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IS THERE A CHANGE IN THE TRADE-OFF BETWEEN OUTPUT AND INFLATION AT LOW OR STABLE INFLATION RATES? SOME EVIDENCE IN THE CASE OF JAPAN

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ABSTRACT/RÉSUMÉ

IS THERE A CHANGE IN THE TRADE-OFF BETWEEN OUTPUT AND INFLATION AT LOW OR STABLE INFLATION RATES?

SOME EVIDENCE IN THE CASE OF JAPAN

This paper examines the relationship between the output gap and inflation in Japan by estimating Phillips curves and testing for changes since the advent of low inflation and/or the stabilisation of the rate of change of inflation. The work provides empirical support for the hypothesis of a change in the relationship between output and inflation in an environment of low inflation for Japan. In particular, there is evidence that the slope of the Phillips curve becomes flatter when the inflation rate is below ½ per cent (quarter-on-quarter, non-annualised) and also that there has been a break in the relationship between demand pressures and inflation in Japan since the beginning of the 1990s. Evidence is also found that the relationship changes when the inflation rate is either rising rapidly or falling sharply. At such times, changes in demand pressure have stronger effects on inflation. These results are robust to a wide range of specifications, including corrections for the impact of rises in indirect taxes and the use of a number of different demand indicators. More importantly, the basic pattern of results still holds when forward-looking expectations are explicitly introduced in the model and other measures of inflation are used in place of consumer prices.

JEL Classification: E31, C22
Keywords: Phillips curves, asymmetry, Japan, low inflation environment

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LA RELATION ENTRE INDICATEURS DE DEMANDE ET INFLATION CHANGE-T-ELLE DANS UN CONTEXTE DE BASSE OU DE STABILITÉ DE L'INFLATION ? LE CAS DU JAPON

Cette étude examine la relation entre l'écart de croissance et l'inflation au Japon en estimant des courbes de Phillips et teste si cette relation se modifie dans un contexte d'inflation basse et/ou de stabilité de l'inflation. Les estimations présentées constituent un support empirique relativement détaillé de l'hypothèse d'un changement dans la relation entre indicateur de demande et inflation dans un environnement de basse inflation pour le Japon. En particulier, la pente de la courbe de Phillips s'aplatit quand le taux d'inflation est en dessous d'½ pour cent (taux trimestriel, non annualisé) et il existe un break dans la relation entre indicateur de demande et inflation au Japon au début des années 90. La relation apparaît aussi se modifier quand le taux d'inflation augmente ou baisse rapidement. Durant de telles périodes, les mouvements dans les indicateurs de demande ont un effet plus fort sur l'inflation. Les résultats obtenus sont robustes à la correction des hausses de taxes indirectes et à l'utilisation de différents indicateurs de demande dans les spécifications de courbes de Phillips. Plus important, les résultats continuent d'être globalement vérifiés quand des anticipations rationnelles sont explicitement introduites dans le modèle et quand des mesures d'inflation (autres que celle basée sur les prix à la consommation) sont utilisées.

Classification JEL : E31, C22
Mots Clefs : Courbes de Phillips, asymétrie, Japon, environnement de basse inflation

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IS THERE A CHANGE IN THE TRADE-OFF BETWEEN OUTPUT AND INFLATION AT LOW OR STABLE INFLATION RATES? SOME EVIDENCE IN THE CASE OF JAPAN

by

A. Mourougane and H. Ibaragi[1]

Introduction and summary

1. Since 1998 Japan has been experiencing an unusually prolonged period of economy-wide price deflation outside the recent historical experience of other industrial countries. An enhanced understanding of the consequences of falling prices and the structural changes that may be associated with this is of importance not only for the Japanese policymakers but also for those in other countries for whom deflation remains a major source of concern. For Japan, there have been fears that ongoing deflation could weaken output sufficiently to set in course a deflationary spiral. By raising real interest rates, deflation further weakens fragile balance sheets especially for domestically oriented firms. On the fiscal side, deflation may also have potentially major effects on public debt: general government gross financial liabilities (as a percentage of nominal GDP) have risen by more than 35 percentage points between 1998 and 2002, reaching 147 per cent in 2002, the highest level amongst the OECD countries. Although underlying inflation has recently been approaching zero per cent, with the economic recovery which started in 2002 gaining stronger momentum since the middle of 2003, the fragility of the financial sector and the risks associated with the rising level of public debt could interfere with the ability of the Japanese economy to get out of deflation (see, for instance, OECD, 2000, 2001 and 2002).

2. There are a number of academic studies that suggest that the relationship between demand pressures and inflation may be non-linear and changes at times of low, or negative, inflation. For example, in the model set out by Lucas (1973), agents cannot observe the current aggregate price and make their decisions using information on the variation of relative prices. When the ratio of the volatility in the general price level to the volatility in individual prices is high, the slope of the Phillips curve will be steep. This happens, for instance, when the variance in relative prices is low, meaning that changes in individual prices reflect accurately changes in the general price level. It also occurs when the variance in aggregate price level is high.

3. An alternative explanation for non-linearity between demand pressures and inflation can be found in Ball *et al.* (1988) who suggest that downward nominal rigidities in prices may be observed at times of low inflation because of the (menu) costs[2] of price adjustments. Such costs may also delay the speed at

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1. The authors are members of the Macroeconomic Analysis and Systems Management Division and the Japan Desk, Country Studies III, respectively, of the Economics Department of the OECD. The authors are grateful to Anne Marie Brook, Jorgen Elmeskov, Rick Imai, Nigel Pain, Pete Richardson and David Turner for helpful comments and suggestions and would like to thank Diane Scott for assistance in preparing the document.

2. In the economic literature this term refers to small fixed costs of changing nominal price *e.g.* costs of printing menus and catalogues or of replacing price tags. In the Ball *et al.* (1988) model, these costs include all costs associated with gathering information on the optimal price.

which prices adjust to any given change in demand pressure. The authors found that the equilibrium interval between price changes is a decreasing function of average inflation. One implication is that the slope of the Phillips curve could decline continuously as the inflation rate falls, because the frequency of price adjustments will also decrease. It is worth noting however that the menu cost explanation for the flattening of the Phillips curve when average inflation is low can be questioned. Indeed, a number of alternative menu cost models [for instance the so-called state dependant or (S,s) rules] do not predict that inflation will affect the trade-off.[3] In these models, prices are left unchanged as long as the desired prices are between some upper and lower bound. In this context, even a small change in costs can trigger a change in prices if the implied shock takes the desired price outside the bounds. Moreover, in practice it is not easy to discriminate between the Ball *et al.* (1988) and Lucas (1973) theories as higher inflation rates are also usually associated with higher inflation volatility. It is beyond the scope of this paper to test the validity of these separate theories; the tests implemented simply seek to identify the existence of nominal rigidities which could arise either from lower variation in inflation or at low rates of inflation.

4. Akerlof *et al.* (1996) provide a further explanation for non-linearity in the Phillips curve, arising from nominal downward wage rigidity. Companies and employees very seldom agree on nominal wage cuts unless those companies face extreme financial constraints. These downward rigidities hamper the adjustment of real wages. When the inflation rate approaches zero, the number of constrained firms, and the degree of their constraints increase sharply. Consequently, the number of firms which reduce nominal wages may not increase in proportion to the degree of disinflation or deflation.[4] Alternatively, Akerlof *et al.* (2000) show that at low rates of inflation, firms and workers may choose to depart from fully rational behaviour when setting wages and prices. However, the cost of not being fully rational will mount with high inflation and above a certain inflation threshold agents will adopt fully rational behaviour, with wage and price setting responding fully to expected inflation. Both arguments imply that the slope of the Phillips curve could have a break at inflation rates close to or below zero. If this is true, such a break might have important implications for monetary policy decisions. In particular, the existence of downward nominal rigidities at low inflation rates could lead to a permanent deviation of output or employment from the equilibrium, implying a very high cost of low inflation.

5. Against this background, this paper examines the relationship between the output gap and inflation in Japan and tests whether it has changed since the advent of low inflation. We estimate Phillips curves using a number of different measures of prices and several different indicators of product or labour market slackness and test the stability of the resulting coefficients. The main advantage of the results presented is that, in contrast to most other studies (with the exception of Nishizaki and Watanabe, 2000 and Yates, 1998) data is used for a country that has been experiencing long periods of low or negative inflation rates. The extent to which structural changes arise at times of low inflation rates and the stabilisation of the rate of change of inflation is also tested.

6. The main results are summarised below:

- There is some evidence of a change in the estimated Phillips curve relationship based on core consumer price when the inflation rate is low. Perhaps surprisingly, the strongest evidence of change occurs when the quarterly inflation rate falls below ½ per cent, rather than when it becomes negative. At lower rates of inflation, demand pressure effects are found to be much

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3. See for instance Caplin and Spulber (1987).

4 . One limitation of this argument is that it relies on money illusion.

smaller than at higher rates and are always insignificant. In other words, the slope of the price Phillips curve tends to become flatter at lower rates of inflation.[5]

- There is also evidence of a flattening in the slope of the Phillips curve over time. In particular there appears to be a break in the relationship at the beginning of the 1990s, when the inflation rate dropped below ½ per cent on a sustained basis. There is less evidence of a further break after the inflation rate became negative in 1998.

- There is also evidence that the slope of the Phillips curve changes when inflation is more stable, with demand pressure effects becoming weaker than otherwise.

- These results are robust to a wide range of specifications using alternative measures of demand pressures. They are also robust to corrections for the impact on inflation of the VAT changes which occurred in 1989 and 1997. They also hold when a survey measure of expectations is introduced in the model (except in the presence of speed limit effects *i.e.* the presence of the change in the gap in the Phillips curve). A price curve based on the GDP deflator (rather than core consumer price inflation) also suggests broadly similar results though the conclusions are less marked. In particular the Phillips curve based on the GDP deflator tends to reject a potential change in the slope of the Phillips curve at stable rates of inflation. A comparable break is also found between wage inflation and the unemployment gap at high and low levels of wage inflation, suggesting that nominal rigidities arise also from sticky wages.

7. The remainder of the paper is organised as follows. Section 1 describes the specification of the Phillips curve used to analyse the link between consumer price inflation and demand pressures for Japan, discusses a range of demand pressure indicators that can be used to describe the degree of slackness in the Japanese economy and reports the corresponding empirical estimates. Section 2 examines whether there are changes in the relationship at low levels of inflation and/or at stable rates of inflation. Section 3 assesses the robustness of the results by introducing expectations explicitly into the model and using the GDP deflator in place of consumer prices. It also uses a wage Phillips curve to examine whether a similar break can be seen between wages and the unemployment gap. Finally, section 4 discusses the implications of the findings.

1. Is there a linear relationship between inflation and demand pressures in Japan?

Specification of the Phillips curves

8. Before examining whether the relationship between indicators of demand and inflation changes in an environment of low inflation, a necessary first step is to show that such a relationship holds at all in Japan. We estimate a standard reduced-form Phillips curve specification for price inflation, similar to that used in other OECD Secretariat studies. Richardson *et al.* (2000) and Rae and Turner (2001) show that such a relationship is relatively well determined for a number of countries, including Japan.

9. The estimated Phillips curve is expressed in terms of core inflation excluding food and energy. This differs from the Phillips curves often estimated for Japan, which typically use headline inflation or core inflation excluding only fresh food (see Mio, 2000 for a survey on Phillips curves estimates for Japan). However, core inflation excluding food and energy appears to be more relevant from a monetary policy perspective as it is not influenced directly by temporary fluctuations in oil and food prices. The relationship is specified such that core inflation depends on expected inflation and a measure of demand

5. In the current work, the focus is on the short term Phillips curve, i.e. the coefficient on demand in the Phillips curves is examined given inflation expectations.

pressure. Expected inflation is initially specified as being backward looking, proxied by lags in the dependant variable.[6] Dynamic homogeneity is imposed, so that in the long run there is no trade-off between inflation and output. Demand indicators are introduced in the relationship to measure pressures from the degree of slackness in product or labour markets. These indicators are discussed in more detail in the following sub section.

