Output gap and inflation: the case of Japan[1]

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Introduction

The Japanese economy has been experiencing disinflation since the beginning of the 1990s when the "bubble" in stock and land prices burst. For example, the year-to-year inflation rate measured by the GDP deflator gradually declined from 3% at the beginning of 1992 to -1% at the second quarter of 1995. Moreover, if we call a fall in the price level deflation, the Japanese economy experienced deflation in 1994 and 1995. The inflation rate measured by the GDP deflator has started to go back above-zero since the third quarter of 1995 reflecting the recovery of the Japanese economy, but the trend of inflation is still very weak (see Figure 1 for the recent trend in various measures of inflation).

There are several discussions inside and outside the country about possible causes of disinflation and deflation. First, the real side of the economy has been very weak since the bubble burst, so that final demand for goods and services has also been weak. Second, reflecting the recent developments in the east Asian economies (i.e. the NIEs, ASEAN countries and China) and the appreciation of the yen during the period of 1990 to early 1995, cheap and good-quality products have flowed into the Japanese markets since 1993. A rising share of imported products as well as intense competition between imported and domestic products has significantly contributed to disinflation and deflation. Third, supply-side shocks within the country have also contributed to some extent. For example, the efficiency of the distribution system in the country has been improved significantly these five years: new types of large-scale shops called discounters or road-side shops have emerged and sell imported and domestic products at very competitive prices; the notoriously inefficient hierarchy of wholesalers has collapsed, at least in part. Also, deregulation in areas such as gas stations and automobile inspection has urged competition in those industries, thereby contributing to reducing their prices.

Common to the above stories is that "excess supply", whatever it might mean, has played an important role in the process of disinflation and deflation. In this paper, based on this understanding, we will first estimate the GDP gap as a measure of "excess supply or demand" and then investigate the relationship between the GDP gap and inflation.

The paper is structured as follows. In the next section, we will estimate the GDP gap. In Section 2 we will investigate the relationship between the GDP gap and inflation, in particular, whether (i) we can observe a stable Phillips curve; (ii) a concept like NAIRU could be applied to the Japanese economy; and (iii) the so-called "speed limit effect" as discussed in Romer (1996) and others, can be observed. Section 3 will conclude the paper by briefly considering the cost of disinflation with a special attention on the recent discussions about the cost and benefit of zero inflation.

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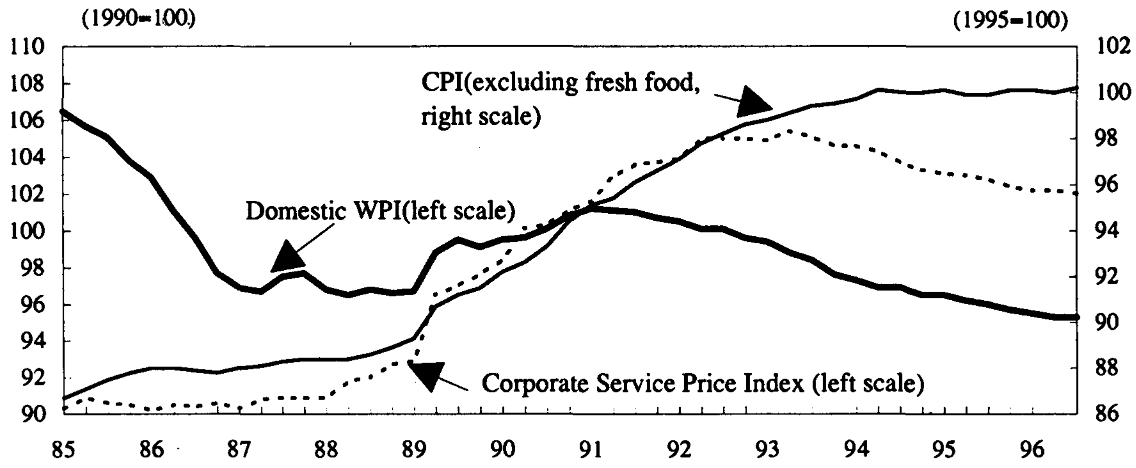
[1] Please do not quote without permission. Part of the analysis in this paper is based on the products of other research projects in the Research and Statistics Department of the Bank of Japan. I want to thank members of those projects for their cooperation. Also, I would like to thank participants at the Central Bank Econometricians' meeting held at the BIS, particularly Steve Kamin, for their helpful comments and suggestions. Needless to say, however, all remaining errors are mine.

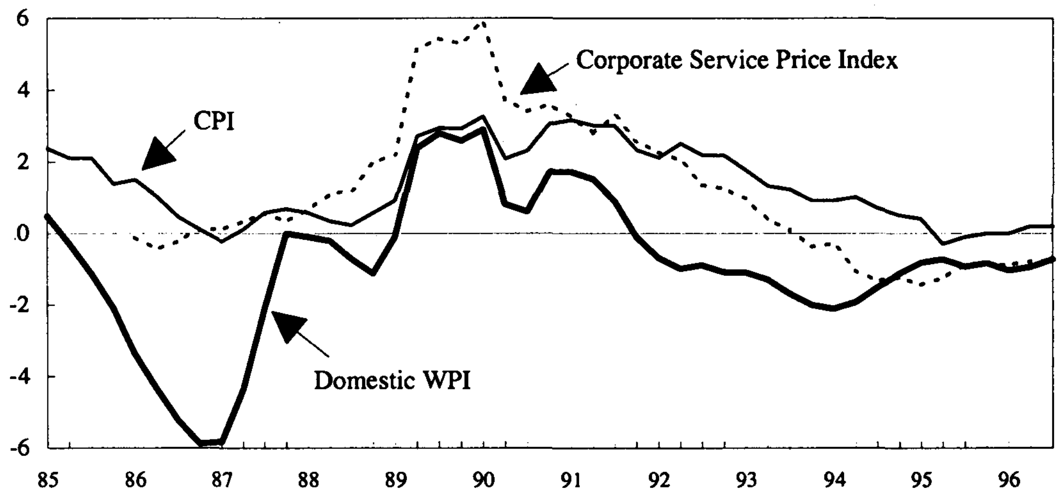
Figure 1

Recent trend in indicators of inflation

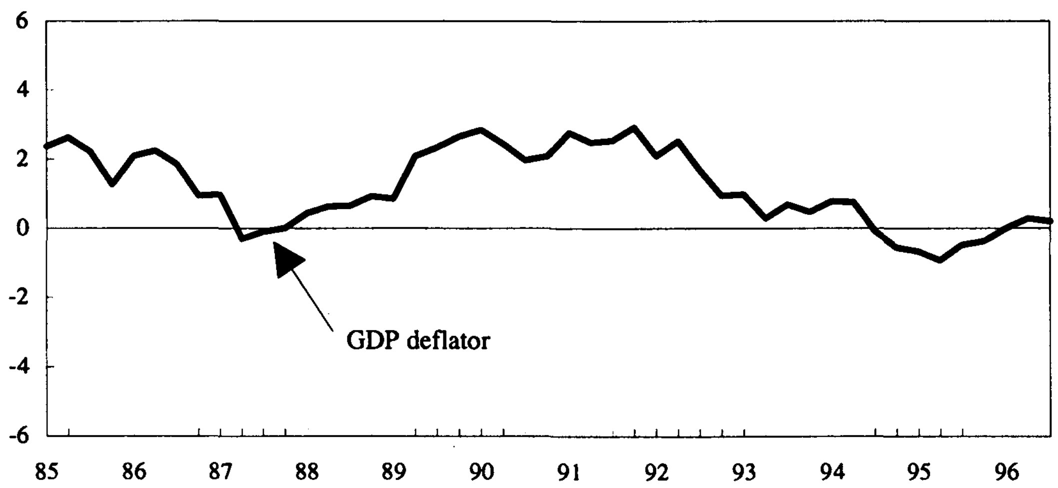
1. Levels of price indexes



2. Year-to-year change



3. Year-to-year change



1. Estimation of the GDP gap

1.1 Production function

To estimate the GDP gap, we first estimate potential output and then calculate the gap as the deviation of actual GDP from potential output. The procedure of estimating potential output is in three steps: (i) specify and estimate a production function of the Cobb-Douglas type; (ii) estimate the potential amounts of labour as well as capital inputs; (iii) put the potential amounts of factors in (ii) into the production function estimated in (i) to obtain potential output.

To begin with, let us assume the following production function:

$$\ln (Y_t / L_t H_t) = a_0 + a_1 \ln (K_t / L_t H_t) + a_2 t_1 + a_3 t_2 \qquad (1)$$

where Y, L, H, and K represent real GDP, employed persons, total working hours and capital stock multiplied by the rate of capital utilisation, respectively. Equation (1) is standard except for two things. First, since no data are available for the rate of capital utilisation in the non-manufacturing sector, we assume that the capital utilisation in that sector is constant. More precisely, we define K as $K = K_m R + K_n$, where K_m and K_n represent the capital stock in, respectively, the manufacturing sector and the non-manufacturing sector and R is the capital utilisation rate index in the manufacturing sector. Second, the way we express technological progress is a bit unusual. That is, we believe that the growth rate of total factor productivity, or TFP, is the same before and after the bubble period, but takes a different value during the bubble period. To express this idea, we introduce two linear time trends, the third and fourth terms on the right hand side of equation (1): the third term is a linear time trend for the entire estimation period (1975 to 1996); the fourth term is a linear time trend only for the bubble period (1985 to 1993). By construction, the growth rate of TFP is a_2 for the normal period and a_2+a_3 for the bubble period.

When equation (1) is estimated by OLS over 1975Q1 to 1996Q3, the result is:

$$a_0 = -2.421; \quad a_1 = 0.320; \quad a_2 = 0.0017; \quad a_3 = 0.0027 \qquad (2)$$

All of the parameters are different from zero at the 1% significance level. The estimated values for a_2 and a_3 mean that the TFP grows at 0.68 (= 0.17 x 4) % per year before and after the bubble period and by 1.76 (= 0.17 x 4 + 0.27 x 4) % per year during the bubble period.

