The Output Gap and the Potential Growth Rate: Issues and Applications as an Indicator for the Pressure on Price Change

SUMMARY[1]

1. There are a number of factors driving price movements. It would be fair to say, however, that one of the fundamentally decisive factors is the extent to which aggregate supply capacity is actually met by aggregate demand. The difference between aggregate supply capacity and aggregate demand is generally known as the *output gap*, and it is widely used by international institutions and central banks in many countries all over the world when analyzing economic conditions, as one of the fundamental indicators for evaluating the pressure for price change. Indeed, the output gap underlies the description of future price movements in the *Outlook and Risk Assessment of the Economy and Prices*, published by the Bank of Japan biannually.
2. In order to calculate the output gap, we need figures for both aggregate supply capacity and aggregate demand. We may think of actual GDP as representing aggregate demand. What we refer to here as aggregate supply capacity, on the other hand, is the supply capacity premised upon the economic structure current at the time, and is more generally termed *potential output*. A problem is to provide a specific definition for potential output, and to select a means of its estimation. The Research and Statistics Department of the Bank of Japan defines potential output as the level of economic activity that would be reached assuming that labor and capital resources are used to their fullest potential within the existing economic structure. Estimation is carried out, based on what is known as the *production function approach*. In this approach, GDP is determined by a macro production function that includes three variables: (1) utilization of the capital stock; (2) labor input; and (3) the efficiency with which these factors are used, namely total factor productivity (TFP). We refer to the annual rate of change in potential output as the potential growth rate.
3. Looking at the estimated potential growth rate in Japan, we see that the rate stood at around about 4 percent throughout the 1980s; it has been trending downward since the bursting of the asset bubble and has recently dropped to around the 1 percent level. During the same period, however, the trend growth rate of actual output has been still lower. The output gap expands when the actual growth rate falls below the potential growth rate. In fact, since the bursting of the asset bubble, the output gap has continued expanding with cyclical movements and is open very widely to date.
4. Carrying out a simple comparison between the inflation rate and the output gap thus obtained for the period of, for example, the last 20 years, we may observe a correlation, though not very strong, between the expansion of the output gap and the drop in the inflation rate. After it hit a peak in the early 1990s, the inflation rate declined gradually, and has been slightly negative in recent years. When we think about this in the context of the above relationship, this price movement may reflect the underlying expansionary trend of the output gap during this period. It must be noted, however, that this relationship holds only on average for the last 20 years or so. When we include the period of high inflation in the 1970s, for example, the relationship breaks down. Accordingly, there is no guarantee that the current relationship will continue to be stable over the long term. Furthermore, looking at the short term (periods of 1–2 years), movements in the inflation rate regularly defy explanation in terms of the output gap. As explanations for this we may cite the facts that (1) the output gap is not only influenced by prices but also by a variety of factors, including exchange rates and competition from imports; and (2) there is considerable potential for error in the estimates of the output gap *per se*.
5. Among various ways of measuring the output gap, the Research and Statistics Department of the Bank of Japan relies on the one explained above for the following practical reasons: (1) since the factors that make up the production function are aggregated in a simple way when carrying out the estimation, it is easy to demonstrate the basis for any hypothesis about the future direction of the output gap; and (2) we can discern the downward-sloping broad relationship with the inflation rate mentioned earlier. On the other hand, our measure of the output gap also has several drawbacks: (1) since the estimation is dependent upon past trends and maximum values of various pieces of data, the output gap tends to be rather slow

1. For a key to the symbols and abbreviations used in this article, see page 41.

in responding to changes in the economic structure; (2) with definitions of potential output differing among international institutions and other such bodies, care needs to be taken when reading the level of the output gap; and (3) the relationship with the inflation rate is not precisely in accordance with economic theory.

6. To amend the above drawbacks, the Research and Statistics Department of the Bank also takes other approaches to measure the output gap. Notable examples are (1) the HP filter approach, in which a smooth trend curve is fitted to the actual GDP data; and (2) the time-varying nonaccelerating inflation rate of unemployment (NAIRU) approach, which is now an international standard and redefines potential output as that level of output consistent with an inflation rate that is neither accelerating nor decelerating. We also make use of (3) the *Tankan* diffusion indices as an indicator for the output gap. As mentioned above, the current measure of the output gap may be considered somewhat slow to respond to changes in the economic structure. Thus, when the pace of structural change accelerates as the result of structural reform in the future, the need to cross-check a variety of measures of the output gap and other comparable indicators becomes more pronounced.
7. In implementing monetary policy to achieve price stability, a central bank is expected not only to make accurate forecasts of future prices, but also to provide an explanation for these. The output gap is a useful statistic for both of these purposes. However, inflation movements often cannot be explained just by looking at the output gap alone. For this reason, while we take the outlook for the output gap as a basis for forecasting prices, we should also balance the advantages and the disadvantages of this indicator, and judgments should be reached only after due consideration has been paid both to a broad range of indicators related to the supply and demand situation and to other determinants of price movements. At the same time, further research in this area should be vigilantly pursued, with the possibility kept in mind that the efficacy of the output gap hitherto employed deteriorates when there is an acceleration in the structural economic change.

I. Introduction

The central tenet of the Bank of Japan's monetary policy is "contributing to the sound development of the national economy through the pursuit of price stability."[2] Consequently, the question of how to evaluate the current state and future outlook for prices is a vital element of the monetary policy decision-making process. Various factors influence price movements.[3] Nonetheless, as the crucial determinants of the prices of any goods or services are balances between their supply and demand, the price in the macroeconomic sense is largely determined by the overall balance between supply and demand on the macro level. Here, we take this macro-level balance between supply and demand to be the extent to which aggregate supply capacity is actually fulfilled by aggregate demand. Then, the output gap is defined as a percentage difference between this supply capacity and aggregate demand. What we term here aggregate supply capacity is more generally referred to as *potential output*, i.e., the aggregate supply capacity premised upon the economic structure at a given point in time. The annual rate of change in potential output is called the potential rate of growth.

The output gap is the degree of tightness or slackness in overall supply and demand in the economy. It is one of the fundamental indicators for evaluating the pressure for price change. For this reason, the output gap is made use of by central banks around the world and international institutions in their analysis of economic conditions. For example, in his lecture explaining the tight monetary policy in the first half of 2000, Dr. Lawrence H. Meyer, a former governor of the Federal Reserve Board, appealed to the notion of the balance of aggregate demand and sustainable supply to speak of a risk of future inflation (Meyer [2000]). Since sustainable supply refers to aggregate supply capacity described above, he based his argument on the relationship between the output gap and inflation. Similarly, in an official document explaining its monetary policy framework, the European Central Bank (ECB) evaluated the pressure for price change, referring explicitly to the output gap[4] as follows: "If actual output growth is above the potential level of growth, a positive output gap may develop that could lead to inflationary pressures" (ECB [1999b]).

2. Bank of Japan Law, Article 2.
3. For a comprehensive account of factors affecting price movements, see Shirakawa and Momma (2001).
4. See ECB (2000) for details on the ECB's philosophy on the output gap and its estimation procedure.

The Bank of Japan publishes a biannual report, *Outlook and Risk Assessment of the Economy and Prices*, and presents its economic outlook and price forecasts about a year to a year and a half ahead. For example, the October 2002 report says: "Looking at demand-supply conditions, despite a decline in the short-term growth rate of supply capacity of Japan's economy to around 1 percent on a year-on-year basis, the output gap will probably stop widening but will not go further to narrow in fiscal 2003." The gap between supply and demand referred to in the report is what we term in this paper the *output gap*, while the short-term growth rate of supply capacity is what we term the *potential growth rate*.[5] The Bank of Japan pays close attention to prospects for the potential growth rate and the output gap when making judgments concerning the outlook for prices that are crucial in the conduct of monetary policy.

Depending, however, on an estimation approach and assumptions, considerable difference could arise in the estimates of the potential growth rate and the output gap. Moreover, the relationship between the output gap and the inflation rate is not so strong. Therefore, when looking at the potential growth rate and the output gap, it is necessary not to lose sight of these limitations and to keep a well-balanced interpretation.

Bearing these points in mind, this paper aims to do the following: explain the estimation methodology for, and recent movements in, the measure of the output gap that has been constructed and most frequently used by the Research and Statistics Department of the Bank to evaluate price conditions and so on (hereafter the *benchmark output gap*); comment on the relationship between this indicator and prices; and lastly introduce several issues of interest that come up in the course of this discussion.

II. Estimation of the Benchmark Output Gap

A. Defining the Concept

As detailed above, the output gap is defined as the percentage difference between aggregate supply capacity premised upon the economic structure and aggregate demand. The aggregate supply capacity is usually referred to as potential output. Since we can think of aggregate demand as being captured by the level of GDP at that moment in time, our definition of the output gap may generally be written as follows:[6]

$$\text{Output gap} = \frac{\text{actual output} - \text{potential output}}{\text{potential output}} \times 100. \quad (1)$$

That is, the output gap is defined as the percentage difference between actual and potential output, and a decrease in actual output (i.e., in aggregate demand) manifests itself as a widening (in negative terms) of the output gap. In this sense, although a recession is generally said to result in an expansion of the output gap, strictly speaking this should be termed a negative expansion of the output gap.[7]

The problem here is that potential output, which appears on the right-hand side of equation (1), is not observable. The reason that estimates of the output gap differ from analyst to analyst is ultimately that it is possible to conceive of several different concepts and different estimation approaches. As to the concept, potential output adopted by the Research and Statistics Department of the Bank when defining its benchmark output gap is the level of economic activity that would be reached assuming that labor and capital resources are used to their fullest potential within the existing economic structure. Since it is impossible for actual output to exceed potential output by this definition, the benchmark output gap will take only a negative value, which is clear from equation (1). As we describe later, there are substantial differences between the numbers that we obtain for our benchmark output gap and those produced by some other international institutions. The most important reason for these differences is simply the difference in the definition of potential output.[8]

Below, we explain the method used by the Research and Statistics Department of the Bank for

5. "Short-term" here is used as opposed to "long-term" over which the economic structure could change. More details on this are given in Section IV.D. The potential growth rate should not be understood as the desirable growth rate. Rather, as described in Section III.B, in a situation such as Japan now finds itself, where the output gap is large, what is desirable is that the actual growth rate exceeds the potential growth rate and so brings about a contraction in the output gap.
6. Unless otherwise specified, GDP refers to real GDP in this paper.
7. In spite of this, since a discussion couched in terms that are in general use is likely to be more easily followed, we tend to refer to a negative expansion in the output gap as simply an expansion in the output gap for the rest of the paper, except when the context requires us to be specific in order to avoid misunderstanding.
8. See Section IV.B for more details on this point.

the estimation of the potential output and the output gap defined above.

B. Overview of the Estimation Procedure

Our benchmark output gap is estimated using the method known as the production function approach. In this approach, output is determined via a macroeconomic production function made up of the following three variables:

(1) the capital input, or the amount of the available capital stock actually being used;
(2) the labor input, defined as the number of workers multiplied by the number of hours worked; and
(3) TFP, which captures the efficiency with which GDP is produced.

Potential output and the potential growth rate are then obtained from the interrelations between these variables.

We start by assuming a log-linear macro production function:[9]

$$\ln Y = (1-\alpha)\ln K + \alpha \ln L + \ln T. \qquad (2)$$

Here Y is GDP, K the capital input, L the labor input, and T is TFP; α is the labor share (we use the average value since 1990, 0.71), and ln denotes the natural log operator.

In other words, we suppose that output (Y) is determined via the interaction of the capital input (K), the labor input (L), and TFP (T). Given this, we may define potential output, i.e., the level of output attained when all capital and labor resources are fully utilized, as

$$\ln Y^* = (1-\alpha)\ln K^* + \alpha \ln L^* + \ln T. \qquad (3)$$

Here Y^* is potential output, K^* the potential capital input, and L^* the potential labor input.

We calculate the benchmark output gap by substituting into equation (1) the level of potential output (Y^*) obtained here.

With the single exception of actual output (Y), the variables appearing in equations (2) and (3) are all theoretically constructed variables, and so we do not have any directly observable data on them. Some of the variables are relatively easy to obtain from the data, and some are not. For example, while it is exceptionally difficult to find observable data that directly reflect TFP, the actual labor input (L) may reasonably be ascertained from data on the number of workers and the number of hours worked. Similarly, although it is not easy to obtain a figure for just the part (K) of the capital stock that is actually being utilized, since data on the total existing capital stock are available, we may take this to be the potential capital input (K^*). Given these sorts of variations in the extent to which we are able to make use of the data corresponding to each concept, we adopt a procedure in which we start with those items for which we are able to find close approximations in the observable data, and we use these to estimate the remaining variables (Chart 1; all charts are appended following the text), as follows.