10. A further step is to control for the effects of supply-side shocks, as a number of articles have shown that they play an important role in the determination of the Phillips curve. For instance Gordon (1998) explains the low level of US inflation in the mid 1990s by the confluence of five beneficial supply shocks (including traditional supply shocks like changes in real food prices, real energy prices and real import prices, and also "new" supply shocks like medical and computer prices as well as recent measurement improvements in the CPI). In discussing Gordon's paper, Stock indicates that only the traditional supply shocks are of relevance. Nishizaki and Watanabe (2000) suggest that a failure to control for supply shocks may bias the slope of the short run Phillips curve. In the current analytical work, supply shock effects are proxied by the variations of non-energy import prices in the short run and by a de-trended measure of real import prices in the long run.[7] The latter correction to import prices is important both from a statistical point of view (to remove the apparent trend in the import price series) and from an econometric point of view (to preserve dynamic homogeneity). Oil prices were also used to proxy supply shock effects but were mostly insignificant or wrongly signed, suggesting negligible second round effects of oil prices on core inflation.[8]

11. The estimated Phillips curve has the following form:

$$\Delta\pi_t = c_0 + c_1\Delta\pi_{t-1} + c_2\Delta\pi_{t-2} + c_3(1-\theta_1(L))*(indic_t) + c_4*(1-\theta_2(L))\omega^m*\Delta\pi_t^m$$
$$+ c_5*(1-\theta_3(L))(\omega^m(\pi_{t-1}^m - \pi_{t-1}^{ulc})) + \varepsilon_t^\pi$$

Δ is the first difference operator and subscripts denote lags. θ is the lag operator.

π_t : inflation in terms of core price i.e. excluding food and energy

$indic$ indicator of demand pressure (in level or in some cases both in level and first difference)

ω^m degree of openness of the economy[9]

π^m : non energy import prices inflation

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6. This assumption is relaxed in Section 3 and explicit measures of expectations are introduced in the estimations.

7. More precisely, we used the difference between import inflation and unit labour cost inflation in the manufacturing sector (which is smoothed by a moving average), weighted by the share of non-oil imports in total imports.

8. Another way to capture supply shock effects would have been to introduce an asymmetry or skewness variable, following Ball and Mankiw (1994). For instance, Nishizaki and Watanabe (2000) introduce measures of price asymmetry to proxy three important supply shocks: inflow of labour-intensive products from East-Asian economies, the improvement in the efficiency of the Japanese distribution system and measures of deregulation such as the abolition of barriers to beef imports. Mio (2000) indicates this method out performs an equation using import prices when supply shocks are controlled for current and also lagged inflation in the case of Japan.

9. It is measured as $\omega^m = \frac{m}{y+m}$ where m are goods and services imports excluding energy and y is GDP.

π^{ulc} : unit labour costs in the manufacturing sector (inflation)

For the indicator and real import price, a moving average was generally introduced to allow for richer dynamics in the equation.

Measuring pressure of demand in Japan

12. Conventional estimates of the Phillips curve use measures of either the output gap or unemployment gap as an indicator of demand pressure or slackness in the labour market. However, it can be argued that these indicators involve significant measurement errors, because potential output and the structural rate of unemployment cannot be observed directly. Such measurement errors may be especially important for Japan. For example, Kamada and Masuda (2001) provide a comprehensive discussion of the measurement errors in output gap estimates in Japan. To attempt to minimise the distortions that might arise, we examine the impact of five different indicators of demand pressure in Japan:

- *The unemployment gap* (UGAP), given by the difference between the unemployment rate and the NAIRU with the latter being estimated as in Richardson *et al.* (2000). This indicator is widely used in Phillips curve estimation either in levels or in first differences (or both), with the first difference term being used to capture potential speed limit effects in the economy. A positive unemployment gap indicates that the unemployment rate is above the NAIRU which, other things being equal, should generate downward pressures on inflation. Despite the wide use of such a measure in empirical studies, it is often argued that the unemployment gap is not a reliable indicator of inflationary pressures in Japan as labour hoarding, which is widely observed among Japanese firms during periods of economic slowdown, leads to an underestimation of the true degree of slack in the labour market.

- *The output gap* (GAP), given by the difference between actual and potential output, with the latter being estimated using a production function approach (Giorno *et al*, 1995).[10] As with the unemployment gap, the output gap is commonly used both in levels and/or in first differences. A positive output gap suggests that current output is above potential which, other things being equal, will induce inflationary pressures. This indicator may be mismeasured if both capital and labour input are not adjusted for quality or utilisation rates. Measurement errors in estimates of the capital stock, GDP and the NAIRU could also lead to the measurement errors in the estimate of output gap.

- *Manufacturing capacity utilisation* (CAP). This index is measured by the Ministry of Economy, Trade and Industry (METI) as the ratio of actual production to production capacity, the latter being adjusted for certain operation dates and labour intensity. It covers 182 manufacturing products and is normalised so that the level in 1995 is equal to 100. The series have been extended up to the most recent period with 1995 fixed sectoral weights. An additional normalisation is to subtract the mean over the 1990s. The resulting series is then used as an alternative estimate of the output gap. An increase in the capacity utilisation measure would normally be seen as a leading indicator of an increase in inflation, although it is limited by its narrow sectoral coverage and can be an unreliable indicator for economy-wide inflation.

- *The production capacity index in the manufacturing sector* (PCIM). This measure is taken from the Tankan survey published by the Bank of Japan. This is a diffusion index, measured as the difference between the number of responding firms which have "Insufficient Capacity" and those which have "Excessive Capacity". A positive number suggests the existence of excess capacity.

10. In the case of Japan, a CES production function is used.

This measure has the same problems as CAP regarding the narrow sectoral coverage. There can be additional problems associated with the use of a balance measure. For example, small changes in the number of respondents with insufficient or excess capacity can generate large changes in the net balance, regardless of the relative size and importance of the respondents.

- *The business condition index in the manufacturing sector* (BIM), is also taken from the Bank of Japan Tankan Survey. This index is calculated as the percentage share of enterprises responding that "Business condition is favourable" minus the percentage share of enterprises responding "unfavourable". This measure is sometimes used as a direct alternative of the output gap. It covers only manufacturing sectors. Its movement over the time is broadly consistent with the business cycle. It is also a balance measure, and therefore suffers from associated deficiencies.

13. The production capacity index for the whole economy published in the Tankan survey may also be used as an alternative to these indicators. However, given that such an indicator moves closely in line with the production capacity index in the manufacturing sector (the coefficient of correlation is very close to 1, see Table 1) and it is available over a shorter time span, it was not used. For the same reasons, the business condition index for the whole economy, which is also published in the Tankan survey, was not used.

Table 1. Correlation

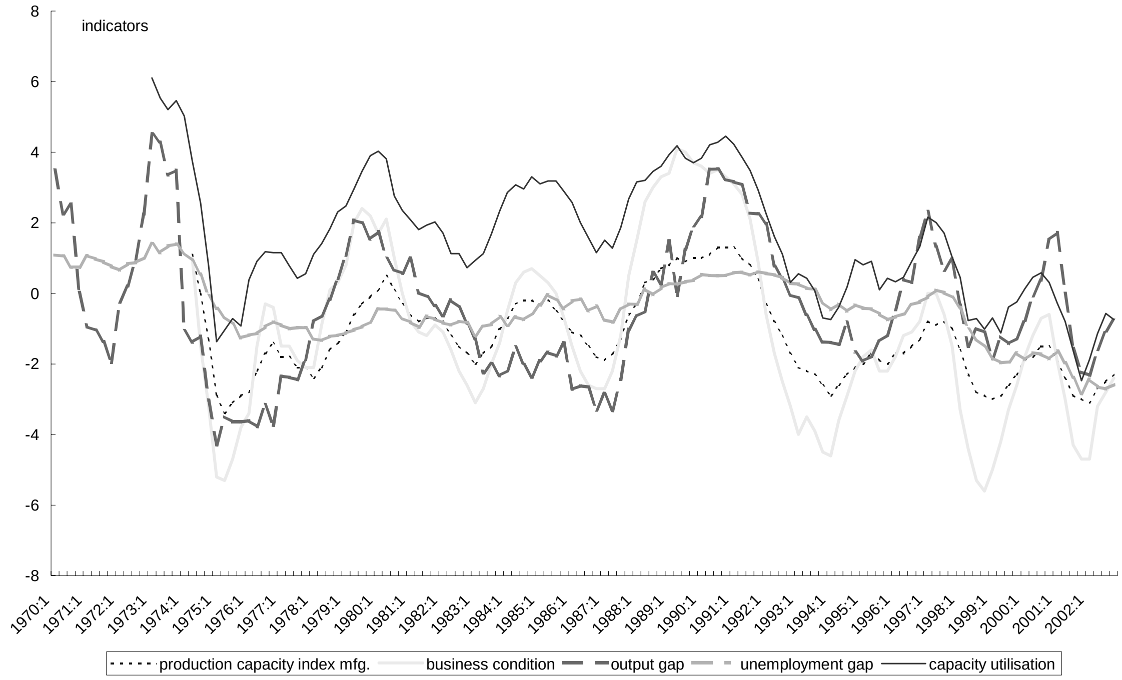
	CAP	BIM	BIT	GAP	PCIM	PCIT	UGAP
CAP	1.00	0.91	0.91	0.59	0.94	0.92	0.73
BIM		1.00	1.00	0.64	0.93	0.85	0.51
BIT			1.00	0.64	0.93	0.85	0.51
GAP				1.00	0.64	0.75	0.46
PCIM					1.00	0.96	0.68
PCIT						1.00	0.67
UGAP							1.00

Note: PCIM: production capacity index in the manufacturing sector, PCIT: production capacity index in the whole economy, UGAP: unemployment gap, CAP: capacity utilisation, GAP: output gap, BIT: business capacity index in the whole economy, BIM: business capacity index in the manufacturing sector.

Source: ABD, BOJ Tankan Survey

14. For comparability purposes, the various indicators have been re-scaled and the sign of the unemployment gap and the production capacity indices are inverted. Thus an increase in each of the corrected indicators is expected to have a positive impact on inflation. All five indicators are quite closely correlated (see Table 1) with correlation coefficients close to or above 0.6 in most cases and is significantly different from zero. However, the output gap measure appears to be less correlated with the other indicators, especially the unemployment gap. As shown in Figures 1 and 2, the five indicators differ on a variety of points. All are relatively volatile apart from the unemployment gap. Their overall patterns generally do not exhibit an obvious visual break in the 1990 (or in 1998), contrary to inflation, although again, the unemployment gap may be a possible exception. However, there are changes in the mean and the variance of most of the indicators, and in the corresponding coefficients of variation, for the period 1998-2001 (see Table 2).