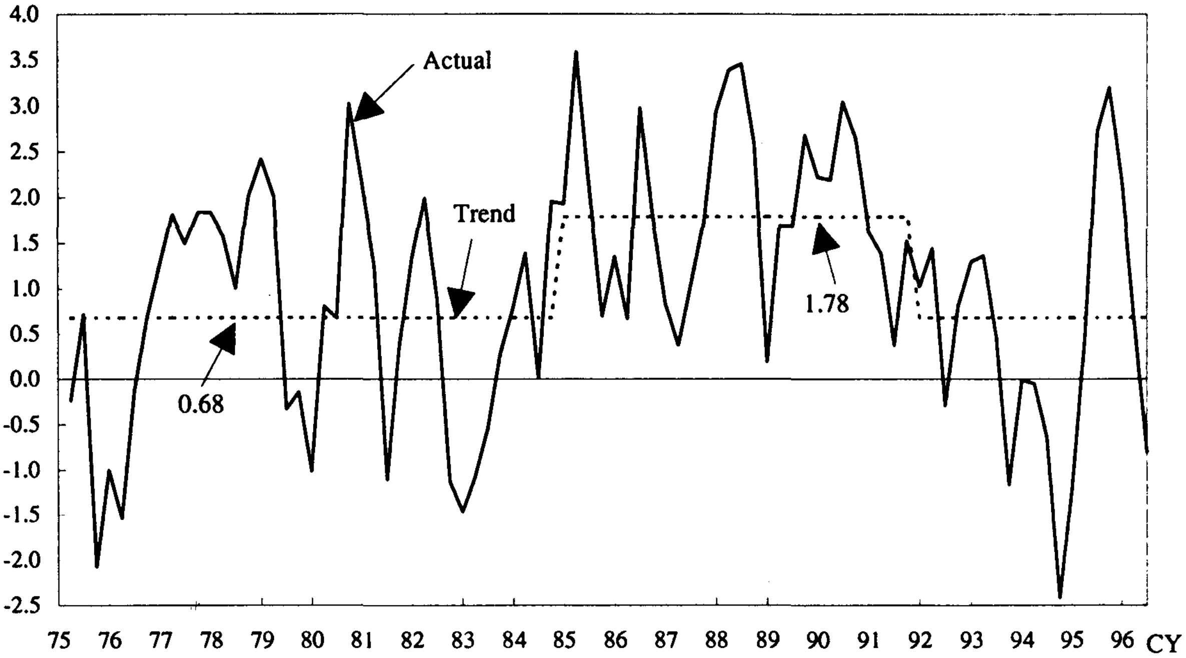
We should make one comment concerning the above result. We can calculate "actual" values of TFP as a residual: $\ln (Y_t / L_t H_t) - a_0 - a_1 \ln (K_t / L_t H_t)$. The solid line in Figure 2 is the growth rate of actual TFP calculated in this way. We expect that the growth rate of actual TFP is near a_2 for normal periods and a_2+a_3 for the bubble period. Indeed, this is true during the pre-bubble period as well as the bubble period. However, the actual growth rate of TFP is much lower than a_2 after the crash of the bubble. If the growth rate of TFP has actually fallen during the post-bubble period, we would need to add another linear time trend for that period. But the problem here is that, as seen in Figure 2, the actual growth rate of TFP was negative in 1994 and 1995. If we added a time trend for the post-bubble period, we would get a negative coefficient. This means that technological *retrogress* occurred in this period and, as a result, potential output grew less than the increase in factor inputs. Clearly this is not plausible and seems to imply that something is wrong with the estimation procedure. For example, effective labour inputs might be much smaller than the actual number of employed persons multiplied by working hours: in other words, the unemployment rate inside the firms might be higher during the post-bubble period. Or, the production function might have increasing returns to scale rather than constant returns to scale as we assumed in the estimation. If this is the case, a significant decrease in demand leads to larger decline in output than in factor inputs.

Although we can think of several reasons, we cannot give a definite answer at this moment. Given the current state of understanding, we do not believe that adding a time trend for the post-bubble period is the best strategy. Recognising that this is still an open question, we take the position in the rest of this paper that the trend growth rate of TFP in the post-bubble period is the same as the pre-bubble period.

Figure 2

Total factor productivity

Percentage change from previous period at annual rate



1.2 Potential inputs

Next, we estimate potential inputs. We define potential capital inputs as the actual capital stock multiplied by the historically maximum value of the capital utilisation rate in the manufacturing sector during the sample period (100.9 in 1990Q4 (see Figure 3)) and use this value throughout the sample. As for the non-manufacturing sector, we ignore capital utilisation as stated before.

We define potential labour inputs as the maximum number of workers multiplied by the maximum number of working hours. To estimate the maximum number of workers, we first calculate the ratio of employed persons to the population aged 15 years and over; i.e. the labour participation rate for the generation of 15-65 years as well as that for the generation of over 65 years, and then estimate trends in labour participation rates in each generation (see Figure 4). Multiplying the trend obtained in this way by the population, we get the maximum number of workers.

The maximum number of the overtime working hours in the sample period was 15.8 hours per month in 1989Q2. We use this value throughout the sample. As for scheduled working hours, there is a downward trend starting in 1988 and ending in 1993 which reflects the fact that more and more firms were adopting a five-day working week during this period (see Figure 5). Taking this observation into consideration, the potential of scheduled hours is estimated to be 162.2 hours per month in and before 1987, decreasing in 1988-93 as depicted in Figure 5, and to 148.6 hours in and after 1994.

Figure 3

Capital utilisation in the manufacturing sector

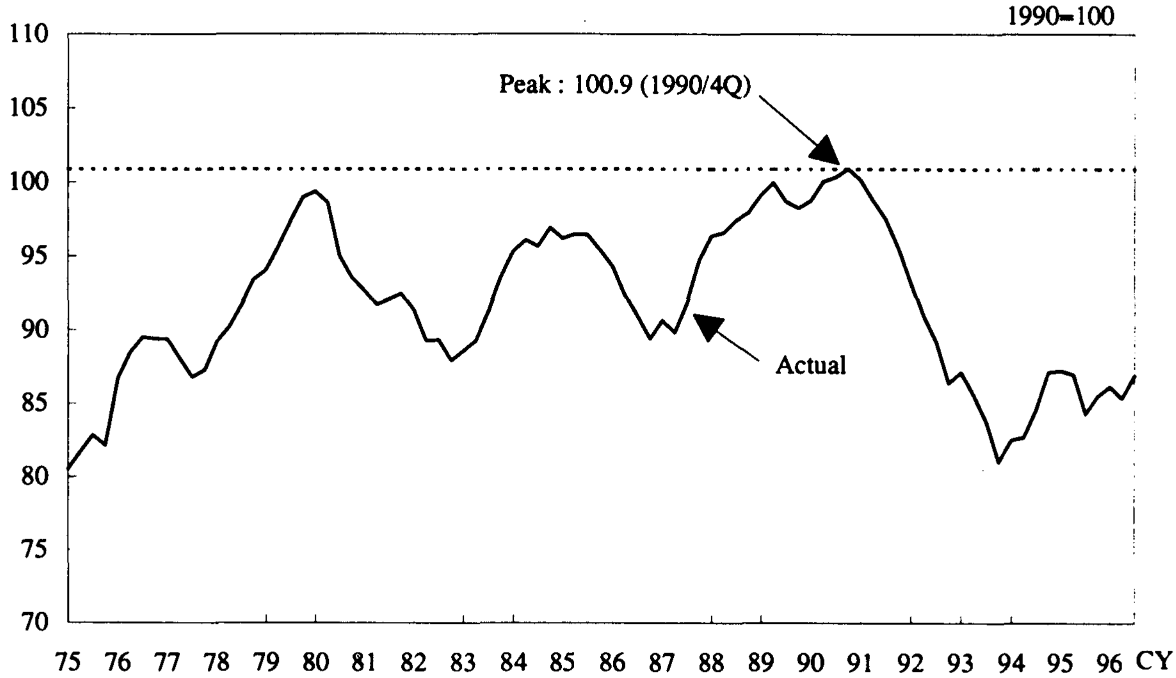


Figure 4

Labour participation rate

Percentage of employed persons in the population of 15 years old and over

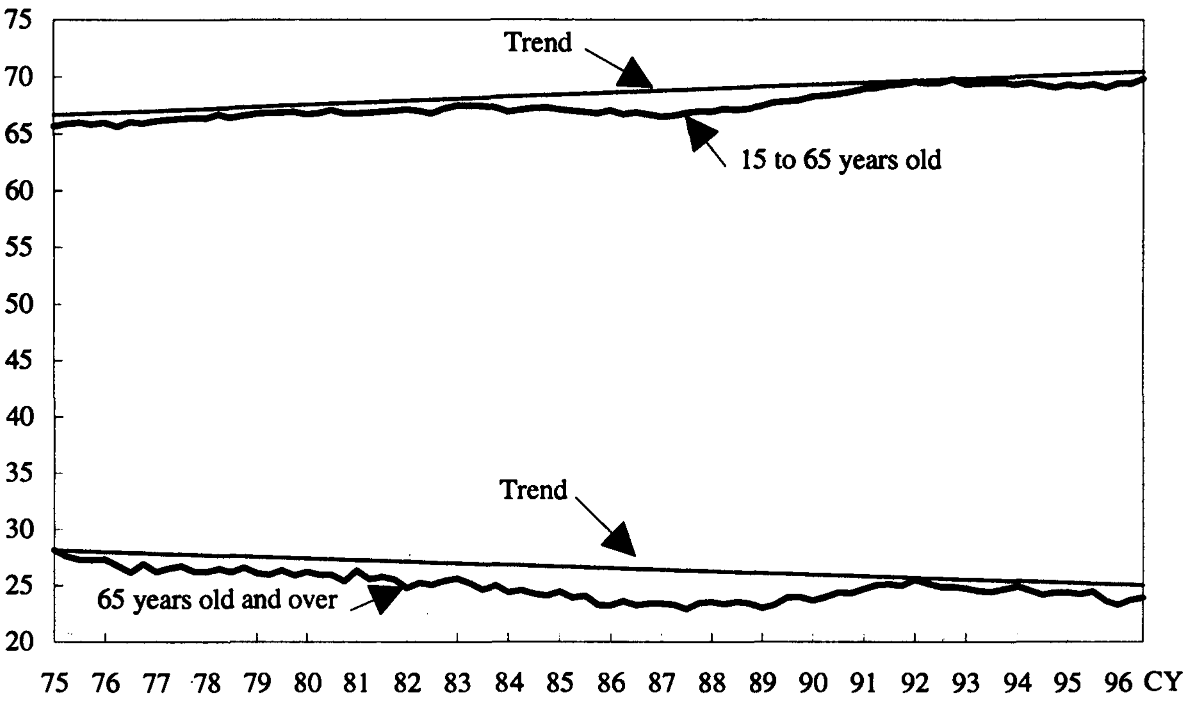
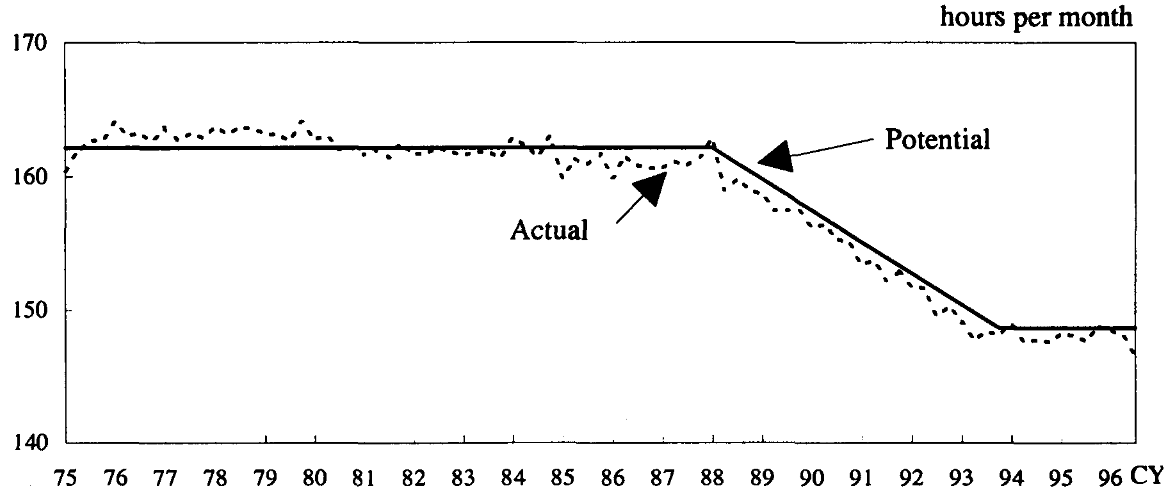