(1) Taking data on the capital stock to represent the potential capital input (K^*), we obtain the actual capital input (K) by estimating the proportion of the former that is actually put to use.
(2) Determining the actual labor input (L) by looking at employment data, we estimate the potential labor input (L^*) from the trend of actual labor input.
(3) Having obtained the actual capital input (K) in (1) above and the actual labor input (L) in (2), we can calculate the one remaining unknown, TFP (T), from equation (2).
(4) With the potential capital input (K^*) from (1), the potential labor input (L^*) from (2), and TFP (T) from (3), we can now obtain potential output by substituting these values into equation (3).

These four steps are explained in more detail in the section that follows.

C. Data Employed and Estimation Methodology

Step 1: Potential and actual capital inputs

Since data on the current capital stock are readily available in the form of the Cabinet Office's *Capital Stock of Private Enterprises Statistics*, we take this as the potential capital input (K^*) (Chart 2).[10]

9. This is called the Cobb-Douglas production function, and it is widely used in macroeconomics. It is simple and tractable, but on the other hand it rests upon some *a priori* assumptions made for the sake of this simplicity (namely [1] that there are constant returns to scale, and [2] that the elasticity of substitution between capital and labor is one), and there is a problem regarding whether or not these assumptions are too strong. In order to investigate this point, Kamada and Masuda (2001) adopt the more complex constant elasticity of substitution (CES) production function, which makes less restrictive *a priori* assumptions, and use this to carry out estimations using Japanese data. By looking at the parameters thus obtained, they are able to ascertain that the *a priori* assumptions described above are reasonable.
10. These figures are, however, based in part on estimation. For more details, please refer to the notes to Chart 2.

Conceptually, since the actual capital input (*K*) is that part of the capital stock that is actually being utilized for economic activity at a given point in time, what we have to do is apply the capacity utilization rate to the capital stock obtained above. At this point, while for the manufacturing industry we can use the capacity utilization index published by the Ministry of Economy, Trade and Industry in its *Indices of Industrial Production*, we run into a problem for the nonmanufacturing industry for which we have no data that correspond to the capacity utilization rate. For our benchmark output gap, therefore, we estimate the capacity utilization rate in the nonmanufacturing industry by making use of survey data on the sense of overcapacity in the industry, and also of data on the demand for electricity for business use (Chart 3).[11] In this way, we obtain separate figures for the capacity utilization rates of the manufacturing and nonmanufacturing industries, and we apply these to their respective capital stocks in order to estimate the actual capital stock (*K*) employed at a given time.

Step 2: Actual and potential labor inputs

In contrast to capital, for labor it is easier to acquire data on the actual labor input (*L*) than on the potential labor input. Specifically, we make use of figures for the number of those in employment taken from the *Labour Force Survey* (Ministry of Public Management, Home Affairs, Posts and Telecommunications) and for average hours worked per person taken from the Ministry of Health, Labour and Welfare's *Monthly Labour Survey* and multiply these figures to obtain the actual labor input (*L*), which takes into consideration both population and working hours.

On the other hand, for the potential labor input (*L**) that we are unable to observe, we first of all decompose the actual labor input (*L*) into its three structural components, (1) the number of workers, (2) regular working hours, and (3) overtime working hours; we then carry out estimation based on the trends or past maximum values observed for each of these structural components. The following provides more details.

a. Number of workers

Starting with the proportion of those in work to the population (workers' population ratio), we draw an upper-bound trend line to act as a ceiling. We take the number of those who would be in work according to this upper-bound trend to be the possible work force, i.e., the potential number of employed, at a given point in time (Chart 4). However, since there is a substantial gap between the absolute levels of the workers' population ratio for those under 65 and for those 65 or older, we perform the operation described above for each age group separately. Taking the appropriate population weights for the two age groups, we combine the two upper-bound trend lines to construct the potential number of workers in the total labor market (Chart 5).

b. Regular working hours

Due to revisions in the Labor Standards Law, regular working hours have undergone step-like reductions (shorter working hours) in two phases: (1) in between the end of the 1980s and the beginning of the 1990s; and (2) toward the end of the 1990s. Thus, drawing a trend line that roughly traces the upper-bound of these regular working hours, we get a kinked trend line that takes into account these systemic changes. By reading regular working hours off this trend line, we obtain the potential regular working hours at any given point in time (Chart 6 [1]).[12]

c. Overtime working hours

Overtime hours being sensitive to changes in economic conditions, this variable reached an extremely high level between the end of the 1980s and about 1990, i.e., the period that marked the peak of the asset bubble. Thinking of this level as

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11. The method here is first to estimate the electricity usage necessary for full capacity utilization, and then to calculate the proportion of this constituted by actual electricity usage. This proportion is taken as the capacity utilization rate. However, since electricity demand may be too volatile, we use the survey data on the sense of overcapacity (from the Ministry of Finance's *Business Outlook Survey*) in order to remove the noise. For more details, refer to Kamada and Masuda (2001).

The benchmark output gap used in this paper is known in Kamada and Masuda (2001) and in the literature up until now as the output gap *adjusted by the capacity utilization rate of nonmanufacturers*. This name was given to contrast with the output gap estimated by the Research and Statistics Department of the Bank of Japan for convenience under the assumption that the capacity utilization rate in the nonmanufacturing industry is fixed at a certain level.

12. With the regular working hours undergoing step-like reductions following revisions in the Labor Standards Law, by which maximum weekly working hours were reduced from 48 to 46 in April 1988, 46 to 44 in April 1991, and 44 to 40 in April 1994, we see the trend line sloping downward between 1988 and 1994. There was, however, a grace period for full implementation of the legal revision extended mainly for the benefit of small and medium-sized businesses. This grace period lapsed in March 1997, and so we see the second gradual downward trend taking place from 1997–99.

representing the physical limit of possible overtime, we take this to be *potential overtime* (Chart 6 [2]).

Using the results of items a–c obtained above, we calculate the potential labor input (L^*) by taking the potential number of workers and multiplying this by the sum of potential regular working hours and potential overtime.

Steps 3 and 4: TFP, the output gap, and the potential growth rate

The next item that we wish to determine is TFP (T) in equation (2) above. Since we have already obtained the actual capital (K) and labor (L) inputs, and the left-hand side of equation (2) comprises actual GDP, we are able to retrieve the only remaining unknown, TFP, from this equation. We may interpret the residual retrieved in this way, the only part of actual GDP that is not explained by the capital or labor inputs, as the part that reflects productivity.[13]

At this point, we have obtained a full complement of the variables that appear on the right-hand side of equation (3): namely, the potential capital input (K^*), the potential labor input (L^*), and TFP (T). We can thus determine potential output (Y^*) from equation (3), and so obtain the output gap from equation (1).

Although this completes our calculation of the output gap, it should be noted that the process through which potential output (Y^*) is determined results in a series which displays considerable noise. This is because the TFP term, derived as the residual in equation (2), includes all the irregular fluctuations and statistical noise that were contained in GDP data *per se* (the thin line in Chart 7). To get a more candid picture of potential output and the potential growth rate,[14] we apply the method known as the HP filter (explained later), and remove the noise from the TFP term (the thick line in Chart 7).

III. Characteristics of the Benchmark Output Gap

A. The Potential Growth Rate and the Output Gap in Japan

Turning to the results of our estimations, we see first of all that the potential growth rate, which stood at around 4 percent during the 1980s, displayed a continuous downward trend throughout the 1990s and has recently fallen to about the 1 percent level (Chart 8). Lying behind this are declines in the respective growth rates of the capital stock, the potential labor supply, and TFP (Chart 9).[15] Of these, the decline in the labor supply reflects the influence of a declining and aging population, and so represents something of a given for the economy.[16] In addition to the fact that the stagnant capital investment lies behind the decline in the rate of growth of the capital stock, the decline in the growth rate of TFP indicates that there has been a drop in the efficiency of the Japanese economy. The collapse of the asset bubble economy and the progress of globalization resulted in substantial changes to the economic environment, but in spite of this, since the 1990s the Japanese economy has failed to shift capital and labor resources from sectors with declining profitability to those with the potential for high profitability. The result is that a certain amount of capital and labor's ability to create economic value, in other words, macroeconomic efficiency, has been lost, and thus the growth rate of TFP has suffered a significant decline.

The trend growth of actual output has been consistently below even this lower potential growth rate. Given that when the actual growth rate falls below the potential growth rate this causes the output gap to expand, a look at changes over time in the output gap since the bursting of the bubble reveals that, notwithstanding some cyclical fluctuations, the trend movement has been toward expansion,

13. The TFP retrieved in this way is known as the "Solow residual," after the noted economist Robert Solow, who carried out pioneering research based on the same idea.
14. The noise contained in TFP and hence in potential output is nothing other than the noise that was contained in the original data for actual GDP. Consequently, when we subtract potential output from actual GDP in calculating the output gap, by leaving the noise in potential output we can get the two noise terms automatically to cancel one another out.
15. The potential growth rate is marked by occasional discrete jumps (second quarter, 1998; third quarter, 1994, etc.). Looking at the factor decomposition in Chart 9, it is evident that this is the result of discrete shifts in the rate of change of the potential labor input, with these points of non-continuity corresponding to kinks in the upper-bound trend line which was fitted to regular working hours (c.f. Chart 6 [1]). Since these discrete jumps in the potential growth rate are an artificial construct of our handling of the data, it is perhaps best to think of them in terms of a smooth join between the values before and the values after.
16. However, if the flexibility of the labor market were to improve and employment opportunities for older workers were to increase, then (compared to the inflexible labor market case) there could be an upward shift in the trend of the labor force participation ratio.

with the output gap today extremely wide (Chart 10). This wide output gap may be thought of as the fundamental backdrop to the continuing gradual decline in current prices. We therefore turn our attention next to the relationship between the output gap and the inflation rate.

B. Relationship between the Output Gap and the Inflation Rate

The relationship referred to as the Phillips curve is one that is well known in macroeconomics. The negative correlation between the unemployment rate and wages was originally observed as a rule-of-thumb by Phillips (1958). However, given the close relationship between wages and prices, since Samuelson and Solow (1960), it is the inverse correlation between the unemployment rate and the inflation rate that has been usually referred to as the Phillips curve. Nowadays, it has become increasingly common to replace the unemployment rate with the macro-level supply and demand gap, so that the Phillips curve traces the relationship between the output gap and the inflation rate (the sloping arrows in Chart 11).[17]

The usefulness of the output gap as an indicator of pressure for price change is premised upon the existence of this downward-sloping Phillips curve. Actual prices are, however, influenced by a variety of factors other than macro-level supply and demand. Typically when import prices fluctuate as a result of changes in oil prices or exchange rates, we may observe movements in prices that are difficult to explain solely by appealing to business cycles. Additionally, it has been pointed out that, when for example inflationary expectations escalate and a predisposition toward high inflation becomes entrenched in the economy, even if the supply and demand balance slackens it is theoretically plausible for the inflation rate to remain stubbornly high. Indeed, precisely this phenomenon was actually observed in the 1970s and 1980s in a number of countries. This phenomenon of movements in inflation springing not from the direct relationship with the output gap but from changes in inflationary expectations or in import prices is captured conceptually by upward and downward shifts in the Phillips curve (the vertical directional arrows in Chart 11).

When looking at the actual economy, not only are movements along the downward-sloping Phillips curve difficult to distinguish from upward and downward shifts in the Phillips curve itself, but, as we discuss below, it is possible that there are significant measurement errors in our estimates of the output gap itself. Consequently, there is no *a priori* guarantee that we will actually be able to observe the posited downward-sloping relationship between the output gap and the inflation rate. We do, therefore, plot an actual Phillips curve, using data spanning the last 20 years on the year-to-year change in consumer prices (nationwide, excluding perishables, and after adjustment for consumption tax) and our benchmark output gap.[18] Looking at the Phillips curve thus obtained, we observe that, for this particular period, there is an unmistakable, if only broad, downward-sloping relationship (Chart 12). In fact, we obtain the following broad quantitative relationship from our regression: an expansion in the output gap of 1 percentage point will result in, on average, a roughly 0.4 percent decline in the inflation rate (see the text accompanying Chart 12).[19]

Needless to say, as we discuss below, we must bear in mind that there is a considerable margin for potential error in estimates of this quantitative relationship. Likewise, this broad relationship holds true only for the particular period, the last 20 years or so, which we examine here. When we include the period of high inflation in the 1970s, for example, the relationship breaks down, so that there is clearly no guarantee that it will continue to be stable over

17. For example, comprehensive discussion by Stock and Watson (1999) of the applications of the Phillips curve from the standpoint of inflation forecasting bases its treatment on the Phillips curve that makes use of the output gap. The existence of a close relationship between the unemployment rate and the output gap, meanwhile, is known as Okun's Law.

