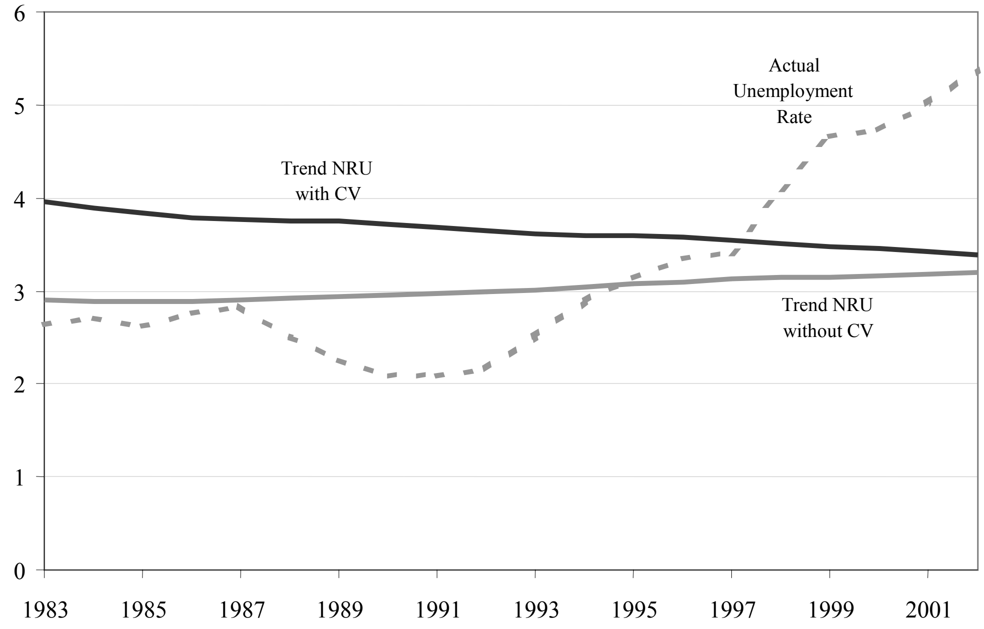

Figure 7. The Natural Active Opening Rate, 1983-2002