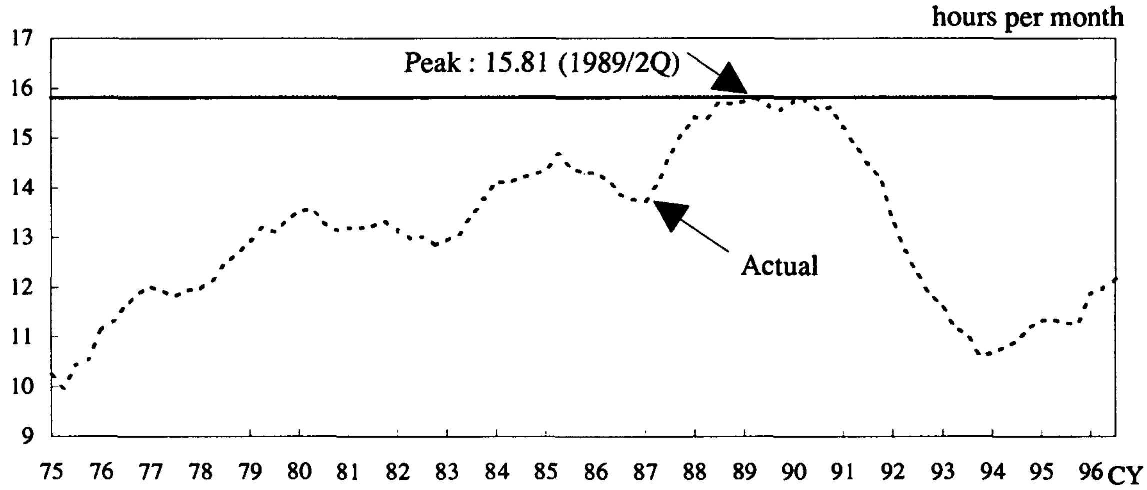
Figure 5

Working hours

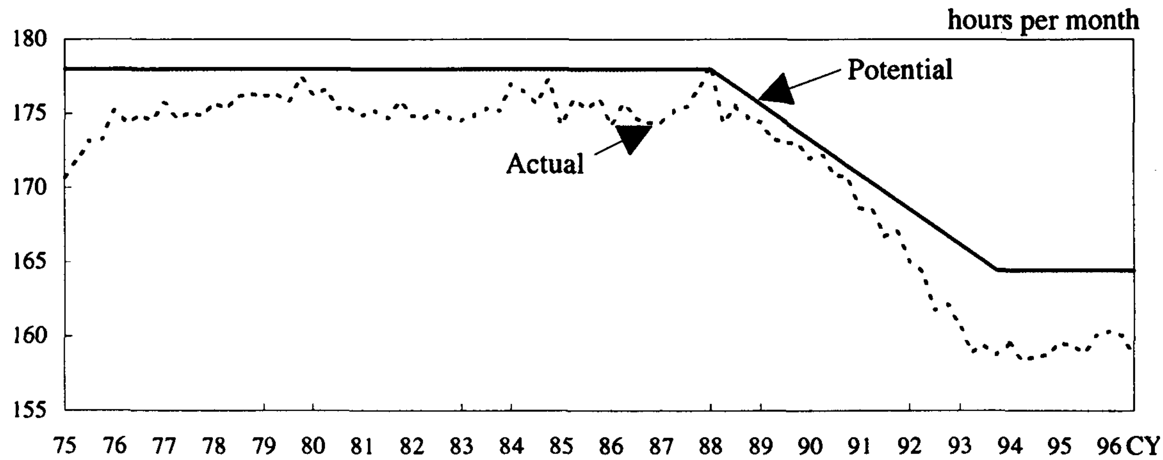
1. Scheduled working hours



2. Overtime working hours



3. Total working hours

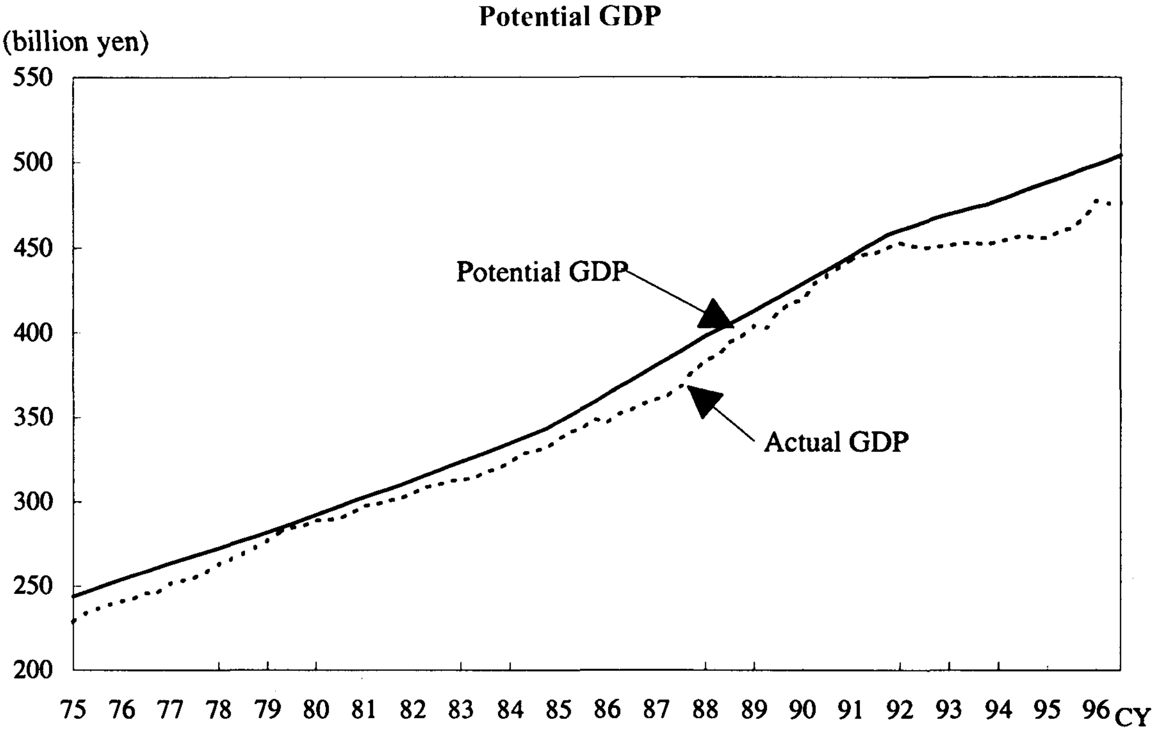


1.3 Potential GDP and GDP gap

We can calculate potential output by putting the potential amount of factor inputs into the production function. Potential GDP in Figure 6 is calculated in this way and the GDP gap in Figure 7 is defined as (actual GDP-potential GDP)/potential GDP.[2] As the figure shows, the GDP gap started to increase or deteriorate at the beginning of 1991 and continued to increase monotonically until the first quarter of 1995 when actual GDP deviated from the potential level by 7%. It tends to improve since the second quarter of 1995, although its level is still as high as 5%.

Figure 6

Potential GDP



To see what caused the deterioration of the GDP gap in the 1990s, we decompose changes in the GDP gap from the previous period into the following two components using the identity:

$$\Delta GDP\ gap = final\ demand\ /actual\ GDP - \Delta potential\ GDP\ /potential\ GDP - \Delta import\ /actual\ GDP \quad (3)$$

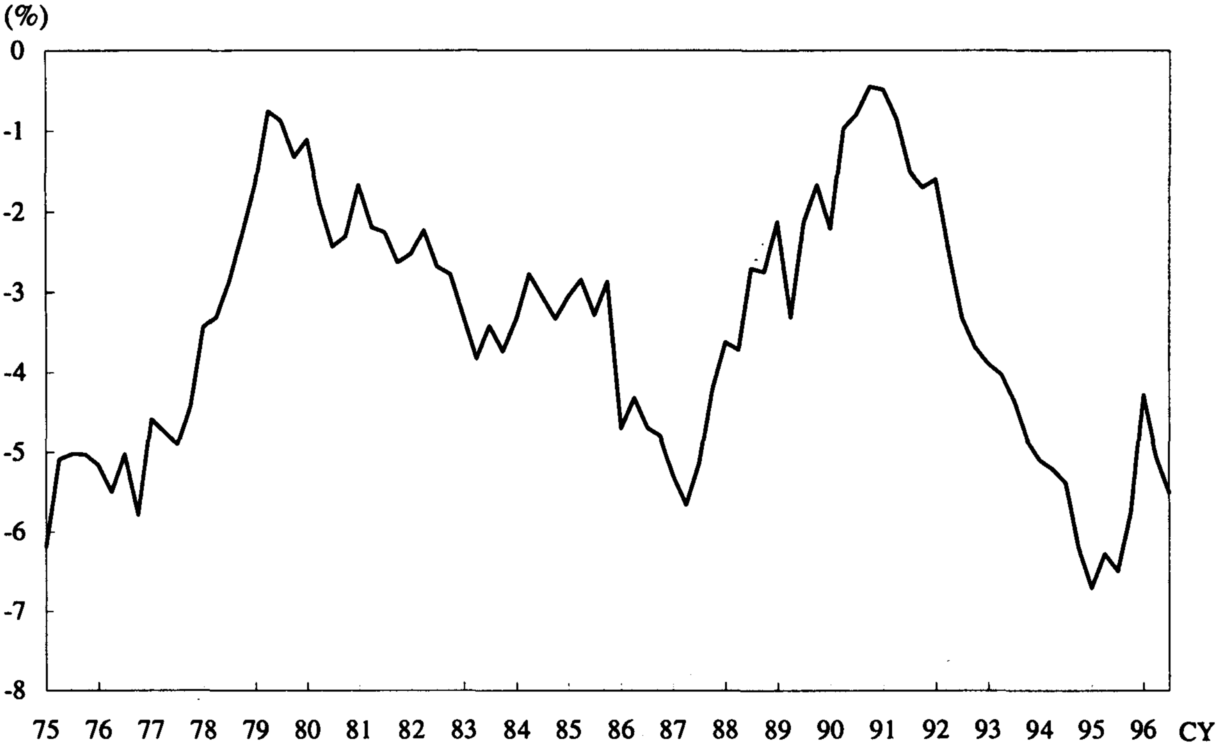
where the first and the second terms on the right-hand side are combined and called "final demand minus potential GDP factor" in Figure 8 and the third term "import factor".