18. From here on, with the exception of occasions when there is the possibility of misunderstanding, we refer to the year-to-year change in consumer prices (nationwide, excluding perishables, and after adjustment for consumption tax) simply as the "inflation rate," without specifying further.

With regard to the inter-temporal correlation between the output gap and the inflation rate, according to our estimations the correlation coefficient is greatest when the inflation rate lags the output gap by one quarter. However, since there is not much difference between this and the contemporaneous correlation coefficient, here we plot simply the contemporaneous output gap and inflation rate.

19. The regression here is simply an estimate of the empirical relationship observed between the output gap and the inflation rate as they stand. For a survey and application of methods that estimate the Phillips curve more strictly, looking to distinguish the influence of other factors affecting price movements such as changes in import prices or inflationary expectations, refer to Mio (2000), whose paper also discusses the ways to capture the underlying inflation rate.

the long term.[20] Similarly, looking at the short term (periods of 1–2 years), movements in the inflation rate regularly defy explanation in terms of the output gap, so that care needs to be taken here also. Although we must pay due attention to these points, we may still reasonably claim that, from the empirically observed downward-sloping relationship described above, the gradual decline in the inflation rate from its peak at around the beginning of the 1990s to the slightly negative position in which it has found itself in recent years may be seen fundamentally to reflect the expansionary trend witnessed in the output gap over the same period.

C. Factors Other than the Output Gap That Affect Price Movements and Measurement Error

As described above, we observe a downward-sloping relationship between the output gap and the inflation rate, although it is true that, as we have already touched upon, there is considerable variance that should be borne in mind when considering this relationship. Turning back to our Phillips curve regression, we note that the standard deviation is as much as 0.7 percent, which means that when we look at the 95 percent confidence interval, there is a band of 2.7 percentage points containing the inflation rate corresponding to a given output gap. We must admit that, when we consider the small changes in inflation witnessed in recent years, this band is uncomfortably wide. Indeed, when we divide the Phillips curve into separate sections, there are more than a few phases during which the relationship between the output gap and the inflation rate is very far from being downward-sloping. For example, if we look locally at the periods 1993–95 and 1999–2000, we see that, in direct contrast to the overall shape, the curves here are actually upward-sloping. Similarly, turning to movements during the period from 2000 until the present, we see that, while the output gap has been expanding, the rate of decline in prices has hardly changed at all so that the Phillips curve is almost completely horizontal (the relevant phases are enlarged and illustrated in Chart 13).

There are two fundamental reasons why there are so many instances in which, in the short term, there is almost no observable relationship between the output gap and inflation: (1) there are factors other than the output gap that influence the inflation rate, and (2) there are errors present in our estimation of the output gap.[21]

With regard to reason (1), when we look for example at any of the three phases mentioned above, it is entirely possible that movements in exchange rates and imports of consumer goods had a significant influence upon the inflation rate. Specifically, phases 1 (1993–95) and 2 (1999–2000) correspond to periods in which the influence of the strong yen was being felt, at a time when there was a surge in the manufacturing power of China and the other East Asian countries. These two factors worked together to cause a sudden jump in Japanese imports of consumer goods (Chart 14). The influences of such developments were felt not only through a reduction in product costs, but also through competition and streamlining in the market for consumer goods and the distribution sector, which may be thought of as factors, quite separate from changes in economic conditions, working to push prices down. On the other hand, in phase 3 (2000 up until the present), in direct contrast to the previous two phases, the yen was rather weak, and there was a pause in surging imports of consumer goods. It is reasonable to assume that these factors contributed to a rate of price decline that remained roughly steady, despite the expansion of the output gap.[22]

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20. As we discuss below, theoretically speaking, over the long term changes in inflationary expectations (i.e., shifts in the Phillips curve) make the downward-sloping relationship difficult to discern, and the long-term Phillips curve is thought to be a vertical line. We may put forward two possible reasons why, in spite of this, we observe a downward-sloping relationship in the actual data even over the relatively long-term period of the last 20 years: (1) even though this may be a relatively long period, it is still not long enough to include an event such as an oil shock that might have a significant effect on inflationary expectations; and (2) in fact, even over the past 20 years inflationary expectations have been gradually trending downward, but this has been accompanied by compensatory rightward shifts in the Phillips curve due to various factors so that the net effect has been to preserve the downward-sloping relationship. Since the latter requires rather more explanation than is given here, we go into more detail in Sections IV.B and IV.C.2.

21. There is also the problem that there may be measurement errors in the inflation rate itself. On this point, refer to, for example, Shiratsuka (2000).

22. There is also research from a more broad-based standpoint, suggesting that in recent years a large number of countries have been experiencing declining rates of inflation, and that in the context of the effect of the downward rigidity in wages upon the economy, it is not only in Japan but throughout the world that the Phillips curve has begun to display a more gentle slope. Refer to Nishizaki and Watanabe (2000) for Japan, and to Akerlof *et al.* (1996) for the situation overseas.

Concerning reason (2), that there may be errors in the estimation of the output gap, we should recall what was discussed in Section II, namely that the output gap is not only a highly artificial construct in itself, but there is also some slippage between the concept and the data that is actually available as well as issues surrounding the assumptions underlying the estimation. There are a variety of factors that could produce estimation error.[23] For example, as we described above, the potential labor input (L^*) is estimated based on the trend observed in the ratio of workers to the population. However, there is substantial variation in the results depending on the choice of point from which to draw this trend line, or putting it another way, where we decide the trend has undergone a substantial change (Chart 15).[24] Thus our handling of the data affects potential output, and hence becomes a factor that potentially causes errors in our estimation of the output gap. Taking such points into consideration, we need to interpret our measure of the output gap as one that is subject to substantial variability.

IV. Other Issues Concerning the Output Gap

A. Advantages of the Benchmark Output Gap

There are various ways of estimating the output gap. The Research and Statistics Department of the Bank uses the output gap that is introduced here as the benchmark output gap most frequently when it carries out its analysis of price conditions. This is chiefly because it possesses the following two advantages.

Firstly, since the factors that make up the macro production function are aggregated in a simple way when estimating potential output, it is easy, compared to the other approaches introduced below, to demonstrate the basis for our thinking when making some hypothesis about the future of potential output and hence of the output gap. More specifically, we are able to assume the future potential output with an explicit awareness of consistency with individual components, i.e., the future growth rate of the capital stock (the potential capital input), the future growth rate of the labor force (the potential labor input), and the growth rate of TFP. When looking at a central bank's outlook for prices, more significant than the headline forecast itself are the thinking that lies behind that forecast and the evaluation of the risk that prices will not move in accordance with the forecast. When we take this into consideration, easy intelligibility of our premises about the outlook for potential output and hence for the output gap may be considered a merit in itself.

The second advantage lies in the stable relationship, albeit only a broad one, which, as described above, is observed between our benchmark output gap and the inflation rate at least over the period of the last 20 years. When we consider that the effects of monetary policy are not certain and may often be thought to take place with a substantial time lag, it becomes important for the central bank not only, of course, to pay due attention to short-term movements in inflation, but also to keep within its field of vision inflationary or deflationary pressure over a several-year horizon, thinking about how to evaluate this pressure and how to incorporate assessments of the risks into monetary policy. For this reason, the fact that we observe the above relationship between the benchmark output gap and the inflation rate may be considered an advantage in terms of practicality.

B. Disadvantages of the Benchmark Output Gap

The benchmark output gap does, however, have some disadvantages, of which we mention three here.

First, in comparison to the other methods introduced below, it cannot be denied that the benchmark output gap, which is estimated using a large amount of information gleaned from trends and past maximum values of several data series, tends to be somewhat slow to respond to structural changes in the economy. A typical example is provided by the estimation of the trend line for the ratio of workers to the total population, mentioned in Section III.C as one of the possible causes of estimation error. Without the benefit of data (on the years to come) which have yet to be accumulated, it is, of course, premature to determine whether or not there is actually a downward kink in the data

23. Kamada and Masuda (2001) offer a comprehensive treatment of the influence of statistical errors on the estimation of potential output and the output gap.
24. Osawa *et al.* (2002) and Kuroda-Nakada (2002) point out that recently the labor force participation rate in Japan, especially among the young, may have experienced a structural decline. Also, when drawing a linear trend for data that represent the ratio of workers to the total population, since at some point this line will exceed 100 percent (or alternatively drop below zero percent), it is inevitable that a kink in the line will occur somewhere.

trend. However, if some such change of trend has already taken place, our benchmark output gap, which neglects that possibility, will contain some bias to exaggerate the negative expansion.[25]

Second, because of the fundamental difference in the concepts of the supply capacity, i.e., of potential output, we are unable to carry out direct comparisons between our benchmark output gap and other estimates produced, for example, by international institutions.[26] Specifically, as we indicated at the very beginning of this paper, our benchmark output gap is determined based on a definition of potential output as the level of economic activity that would be reached *assuming that labor and capital resources are used to their fullest potential* within the existing economic structure. The result of this is that our benchmark output gap takes the value of zero when the economy is operating at full capacity, and it takes on a negative value at any other time.[27] In contrast to this, measures of the output gap adopted by other institutions tend to define potential output in terms of some neutral output such as the level of output consistent with a non-accelerating inflation rate, dealt with below.[28] They then adopt this as the zero level of the output gap, meaning that when the operational level of the economy is higher the output gap takes a positive value, and when the operational level is lower it takes a negative value. It is mainly because of this difference in where the zero value is placed that when, for example, the benchmark output gap registers a value of –8.9 percent for 2001, the corresponding figure calculated by the Organisation for Economic Co-operation and Development (OECD) is of a completely different order and stands at –1.4 percent. The reasons behind our decision not to adopt a zero point that may in some way or other be described as "neutral" when estimating our benchmark output gap are as follows: (1) considerable uncertainty attends the estimation of where this zero point should actually lie; and (2) when, in spite of all the uncertainty involved, we establish a zero point in this way, it is possible that, rather than clarifying the analysis, we may cause confusion and misunderstanding about exactly what is signified by this zero point. Leaving aside the question of which methodology is to be preferred, the fact remains that our benchmark output gap and the measures of the output gap produced by other institutions are not directly comparable, and care therefore needs to be taken here.

The third disadvantage, related to that discussed above, is that the relationship between the benchmark output gap and the inflation rate is not entirely consistent with economic theory. If (as in Chart 12) we depict the empirical relationship between the output gap and the inflation rate in simple linear terms, even with a sizeable spread, then the implication is that an expansion in the output gap will be accompanied by a fall in the inflation rate, but that if the output gap remains for a while unchanged at this new level then there will be no further fall in the inflation rate. This is, however, no more than an applied empirical observation. According to theory, it is most commonly assumed that if the output gap remained stuck at a new level in this way then there would be a corresponding change in inflationary expectations (a shift downward of the Phillips curve), and this would result in a further reduction in the inflation rate. Of course, for practical purposes, a relationship that can be roughly applied empirically, even if it is not strictly consistent with theory, has useful aspects, and this is one reason why, as mentioned earlier, the Research and Statistics Department of the Bank chooses to make use of the benchmark output gap. When considering the pressure for price change that is suggested by this benchmark output gap, however, it is clearly necessary to bear in mind the discrepancy with generally accepted theory detailed above.

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25. In addition, during phases in which there is an acceleration in the speed of change in the economic structure and in the spread of IT so that plant and machinery become obsolete more quickly, it is likely that the data on the capital stock will increasingly evince a tendency to overestimate the economically meaningful stock. In such a case, TFP, which we determined as a residual, will by contrast tend to be underestimated, and the decomposition of the contributions of individual factors to the potential growth rate (Chart 9) will become distorted. Even if the estimate of the potential growth rate itself were to be correct, since our thinking about the prospects for the output gap is based on this decomposition of the contribution of individual factors to the current potential growth rate, distortion here would still be a problem.

26. For an outline of the measures of the output gap produced by other institutions, please refer to the Box on pages 38–39.

27. During the asset bubble, at the point when supply and demand conditions were at their tightest, our benchmark output gap registered a value at somewhere between –1 and –2 percent (Chart 10).