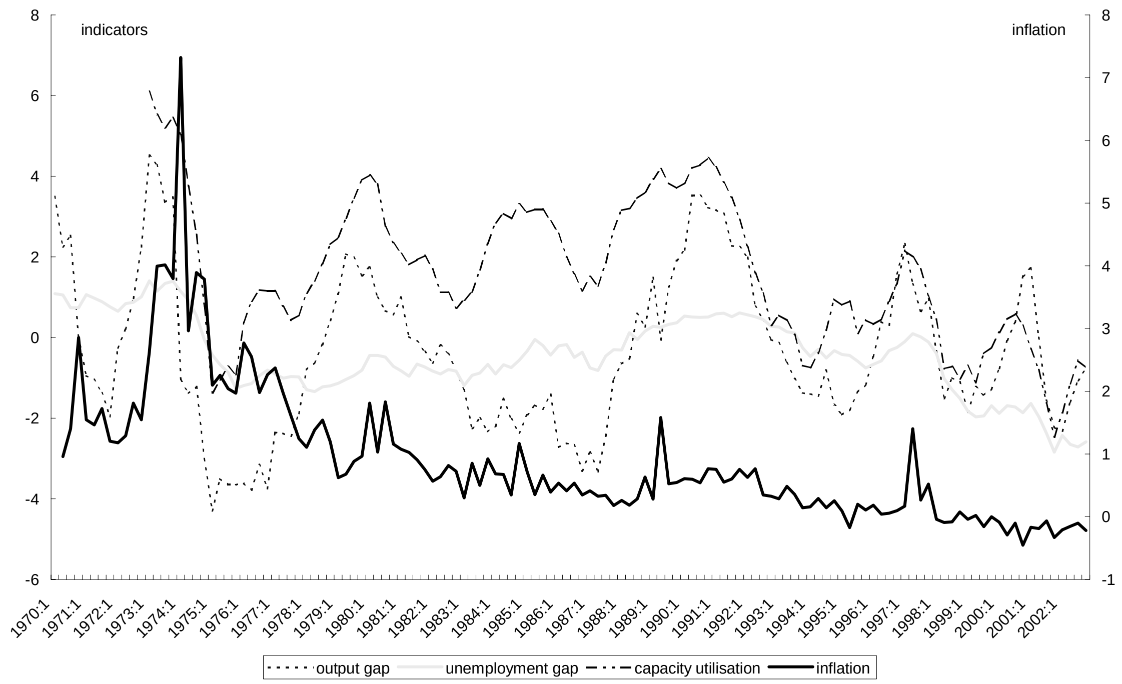
Figure 1. Indicators of demand pressures in Japan



Note: The indicators have been re-scaled and their signs inverted (only for the unemployment gap and the production capacity index)

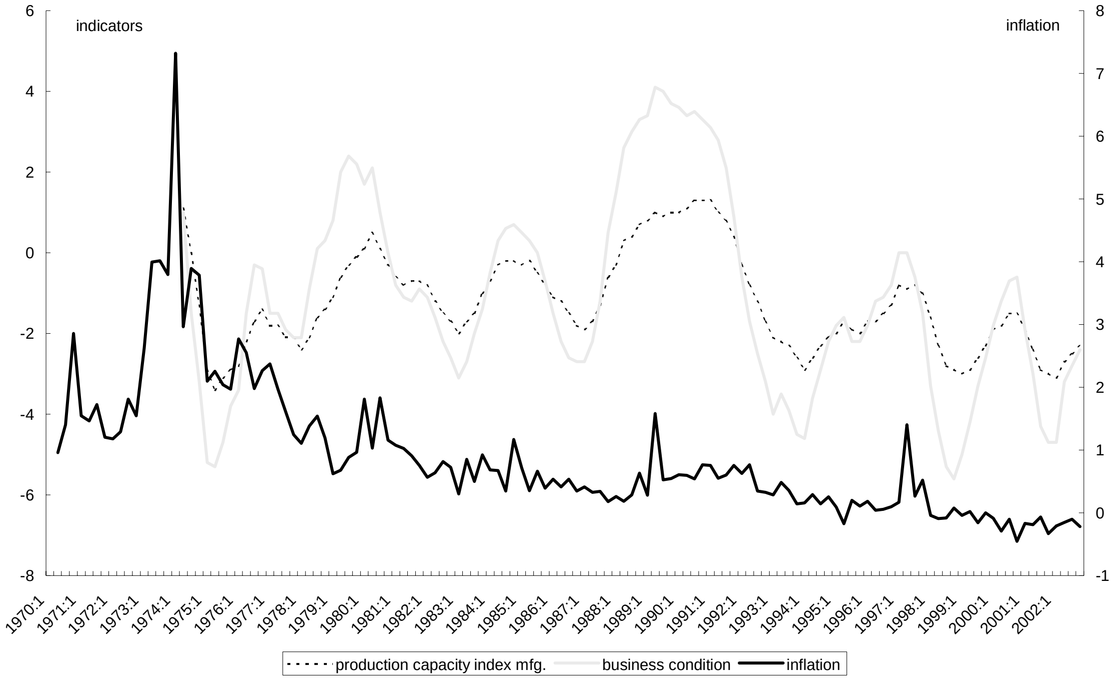
Source: ADB, BOJ Tankan survey.

Figure 2a. Indicators and inflation pressures



Source: ADB, BOJ Tankan survey

Figure 2b. Indicators and inflation pressures



Source: ADB, BOJ Tankan survey

Table 2. Basic statistics

	inflation	correction	GAP	UGAP	PCIM	BIM	CAP
mean							
whole period	0.9	0.9	-0.4	-0.4	-1.2	-1.1	1.6
1960-1990	1.4	1.3	-0.5	-0.1	-0.8	-0.3	2.4
1990-1998	0.2	0.1	-0.1	-0.8	-1.7	-2.1	0.5
1998-2002	-0.1	-0.1	-0.8	-1.9	-2.4	-3.3	-0.6
1960-1998	1.1	1.1	-0.3	-0.1	-1.0	-0.7	2.1
standard error							
whole period	1.1	1.1	1.9	0.9	1.2	2.4	1.8
1960-1990	1.2	1.2	2.2	0.7	1.2	2.4	1.6
1990-1998	0.4	0.3	1.5	1.1	1.1	2.1	1.5
1998-2002	0.1	0.1	1.1	0.6	0.5	1.5	0.8
1960-1998	1.1	1.1	2.1	0.7	1.2	2.3	1.6
coefficient of variation							
whole period	1.2	1.2	-4.5	-2.1	-1.0	-2.2	1.1
1960-1990	0.9	0.9	-4.3	-5.4	-1.4	-7.8	0.7
1990-1998	2.2	2.2	-10.8	-1.3	-0.7	-1.0	3.1
1998-2002	-0.9	-0.9	-1.3	-0.3	-0.2	-0.5	-1.3
1960-1998	1.0	1.0	-6.4	-5.8	-1.2	-3.5	0.8

Note: See Table 1 for indicator names.

Source: ABD, BOJ Tankan Survey.

15. Unit root tests were undertaken for the set of demand indicators.[11] The results are clear-cut most of the time, with the majority of indicators found to be stationary (see Table 3).[12] The unemployment gap is again an exception and appears to be integrated of order one, but this result depends markedly on the most recent observations in the sample, where there is a growing difference between the actual unemployment rate and the estimated NAIRU.

Table 3. Stationarity tests

	GAP		**DGAP**		**UGAP**		**DUGAP**
ADF(1)	-3.3	*	-6.8		-0.8	***	-7.3
ADF(2)	-3.9		-5.0		-1.1	***	-5.6
ADF(3)	-4.5		-5.4		-1.5	***	-5.1
PP(1)	-3.3	*	-10.3		-0.5	***	-11.0
PP(2)	-3.4	*	-10.4		-0.7	***	-11.1
PP(3)	-3.6		-10.5		-0.8	***	-11.2

	CAP		**PCIM**		**BIM**	
ADF(1)	-3.2	*	-3.8		-4.2	
ADF(2)	-3.6		-3.7		-4.0	
ADF(3)	-3.6		-3.0	**	-3.4	*
PP(1)	-2.6	**	-2.6	**	-2.3	***
PP(2)	-2.8	**	-2.8	**	-2.6	**
PP(3)	-2.9	**	-3.0	*	-2.8	**

Note: ADF= Augmented Dickey-Fuller , PP=Phillips Perron. The tests include a constant and the number in brackets indicates the number of first difference terms included in the regression. No star means that the variable is stationary at a 1% level, * stationary at a 5% level, **stationary at a 10% level, *** no stationary. See Table 1 for indicator names.

Estimation results for the Phillips curve

16. Equation (1) was estimated on quarterly data using samples starting in the 1960s or the 1970s, depending on data availability.[13] To get some insights into robustness, estimates were made using both headline core inflation and a measure corrected for significant changes in the rate of indirect taxes on consumption. The latter adjustment reduces core inflation by 1.2 percentage points in the second quarter of 1997 and by 0.4 and 0.3 percentage points in the following quarters (see Figure 3). In the second quarter of 1989, core inflation is reduced by 1.2 percentage points.

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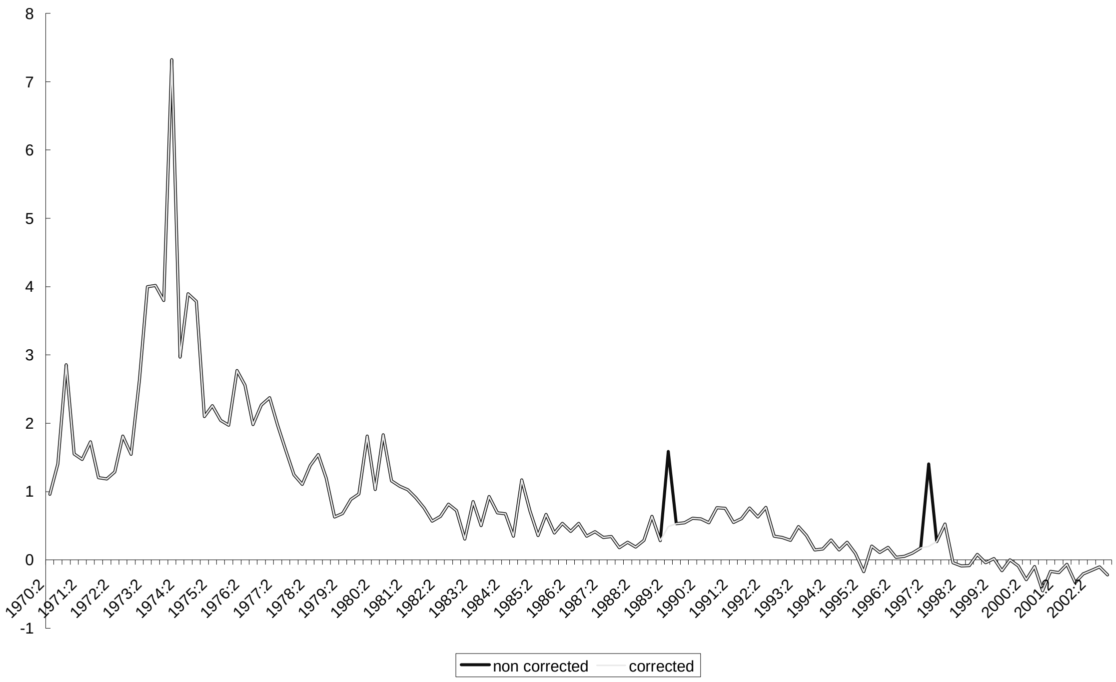
11. Given that it is well known that price levels are generally integrated of order 2, inflation series were not tested.

12. We used Augmented Dickey-Fuller test to check the stationarity of the variables. The Phillips Perron test gives some indication of the robustness of the results and confirms most of the time the Dickey-Fuller results.

13. All data except CAP, DIM and PCIM were taken from the OECD Analytical Database.

Figure 3. Core inflation in Japan



Source: ADB

17. All equations are generally well determined, with standard errors lower than similar Phillips curves estimated for Japan (see Table 4)[14] The equations pass most of the standard diagnostic tests, including the reset test for functional form, the White test for heteroskedasticity and the Lagrange multiplier test for serial correlation of order 1 and 4. However, they all fail the Jarque and Bera test for the normality of the residuals. This largely reflects some very large negative residuals during the first oil shock (between the first quarter of 1973 and the second quarter of 1976) and at the time of other indirect tax rises in the second quarters of 1982 and 1997, when inflation is not adjusted.[15] Dummying out these episodes was found to remove this feature without greatly changing the elasticity estimates or their significance.

18. As shown in Table 4, the chosen demand pressure indicators all have the expected sign in all the estimated equations, although not always statistically significant. For the unemployment and output gap measures, both the level and the first difference are found significant, suggesting the presence of speed limit effects in the economy. The influence of the first difference of the output gap on inflation was found to be best captured by using a 4 quarter moving average term. Real import prices also appear to have a positive influence on core inflation. These results hold whether inflation is corrected for tax changes or not and the real import price and the demand pressure coefficients are modified only marginally.

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14. See for instance Rae and Turner (2001). The differences might be due to a different sample period, the correction made on inflation for VAT increases, the use of different supply shocks. Rae and Turner also focus only on a Phillips curves with the output gap as the indicator of demand pressure.

15. A dummy variable was introduced in the first quarter of 1974, when Japan experienced a peak in inflation (7.3 per cent, quarter-on-quarter, after an average of 4 per cent in the preceding three quarters and a similar 4 per cent average in the next two quarters) stemming from the first oil price shock.