As shown in Figure 8, the deterioration in the GDP gap in 1991 and 1992 was mainly explained by the first factor. That is, final demand, particularly domestic private demand, was weak as compared with potential output during this period, so that the GDP gap deteriorated. Fiscal and monetary stimulus starting in 1992 reduced the downward pressure from the import factor in and after

[2] Note that the GDP gap obtained here and used in the rest of this paper is not the deviation of the gap from the natural rate. According to the Lucas supply function, the natural rate is defined as the level of the GDP gap where the actual rate of inflation coincides with the expected rate of inflation, as long as the supply shocks are negligible. Using the inflation forecasts made by private think-tanks each year as a proxy for the expected rate of inflation, we have found that the natural rate is about 3%.

Figure 7

GDP gap



1993. Instead, the downward pressure from the second factor has started to increase. This is due to an increase in imports from east Asian countries reflecting the appreciation of the yen as well as industrialisation in those countries. An important thing to note is that increase in imports cannot be explained by the movement of final demand. If all increases in imports had been induced by increases in final demand, they would have been neutral to the GDP gap, or the supply-demand condition in goods and service markets. In fact, final demand was too weak to induce any imports in this period, although it was gradually recovering. In this sense, the increase in imports in and after 1993 was almost independent of final demand, so that it increased the GDP gap significantly.[3]

Table 1

Selected examples of estimation of potential GDP

	Growth rate of potential GDP, in percentages				
	1991	**1992**	**1993**	**1994**	**1995**
Present paper	3.9	2.7	1.9	2.0	2.2
Economic Planning Agency	4.9	3.0	1.3	1.1	n.a.
Industrial Bank of Japan	4.1	4.1	3.1	n.a.	n.a.
Japan Development Bank	4.0	2.7	1.9	2.3	2.2
Bank of Tokyo-Mitsubishi	4.0	4.0	3.5	3.5	3.5
IMF	4.5	3.9	3.3	2.8	2.6
OECD	2.9	2.3	2.2	3.2	3.0

3 Table 1 shows the selected estimates of potential GDP and the GDP gap by various institutions, including the Economic Planning Agency and private think-tanks.

Figure 8

Decomposition of movements in the GDP gap

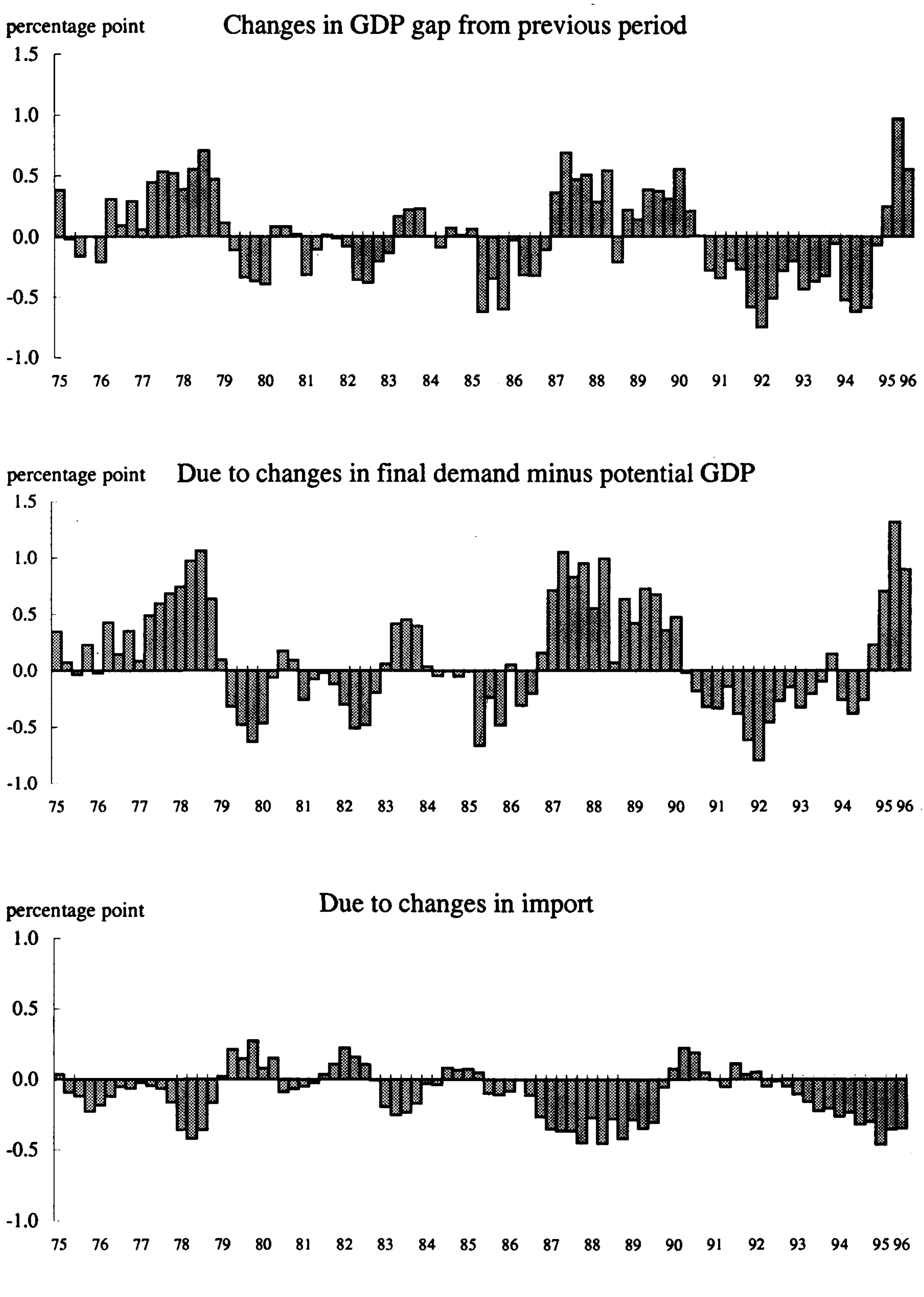
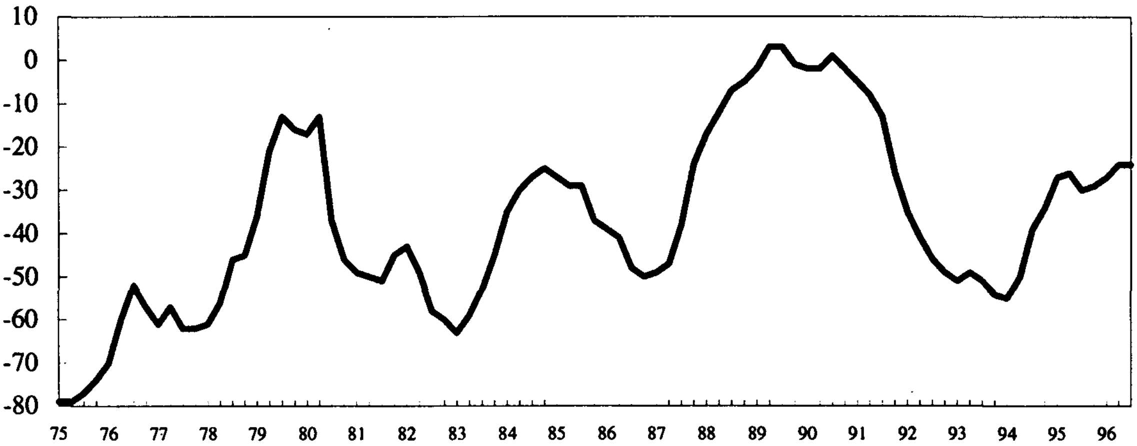


Figure 9

Indicators of the output gap

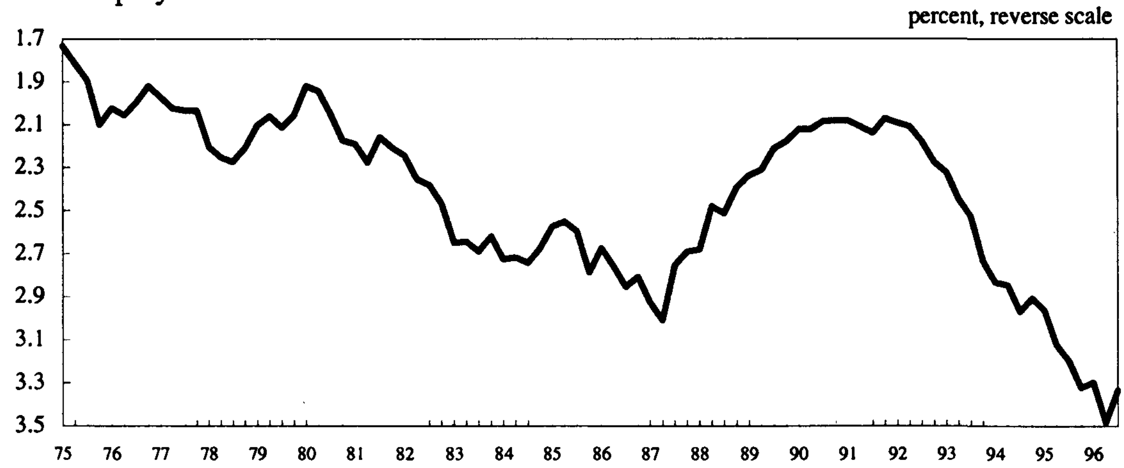
1. Diffusion index for "Supply/demand conditions for products"



Note:
Short-term Economic Survey of Principal Enterprises. Figures represent the percentage of "Excess of Demand" in total minus the percentage of "Excess of Supply".