28. For example, the Congressional Budget Office (CBO) defines potential output as "the level of real GDP in a given year that is consistent with a stable rate of inflation" (CBO [1995]). Former FRB director Meyer's definition of "sustainable supply," quoted in the introduction of this paper, may be considered to have much the same meaning.

C. Measures of the Output Gap Based on Other Approaches

Since the benchmark output gap has the several disadvantages detailed above, the Research and Statistics Department of the Bank bolsters its research by making use of various other measures of the output gap based on alternative approaches. In the sections that follow, we provide details on two differing methodologies for estimating the output gap: (1) the HP filter approach and (2) the time-varying NAIRU approach. In addition, we introduce (3) a proxy indicator of the output gap that makes use of the *Tankan* diffusion indices and (4) we compare the actual changes in these indicators over time.

1. The output gap based on the HP filter approach

In response to the first of the shortcomings of the benchmark output gap mentioned above, namely that it is rather slow to reflect structural changes, one of the methods that may be employed is fitting a nonlinear trend curve that follows changes in the most recent data so that the trend curve becomes less constrained by past values of the data as time progresses. The most widely used method of fitting such a nonlinear trend is the HP filter.[29] In the current case, the simplest technique involves applying the HP filter to the GDP time series, and then taking the resultant nonlinear trend curve to represent potential output (Chart 16). Since potential output obtained in such a way traces a curve that sticks closely to movements in actual output, which fluctuates cyclically, the corresponding output gap that is centered upon this may take either positive or negative values. In this way, the HP approach also, in a simple and convenient manner, overcomes the second of the shortcomings of the benchmark output gap mentioned above, specifically the problem of where the zero point is defined.

The major advantage of this method is that the estimation is simple to perform. Another advantage is that, should there actually be a structural change so that the output trend develops a kink, this kink will be reflected in the estimation of potential output relatively swiftly. The reverse side of such an advantage, however, is that when large fluctuations that do not involve any core structural changes occur, such as during an asset bubble or a long-lasting recession, the resultant figures for potential output also follow such fluctuations closely. With the absolute value of the output gap being calculated as the difference between actual and potential output, it therefore becomes highly likely that disequilibrium in the economy will be underestimated. In short, in direct contrast to the benchmark output gap, cyclical fluctuations are liable to misinterpretation as structural changes. In addition, there are several other practical problems associated with this method, such as the facts, inevitable in trend curve methods of this type, that estimates for recent periods may change significantly as soon as new data are appended, and also that, since the method is entirely data-dependent without appeal to any theory, it is difficult to form hypotheses about the future potential output gap.

2. The output gap based on the time-varying NAIRU approach

The time-varying NAIRU approach that we introduce here is one way of mitigating the third shortcoming of the benchmark output gap, namely its conceptual inconsistency with the way the output gap is expected to function in theory. As explained above, it is most commonly assumed that, in theory, when the output gap remains at the same level for some time, this will work through changes in inflationary expectations to cause the actual inflation rate to change continuously. However, even in this case, it is thought that there is one particular level of the output gap for which the inflation rate remains fixed wherever it is, neither increasing nor decreasing, and this point is known as the NAIRU.[30] Based on this line of reasoning, it is common to take the NAIRU as the zero point of the

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29. The HP filter was named after Hodrick and Prescott, who devised it. More specifically, the HP filter involves drawing a curve that (1) fits the actual data closely and (2) is smooth; and this is accomplished by extracting from the data the nonlinear trend curve that minimizes the following loss function:

$$\text{Loss function} = \sum (\text{trend} - \text{actual data value})^2 + W \times \sum (\text{the trend slope between the previous and current periods} - \text{the trend slope between the period before the previous period and the previous period})^2.$$

W is a positive constant known as the smoothing parameter. When W is small, we get a noisy series very close to the actual data; the larger W is, the closer this series comes to becoming a simple linear trend. To select the well-balanced W, it is common practice to follow Hodrick and Prescott: for annual data, $W = 100$; for quarterly data, $W = 1{,}600$; while for monthly data, $W = 14{,}400$. For more details, refer to Hodrick and Prescott (1997) or Higo and Kuroda-Nakada (1998).

30. The NAIRU was originally used to refer to the "level of unemployment consistent with an inflation rate that is neither increasing nor decreasing." However, just as it has become common to take the Phillips curve out of its original labor market context and to use it to

output gap. More specifically, if we presume the existence of the NAIRU then, even if the output gap is not expanding, so long as it remains at a negative value the inflation rate will continue to decline. The greater the (negative) magnitude of the output gap, the faster this pace of decline will be. The reverse also holds when the output gap is positive: the greater the (positive) magnitude of the gap, the faster the pace at which the inflation rate will accelerate. We can capture this diagrammatically by causing the slope of the Phillips curve to become steeper with the passage of time, pivoting around the NAIRU (Chart 17, case 2). Provisionally speaking, assuming that such a NAIRU exists and that we can establish from the actual data at which percentage level of the benchmark output gap we should set it, then it becomes possible to establish a theoretically meaningful zero point, and so to deal simultaneously with both the second and third shortcomings of the benchmark output gap.

However, as we discussed above, the Japanese data brought us a broadly linear relationship between the benchmark output gap, which is not premised upon the existence of the NAIRU, and the inflation rate (Chart 17, case 1). To put it another way, the phenomenon of a rate of inflation that declines at a faster pace when the output gap stands at a large (negative) value does not seem to occur in reality. Consequently we may intuitively conjecture that finding empirical support for the existence of the NAIRU is likely to be problematic, and indeed it proves to be so. When we try to determine a specific value for the NAIRU, we find that the estimate has an extremely high variance.[31]

One way of bridging this gap between theory and reality is to make use of the hypothesis that the NAIRU itself may be subject to change. This is the *time-varying NAIRU* approach.[32] For example, if we take the premise that the NAIRU exists, but assume that it is not actually fixed and may therefore shift downward for some reason (in other words, we suppose that the true output gap does not expand quite so far), then it becomes possible to reconcile the two observations: that the output gap, based on the notion of a fixed NAIRU, is large; and that the inflation rate is not decreasing at a faster pace (Chart 17, case 3).[33] Looking at the actual results of our estimation of the time-varying NAIRU, we see that it has been moving more or less consistently downward since about the mid-1990s up until the present (Chart 18).[34] This allows us to reconcile thinking premised on the NAIRU, that when the output gap is large the decline in the inflation rate should accelerate, with the empirical fact that the declining trend traced out by the inflation rate does not exhibit any acceleration, by reinterpreting the data to suggest that the decline in the NAIRU itself has meant that the true output gap has not expanded so much. By redefining the zero point of the benchmark output gap to correspond with the variable value of the NAIRU estimated for each respective point in time, we obtain the output gap based on the time-varying NAIRU approach.

A desirable quality of the output gap calculated in this way is its logical consistency with the much-used NAIRU concept. However, even assuming a NAIRU that may vary, we still end up with an estimation error that is far from small so that our estimate needs to be viewed with full awareness of its substantial variance (Chart 18). Moreover, even if we manage to estimate movements in the NAIRU that have taken place in the past, there is still the tricky problem of forecasting changes that are yet to come. In short, the output gap based on the time-varying NAIRU is the product of efforts to find the value *ex post* that best explains actual past movements in

discuss the relationship between the output gap and inflation, it has now become standard practice to define the NAIRU as a particular level of the output gap.

31. For further discussion of the sizeable uncertainty that characterizes the estimation when we try to specify a single value of the NAIRU, refer to Hirose and Kamada (2002).

32. As is explained in more detail in Hirose and Kamada (2001), in cases where interest does not lie with the output gap but it is enough simply to look at the potential growth rate, there are methods of deriving a potential growth rate that is consistent with the NAIRU concept without actually estimating the NAIRU itself directly. In essence, however, these methods are implicitly the same as the approach in which the time-varying NAIRU is estimated. In the United States, in addition to Staiger *et al.* (1997), who discuss the uncertainty inherent in the NAIRU, Gordon (1997) offers support for the idea of a time-varying NAIRU.

33. The idea that it is impossible to discern the existence of the NAIRU (Chart 17, case 1) and the idea that the NAIRU exists but moves over time (Chart 17, case 3) are not mutually exclusive. What Chart 17 tells us is that, for the observed data *A* and *B*, two interpretations are possible: (1) the NAIRU does not exist; or (2) the NAIRU exists but moves over time, while the other interpretation, that the NAIRU exists and is fixed, as illustrated in case 2, is relatively poorly supported by the data. Ultimately, the choice of which of (1) or (2) interpretations to adopt is left to the judgment of the individual researcher, based on the relative advantages and disadvantages of the various methods discussed in this paper.

34. For more details on the method of extracting the time-varying NAIRU, refer to Hirose and Kamada (2002).

the observed inflation rate. As a result, it is difficult to project the future output gap and then to use it as the basis for forecasting future price developments.

3. The *Tankan* DI as an output-gap indicator

Ultimately, the reason that estimating the output gap is difficult lies in the problem of obtaining an accurate picture from the objective data of the level of operation of the factors of production, capital, and labor. One possible way of approaching this problem is to obtain information directly from business management on its sense, at first hand, of the degree to which capital and labor are being held in excess. Based on this line of reasoning, the Research and Statistics Department of the Bank of Japan produces an indicator composed from the diffusion indices measuring production capacity as well as employment conditions, taken from the *Short-Term Economic Survey of Enterprises in Japan* (the *Tankan*).[35] This can be used as a supplementary indicator of the level of economic activity, similar to the output gap, which is useful when analyzing price conditions.[36]

The advantage of such an indicator is that, with a low degree of processing, it does not depend on estimation assumptions and specifications. However, since it does not involve any estimation of the potential growth rate, it is difficult to see whether this indicator will display an improvement or a deterioration for some given economic growth in the future. At the same time, since this is an indicator that does no more than reflect the level of utilization of production resources hoarded within businesses, there is no guarantee of its suitability as a macroeconomic supply-demand indicator that should take due account of the unemployed or the potential labor force that exists outside of businesses.[37]

4. A comparison of the various measures of the output gap

We now turn to a comparison of these various measures of the output gap, and of the potential growth rate which is estimated as a by-product. Looking first of all at the potential growth rate, we observe the following characteristics (Chart 19):

(1) If we restrict our attention to the recent past, the benchmark output gap and the time-varying NAIRU approach produce broadly the same figures for potential growth rate of about 1 percent.

(2) Looking more closely, however, we see that, since the mid-1990s, the estimate of the potential growth rate from the time-varying NAIRU approach has been consistently below that from the benchmark output gap. As explained above, this reflects the broadly consistent decline in the value of the NAIRU that continued throughout this period.[38]

(3) The estimate of the potential growth rate produced via the HP filter approach has stood recently at an extremely low level of just over 0.5 percent. The characteristic feature of this estimation methodology that its estimate of the potential growth rate is easily influenced by the actual economic growth rate is very much in evidence.

Next, we turn to the comparison between the different measures of the output gap (Chart 20). Here, since the benchmark output gap can only register negative values, we align the scale so that its starting point is roughly the same as the other measures of the output gap.[39] We observe the following characteristics:

(1) Even when we carry out a rough realignment of the scales as described above, the benchmark output gap still registers the largest negative value of the three in recent years. Looking at the output gap for 2001, the time-varying NAIRU approach gives –1.7 percent, which is closest to those of other institutions (see the Box on pages 38–39), while the HP filter approach stands at a positive 0.3 percent. In contrast, reading figures for the

35. Since the diffusion index measuring production capacity of the nonmanufacturing sector was first produced in the third quarter of 1990, we are unable to produce composite indicators for periods preceding this date. Also worth mentioning is that we use the labor share as a weight when composing the two diffusion indexes.

36. In issues of the Bank of Japan's *Monthly Report of Recent Economic and Financial Developments* that coincide with months in which the *Tankan* is released (i.e., April, July, October, and December), this composite diffusion index indicator is included as "factors contributing to the change in prices" (see, for example, chart 30 in the December 2002 issue of the *Monthly Report*).

37. It is well known that, as part of Japanese employment practices, excess labor is to a large extent stockpiled within companies during recessions. However, if these types of practice change, or if they have already begun to change, then the *Tankan* diffusion index of employment conditions may underestimate the degree to which there is an excess of labor in the overall macroeconomy and hence contain some bias.

38. The difference in the estimates of the potential growth rate between the time-varying NAIRU approach and the benchmark output gap equals the size of the change in the estimate of the NAIRU for a given period. In other words, when the NAIRU declines, the latter exceeds the former by the amount of the decline.