Table 4. Standard Phillips curve

Dependant variable	Δπ 1971Q1-2002Q4		Δπ corrected 1971Q1-2002Q4		Δπ 1972Q1-2002Q4		Δπ corrected 1972Q1-2002Q4		Δπ 1975Q1-2002Q4		Δπ corrected 1975Q1-2002Q4		Δπ 1974Q3-2002Q4		Δπ corrected 1974Q3-2002Q4		Δπ 1973Q1-2002Q4		Δπ corrected 1973Q1-2002Q4	
	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT
c	0.00	0.03	0.00	0.06	0.03	0.86	0.03	0.92	0.00	0.00	0.00	0.02	-0.03	-0.80	-0.03	-0.95	-0.12	-2.35	-0.11	-2.55
Δπ(−1)	-0.39	-5.96	-0.34	-5.79	-0.35	-5.10	-0.30	-4.67	-0.56	-5.96	-0.48	-5.09	-0.46	-5.97	-0.40	-5.62	-0.38	-5.23	-0.32	-4.72
Δπ(−2)	-0.16	-2.64	-0.16	-2.92	-0.14	-2.06	-0.13	-2.17	-0.19	-2.09	-0.23	-2.59	-0.17	-2.55	-0.16	-2.64	-0.13	-1.96	-0.12	-1.96
GAP	0.04	1.77	0.04	2.17																
@MOVAV(Δ(GAP),4)	0.13	1.70	0.12	1.73																
Δ(UGAP)					0.40	2.34	0.34	2.30												
UGAP					0.06	1.61	0.06	1.77												
PCIM									0.04	1.36	0.04	1.65								
BIM													0.02	1.52	0.02	1.61				
CAP																	0.06	2.93	0.06	3.14
@MOVAV(RPM,2)	0.20	1.51	0.19	1.63	0.22	1.69	0.21	1.89												
RPM									0.23	2.05	0.17	1.81	0.15	1.28	0.12	1.18	0.16	1.34	0.11	1.07
S.E.	0.38		0.33		0.38		0.33		0.35		0.29		0.35		0.30		0.38		0.34	
R2 ADJUSTED	0.67		0.72		0.66		0.71		0.23		0.18		0.25		0.22		0.67		0.72	
CHOW MID-SMPL	0.05	1986Q4	0.12	1986Q4	0.09	1987Q2	0.18	1987Q2	0.29	1988Q4	0.25	1988Q4	0.15	1988Q3	0.22	1988Q3	0.00	1987Q4	0.00	1987Q4
CHOW 3Y FCST	0.99	1999Q4	0.97	1999Q4	0.99	1999Q4	0.98	1999Q4	1.00	1999Q4	0.97	1999Q4	1.00	1999Q4	0.98	1999Q4	0.96	1999Q4	0.91	1999Q4
RESET	0.09		0.21		0.88		0.72		0.02		0.03		0.01		0.03		0.53		0.82	
HETEROSKED.	0.03		0.00		0.12		0.18		0.11		0.00		0.09		0.01		0.03		0.03	
SERIAL COR.(1)	0.73		0.37		0.79		0.34		0.42		0.77		0.46		0.98		0.84		0.22	
SERIAL COR.(4)	0.60		0.80		0.66		0.88		0.00		0.00		0.06		0.27		0.26		0.44	
NORMALITY	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
sacrifice ratio	2.54		2.30		1.46		1.47		2.74		2.61		4.41		4.62		1.50		1.52	

Note: @MOVAV denotes moving average

The p-values of a set of diagnostic tests are reported in the tables, these tests are as follows:

Chow Stability test: Based on the stability of parameters when the sample estimation period is divided into two halves.

Chow Forecast test: based on comparing an equation estimated over the full sample and a sample in which recent observations are omitted.

RESET test for functional form: Ramsey's test based on the significance of f adding squared fitted values.

Heteroscedasticity: Whites test based on the regression of squared residuals on squared fitted values.

Serial correlation: Lagrange Multiplier test for up to one or four order serial correlation.

Jarque-Bera test for the normality of the residuals.

Key to variables:

Δπ	variation of core inflation, CPI excluding food and energy
RPM	real import prices defined as import price in the manufacturing and service sector deflated by core inflation (weighted by the degree of openness)
PCIM	production capacity index in the manufacturing sector
UGAP	unemployment gap
CAP	capacity utilisation
GAP	output gap
BIM	business capacity index in the manufacturing sector

19. A common way of assessing the broad properties of the Phillips curve is to derive the implied sacrifice ratio, measured as the cumulative change in the output gap required to permanently decrease the inflation rate by one percentage point. For the equation including the output gap, the sacrifice ratio is estimated at around 2.3-2.6 per cent. This is higher than the estimate reported by Rae and Turner (2001) (1.6 per cent) using a similar specification, but with a sample stopping in the first quarter of 2000, thereby excluding the most recent period of sustained deflation. In addition, there are differences in the way supply shocks are captured. The estimated sacrifice ratios obtained with the other indicators vary considerably, being somewhat lower using the unemployment gap and capacity utilisation measures (at around 1.5 per cent), but higher for the business confidence index (around 4.5 per cent).

2. The evidence of a flatter slope for the short run Phillips curve at low levels of inflation or at stable inflation rates.

20. A number of studies have investigated the possible presence of non-linearity in Phillips curve relationships. The results of Laxton *et al.* (1993) suggest that the inflationary effects of a positive output gap in Canada are more than five times the size of the deflationary effects from a similar negative output gap. They also suggest that inflation responds more quickly to a positive gap. Evidence of this type of non linearity is also found using panel estimation for the G7 economies by Laxton (1994). Turner (1995) finds evidence of asymmetric effects from the output gap in the United States, Japan and Canada, suggesting that the inflationary effect of positive output gaps would be up to four times larger than the deflationary effect of negative output gaps. Barnes and Olivei (2003) suggest that the trade-off between inflation and the unemployment gap in the United States varies with the level of the unemployment gap. They estimate a range of values for the unemployment gap over which there is no significant trade-off in Phillips curves based on different measures of inflation. Outside this range a significant trade-off can be observed.[16] Contrary to these studies, however, the present tests look for asymmetries from different inflation rates rather than different movements in gaps.

21. This section examines whether the slope of the Phillips curve has changed with low inflation. Whilst the residual pattern of the equations reported in Section 1 gives no evidence of a break in the overall relation in 1999, when inflation was low, as indicated by the Chow tests (see Table 4), the main focus of interest here is the stability of the individual coefficient associated with the demand pressure indicator. To investigate this point further, the preceding equations were re-run to allow the demand pressure coefficient to differ when inflation is above or below certain thresholds. Two thresholds were tested: 0 per cent and ½ per cent (quarter-on-quarter, non-annualised growth rates).[17] The possibility of three breaks for the inflation rate, below 0, between 0 and ½ and above ½ per cent, was also investigated.

22. The corresponding estimation results reported in Table 5 provide clear evidence that at low, or negative, inflation rates, indicators of demand pressure have no statistically significant effect on price inflation. The coefficient on the demand indicator is also found to be statistically different when inflation is above or below ½ per cent, as indicated by the Wald tests in Table 6.[18] When inflation is negative, the coefficient associated with the demand indicator is approximately halved (compared to when inflation is positive) and the demand influence is not significant. With a threshold of ½ per cent (approximately 2 per cent on an annualised basis), the reduction in the coefficient on the demand indicator is greater (by a factor of 5). This corresponds to an increase (in absolute terms) of the sacrifice ratio from 0.2 to 0.7 percentage point depending on the indicator considered, meaning that the slope of the short-run Phillips curve is flatter

16. For instance, the unemployment gap must be below -1.4 per cent or above 1.4 per cent for the trade-off to be significant, using a core CPI Phillips curve with a time-varying Nairu.

17. The ½ per cent threshold has been chosen because this quarterly rate is close to the medium-term target rates for the annual rate of inflation in most OECD countries with inflation targeting regimes.

18. *A priori* a Fisher test would be more appropriate as it does not assume asymptotic hypotheses, which in the case of our relatively small samples are not verified. However, given that the two tests give very similar results, only Wald tests are presented. Fisher tests results are available upon request.

at low rates of inflation. These results are consistent with those of Nishizaki and Watanabe (2000), who use both a time series and a panel approach with data up to 1997 and find that the slope of the Phillips curve declines by about a half when inflation is below 3 per cent (on an annualised basis).

Table 5. Existence of asymmetry in the relation

Table 5a. Threshold of 0

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	π <0	-0.12	-1.25	-0.10	-1.25
	π >0	0.08	3.52	0.08	3.74
gap	π <0	0.00	-0.02	0.02	0.17
Δgap		0.08	0.30	0.02	0.09
	π >0	0.04	1.79	0.04	2.17
		0.15	1.83	0.14	1.95
bim	π <0	0.01	0.48	0.01	0.43
	π >0	0.03	1.57	0.02	1.70
pcim	π <0	0.03	0.67	0.03	0.75
	π >0	0.05	1.42	0.05	1.76
ugap	π <0	0.02	0.40	0.02	0.45
Δugap		0.28	0.83	0.25	0.84
	π >0	0.13	2.31	0.12	2.52
		0.49	2.46	0.42	2.43

Note: See Table 1 for indicator names

Table 5b. Threshold of ½

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	π <½	-0.02	-0.61	0.01	0.23
	π >½	0.11	4.63	0.09	4.30
gap	π <½	-0.01	-0.26	0.01	0.23
Δgap		0.00	0.03	-0.02	-0.16
	π >½	0.06	2.31	0.06	2.51
		0.20	2.13	0.18	2.29
bim	π <½	0.00	-0.23	0.00	0.01
	π >½	0.08	3.56	0.07	3.33
pcim	π <½	0.02	0.49	0.02	0.62
	π >½	0.10	2.39	0.10	2.94
ugap	π <½	0.02	0.42	0.02	0.58
Δugap		0.14	0.65	0.10	0.55
	π >½	0.19	3.16	0.18	3.36
		0.90	3.60	0.81	3.70

Note: See Table 1 for indicator names

Table 5c. Threshold of 0 and ½

		non corrected		corrected	
		coeff.	t.stat	coeff.	t.stat
cap	$\pi < 0$	-0.10	-1.18	-0.09	-1.20
	$½ > \pi > 0$	0.00	-0.05	0.02	0.83
	$\pi > ½$	0.11	4.73	0.10	4.52
gap	$\pi < 0$	-0.01	-0.12	0.01	0.10
Δgap		0.09	0.34	0.02	0.09
	$½ > \pi > 0$	-0.01	-0.23	0.01	0.21
		-0.06	-0.38	-0.06	-0.37
	$\pi > ½$	0.06	2.29	0.06	2.49
		0.20	2.12	0.18	2.27
bim	$\pi < 0$	0.01	0.43	0.01	0.36
	$½ > \pi > 0$	-0.01	-0.60	0.00	-0.23
	$\pi > ½$	0.08	3.55	0.07	3.30
pcim	$\pi < 0$	0.03	0.68	0.03	0.77
	$½ > \pi > 0$	0.01	0.13	0.01	0.26
	$\pi > ½$	0.10	2.37	0.10	2.91
ugap	$\pi < 0$	0.02	0.33	0.02	0.44
Δugap		0.29	0.88	0.25	0.87
	$½ > \pi > 0$	0.00	0.04	-0.02	-0.08
		0.02	0.07	0.04	0.49
	$\pi > ½$	0.19	3.13	0.18	3.35
		0.89	3.57	0.81	3.67

Note: See Table 1 for indicator names

23. These results hold independently of the demand pressure indicator used and whether or not inflation is corrected for indirect taxes. Perhaps surprisingly, the period of deflation does not appear to coincide with significant changes in the relationship, with the possible exception of the equation using capacity utilisation (see Table 6a). This may reflect the lower number of observations of deflation, making the outcome of the test more sensitive to sample size. To some extent, this result is also consistent with the Chow tests results reported in Table 4, which indicate a mid-sample break (moving to a low inflation rate) but none after 1999 (in the deflation period).[19]

19. As already indicated, the Chow test and the Wald test of a significant change in the demand pressure coefficient at certain thresholds do not measure exactly the same things. The former is based on the residuals and tests the existence of a break in the whole relationship whilst the second focuses on the coefficient on the demand indicator.