2. Capital utilization rate

3. Unemployment rate



1.4 Other indicators of the output gap

Figure 9 (on the previous page) shows recent movements in various measures of slack in the economy: (i) the diffusion index, DI, concerning "supply/demand conditions for products" in *Short-term Economic Survey of Principal Enterprises*; (ii) the capital utilisation rate; and (iii) the unemployment rate. As clearly seen, all three measures commonly indicate the deterioration in the output gap during the period of 1990 to 1993. This is consistent with the movement of the GDP gap estimated above. However, the movements of those measures differ significantly in and after the beginning of 1994: the DI and capital utilisation rate have started to improve gradually since the beginning of 1994, while the unemployment rate and the GDP gap continued to deteriorate.[4]

We can point to the following reasons in explaining the different movements since the beginning of 1994. First, the difference in coverage: the DI and the capital utilisation rate represent slack in the manufacturing sector, while the GDP gap and the unemployment rate cover the whole economy. Second, the DI and the capital utilisation rate might fail to capture the impact of the rapid increase in imports from east Asian countries, which was the main source of deterioration of the GDP gap in 1994 and 1995. For example, correspondents of the *Short-term Economic Survey*, major enterprises from capital of over 1 billion yen, might not face severe competition from east Asian countries. It might be smaller enterprises whose products are more labour intensive that are exposed to competition from east Asia. The third possible reason is measurement error. In particular, we cannot deny the possibility of overestimating the potential growth rate, given that the growth rate of TFP we use in calculating the potential GDP is higher than the actual growth rate of TFP during this period.

2. Relationship between the output gap and inflation

2.1 Three hypotheses

There are three alternative hypothesis about the relationship between the output gap and inflation. First, the *level* of the output gap is related to the rate of inflation. The theory of general equilibrium tells us that the rate of change in each commodity price depends on the excess supply or demand for that commodity. By analogy, at the macro level this implies that the rate of change in the general price level, or the inflation rate, depends on the level of slack in the economy, or the output gap. A famous example of this type of relationship is the so-called Phillips curve, a stable relationship between the rate of change in wages and the unemployment rate.

Second, the level of the output gap might be related with the rate at which inflation rate increases, or the *acceleration* of the general price level. A famous example of this sort is the Non-Accelerating Inflation Rate of Unemployment (NAIRU). The rate of inflation continues to increase if the unemployment rate is below the natural rate, and continues to decrease if the unemployment rate is above the natural rate. It is only when the unemployment rate coincides with the natural rate that the rate of inflation remains unchanged. The NAIRU is a special case of the hypothesis of the natural rate of unemployment where the expected rate of inflation is equal to the rate of inflation in the previous period.

Third, the *change* in output gap might be related with the rate of inflation. For example, the general price level started to rise in the US economy just after the Great Depression reflecting the rapid shrinking of the output gap, with the level, measured by the GNP gap still being over 40%.

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4 As for the unemployment rate, since a structural change is going on in the labour market, it might be inappropriate to consider such rise in the unemployment rate as entirely cyclical.

Some argue that this sort of relationship was observed in instances other than Great Depression and call it the "speed limit effect" (for example, see Romer (1996)).

In what follows, we will see which of the three hypothesis holds for the Japanese economy. Before proceeding further, however, let us briefly think about implications of each hypothesis for the future course of inflation in the Japanese economy. As we saw in Section 1, the current level of the GDP gap in Japan is as high as 5% and the current rate of inflation is near zero. Suppose someone predicts that the GDP gap will improve in 1997 as the economy recovers but the speed of improvement will be limited reflecting the weakness of final demand. What does this prediction imply for the future rate of inflation?

According to the first hypothesis, it is the level of output gap that is related to the rate of inflation. Therefore, those who believe in the first hypothesis predict that the rate of inflation will gradually rise as the GDP gap improves. For those who believe in the second hypothesis, the critical thing is to know whether the current level of the GDP gap is below or above the natural level. Needless to say, it is impossible to prepare any answer about the natural rate without close examination of the data; nevertheless, most economists will probably agree that the natural rate, if it exists, will be lower than 5%. If this is the case, the rate of inflation will continue to go down in the near future. Finally, according to the third hypothesis, it is not the level of the GDP gap but the speed of improvement that determines the rate of inflation. No matter how large the current and future level of the GDP gap, inflation will surely increase as long as the GDP gap improves.

In the rest of this section, we will investigate which of the three hypotheses holds for the Japanese economy through "eyeball econometrics" as well as simple regressions.

2.2 The Phillips curve

Figure 10 plots the level of the GDP gap and the rate of inflation measured by the CPI. It is clearly seen that there exists a stable trade-off between the two variables since 1980. In other words, we can observe something like the Phillips curve in the 1980s and the first half of the 1990s. It is surprising that we observe such a stable relationship between the two in spite of various shocks hitting the Japanese economy during this period such as the rapid appreciation of the yen after the Plaza Agreement in 1985, the asset price inflation in the late 1980s, and the burst of the bubble in the 1990s.

Those who believe in the natural rate hypothesis might argue that from 1980 to 1996 is too long a time range to observe a stable Phillips curve: the expected rate of inflation must have shifted at least several times during such a long period. We agree that there might not be a single Phillips curve but a set of multiple Phillips curves. For example, the curve in 1980-84 clearly differs from that in 1985-87 with respect to slope and intercept. Even if we take this point into consideration, however, it still seems surprising that the two variables are closely related with each other. An interpretation of this fact based on the natural rate hypothesis is that expectations about future inflation were relatively stable. In fact, various surveys, including the *Short-term Economic Survey* conducted by the Bank of Japan, commonly indicate that the expectations of firms and households have been relatively stable since the beginning of the 1980s.[5]

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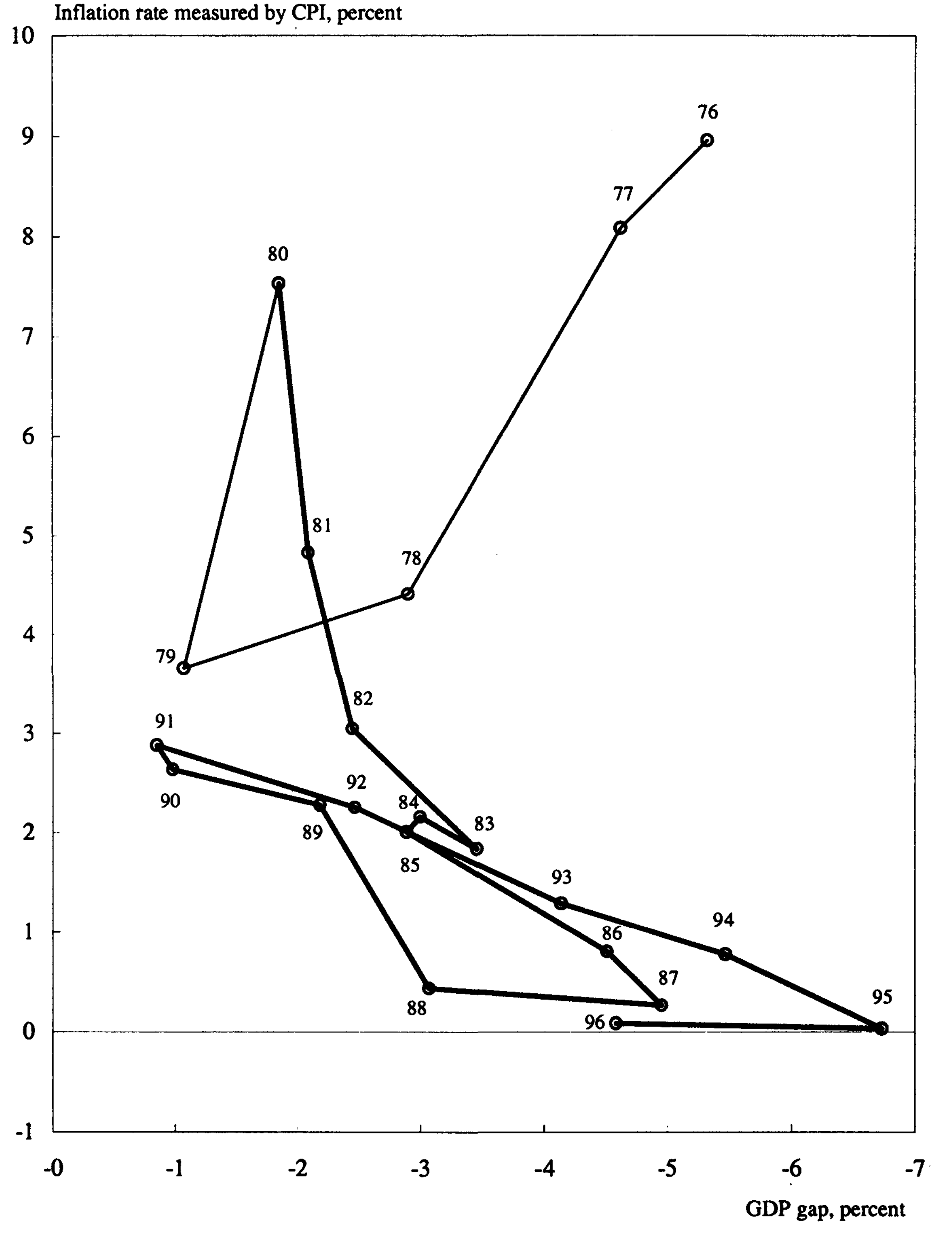
[5] This is consistent with the observations that the money supply and nominal GDP have been moving together since the beginning of the 1970s, and that the money supply and the GDP deflator were also moving together up to the early 1980s, whereas a stable relationship has been missing since the mid-1980s. That is, according to the natural rate hypothesis, there is a trade-off between inflation and unemployment in the short run, during which the expected rate of inflation is kept constant; the Phillips curve is vertical in the long run when the expected rate of inflation coincides with the actual rate. In the 1970s, the inflation rate was so high that the Phillips curve was almost vertical. As a consequence, the rate of inflation was governed by the growth rate of money supply. In contrast, the expected rate of inflation was stable in the 1980s and 1990s, so that the rate of inflation was mainly determined by the GDP gap.