39. Although the levels of the left and right scales in Chart 20 differ, intervals between values are the same.

benchmark output gap off the realigned (right-hand) scale, we see that the gap has expanded to as much as –4 to –5 percent. As we saw above, since the potential growth rate estimated for the benchmark output gap has been consistently higher since the mid-1990s than the rates estimated using the other approaches, these differences when accumulated over the period result in the observed gap between the respective measures of the output gap.

(2) Looking for reference at the proxy of the output gap based on the *Tankan* diffusion indices, we see that its movement follows, broadly speaking, that of the three measures of the output gap although it is impossible to compare absolute values directly since the unit of measurement is different. If we then turn our attention, in a little more detail, to the differences between cyclical troughs, we observe that, like the benchmark output gap, the trough recorded in 1999 falls below that recorded in 1993–94. However, looking at more recent periods, we see that the trough touched in 2001 is not as low as the one in 1999, and in this the diffusion index resembles the output gap produced using the HP filter.

D. Caveats Relating to Changes in the Economic Structure

When we consider the relationship between the output gap and changes in the economic structure, in addition to issues touched upon earlier relating to how such changes can be correctly reflected in estimation of the output gap and the potential growth rate, there are also some philosophical matters that we must keep in mind in interpreting the estimate of the potential output. Here we mention two points in particular.

First, the potential growth rate that we are considering when we talk about the output gap is always the one predicated on the existing economic structure. It differs from the growth rate that could be achievable if the economic structure were to change and resources were to be distributed with greater efficiency—in other words, if the Japanese economy were to perform absolutely to the best of its ability. Usually, it is clear from the context which of these two separate concepts is being discussed, so that confusion is unlikely to arise. However, in order to avoid any misunderstanding, it is not uncommon to distinguish between the two by calling the potential growth rate referred to in the output gap context the *short-term potential growth rate*, and that referred to in the context of the sustainable growth rate which may be achieved when the economy is at full efficiency the *long-term potential growth rate*. It is with this intention of avoiding misunderstanding that we refer to the "short-term" growth rate of supply capacity in the *Outlook and Risk Assessment of the Economy and Prices*, quoted in the introduction of this paper.

The second point concerns how we ought to consider the influence upon the potential growth rate and hence upon the output gap of the process of structural economic change and increasing efficiency of resource allocation. Thinking simply, we might expect an increase in economic efficiency to result in a rise in the growth rate of TFP and hence in the potential growth rate. Indeed, it is reasonable to assume that in cases (such as the United States in the latter half of the 1990s) when the economy is operating at almost full capacity, a technological innovation that brings about an increase in the sustainable growth rate will also, quite simply, cause the potential growth rate to rise. However, in cases where capital and labor are being left under-utilized in sectors within which there are no longer any prospects for an expansion in demand, and where therefore the increase in economic efficiency is to be gained by shifting these resources to sectors with potential for growth (rather as is hoped for via structural reforms in Japan), we will see for a while the coexistence of (1) the contraction of supply capacity in declining sectors and (2) the expansion of supply capacity in growth sectors.

More specifically, for an economy with a chronically large output gap gradually escaping from this condition as it shifts resources across sectors, there will be a transition period during which it transforms itself from an "old economy" with a low potential growth rate into a "new economy" with a high potential growth rate. Furthermore, it is natural to assume that, during this period when supply capacity in the former is being reduced even as supply capacity in the latter is being expanded, we can no longer be sure whether or not the potential growth rate will rise overall, since these two effects will, to some extent, cancel one another out (Chart 21). While this phenomenon continues, since it will not be easy to determine the direction of the potential growth rate from the macro data on the capital stock and on employment, we may

reasonably expect that, for the duration of the transition period, the uncertainty that attaches to the potential growth rate and hence the output gap will be especially great.

On this point, the HP filter approach and the time-varying NAIRU approach both possess the disposition that they respond flexibly to the most recent output movements and the relationship between these and inflation in estimating the output gap. Meanwhile, our proxy of capacity utilization based on the *Tankan* diffusion indices may be thought to provide a clue as to the true output gap, at least to the extent that the *Tankan* employs a timely sample that reflects well changes in the economic structure. Of course, since up until this juncture the broad downward relationship that exists between the benchmark output gap and the inflation rate has shown little definite sign of breaking down, we do not anticipate any undue problems arising if we continue to place relatively strong emphasis on the benchmark output gap, which outperforms other indicators in terms of intelligibility and consistency with the analyses in the past. However, at times when structural change appears to be accelerating, it is important, as discussed above, to follow closely and compare the movements in other measures of the output gap and to aim to produce a well-balanced analysis.

CONCLUSION

Focusing on the benchmark output gap, used as a primary reference by the Research and Statistics Department of the Bank of Japan, this paper has not only discussed estimation methodologies and the relationship between the output gap and the inflation rate, but also touched on other related issues thought to be important.

In implementing monetary policy to achieve price stability, a central bank is expected not only to make accurate forecasts of future prices, but also to provide an explanation for these. The output gap is a useful statistic for both of these purposes. However, inflation movements often cannot be explained just by looking at the output gap alone. For this reason, while we take the outlook for the output gap as a basis for forecasting prices, we should also balance the advantages and the disadvantages of this indicator, and judgments should be reached only after due consideration has been paid both to a broad range of indicators related to the supply and demand situation and to other determinants of price movements. At the same time, further research in this area should be vigilantly pursued, with the possibility kept in mind that the efficacy of the output gap hitherto employed deteriorates when there is an acceleration in the structural economic change.

Chart 1

Procedure for Estimating the Benchmark Output Gap

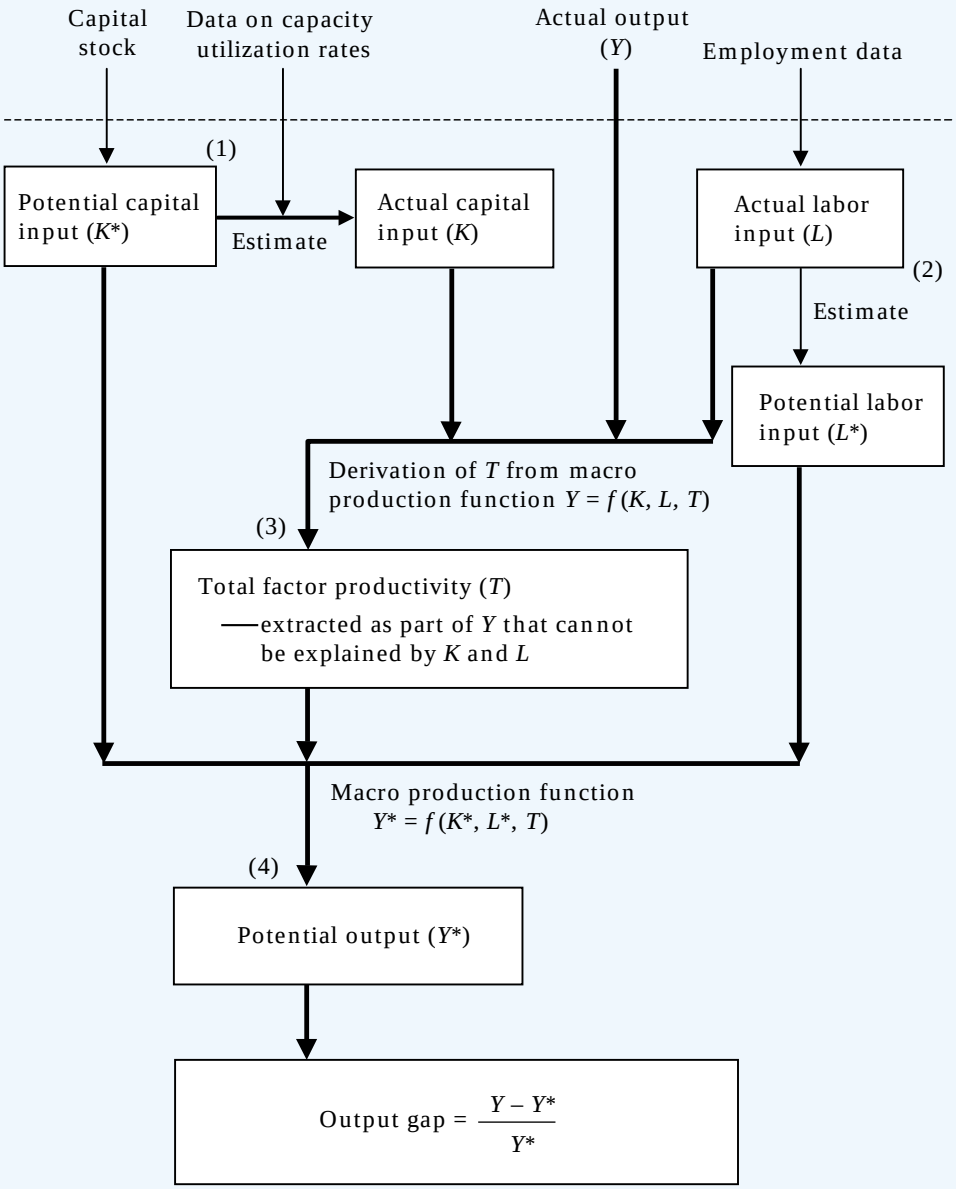
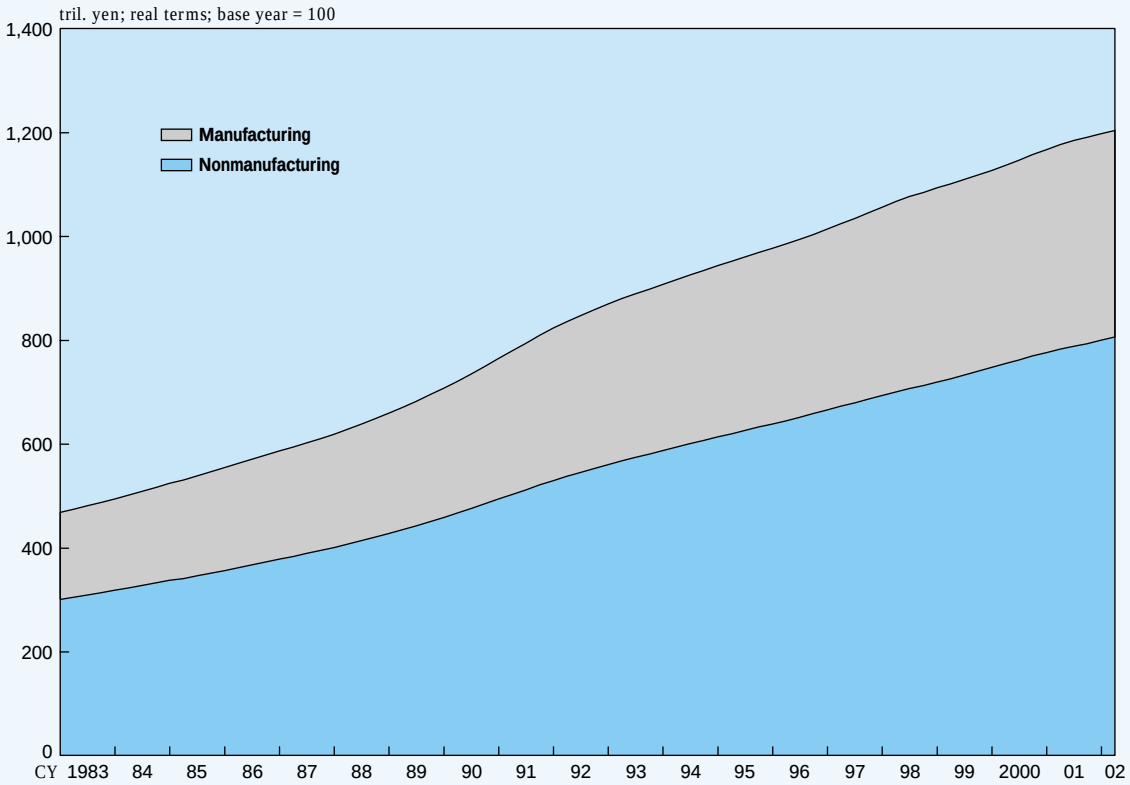