Table 6. Wald tests for asymmetry

Table 6a: Threshold of 0

	π	corrected
cap	0.05	0.04
gap, Δgap	0.67	0.55
bim	0.64	0.55
pcim	0.65	0.51
ugap,Δugap	0.21	0.17

Table 6b: Threshold of ½

	π	corrected
cap	0	0
gap, Δgap	0.02	0.02
bim	0	0
pcim	0.04	0.01
ugap,Δugap	0	0

Table 6c: Threshold of 0 (given break at ½)

	π	corrected
cap	0.3	0.18
gap, Δgap	0.81	0.92
bim	0.45	0.65
pcim	0.63	0.65
ugap,Δugap	0.80	0.78

Note: The Wald test tests whether or not the coefficients on the demand indicator are the same in the different samples. A probability above 10% indicates that we can not conclude that the coefficients are significantly different.

See Table 1 for indicator names.

24. The absence of a significant break when inflation becomes negative is also found when allowance is made for a break at the ½ per cent threshold (see Table 6c).[20] Allowing the coefficient on the demand pressure indicator to vary when inflation is below zero, positive but below ½ per cent or above ½ per cent, suggests that the most important changes are visible around the ½ threshold. The size of the estimated coefficient is generally lowered by a factor of 10 or more when inflation is below ½ per cent (compared to when it is above ½ per cent). By contrast, including the period of negative inflation rates changes only marginally the coefficient, which continues to stay insignificant. This is confirmed by Wald tests, which give no indication of an additional break at zero inflation rates when allowance is made for a break at a ½ per cent threshold.

25. These results contrast with those reported for other countries in periods of low or negative inflation. For example Yates (1998) estimated Phillips curves using annual data from 1800-1938 for Denmark, France, Italy, Sweden, the United Kingdom and the United States, and found little evidence that the slope of the Phillips curve varies with the direction of aggregate price movements. However, in that case the Phillips curves are "quite badly determined"[21] with few significant coefficients. It is less likely that structural breaks will be found in poorly determined equations.

20. Ignoring the existence of a break at the ½ threshold reduces the power of the test at the zero threshold. That is why it is important to check whether our results still hold when allowance is made for a break at the threshold.

21. In part this may result from the use of a Hodrick Prescott filter with lambda set to 1600 for annual data in order to construct an estimate of the output gap.

26. Another way to examine whether the Phillips curve slope shifts down at low levels of inflation is to test for a break in the 1990s, as inflation rates approached zero or even came down to negative rate. This differs somewhat from the previous tests, as core inflation was below ½ per cent during some quarters before 1990. This has happened after 1983, and in particular from the fourth quarter of 1985 to the third quarter of 1988.[22] One major drawback of this procedure is that it does not correct for other factors, such as structural reforms which might also have influenced the inflation process[23]. There is no evidence from the residual pattern of the equations reported in Section 1 of such a break in the 1990s or in 1998, at the start of the deflation period. By contrast most equations appear to show a break from the late 1980s, as can be seen from the Chow mid-sample tests in Table 4. To investigate this point further, the Phillips curve equations were re-estimated allowing for different demand indicator coefficients before and after 1990. The existence of a break before and after 1998 was also examined.

27. The results reported in Table 7 suggest that the coefficient associated with the demand indicator is significant and correctly signed before 1990 but not after. The amplitude of the coefficient declines in the second period (starting in 1990). It is more than halved in the majority of cases. Testing for a break in 1998 leads to very similar conclusions, the only significant difference being that the coefficients associated with capacity utilisation and the level of the output gap are wrongly signed after 1998 (although still not significantly different from zero).

Table 7. Variation over time of the coefficient on the indicator of demand pressure

Table 7a. 2 periods - before 1990 and after

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	-1990	0.08	3.17	0.07	3.43
	1990-	0.04	1.14	0.03	1.19
gap	-1990	0.05	1.94	0.06	2.38
Δgap		0.17	1.84	0.17	2.09
	1990-	0.01	0.21	0.01	0.30
		0.05	0.31	0.00	0.03
bim	-1990	0.06	2.56	0.06	2.83
	1990-	0.01	0.27	0.00	0.20
pcim	-1990	0.10	2.49	0.11	2.96
	1990-	0.02	0.60	0.02	0.78
ugap	-1990	0.19	3.04	0.18	3.34
Δugap		0.50	2.31	0.52	2.76
	1990-	0.01	0.20	0.02	0.39
		0.39	1.46	0.21	0.93

Note: See Table 1 for indicator names

22. By contrast, inflation was above ½ per cent in the first quarter of 1997.

23. Many such reforms were implemented in Japan in the 1990s. From mid-1990s onwards, a new financial regulatory and supervisory regime was set up by a series of institutional changes. In 1997, the statutes of the Bank of Japan were modified to give the central bank enhanced legal independence from the Ministry of Finance.

Table 7b. 2 periods - before 1998 and after

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	-1998	0.09	3.79	0.09	4.01
	1998-	-0.15	-1.65	-0.13	-1.67
gap	-1998	0.04	1.87	0.04	2.27
Δgap		0.15	1.85	0.14	1.97
	1998-	-0.07	-0.64	-0.05	-0.54
		0.18	0.70	0.13	0.54
bim	-1998	0.03	1.95	0.03	2.14
	1998-	0.00	0.00	0.00	-0.12
pcim	-1998	0.06	1.77	0.06	2.20
	1998-	0.01	0.30	0.01	0.34
ugap	-1998	0.16	2.85	0.16	3.15
Δugap		0.51	2.56	0.44	2.55
	1998-	0.01	0.20	0.01	0.22
		0.26	0.84	0.23	0.85

Note: See Table 1 for indicator names

Table 7c. 3 periods - before 1990, between 1990-1998 and after 1998

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	-1990	0.10	3.76	0.09	4.03
	1990-1998	0.07	2.10	0.07	2.16
	1998-	-0.15	-1.64	-0.13	-1.66
gap	-1990	0.05	1.76	0.05	2.19
Δgap		0.17	1.89	0.17	2.12
	1990-1998	0.02	0.50	0.02	0.54
		0.01	0.04	-0.04	-0.21
	1998-	-0.06	-0.59	-0.04	-0.48
		0.18	0.68	0.12	0.51
bim	-1990	0.06	2.53	0.06	2.81
	1990-1998	0.01	0.34	0.01	0.37
	1998-	0.00	0.05	0.00	-0.08
pcim	-1990	0.10	2.47	0.10	2.94
	1990-1998	0.02	0.44	0.02	0.70
	1998-	0.02	0.50	0.02	0.54
ugap	-1990	0.19	3.00	0.18	3.28
Δugap		0.50	2.29	0.51	2.73
	1990-1998	0.02	0.11	0.04	0.26
		0.68	1.37	0.16	0.38
	1998-	0.01	0.29	0.01	0.29
		0.27	0.84	0.23	0.85

Note: See Table 1 for indicator names

28. Wald tests confirm the existence of a significant break in 1990 in most of the cases (see Table 8), a notable exception being for capacity utilisation. By contrast, there is little evidence of a significant change in the link between inflation and demand indicator in 1998, except when capacity utilisation and unemployment gap are used. In the latter case, the result may reflect the fact that the profile of the unemployment gap changes in 1998, and begins to exhibit a downward trend (see Figure 1).

Table 8. Wald tests for the break in 1990/1998

Table 8a: Break in 1990

	π	corrected
cap	0.21	0.16
gap, Δgap	0.19	0.06
bim	0.04	0.02
pcim	0.03	0.01
ugap,Δugap	0.03	0.01

Table 8b: Break in 1998

	π	corrected
cap	0.02	0.01
gap, Δgap	0.36	0.27
bim	0.21	0.14
pcim	0.23	0.12
ugap,Δugap	0.04	0.03

Table 8c: Break in 1998 (given break in 1990)

	π	corrected
cap	0.03	0.03
gap, Δgap	0.78	0.82
bim	0.83	0.74
pcim	0.98	0.86
Δugap	0.77	0.98

Note: See Table 1 for indicator names

Note: The Wald test tests whether or not the coefficients on the demand indicator are the same in the different samples. A probability above 10% indicates that we can not conclude that the coefficients are significantly different.

29. Again, testing for a break in 1998, conditional on a break in 1990, confirms the absence of a break in 1998. Indeed as can be seen from Table 7c the more important changes are seen between the pre-1990 and 1990-1998 period. After 1998, few changes in the amplitude of the demand coefficients are visible. This is confirmed by the corresponding Wald test.

30. To examine whether the slope of the Phillips curve flattens as inflation decelerates, tests were conducted for a change in the slope of the Phillips curve when the change in the inflation rate ($\Delta\pi$) was below or above a certain threshold. In practice, as the variability of inflation is closely related to the average rate of inflation, this corresponds to testing whether the short-run trade-off between output and inflation changes when the average inflation rate is lower. For estimation purposes, the threshold was chosen as the average quarterly change in the inflation rate between the peak of inflation in the 1970s and trough of inflation in the 1980s. The coefficient associated with the demand indicator was then allowed to vary according to whether the change in the rate of inflation was below or above this threshold.[24] The

24. More precisely this threshold has been computed as 1/54*absolute value of (inflation in the third quarter of 1987-inflation in the second quarter of 1974) and is equal to 0.04, where inflation is the quarter-on-quarter growth rate of core prices, non annualised. To avoid discontinuity and to be consistent with Ball *et al.* (1988)'s use of trend inflation, the inflation rate has been smoothed.

results are reported in Table 9. In most cases, the demand indicator is found to be significant when changes in the inflation rate are high, but not when they are low. The amplitude of the coefficient is substantially reduced at stable inflation rates (often by a factor of 10). The differences are even larger than those observed at times of low, or negative, levels of inflation. The corresponding Wald tests confirm that the differences in the demand pressure coefficients for high and low changes in inflation rates are statistically significant. These results are in line with those of Ball *et al.* (1988) and Yates and Chapple (1996), who report that there is a significant and negative correlation between the average level of inflation and the sacrifice ratio.[25] Defina (1991) also reports similar results using a cross country analysis (using the same sample of countries as Ball *et al.* (1988)). The results are also consistent with Ball (1993) who finds that faster disinflations are associated with lower sacrifice ratios.

Table 9. Test of disinflation

Table 9a. Estimation results

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	$\|\Delta\pi\| < s$	0.04	1.62	0.03	1.65
	$\|\Delta\pi\| > s$	0.13	4.27	0.13	4.89
gap	$\|\Delta\pi\| < s$	-0.01	-0.27	0.00	-0.02
Δgap		0.06	0.71	0.04	0.54
	$\|\Delta\pi\| > s$	0.09	2.71	0.08	3.07
		0.31	2.45	0.31	2.84
bim	$\|\Delta\pi\| < s$	0.01	0.90	0.01	0.87
	$\|\Delta\pi\| > s$	0.10	2.95	0.10	3.54
pcim	$\|\Delta\pi\| < s$	0.02	0.60	0.02	0.78
	$\|\Delta\pi\| > s$	0.13	2.80	0.13	3.37
ugap	$\|\Delta\pi\| < s$	0.02	0.42	0.02	0.50
Δugap		0.33	1.80	0.26	1.66
	$\|\Delta\pi\| > s$	0.21	2.85	0.20	3.12
		0.79	2.04	0.79	2.34

Note: See Table 1 for indicator names

Table 9b. Wald test

	π	corrected
cap	0.00	0.00
gap, Δgap	0.00	0.00
bim	0.01	0.00
pcim	0.01	0.00
ugap,Δugap	0.02	0.00

Note: See Table 1 for indicator names

25. The tests implemented by Ball *et al.* (1988), and subsequently by many papers which have followed the same approach, are rather different from ours. They rely on cross section regressions and estimate the trade-off between output and inflation (as defined as the proportion of a shift in nominal GDP that shows up in real GDP one period later) as the function of average inflation, the standard error of nominal demand and their respective square. In this regard, they provide a joint test of the hypothesis that inflation and the variance of nominal demand affect the trade-off.