Figure 10

GDP gap versus CPI inflation

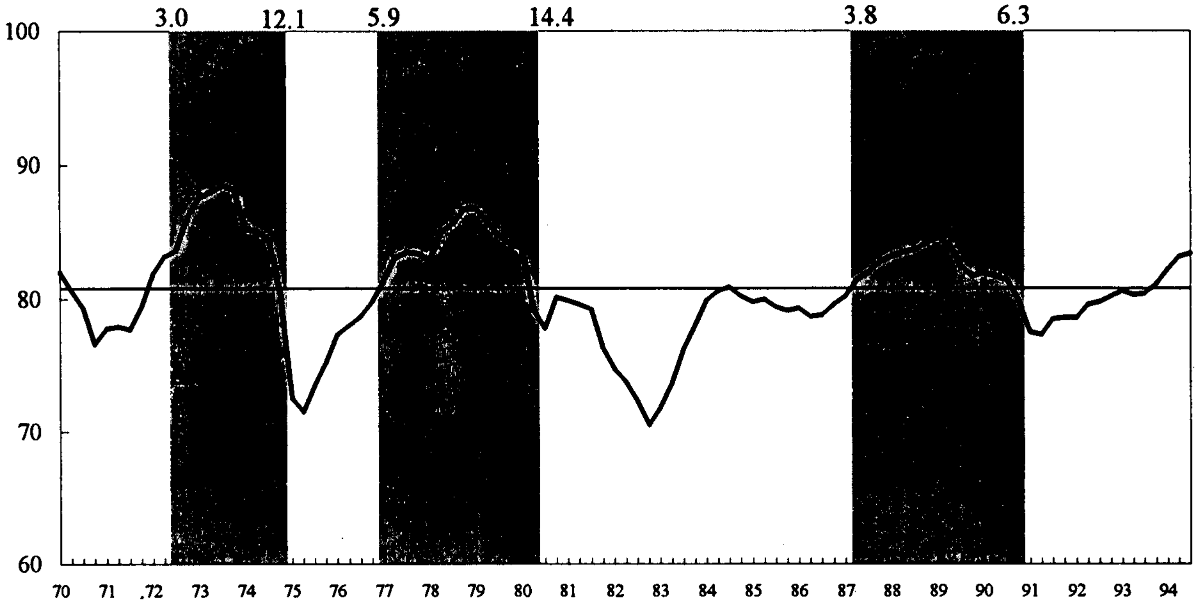


Notes: CPI is excluding fresh food and consumption tax. Figures are computed on calendar-year basis. The figure for 1996 is the percentage change from a year ago of the 1st semester 1996.

Figure 11

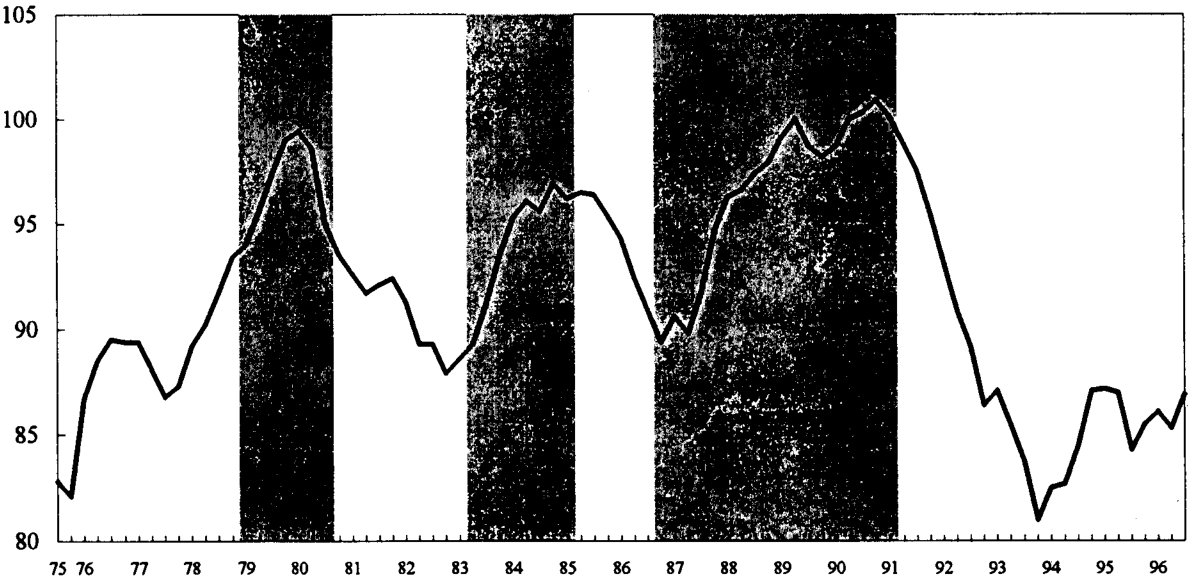
Capital utilisation rate versus acceleration of inflation

U.S.



Note : Shaded areas represent the periods during which the inflation rate increased.
Source : Garner,Alan,C. (1994). "Capacity Utilization and U.S. Inflation." *Economic Review*, Federal Reserve Bank of Kansas City. Vol.79,No.4,5-21.

JAPAN



Note: Shaded areas represent the periods during which the inflation rate measured by the TC component of the CPI excluding fresh food and consumption tax increased.

2.3 The NAIRU

Figure 11 shows the relationship between the acceleration of the CPI and the capital utilisation rate in the manufacturing sector. The shaded area represents the period during which the rate of inflation increased. If the relationship is of the NAIRU type, we should observe that the rate of inflation increases when the capital utilisation is above a specific level, or the natural level, and vice versa.

The upper panel, which is taken from Garner (1994), shows the relationship in the US economy. As clearly seen, there is a tendency that the CPI accelerates when the capital utilisation is above 80.2 and decelerates when it is below that level.[6] In contrast to this, as shown in the lower panel, we cannot observe such regularity for the Japanese economy: the NAIRU-type relationship between the output gap and inflation does not exist in Japan. Rather, looking more closely, it seems that the rate of inflation increases when the capital utilisation increases and vice versa. In other words, it is not the acceleration of CPI but the inflation rate of CPI that is related to the level of the capital utilisation rate. This is consistent with what we observed in Figure 10.

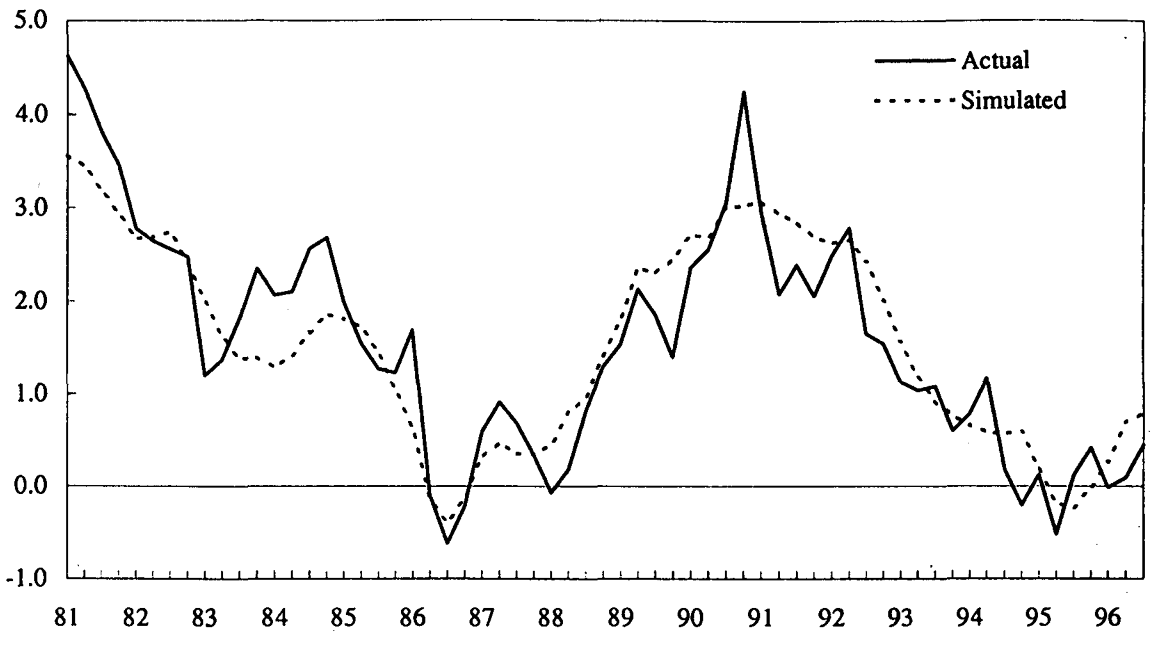
2.4 Estimation of the inflation equation

Examination of Figures 10 and 11 through "eyeball econometrics" seems to indicate that the rate of inflation is related to the level of the output gap in Japan. To formalise this finding, we regress the rate of inflation (π_t) on the lagged rate of inflation (π_{t-1}), the output gap (g_{t-1}), change in the output gap (Δg_{t-1}), and the rate of change in import prices (m_t). That is,

$$\pi_t = a_0 + a_1 \pi_{t-1} + a_2 g_{t-1} + a_3 \Delta g_{t-1} + a_4 m_t \qquad (4)$$

Figure 12

Dynamic simulation of the inflation equation (CPI excluding fresh food and consumption tax versus the GDP gap) estimated over 1981Q1 to 1996Q3



6 Note that the rate of inflation has not significantly increased since 1994 although the capital utilisation rate is well above 80.8. In this sense, the relationship of the NAIRU type seems to disappear even in the US economy.

We will use changes in CPI total and CPI goods as indicators of π_t and the GDP gap, the capital utilisation rate and the unemployment rate for g_{t-1}. The sample period is 1981Q1 to 1996Q3 and the estimation method OLS.

If the first hypothesis holds, a_2 should be significantly different from zero and a_1 should be close to zero. If the second hypothesis holds, a_2 should be significantly different from zero and a_1 should be equal to unity. Finally, if the third hypothesis holds, a_3 should be significantly different from zero.

Table 2 shows the results of the regressions.[7] Numbers in parentheses represent standard errors. The results are summarised as follows: (i) a_2 is different from zero at the 5% significance level in all cases; (ii) a_1 is different from zero at the 5% significance level in all cases except the combination of CPI total and the unemployment rate; (iii) in all cases, the null hypothesis that a_3 is zero cannot be rejected at the 5% significance level. Altogether, we can conclude that the data support the first hypothesis but contradict the other two. This is consistent with the finding obtained through "eyeball econometrics".

Table 2

Estimation of inflation equation

Output gap measured by:		**Inflation measured by:**	
		CPI total	**CPI goods**
GDP gap	a_0	1.64 (0.33)	2.70 (0.61)
	a_1	0.54 (0.08)	0.25 (0.11)
	a_2	0.27 (0.06)	0.60 (0.15)
	a_3	-0.10 (0.11)	0.21 (0.30)
	a_4	0.02 (0.01)	0.04 (0.02)
	$\bar{R}^2$	0.83	0.51
	S.E.	0.50	1.44
	D.W.	0.76	-1.48
Unemployment rate	a_0	2.52 (0.87)	5.80 (1.87)
	a_1	0.66 (0.08)	0.36 (0.11)
	a_2	-0.78 (0.30)	-2.06 (0.71)
	a_3	0.99 (0.79)	2.49 (2.22)
	a_4	0.02 (0.01)	0.04 (0.02)
	$\bar{R}^2$	0.80	0.43
	S.E.	0.54	1.55
	D.W.	0.89	-0.98
Capital utilisation rate	a_0	-3.25 (1.37)	-9.10 (4.03)
	a_1	0.73 (0.06)	0.43 (0.11)
	a_2	0.04 (0.02)	0.10 (0.04)
	a_3	-0.05 (0.05)	-0.04 (0.15)
	a_4	0.02 (0.01)	0.04 (0.02)
	$\bar{R}^2$	0.80	0.41
	S.E.	0.55	1.59
	D.W.	0.07	-1.94

Notes: Numbers in parenthesis represent standard errors. The rate of inflation is measured by the annualised rate of change from the previous quarter of the TC component of CPI total or CPI goods. Equations are estimated by OLS. See descriptions in the text for details.