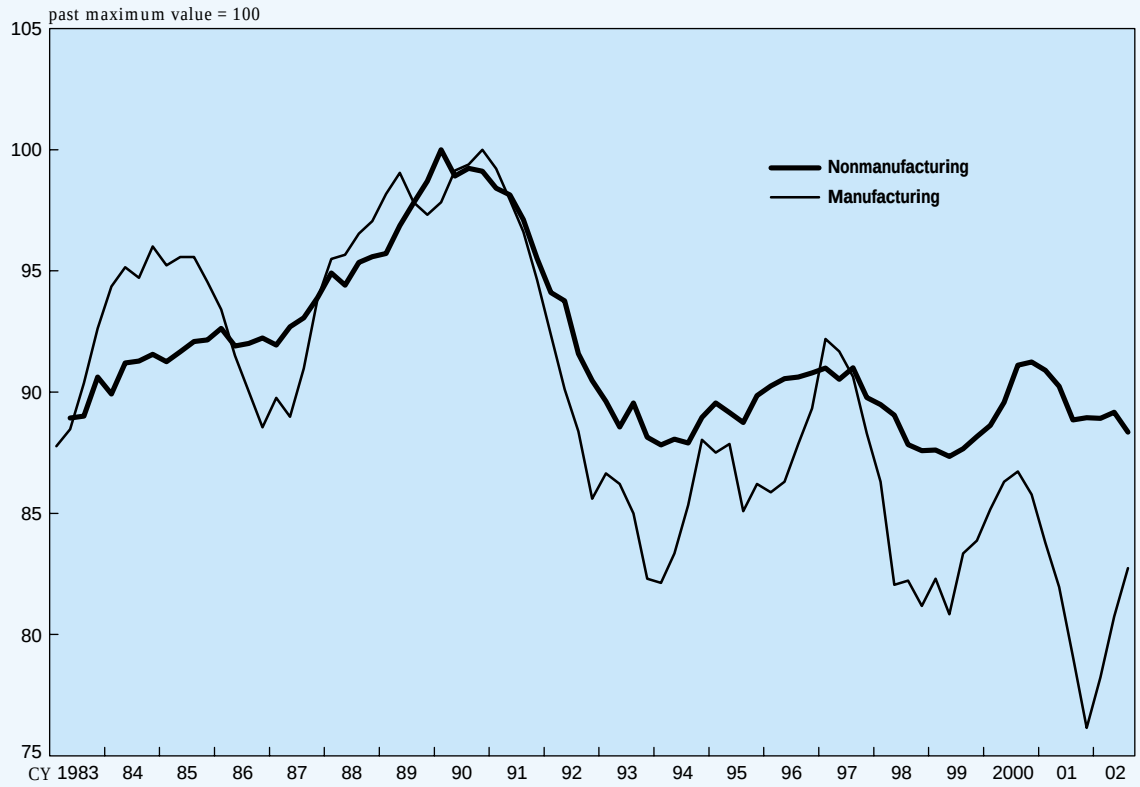
Chart 2
Capital Stock[1,2]



Notes: *1.* Intangible fixed assets are divided up proportionately using, as weights, the respective software orders for manufacturing and nonmanufacturing industries, calculated from "Report on the Survey of Selected Service Industries."
2. Discontinuities in the capital stock caused by the privatization of formerly public companies such as NTT and JR are adjusted for.
Sources: Cabinet Office, "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Tokutei Sabisusangyo Jittai Chousa Houkokusho (Report on the Survey of Selected Service Industries)," available in Japanese only.

Chart 3

Capacity Utilization Rates[1,2]



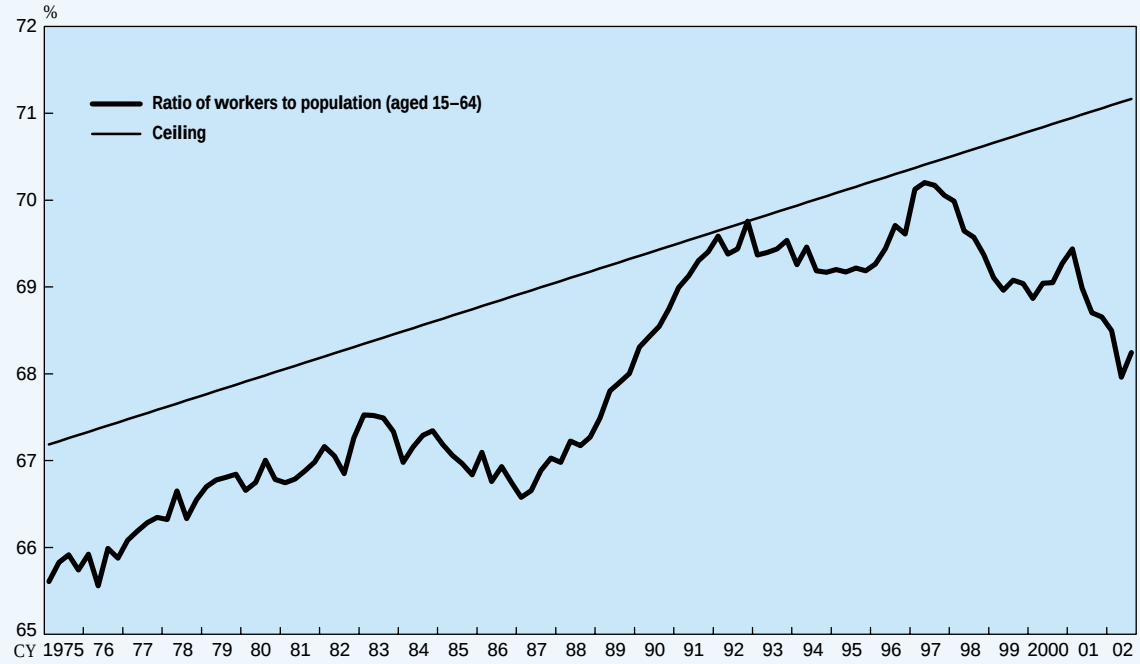
Notes: *1*. To get the capacity utilization rate for nonmanufacturing, we take electrical power for business use as the base unit (defined as actual electrical power usage/contracted electrical power usage), and we then regress this on the investment BSI, a constant, and a time trend. The part that is explained by the BSI and the constant is extracted, and its past maximum value taken as the point of 100 percent capital utilization. Values after 2000 are derived using the results of the regression up to the fourth quarter of 1999 and an extrapolation of the investment BSI.

2. The capacity utilization rate for the manufacturing industry is taken from the "Indices of Industrial Production."

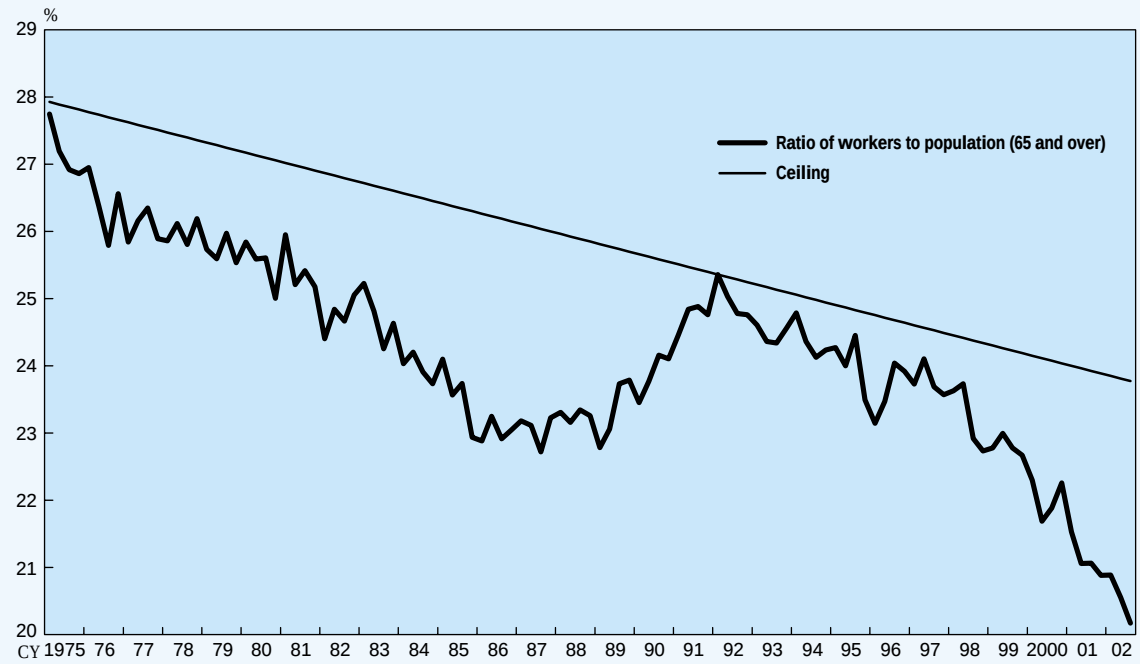
Sources: Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Finance, "Business Outlook Survey";
The Federation of Electric Power Companies of Japan, "Electricity Demand."

Chart 4
Changes in the Ratio of Workers to the Total Population

(1) Workers between the Ages of 15 and 64 (Inclusive)



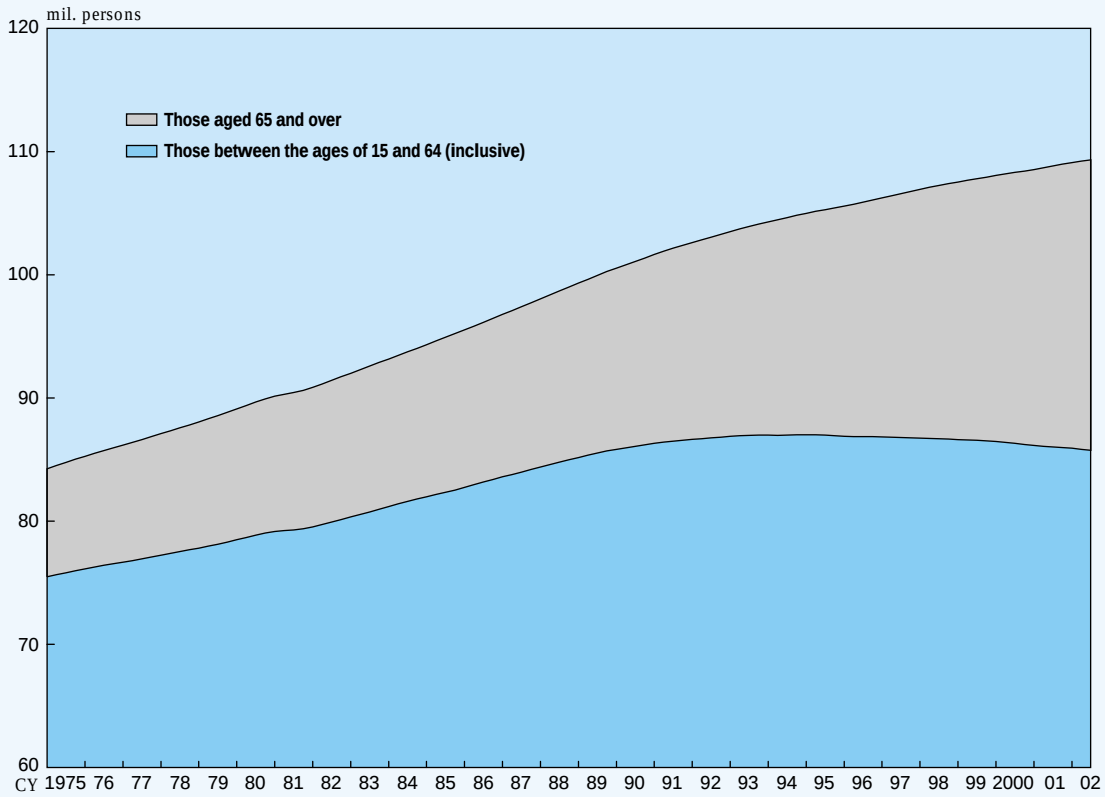
(2) Those Aged 65 and Over



Source: Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Labour Force Survey."