31. Taking all these results together, there is clear evidence that the relationship between inflation and demand pressures in Japan can change at low levels of inflation or at stable inflation rates. A natural follow-up of this result is to ask whether different behaviour can be observed for combinations of the level and variability of inflation. Given the small number of observations, special caution must be taken when drawing conclusions and because of data constraints, it was only possible to distinguish between three alternatives: low and stable inflation, high and stable inflation and high and unstable inflation.[26] Low inflation is defined here as an inflation rate below ½ per cent and stable inflation as a period when inflation has been increasing or decreasing at a small pace (below 0.04 per cent in a quarter -- non annualised rate). Results are reported in Table 10.

Table 10. Variability and level of inflation

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	high-stable	0.08	3.12	0.06	2.35
	high-unstabl	0.13	4.50	0.13	5.01
	low-stable	-0.02	-0.60	0.01	0.23
gap	high-stable	0.00	-0.08	-0.01	-0.36
Δgap		0.09	0.72	0.08	0.66
	high-unstabl	0.08	2.64	0.08	3.06
		0.31	2.41	0.31	2.77
	low-stable	-0.01	-0.22	0.01	0.31
		0.03	0.23	0.01	0.11
bim	high-stable	0.07	2.30	0.04	1.48
	high-unstabl	0.10	2.96	0.10	3.55
	low-stable	0.00	-0.15	0.00	0.22
pcim	high-stable	0.01	0.16	0.02	0.38
	high-unstabl	0.13	2.79	0.13	3.35
	low-stable	0.02	0.60	0.02	0.73
ugap	high-stable	0.12	1.20	0.09	0.99
Δugap		0.90	2.64	0.73	2.42
	high-unstabl	0.22	3.03	0.21	3.32
		0.80	2.07	0.79	2.35
	low-stable	0.02	0.43	0.02	0.58
		0.14	0.63	0.10	0.54

Note: See Table 1 for indicator names

32. One major finding is that there appears to be a significant difference in the results for low and stable inflation rates as compared to high and unstable inflation rates. In all cases, the coefficient on the demand indicator becomes less significant and is characterised by a lower amplitude when inflation is low and stable. These differences are statistically significant. By contrast, there is less evidence of a significant difference between a regime of high and stable inflation and a regime of high and unstable inflation,

26. Given our definition of low and stable inflation, there was no observation corresponding to low and unstable inflation in the sample period.

though the results depend on the demand indicator used (see Table 10). For most indicators (all except capacity utilisation and the variation in the unemployment gap), the demand indicator is significant only when inflation is high and unstable. However, in the Phillips curves based on capacity utilisation or the unemployment gap, the demand indicator is found to be significant both when inflation is high and stable and when it is high and unstable.[27] Wald tests suggest that these differences are significant only in a few cases. Regarding the differences between low and stable inflation and high and stable inflation, results vary according to the indicator used, but in general tend to reject the existence of a significant break (Table 11).

Table 11. Variability and level of inflation – Wald test

	Table 11a: low/stable versus high/unstable		Table 11b: low/stable versus high/stable		Table 11c: high/stable versus high/unstable	
	π	corrected	π	corrected	π	corrected
cap	0.00	0.00	0.00	0.09	0.14	0.01
gap, Δgap	0.00	0.00	0.91	0.88	0.02	0.00
bim	0.00	0.00	0.04	0.22	0.55	0.11
pcim	0.01	0.00	0.92	0.95	0.15	0.11
Δugap	0.00	0.00	0.13	0.18	0.73	0.52

Note: See Table 1 for indicator names

3. Robustness tests: introduction of expectations, Phillips curves based on GDP deflator and wage Phillips curves

Introduction of explicit expectations in the inflation process

33. The tests implemented so far are all based on a relatively standard specification of the Phillips curve.[28] In particular, it is assumed that expectations are fully backward looking *i.e.* agents forecast

27. In the equation with the unemployment gap, it is only the first difference of the unemployment gap which is found significant in the two regimes.

28. Another limitation is that the estimation does not incorporate the impact of deregulation on prices, which in the case of Japan might be an important omission. Tests using public service prices as an additional explanatory variable showed no significant change in the estimation results. Finally, we do not test for alternative sources of non-linearity (for instance having the trade-off between inflation and output depend on the sign of the demand indicator). Some papers have tried to test whether the trade-off between inflation and output depends on the level of inflation or the sign of the gap (see for instance Dupasquier and Ricketts (1998) and Eliasson (2001)) but the evidence of non-linearity from these papers is mixed. Dupasquier and Ricketts (1998) show that there are some signs of non-linearity in the Phillips curve in terms of gap and inflation in the United States and Canada but their results are very sensitive to the measure of the gap and of inflation expectations. By contrast, Eliasson (2001) finds no evidence of non linearity in terms of unemployment rate and inflation in the United States. One limitation of the latter study is, however, that it assumes that the NAIRU is constant.

inflation using only past information. This may not be an appropriate assumption, especially at times of deflation, when agents may perceive that there has been a structural change in the economy and therefore behave differently. In such cases, it might be more appropriate to consider also a forward looking component in inflation expectations, as done in a number of papers who explicitly introduce survey expectations in Phillips curves (for instance, Fuhrer, 1997, Roberts, 1997, Dupasquier and Ricketts, 1998 and Driver *et al.*, 2003). For this purpose, a diffusion index of output price expectations from the Tankan Survey (for all industries including both manufacturing and non-manufacturing) is introduced in the estimation. Long-run neutrality is achieved by imposing dynamic homogeneity. As shown in Table 12, this measure of price expectations is found to be significant in the Phillips curve but with a very small coefficient compared to past inflation. The overall fit of the equation (as measured by the standard error) is not modified by the introduction of explicit inflation expectations, with the observed fall in the standard error reflecting only a change in the sample period as data for inflation expectations were not available before 1975. The introduction of an expectations term increases the stability of the equation (as indicated by the mid-sample Chow test) but lowers the significance of the demand indicator, in particular of the output gap and of the unemployment gap (in level). However, the significance of the demand indicator increases markedly once allowance is made for the level of inflation or its variability.[29]

34. These results are broadly consistent with other findings in the literature. Fuhrer (1997) finds that the US inflation data are consistent with a very low weight on expected future inflation and that including both forward and backward looking inflation terms improves the simulation properties of the Phillips curve equation. Roberts (1997) uses survey data on expectations from the Livingston and Michigan surveys in a price Phillips curve for the United States, and also looks at several measures of demand pressure including the output gap, the unemployment gap and capacity utilisation. His results suggest that the coefficients on the survey measures are small and in some cases not significantly different from zero using annual data. By contrast, Driver *et al.* (2003) find that inflation expectations are strongly significant for the United States. Their inclusion increases the log-likelihood of a price Phillips curve equation and leads to a significant reduction in the size of the coefficient on the unemployment gap, though it remains statistically significant. For the United Kingdom, the coefficient on inflation expectations is found to be smaller and significant only at the 90 per cent level.[30] Dupasquier and Ricketts (1998) find a strong weight on expected inflation, which they compute using a Markov Switching model for the United States and Canada, but this result might stem from the fact that their measures of expectations incorporate a large backward looking element.

35. Tests for an asymmetric relationship between demand pressures and inflation at low rates of inflation in models for Japan that include explicit expectations terms point to broadly similar conclusions as those shown in Table 5 (see Table A1). The demand indicator continues to have a significant effect when inflation is high but not when it is low, particularly below a threshold of ½ per cent (Table A1b). Wald tests also indicate the existence of a significant break below and above the ½ per cent threshold for most measures of demand pressure (Table A2b), with the exception of the equation which uses the output gap.

36. The tests concerning the evolution of the coefficient on demand pressures over time (shown in Tables A3 and A4) confirm that demand pressures have had a smaller impact on inflation after 1990 (or 1998). However in many cases (in particular for the output gap) the differences in the point estimates of the coefficients are not statistically significant because the demand indicator is not significant before the break point in either 1990 or 1998. Two notable differences from the results using only 'backward-looking expectations' are that there is no longer a significant break in 1990 in the relationship between inflation and the output gap, or in 1998 in the link between inflation and the unemployment gap.

29. Except for capacity utilisation.

30. According to the authors one explanation of this difference between the United States and the United Kingdom is due to different measures of inflation used in the two countries and their accuracy.

Robustness checks

Table 12. Estimation result with explicit measures of expectations

Dependant variable	Δπ		Δπ corrected		Δπ		Δπ corrected		Δπ		Δπ corrected		Δπ		Δπ corrected		Δπ		Δπ corrected	
	1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4		1975Q1-2002Q4	
	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT	COEF	T-STAT
c	-0.04	-1.01	-0.03	-1.08	-0.04	-1.01	-0.04	-1.17	-0.01	-0.19	-0.01	-0.21	-0.03	-0.90	-0.03	-1.13	-0.09	-1.90	-0.08	-2.08
Δ(π(−1))	-0.57	-6.10	-0.49	-5.29	-0.57	-6.19	-0.48	-5.30	-0.58	-6.17	-0.48	-5.23	-0.57	-6.10	-0.47	-5.14	-0.58	-6.20	-0.48	-5.22
Δ(π(−2))	-0.20	-2.21	-0.23	-2.63	-0.22	-2.44	-0.25	-2.90	-0.20	-2.20	-0.23	-2.60	-0.20	-2.18	-0.22	-2.51	-0.19	-2.18	-0.22	-2.54
@MOVAV(Δ(EXPEC),2)	0.02	1.89	0.02	2.04	0.01	1.33	0.01	1.38	0.02	1.94	0.02	2.21	0.02	2.03	0.02	2.29	0.02	1.83	0.02	2.13
GAP	0.02	0.89	0.02	1.32																
@MOVAV(Δ(GAP),4)	0.00	-0.01	-0.02	-0.30																
UGAP					-0.01	-0.16	-0.01	-0.14												
Δ(UGAP)					0.40	2.28	0.35	2.37												
PCIM									0.03	1.05	0.03	1.28								
BIM													0.02	0.97	0.01	0.99				
CAP																	0.03	1.30	0.02	1.31
RPM	0.13	0.85	0.12	0.92	0.18	1.17	0.17	1.32	0.12	0.99	0.07	0.65	0.08	0.70	0.04	0.43	0.12	0.99	0.07	0.67
S.E.	0.34		0.29		0.34		0.28		0.34		0.29		0.34		0.29		0.34		0.29	
R2 ADJUSTED	0.25		0.22		0.28		0.24		0.25		0.21		0.25		0.21		0.26		0.21	
CHOW MID-SMPL	0.81	1988Q4	0.94	1988Q4	0.47	1988Q4	0.39	1988Q4	0.40	1988Q4	0.39	1988Q4	0.43	1988Q4	0.44	1988Q4	0.13	1988Q4	0.07	1988Q4
CHOW 3Y FCST	1.00	1999Q4	0.99	1999Q4	0.99	1999Q4	0.96	1999Q4	0.99	1999Q4	0.97	1999Q4	1.00	1999Q4	0.98	1999Q4	0.98	1999Q4	0.94	1999Q4
RESET	0.01		0.01		0.01		0.00		0.02		0.00		0.01		0.00		0.01		0.00	
HETEROSKED.	0.19		0.00		0.59		0.00		0.06		0.00		0.06		0.00		0.09		0.00	
SERIAL COR.(1)	0.97		0.85		0.55		0.38		0.74		0.88		0.75		0.86		0.57		0.96	
SERIAL COR.(4)	0.01		0.01		0.02		0.02		0.01		0.00		0.01		0.00		0.01		0.00	
NORMALITY	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	

Note: @MOVAV denotes moving average

The p-values of a set of diagnostic tests are reported in the tables, these tests are as follows:

Chow Stability test: Based on the stability of parameters when the sample estimation period is divided into two halves.

Chow Forecast test: based on comparing an equation estimated over the full sample and a sample in which recent observations are omitted.

RESET test for functional form: Ramsey’s test based on the significance of f adding squared fitted values.

Heteroscedasticity: Whites test based on the regression of squared residuals on squared fitted values.

Serial correlation: Lagrange Multiplier test for up to one or four order serial correlation.

Jarque-Bera test for the normality of the residuals.