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7 Figure 12 shows a dynamic simulation of the estimated equation which clearly performs well.

3. The cost of disinflation

As a concluding remark, let me briefly discuss the cost of disinflation the Japanese economy has experienced since the burst of the bubble. According to the literature, including Krugman (1996) and Fischer (1996), disinflation from, say, 5 to 0% is more costly in the terms of the sacrifice ratio than disinflation from, say, 10 to 5%. This is because the nominal wage has some downward rigidity so that the real wages rise when the rate of inflation approaches zero, leading to a decrease in the demand for labour and a higher rate of unemployment. According to their argument, since the cost of disinflation is higher than the benefit of such disinflation when the rate of inflation is close to zero, central banks should not target zero inflation. They should target, say, 3% or moderate inflation.

Their theoretical reasoning as well as the policy implication seems crystal clear, but their argument lacks empirical evidence because inflation rates have been far from zero in almost all industrial countries, at least during the post-war period.[8] In this circumstance, the experience of Japan since the burst of the bubble seems quite valuable from the point of view of evaluating the cost of moving to zero inflation.

3.1 Is the real wage too high?

According to the argument for moderate inflation, zero inflation is costly because of rigid nominal wages. It is not easy to test whether nominal wages are rigid or not, and this is beyond the scope of this paper. But, if the argument is correct, we should observe a rise in real wages as the rate of inflation approaches zero. More precisely, we should observe that real wages become too high as compared with labour productivity.

Based on this understanding, we compare the real wage and labour productivity in Figure 13. As the figure shows, dots are on or near the 45-degree line in the 1980s which means that the real wage has tended to comove with labour productivity during this period.[9] In contrast, dots deviate significantly from the 45-degree line in the 1990s. In this sense, the real wage has been too high during this period. By closer inspection, a similar phenomenon is found in the early 1980s when the Japanese economy was also weak.[10] These two observations seem to suggest that, when the growth rate of output is low, firms try to reduce labour inputs by first cutting overtime working hours and then the number of employed persons. But such adjustments usually take time, particularly the second, thereby leaving labour inputs too high as compared with the level of output during the adjustment process. As a result, the growth of labour productivity goes down. In this situation, firms try to control real wages in accordance with the lower labour productivity, but this is also a difficult task and takes time to complete. As a consequence, dots deviate from the 45-degree line during a recession.

One thing special to the first half of the 1990s is that the rate of inflation has been very low. We cannot deny the possibility that the lower rate of inflation makes it even harder for firms to control real wages during the recession.

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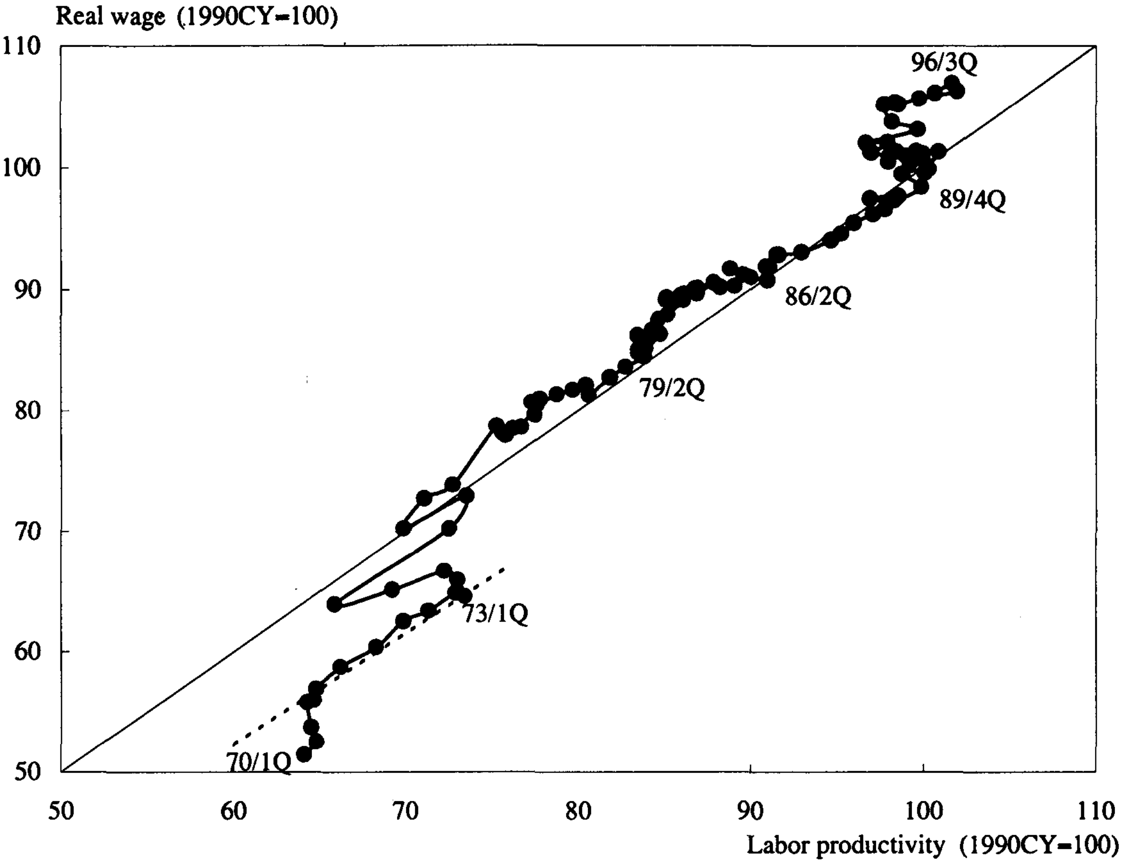
8 Needless to say, if we go back to the Great Depression or the period of the gold standard, you might find ample instances of zero or below-zero inflation.

9 Note that both the real and labour productivity are indices with 1990CY=100. Hence, the fact that dots are on the 45-degree line does not necessarily mean the level of real wages and the level of labour productivity coincide.

10 Another episode is the period 1973-74 when dots deviate from the 45-degree line of the 1970s. In this period, the rate of inflation of over 20% made expectations of inflation very unstable. People started to expect higher and higher inflation and nominal wages rose at a very high speed. In fact, the growth rate of wage outweighed the actual inflation rate. As a result, real wages rose while the growth of labour productivity was very low. Given this story, the deviation from the 45-degree line in 1973 and 1974 can be interpreted as caused by an overshooting of expectations.

Figure 13

Real wage and labour productivity



Notes: Real wage = nominal wage/GDP deflator. Labour productivity = real GDP * nominal wage/compensation of employees.

3.2 Is the Phillips curve flatter?

The observation that the real wage is too high is consistent with the argument for moderate as opposed to zero inflation. The next thing to check is whether the high real wage led to a rise in the unemployment rate. As we saw in Figure 9, the rate of unemployment has indeed been high since the burst of the bubble. But, as we noted in footnote 4, this is partly due to a structural change in the labour market; therefore, it might not be appropriate to attribute the rise in unemployment to higher real wages alone.

A more straightforward way to see the consequence of higher real wages is to check the slope of the Phillips curve. If a rise in the real wage reduces the demand for labour significantly, the slackness of the economy, including unemployment, must increase. If this is the case, the Phillips curve we observed in Figure 10 should be flatter in the first half of the 1990s than before. Looking at Figure 10 from such a point of view, we can say that the slope of the curve is clearly flatter in the period 1991-95 than in 1980-83. On the other hand, no significant change is observed between 1985-87 and 1991-95. What do these two observations mean? First, since the rate of inflation in both 1985-87 and 1991-95 was between zero and 3%, there is no reason why the slope should differ between these periods. Therefore, the second observation is exactly what the theory predicts. The first observation is more interesting. If we take this fact as it is, the Phillips curve is flatter in the 1990s and disinflation from 3% (in 1991) to zero (in 1995) is, therefore, more costly than disinflation from 7.5% (in 1980) to 1.8% (in 1983).