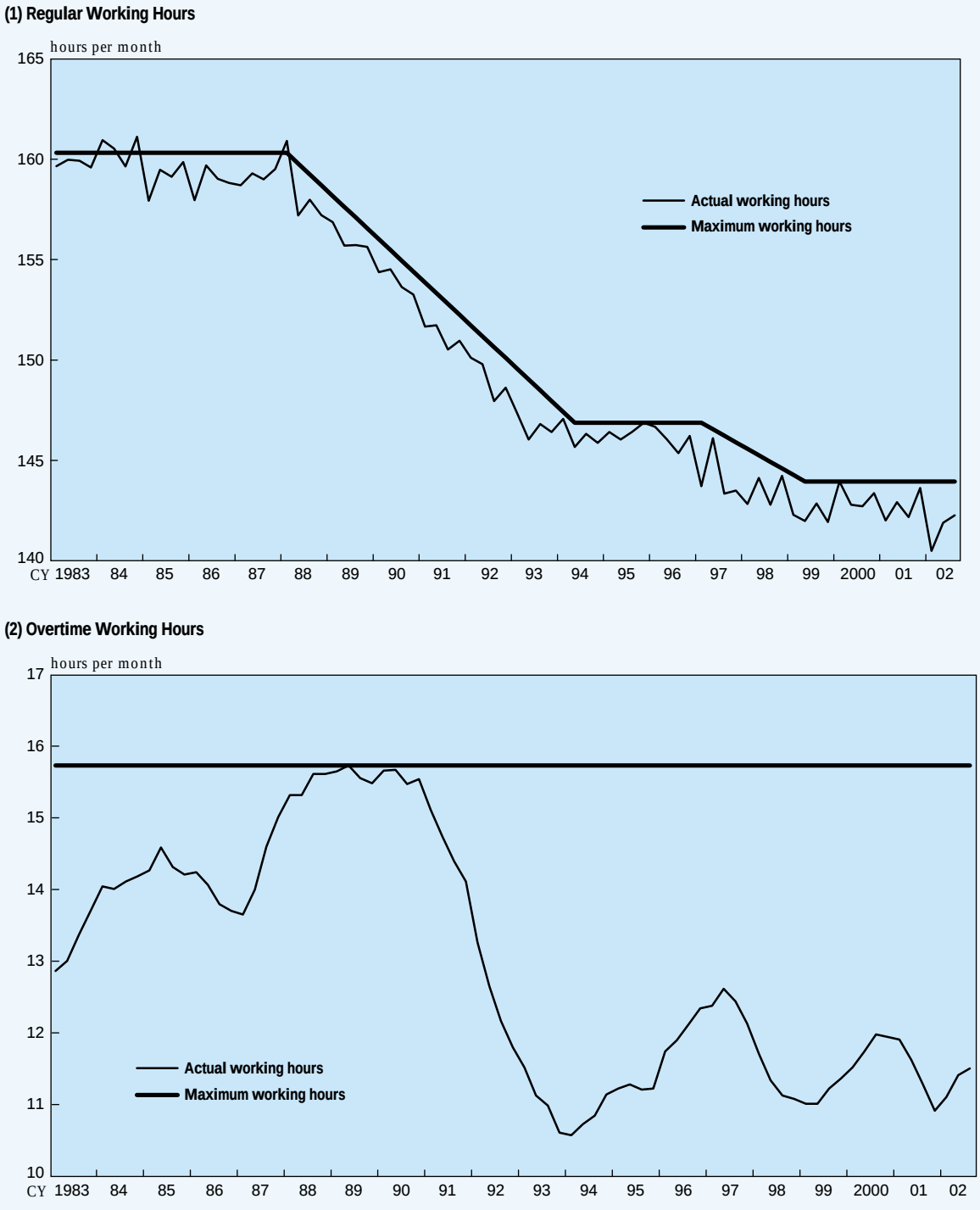
Chart 5

Changes in the Population



Source: Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Labour Force Survey."

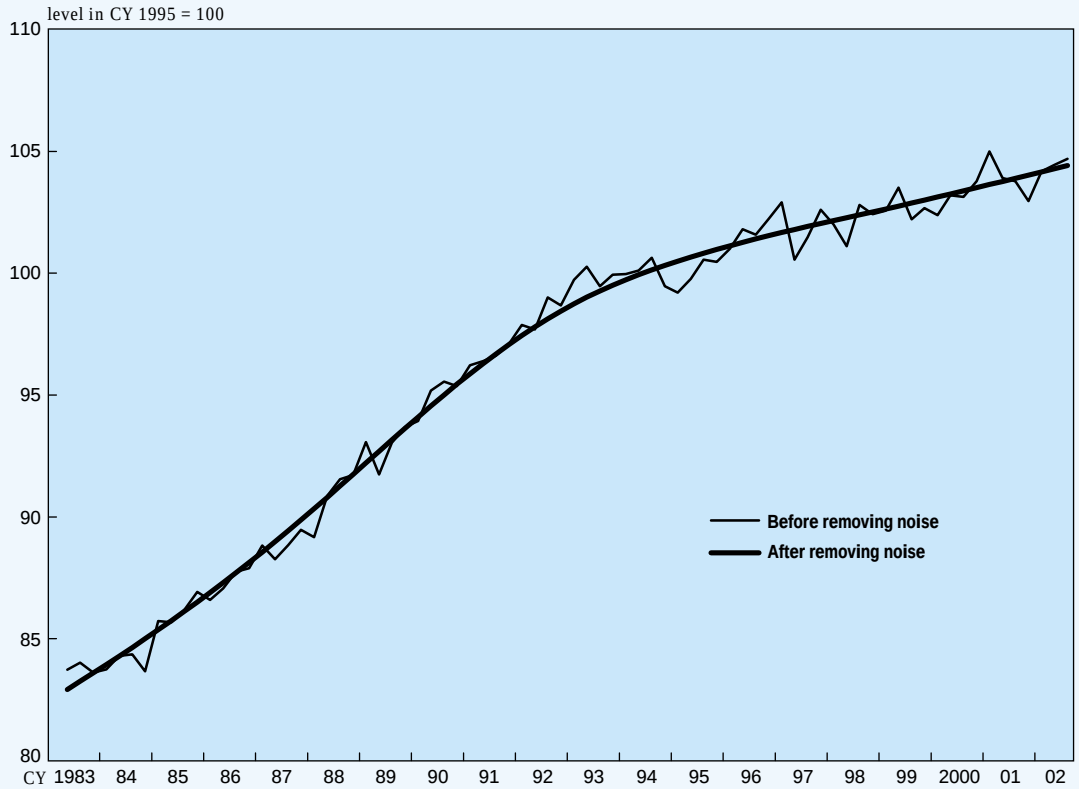
Chart 6
Hours Worked per Person



Source: Ministry of Health, Labour and Welfare, "Monthly Labour Survey."

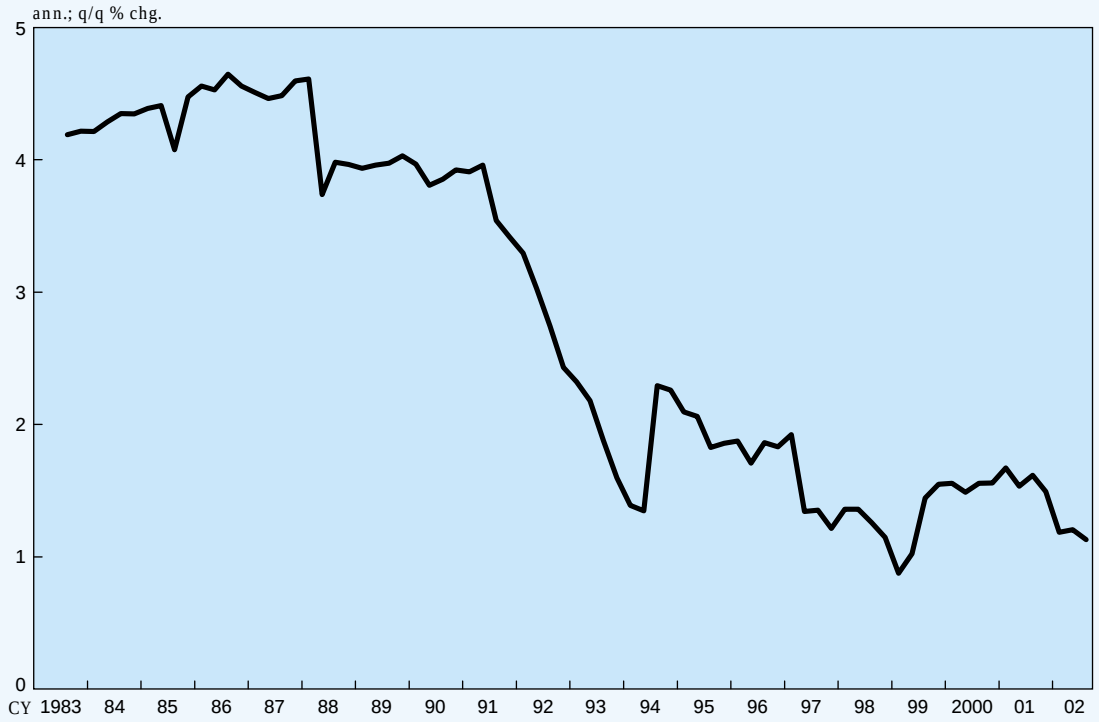
Chart 7

Total Factor Productivity[1]



Note: *1*. The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey," etc.

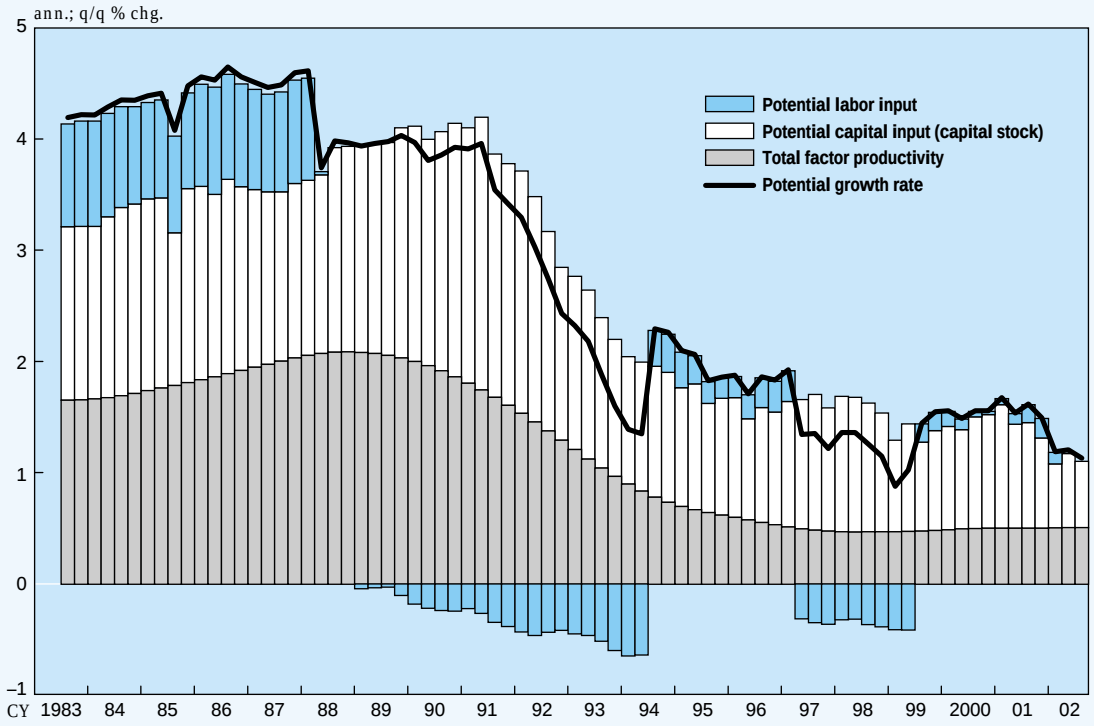
Chart 8
Potential Growth Rate[1]



Note: *1*. The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey," etc.

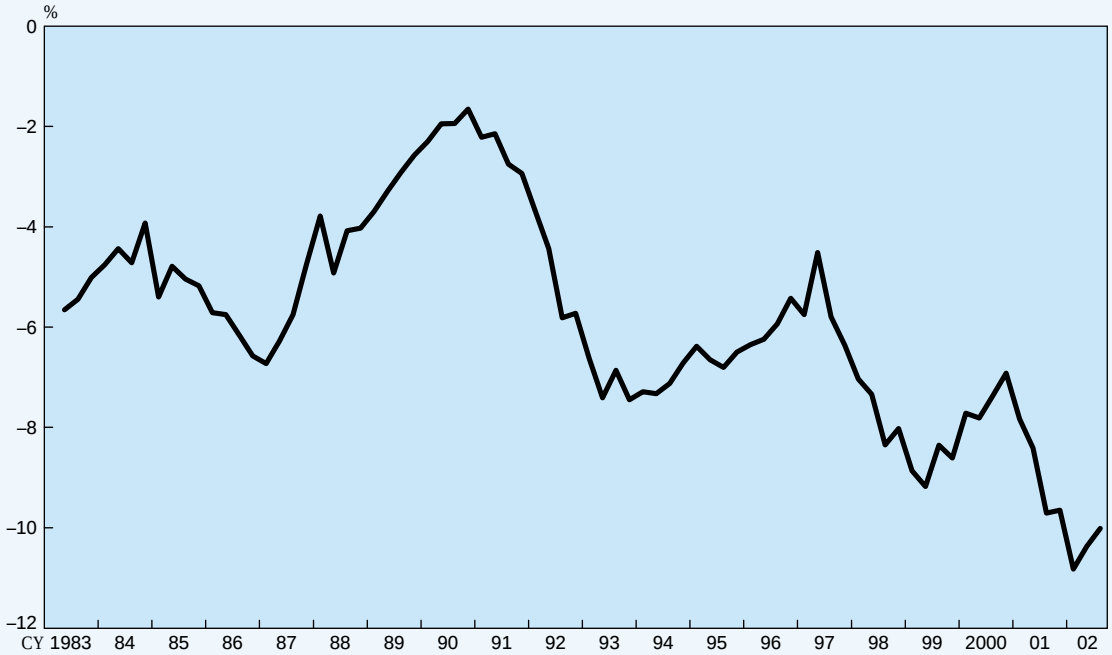
Chart 9

Breakdown of Contributions to the Potential Growth Rate[1]



Note: *1.* The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey," etc.