Key to variables:

Δπ variation of core inflation, CPI excluding food and energy

RPM real import prices defined as import price in the manufacturing and service sector deflated by core inflation (weighted by the degree of openness)

PCIM production capacity index in the manufacturing sector

UGAP unemployment gap

CAP capacity utilisation

GAP output gap

BIM business capacity index in the manufacturing sector

37. The major change observed in the tests of whether the impact of demand pressure varies according to the rate of change of inflation, is for the Phillips curve based on capacity utilisation. There is no longer any evidence of significant differences when inflation is changing rapidly or slowly. For all other indicators, there continues to be evidence of significant differences (see Table A5).

38. The introduction of explicit expectations term also fails to change the results obtained previously regarding the variation of demand pressure effects across different combinations of the level and the stability of inflation. There is a significant break between low and high and unstable inflation but no clear evidence of a break between high and stable inflation and high and unstable inflation (see Tables A6 and A7). Some differences can however be observed (*e.g.* regarding the significance of capacity utilisation or the unemployment gap when inflation is high and instable), casting some doubt once again on the robustness of these tests.

39. Overall, the explicit inclusion of price expectations leads to some differences from the purely backward looking model, particularly for the equations including a speed limit effect (in the tests on the level of inflation) and for the equation with capacity utilisation (in the test on the change in the inflation rate). But despite these differences, the broad pattern of the results obtained with a purely backward looking model appear to be confirmed when explicit measures of expectations are introduced. Although the tests implemented are not really comparable, this finding is consistent with Driver *et al.* (2003) who report that the explicit introduction of expectations into a price Phillips curve does not alter the conclusion from purely backward-looking models that there has been a fall in inflationary pressures for a given level of actual demand in the 1990s in the United States and the United Kingdom.

Phillips curves based on the GDP deflator

40. A further issue that can be explored is whether the conclusions obtained so far are sensitive to the choice of the inflation measure used in the Phillips curves. To address this issue, we have re-estimated the Phillips curve models using the GDP deflator rather than core consumer price inflation. The results are mixed. Most of the demand indicators do not appear to have a significant impact on GDP inflation (see Table A8). This is especially true of the BIM and PCIM indicators and the unemployment gap term (in levels). However the estimation results do confirm the existence of a significant break at low levels of inflation, with an increase in the significance and the amplitude of the demand coefficient when inflation is high (both in levels and rates of change) as can be seen from Tables A9 and A10. In contrast, there is no evidence of a significant break over time, either in 1990 or in 1998, as can be seen in Tables A10 and A11. Another difference from the core consumer price Phillips curve results is that Wald tests also reject the existence of a break at stable rates of inflation. So it appears that at least some of our earlier findings may be sensitive to the definition of inflation used.

A break is also visible between wage inflation and the unemployment gap

41. A further extension is to ask whether there are breaks in the impact of demand indicators on wage pressures in the labour market. If there is considerable (downwards) nominal rigidity in wages at times of low inflation, the relationship between wage inflation and the unemployment gap may also change. To give some insights into this question, a wage equation was also estimated.

42. The specification of the estimated equation is very simple: the nominal wage (per hour worked) depends on expected inflation and productivity (with a unit coefficient) and the unemployment gap (defined as the difference between the NAIRU and the actual unemployment rate). For simplicity, expected

inflation is set equal to inflation lagged by one quarter[31] and expected productivity is measured by trend productivity.[32] The equation was estimated from the second quarter of 1970 to the fourth quarter of 2001. The estimation results are reported in Table A12 and indicate a significant and correctly signed unemployment gap. However, the fit of the equation is not good and, in particular, the equation does not pass a mid-sample Chow test, the associated p-value being zero. This provides evidence of significant joint parameter instability; it does not in itself mean that the unemployment gap parameter has a break.

43. Further tests however reveal that the wage curve appears to exhibit similar properties to the price Phillips curve. The coefficient of the unemployment gap is significant (and with a higher amplitude) only at times when the inflation rate is either high or changing rapidly and prior to 1990, but not after. These breaks are significant on the basis of Wald tests. When allowing for a break at the ½ per cent inflation rate, no further break is found at the 0 per cent threshold. As for the price Phillips curve, a significant change is found in the unemployment gap coefficient when inflation is low and stable as opposed to high (stable or unstable). The results are consistent with those in Stark and Sargent (2003) who find that the slope of the wage Phillips curve in Canada shifts down in 1991, at the start of the low inflation period. Other evidence provides support for the view that Japan is experiencing nominal rigidity in wages. Nominal compensation per worker declined by 0.8 per cent on average from 1997 to 2002, but real compensation increased. Indeed, the real producer wage, as measured using compensation and the GDP deflator, actually rose by 0.8 per cent over the same period, whilst the real consumer wage stayed more or less constant. The increase in the labour share over the 1990s from 52 per cent of GDP to 54½ per cent is also suggestive of the existence of nominal rigidity.[33]

4. Overall conclusions

44. The estimates reported in this paper provide fairly extensive empirical support for the hypothesis of a change in the relationship between output and inflation in an environment of low inflation for Japan. In particular, there is evidence that the slope of the Phillips curve becomes flatter when the inflation rate is below ½ per cent (quarter-on-quarter, non annualised) and also that there has been a break in the relationship between demand pressures and inflation in Japan since the beginning of the 1990s. Some evidence has also been found that the relationship changes when the inflation rate is either rising rapidly or falling sharply. At such times, changes in demand pressure have stronger effects on inflation.

45. These results are robust to a wide range of specifications including corrections for the impact of rises in indirect taxes and the use of a number of different demand indicators. More importantly, the basic pattern of results still holds when forward-looking expectations are explicitly introduced in the model and other measures of inflation are used in place of consumer prices.

46. Bearing in mind the usual caveats regarding the potential sensitivity of empirical work to the data and model specification employed, the results may nonetheless have important implications. At times of unusually low or negative inflation, the use of a relationship between output and inflation based on past behaviour may be misleading. Indeed, in the presence of asymmetries, the trade-off between inflation and output will be a function of the initial inflation level. These results may also have important implications for economies other than Japan, as they indicate that the principal breaks in the relationship between inflation and demand pressures occur at times of low, rather than zero or negative, rates of inflation.

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31. It was found difficult to use the explicit survey measure of expectations, as the associated coefficient was very small and not significantly different from zero.

32. More precisely, trend productivity is constructed using an HP filter on actual productivity.

33. Hattori and Maeda (2000) suggest that most of the rise in wages per worker in the 1990s can be explained by higher educational attainment and ageing of workers under the seniority wage system.

47. The estimates suggest that there are increased costs associated with disinflation when inflation is low. At low levels of inflation, prices are less reactive to fluctuations in aggregate demand. Targeting an inflation rate close to zero could thus be costly as it would be associated with an increased welfare loss from higher fluctuations in output and unemployment. So the wider benefits of lower inflation have to be high to warrant further disinflation when inflation is already low.

48. This reasoning also holds for an economy where prices are falling and deflation is more rapid. Indeed, for Japan the estimates presented have suggested that the rise in the sacrifice ratio when inflation becomes negative (by about 0.9 percentage points for the equation with the output gap) would be only partially compensated for by a decline in the sacrifice ratio due to higher demand effects when deflation is more rapid (the latter corresponding to a decline by about 0.4 percentage points).

ANNEX

Table A1. Introduction of expectations - Existence of asymmetry in the relation

Table A1a. Threshold of 0

		non corrected		corrected	
		coeff.	t.stat	coeff.	t.stat
cap	$\pi <0$	-0.11	-1.21	-0.09	-1.24
	$\pi >0$	0.08	3.48	0.07	3.79
gap	$\pi <0$	-0.01	-0.10	0.01	0.15
Δgap		0.04	0.17	-0.03	-0.14
	$\pi >0$	0.02	0.90	0.02	1.32
		0.00	0.03	-0.01	-0.15
gap	$\pi <0$	0.00	0.05	0.00	0.08
	$\pi >0$	0.02	0.97	0.02	1.34
bim	$\pi <0$	0.01	0.25	0.00	0.15
	$\pi >0$	0.02	1.04	0.02	1.11
pcim	$\pi <0$	0.02	0.46	0.02	0.51
	$\pi >0$	0.04	1.14	0.04	1.42
ugap	$\pi <0$	-0.01	-0.23	-0.01	-0.23
Δugap		0.17	0.57	0.15	0.58
	$\pi >0$	0.03	0.42	0.03	0.50
		0.52	2.43	0.46	2.54

Note: See Table 1 for indicator names

Table A1a. Threshold of ½

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	π <½	-0.03	-1.10	-0.01	-0.32
	π >½	0.07	2.96	0.05	2.29
gap	π <½	-0.02	-0.53	0.00	0.05
Δgap		-0.01	-0.05	-0.03	-0.29
	π >½	0.04	1.47	0.03	1.63
		0.10	0.66	0.04	0.32
gap	π <½	-0.02	-0.65	0.00	-0.12
	π >½	0.04	1.76	0.04	1.83
bim	π <½	-0.01	-0.45	0.00	-0.25
	π >½	0.07	2.93	0.06	2.66
pcim	π <½	0.01	0.28	0.01	0.37
	π >½	0.09	2.09	0.09	2.56
ugap	π <½	-0.02	-0.38	-0.01	-0.33
Δugap		0.10	0.54	0.08	0.48
	π >½	0.07	1.02	0.06	1.10
		1.25	4.23	1.15	4.63

Note: See Table 1 for indicator names

Table A1a. Threshold of 0 and ½

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	π <0	-0.11	-1.32	-0.09	-1.35
	½ > π > 0	-0.01	-0.48	0.01	0.33
	π > ½	0.08	3.13	0.06	2.57
gap	π <0	-0.02	-0.16	0.01	0.10
Δgap		0.05	0.19	-0.02	-0.11
	½ > π > 0	-0.02	-0.51	0.00	0.03
		-0.06	-0.35	-0.05	-0.35
	π > ½	0.04	1.46	0.03	1.62
		0.09	0.64	0.04	0.31
bim	π <0	0.01	0.23	0.00	0.13
	½ > π > 0	-0.02	-0.75	-0.01	-0.42
	π > ½	0.07	2.92	0.06	2.65
pcim	π <0	0.02	0.49	0.02	0.54
	½ > π > 0	0.00	-0.02	0.00	0.08
	π > ½	0.08	2.07	0.09	2.54
ugap	π <0	-0.01	-0.32	-0.01	-0.26
Δugap		0.19	0.67	0.11	0.52
	½ > π > 0	-0.04	-0.48	-0.02	-0.37
		0.04	0.14	-0.04	-0.21
	π > ½	0.07	0.98	0.04	0.85
		1.25	4.18	0.85	3.56

Note: See Table 1 for indicator names

Table A2. Introduction of expectations - Wald tests for asymmetry

Table A2a: Threshold of 0

	π	corrected
cap	0.08	0.08
gap, Δgap	0.95	0.96
gap	0.79	0.72
bim	0.7	0.6
pcim	0.65	0.53
ugap,Δugap	0.45	0.4

Table A2b: Threshold of ½

	π	corrected
cap	0	0.03
gap, Δgap	0.19	0.4
gap	0.09	0.18
bim	0	0.01
pcim	0.06	0.02
ugap,Δugap	0	0

Table A2c: Threshold of 0 (given break at ½)

	π	corrected
cap	0.31	0.19
gap, Δgap	0.87	0.97
gap	0.73	0.92
bim	0.48	0.69
pcim	0.66	0.69
ugap,Δugap	0.84	0.81

Note: See Table 1 for indicator names

Table A3. Introduction of expectations - Variation over time of the coefficient on the indicator of demand pressure

Table A3a. Break in 1990

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	-1990	0.03	1.21	0.03	1.21
	1990-	0.02	0.82	0.02	0.83
gap	-1990	0.02	0.80	0.03	1.19
Δgap		0.03	0.18	0.03	0.27
	1990-	0.01	0.36	0.02	0.54
		-0.01	-0.07	-0.05	-0.46
gap	-1990	0.02	0.94	0.03	1.47
	1990-	0.01	0.37	0.01	0.34
bim	-1990	0.05	2.00	0.05	2.23
	1990-	0.00	0.00	0.00	-0.12
pcim	-1990	0.09	2.26	0.09	2.67
	1990-	0.01	0.33	0.01	0.46
ugap	-1990	0.07	0.96	0.07	1.06
Δugap		0.53	2.21	0.59	2.95
	1990-	-0.02	-0.36	-0.01	-0.29
		0.29	1.18	0.13	0.64