Figure 14

CPI inflation and nominal interest rate

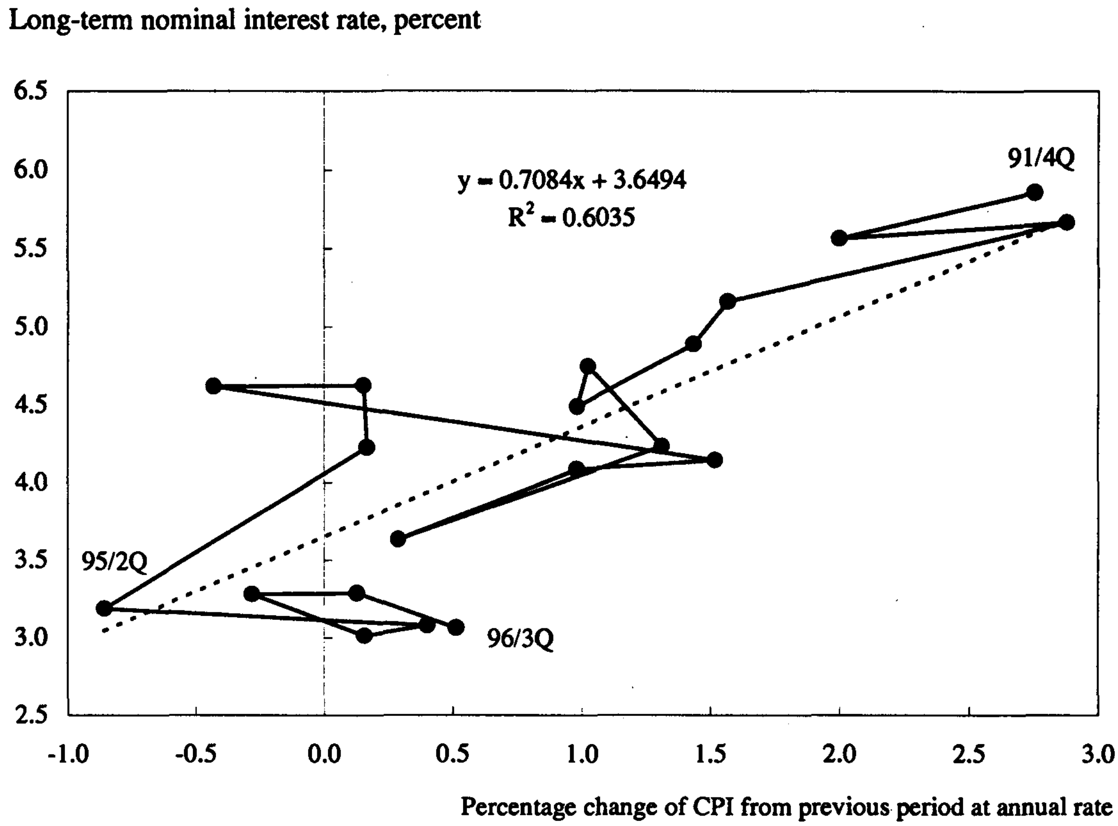
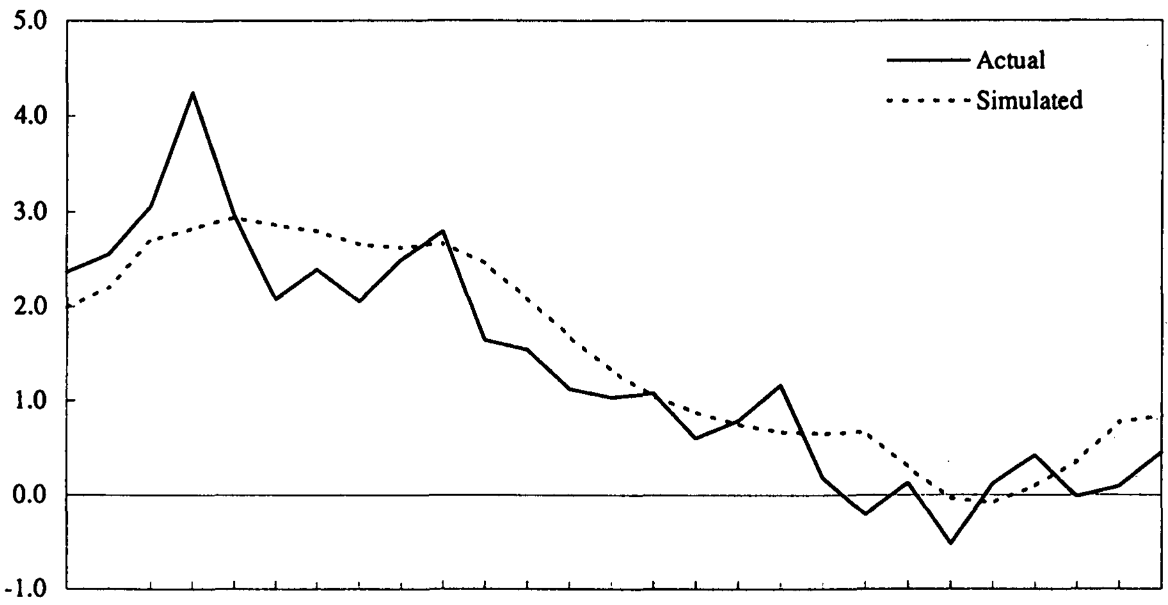


Figure 15

Dynamic simulation of the inflation equation (CPI excluding fresh food and consumption tax versus the GDP gap) estimated over 1981Q1 to 1989Q4



One caveat is that the CPI inflation rates in 1980 and 1981 were governed by oil prices. Obviously, it is not appropriate to look at the slope of the Phillips curve when a cost-push factor like higher oil prices affects the price index. In such a case, it is important to control for the effects of supply-side factors. Based on this understanding, we have conducted a simple experiment using the inflation equation estimated in Section 2.4. That is, we have reestimated the inflation equation using data for the 1980s and conducted out-of-sample forecast. If zero-inflation is costly, we should observe *underprediction*: that is, the forecast values should be lower than actual values. However, as shown in Figure 15, the forecast values are consistently higher than actual. In other words, when we properly control for the supply-side factors, the relationship between the rate of inflation and the GDP gap during the post-bubble period remains the same as that of the 1980s. In this sense, we cannot find any evidence supporting the hypothesis that the sacrifice ratio goes up as the rate of inflation approaches zero.

3.3 Future works

In sum, the evidence is mixed: the data seem to suggest that the disinflation since the burst of the bubble in Japan has caused higher real wages; at the same time, however, we cannot find strong evidence of a higher sacrifice ratio during that period.

This is just the beginning of research on this topic and lots of things need to be done to evaluate the cost of zero inflation.[11] For example, we need to investigate further why real wages remained high during the post-bubble period and whether this is an immediate and direct consequence of zero inflation. Also, further analysis of the downward rigidity of nominal wages will be needed.[12]

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[11] The advocates of moderate inflation are also concerned that zero inflation tends to lead to a higher real interest rate. For example, suppose a central bank, struggling with recession, wants to create a negative real interest rate. If the rate of inflation is zero, it is impossible to create a negative real interest rate because nominal interest rates cannot be negative. Also, if deflation is going on, the real interest rate remains high or continues to rise even if the nominal interest rate is very close to zero. From this point of view, the relationship between the long-term nominal interest rate and the rate of inflation is shown in Figure 14. As immediately seen, there is no evidence that the long-term nominal interest rate remained too high in comparison with the rate of inflation.

[12] See Kimura and Ueda (1997) as an example of this sort of study for Japan.

Comments on: "Output gap and inflation: the case of Japan" by Tsutomu Watanabe

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by Steve Kamin

Mr. Watanabe's contribution is a clear, straightforward, and interesting analysis of the behaviour of inflation in Japan. During the 1980s, Japanese inflation was well below the OECD average, and more recently, Japan experienced the relatively novel phenomenon of price *deflation*. Under these circumstances, it is interesting to see whether Japanese inflation might be consistent with a standard Phillips-Curve model such as Mr. Watanabe estimates for Japan.

To review, the paper first estimates a production function for Japan and then, based on hypothetical values for inputs, calculates a measure of potential GDP. Using the resultant measure of the output gap for Japan, Mr. Watanabe estimates a standard Phillips-Curve type equation, augmented with a measure of import prices. Finally, he discusses the applicability to Japan of the hypothesis that as inflation declines, money illusion may make it increasingly difficult to achieve zero inflation itself.

I found the modelling strategy employed by Mr. Watanabe to be reasonable, and his basic results were plausible as well. He finds the level of the output gap to affect inflation significantly, as one might expect, but identifies no "speed limit" effects – that is, the change in the output gap does not affect inflation. In contrast to findings for some other countries, including the United States, he finds the coefficient on the lagged inflation rate in the Phillips Curve equation to be significantly less than one, suggesting that the long-run Phillips Curve for Japan is less than vertical. This should not dismay devotees of rational expectations theory: rational expectations behaviour tends to emerge when inflation is high and variable, and given the relatively low inflation enjoyed by Japan in recent years, it is not surprising that past inflation is not fully and immediately incorporated into current inflation.

Mr. Watanabe's approach towards calculating potential output – estimating an actual production function – may be superior to "black box" methods such as fitting a curve or filter to actual GDP. However, it should be cautioned that because certain crucial questions about the Japanese economy remain unresolved, Mr. Watanabe is forced to make modelling decisions that are only slightly less "ad hoc" than, say, fitting an HP filter to the data. For example, it remains a mystery why Japanese output grew so rapidly during the "bubble economy" period of the late 1980s, and then has remained so stagnant thereafter. Observers have argued that the slump of the 1990s reflects a ratcheting down of Japan's potential growth rate, but no convincing rationale for the timing of this decline has been offered. In order to capture this phenomenon, Mr. Watanabe allows for a greater rate of total factor productivity growth during the late 1980s than either before or after. Since the bubble economy period probably was demand rather than supply-driven, however, the justification for this procedure is unclear; it probably was required in order to keep the measured output gap from becoming too large and positive during the bubble economy period, and then becoming too large and negative during the 1990s.

A second concern raised by the paper is the role of import prices in the recent slowdown in Japanese prices. While import prices (measured in yen) are estimated to have a statistically significant impact on Japanese inflation, they are not discussed sufficiently in the text of the paper. Considering the tremendous appreciation of the yen during the 1990s, the fall in yen import prices would seem to be a good candidate for explaining much of the decline in inflation. It would have been useful to see a counterfactual simulation of the path of inflation during the 1990s, holding import prices constant.

Finally, Mr. Watanabe's discussion of the costs associated with zero inflation is apt, considering that Japan recently has experienced negative inflation. However, more could have been done with the data to test the hypothesis that, as price growth approaches zero, it becomes more difficult to reduce nominal wage growth accordingly. The paper shows that real wages, relative to productivity, have risen as of late, but it is difficult to tell whether this reflects lower inflation or other, unrelated factors such as lower productivity growth due to labour hoarding. An attempt also is made to determine whether the Phillips Curve has become flatter in recent years, but it is tough to make sense of the spaghetti squiggle of lines in Figure 10. Finally, the out-of-sample forecast presented in Figure 15, showing that the inflation equation estimated during the 1980s continues to track relatively well in the 1990s, *does* present prima facie evidence against the "costly disinflation" hypothesis. However, it is possible that other factors not included in the equation, such as the spread of discount stores, may have acted to offset inflationary pressures resulting from nominal wage rigidities.

It might have been more informative to have performed a direct test of the hypothesis that wages or prices behave differently at different levels of inflation. For example, one could examine the linkage between wage growth and inflation at different levels of inflation:

$$\Delta[\textit{Wage Growth}]_t = \alpha + \beta\Delta[\textit{Inflation}]_{t-1} + \eta\Delta[\textit{Dummy}]*[\textit{Inflation}]_{t-1} + \delta\Delta[\textit{Output Gap}]_{t-1}$$

Dummy: 1 if inflation < 3%, else 0

Δ: difference operator

This equation can be used to test the hypothesis that when inflation is sufficiently high – say, over 3% – changes in inflation, for a given output gap, translate one-for-one into changes in wage growth; this would be reflected in an estimated β of unity. On the other hand, if, as inflation fell below 3%, wage growth declined by a lesser amount as a result of money illusion, the estimated η should be negative.

One could perform an analogous regression in Phillips Curve space to determine whether changes in the output gap had a smaller impact on inflation as inflation declined:

$$\Delta[\textit{Inflation}]_t = \alpha + \beta\Delta[\textit{Inflation}]_{t-1} + \delta\Delta[\textit{Output Gap}]_{t-1} + \eta\Delta[\textit{Dummy}]*[\textit{Output Gap}]_{t-1}$$

With this equation, if progressively larger increments to the (negative) output gap are required to reduce inflation as it nears zero, the estimated η should be negative, as above.