Note: See Table 1 for indicator names

Table A3b. Break in 1998

		non corrected		corrected	
		coeff.	t.stat	coeff.	t.stat
cap	-1998	0.05	2.18	0.05	2.21
	1998-	-0.14	-1.65	-0.12	-1.68
gap	-1998	0.02	0.95	0.02	1.38
Δgap		0.01	0.11	-0.01	-0.05
	1998-	-0.07	-0.74	-0.05	-0.61
		0.14	0.57	0.07	0.35
gap	-1998	0.02	1.07	0.02	1.47
	1998-	-0.03	-0.47	-0.03	-0.54
bim	-1998	0.02	1.37	0.02	1.51
	1998-	0.00	-0.17	-0.01	-0.34
pcim	-1998	0.05	1.46	0.05	1.82
	1998-	0.01	0.14	0.00	0.14
ugap	-1998	0.06	0.89	0.06	1.11
Δugap		0.54	2.54	0.48	2.66
	1998-	-0.02	-0.37	-0.02	-0.41
		0.15	0.54	0.14	0.57

Note: See Table 1 for indicator names

Table A3c. Break in 1990 and 1998

		non corrected		corrected	
		coeff.	t.stat	coeff.	t.stat
cap	-1990	0.05	1.87	0.04	1.88
	1990-1998	0.06	1.77	0.05	1.81
	1998-	-0.14	-1.64	-0.12	-1.67
gap	-1990	0.01	0.45	0.02	0.85
Δgap		0.04	0.28	0.04	0.35
	1990-1998	0.03	0.78	0.03	0.89
		-0.04	-0.22	-0.09	-0.54
	1998-	-0.08	-0.79	-0.06	-0.64
		0.16	0.61	0.08	0.37
bim	-1990	0.05	1.98	0.05	2.21
	1990-1998	0.00	0.10	0.00	0.11
	1998-	0.00	-0.10	-0.01	-0.28
pcim	-1990	0.09	2.25	0.09	2.66
	1990-1998	0.01	0.17	0.01	0.39
	1998-	0.01	0.34	0.01	0.34
ugap	-1990	0.07	0.91	0.06	0.96
Δugap		0.53	2.21	0.59	2.92
	1990-1998	0.02	0.17	0.04	0.36
		0.59	1.33	0.10	0.28
	1998-	-0.01	-0.30	-0.02	-0.43
		0.16	0.53	0.14	0.58

Note: See Table 1 for indicator names

Table A4. Introduction of expectations - Wald tests for the break in 1990/1998

Table A4a: Break in 1990

	π	corrected
cap	0.80	0.82
gap, Δgap	0.92	0.69
gap	0.72	0.46
bim	0.08	0.03
pcim	0.04	0.02
ugap,Δugap	0.29	0.06

Table A4b: Break in 1998

	π	corrected
cap	0.04	0.04
gap, Δgap	0.61	0.59
gap	0.41	0.31
bim	0.29	0.20
pcim	0.27	0.16
ugap,Δugap	0.19	0.13

Table A4c: Break in 1998 (given break in 1990)

	π	corrected
cap	0.04	0.04
gap	0.62	0.68
bim	0.87	0.77
pcim	0.90	0.94
Δugap	0.65	0.89

Note: See Table 1 for indicator names

Table A5. Introduction of expectations – Test of disinflation

Table A5a. Estimation results

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	|Δπ| < s	0.03	1.21	0.02	1.15
	|Δπ| > s	0.00	0.00	0.00	0.00
gap	|Δπ| < s	-0.01	-0.25	0.00	0.08
Δgap		0.01	0.12	-0.02	-0.22
	|Δπ| > s	0.06	1.87	0.06	2.20
		0.13	0.71	0.12	0.80
gap	|Δπ| < s	0.00	-0.19	0.00	0.01
	|Δπ| > s	0.07	2.20	0.07	2.62
bim	|Δπ| < s	0.01	0.48	0.01	0.40
	|Δπ| > s	0.10	2.80	0.10	3.42
pcim	|Δπ| < s	0.01	0.28	0.01	0.40
	|Δπ| > s	0.12	2.66	0.12	3.18
ugap	|Δπ| < s	-0.01	-0.20	-0.01	-0.20
Δugap		0.25	1.41	0.18	1.30
	|Δπ| > s	0.10	1.15	0.07	1.07
		1.41	3.35	0.79	2.20

Note: See Table 1 for indicator names

Table A5b. Wald test

	π	corrected
cap	0.78	0.53
gap, Δgap	0.10	0.06
gap	0.04	0.02
bim	0.01	0.00
pcim	0.01	0.00
ugap,Δugap	0.01	0.10

Note: See Table 1 for indicator names

Table A6. Introduction of expectations -Variability and level of inflation

		non corrected		**corrected**	
		coeff.	t.stat	coeff.	t.stat
cap	high-stable	0.08	3.18	0.05	2.20
	high-unstabl	0.03	0.82	0.04	1.16
	low-stable	-0.03	-1.21	-0.01	-0.34
gap	high-stable	0.00	0.07	-0.01	-0.15
Δgap		0.09	0.35	-0.03	-0.15
	high-unstabl	0.06	1.77	0.06	2.18
		0.13	0.72	0.12	0.78
	low-stable	-0.01	-0.37	0.01	0.23
		0.00	0.01	-0.02	-0.20
bim	high-stable	0.05	1.60	0.02	0.72
	high-unstabl	0.09	2.72	0.10	3.39
	low-stable	-0.01	-0.28	0.00	0.09
pcim	high-stable	-0.02	-0.29	-0.01	-0.14
	high-unstabl	0.12	2.66	0.12	3.17
	low-stable	0.01	0.38	0.01	0.47
ugap	high-stable	0.05	0.48	0.03	0.37
Δugap		1.04	2.59	0.83	2.49
	high-unstabl	0.08	0.98	0.08	1.19
		1.46	3.50	1.45	4.21
	low-stable	-0.01	-0.31	-0.01	-0.21
		0.10	0.54	0.08	0.47

Note: See Table 1 for indicator names

Table A7. Variability and level of inflation – Wald test

Table A7a: low/stable versus high/unstable

	π	corrected
cap	0.12	0.18
gap, Δgap	0.10	0.11
bim	0.00	0.00
pcim	0.01	0.00
Δugap	0.00	0.00

Table A7a: low/stable versus high/stable

	π	corrected
cap	0.00	0.04
gap, Δgap	0.84	0.95
bim	0.12	0.55
pcim	0.65	0.74
Δugap	0.09	0.10

Table A7a: high/stable versus high/unstable

	π	corrected
cap	0.25	0.81
gap, Δgap	0.47	0.15
bim	0.36	0.04
pcim	0.08	0.06
Δugap	0.72	0.35

Note: See Table 1 for indicator names

Table A8. PGDP equation

	coeff.	t.stat
cap	0.05	1.24
gap	0.05	1.43
bim	0.01	0.42
pcim	0.01	0.25
ugap	0.05	0.72
Δugap	0.51	1.83

Note: See Table 1 for indicator names

Table A9. PGDP equation and asymmetry

		π^s=½		π^s=0		Desinflation	
		coeff.	t.stat	coeff.	t.stat	coeff.	t.stat
cap	below	-0.01	-0.14	-0.06	-0.37	0.03	0.68
	above	0.08	2.00	0.06	1.56	0.11	2.12
gap	below	-0.04	-0.75	0.06	0.57	0.01	0.33
	above	0.10	2.59	0.05	1.63	0.10	2.19
bim	below	-0.02	-0.59	0.02	0.35	0.01	0.34
	above	0.11	2.60	0.02	0.71	0.04	0.60
pcim	below	-0.01	-0.18	0.02	0.37	0.01	0.10
	above	0.06	0.93	0.01	0.10	0.04	0.52
ugap	below	0.00	0.00	0.03	0.40	0.01	0.19
Δugap		0.18	0.49	0.61	0.83	0.55	1.78
	above	0.17	1.76	0.88	2.31	0.15	1.27
		1.07	2.58	1.81	2.46	0.34	0.49

		0<π^s<½	
		coeff.	t.stat
cap	below	-0.05	-0.32
	between	0.00	0.01
	above	0.08	1.99
gap	below	0.05	0.46
	between	-0.06	-1.06
	above	0.10	2.60
bim	below	0.01	0.32
	between	-0.04	-0.99
	above	0.11	2.57
pcim	below	0.03	0.39
	between	-0.04	-0.64
	above	0.06	0.91
ugap	below	0.02	0.27
Δugap		0.33	0.60
	between	-0.14	-0.87
		0.07	0.14
	above	0.17	1.71
		1.06	2.52

Note: See Table 1 for indicator names

Table A10. PGDP equation and variation over time

		1998		1990			1990/1998	
		coeff.	t.stat	coeff.	t.stat		coeff.	t.stat
cap	before	0.07	1.79	0.06	1.47	before 1990	0.08	1.75
	after	-0.12	-0.82	0.03	0.59	1990-1998	0.06	1.06
						after 1998	-0.12	-0.81
gap	before	0.06	1.80	0.06	1.57	before 1990	0.06	1.56
	after	0.02	0.19	0.01	0.27	1990-1998	0.01	0.17
						after 1998	0.03	0.23
bim	before	0.03	0.83	0.06	1.43	before 1990	0.06	1.41
	after	-0.02	-0.47	0.00	0.05	1990-1998	0.01	0.18
						after 1998	-0.01	-0.11
pcim	before	0.02	0.36	0.03	0.38	before 1990	0.03	0.37
	after	0.00	0.00	0.01	0.14	1990-1998	0.01	0.21
						after 1998	0.00	0.02
ugap	before	0.12	1.28	0.13	1.29	before 1990	0.13	1.26
Δugap		0.61	1.84	0.59	1.65	1990-1998	0.06	0.21
						after 1998	0.01	0.12
	after	0.01	0.09	0.01	0.12	before 1990	0.60	1.64
		0.35	0.65	0.46	1.03	1990-1998	0.74	0.88
						after 1998	0.35	0.65

Note: See Table 1 for indicator names

Table A11. PGDP equation – Wald tests

	break 1998	break 1990	break in 1998 given break in 1990
cap	0.24	0.59	0.29
gap, Δgap	0.66	0.36	0.90
bim	0.35	0.22	0.83
pcim	0.76	0.77	0.87
ugap,Δugap	0.50	0.53	0.90

	π^s=½	π^s=0	π^s=0 given break in π^s=½	Desinflation
cap	0.1	0.47	0.77	0.11
gap, Δgap	0.08	0.82	0.35	0.15
bim	0	0.92	0.36	0.65
pcim	0.28	0.77	0.39	0.63
ugap,Δugap	0.06	0.79	0.53	0.58

Note: See Table 1 for indicator names

Table A12. Coefficient of the unemployment gap in the wage equation

	coef	T-stat	Wald
standard	0.05	4.58	
π <½	0.03	1.65	0
π >½	0.08	4.96	
π <0	0.01	0.50	0.03
π >0	0.08	5.52	
π <0	0.02	0.98	0.83
½ > π > 0	0.02	0.94	
π >½	0.07	5.62	
low-stable	0.02	1.21	
high-stable	0.06	2.73	0.08
high-unstabl	0.07	4.64	0
-1990	0.08	5.32	0
1990-	0.02	1.45	
-1998	0.08	5.48	0
1998-	0.02	0.95	
-1990	0.01	5.94	0.98
1990-1998	0.00	0.45	
1998-	0.00	1.04	
|Δπ| < s	0.03	1.76	0.02
|Δπ| > s	0.07	4.77	

Note: The coefficient of the unemployment gap has been multiplied by 10. For the test on both the variability and the level of inflation, the first Wald test tests the low-stable inflation versus high stable and the second low stable versus high unstable. The test on a significant change between high/stable and high/unstable is rejected at the 10 per cent level.

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