Chart 10
Benchmark Output Gap[1]



Note: *1*. The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey," etc.

Chart 11

Phillips Curve (Conceptual Diagram)

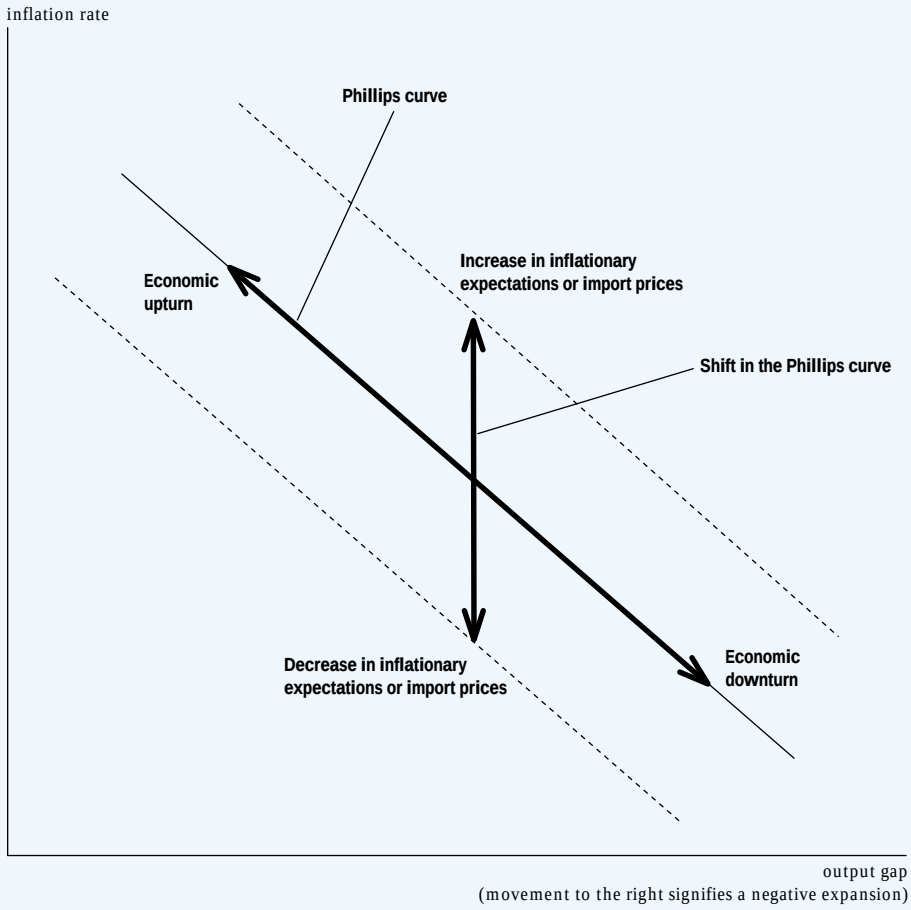
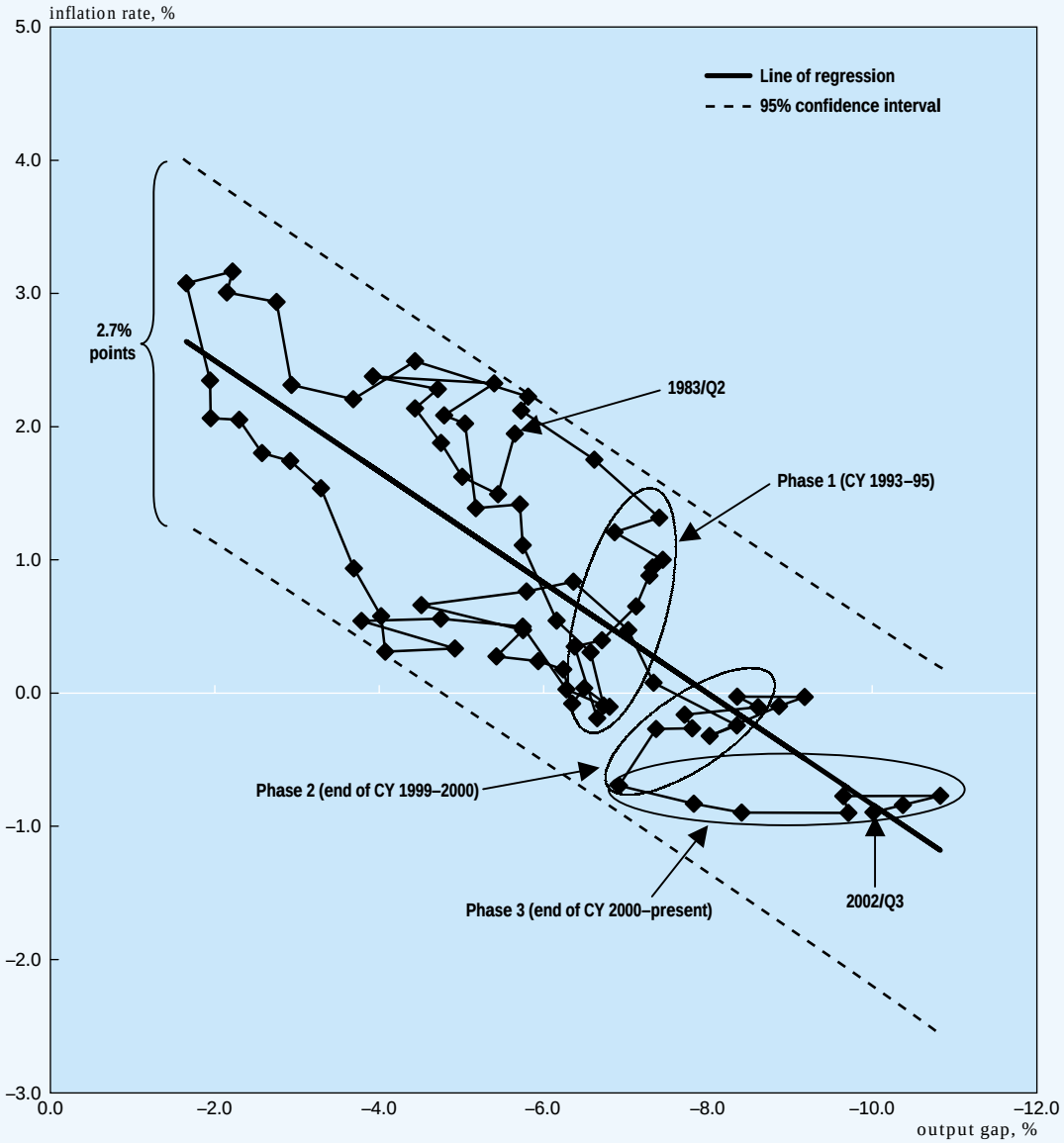


Chart 12
Phillips Curve for Japan (CY 1983–2002)[1,2]



Estimation results:

Inflation rate = 3.33 + 0.42 × output gap.
(14.91) (11.70)

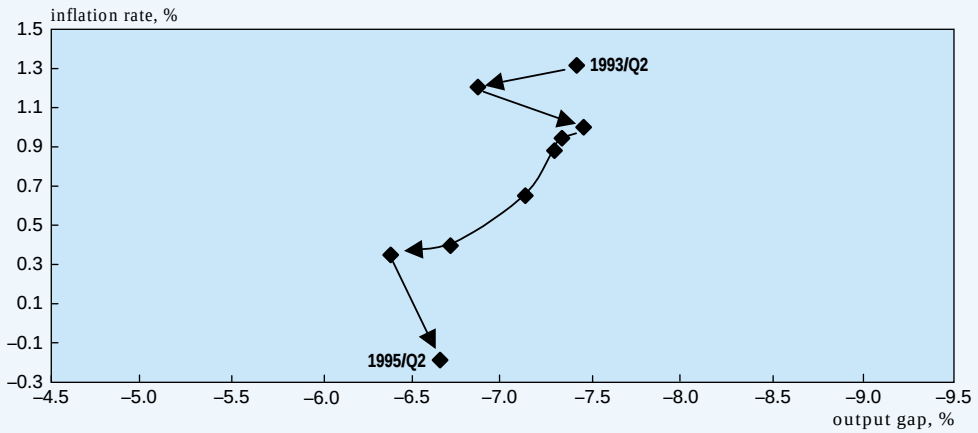
(R^2: 0.64, standard deviation: 0.66, *t*-statistics in parentheses)

Notes: *1*. Sample period runs from 1983/Q2 to 2002/Q3.
2. The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey";
Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index," etc.

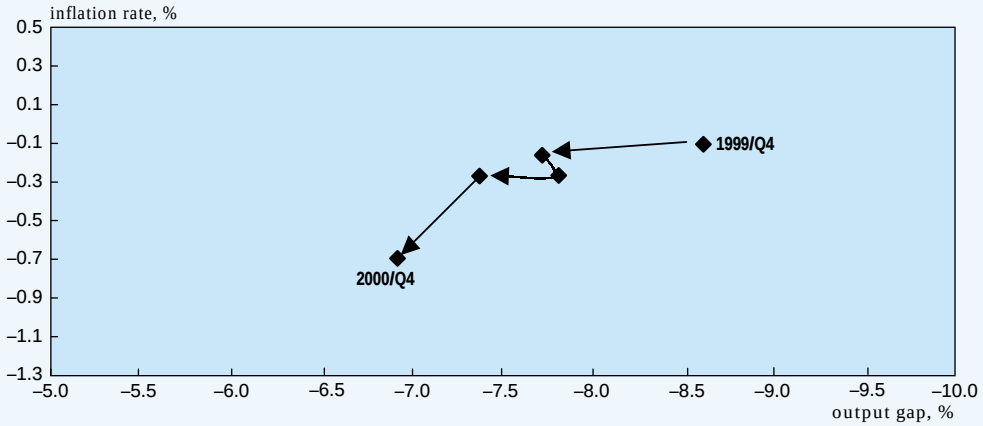
Chart 13

Phillips Curves for Individual Phases

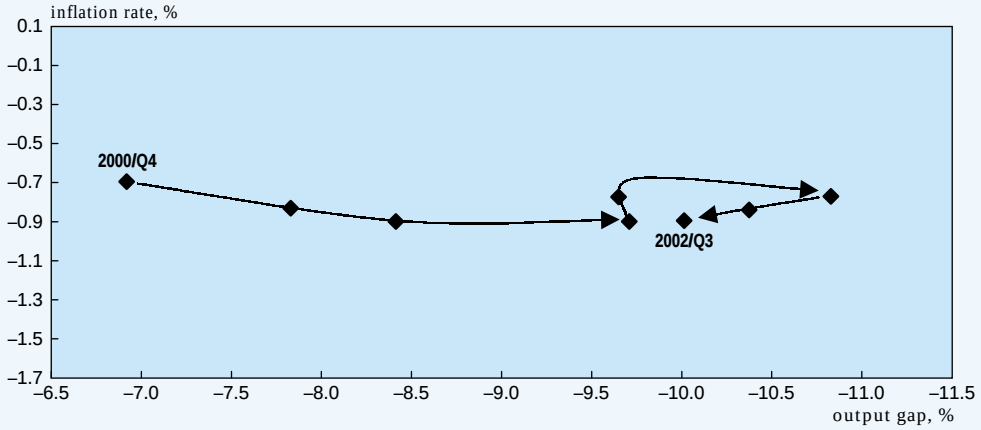
(1) Phase 1 (CY 1993–95)



(2) Phase 2 (End of 1999–2000)



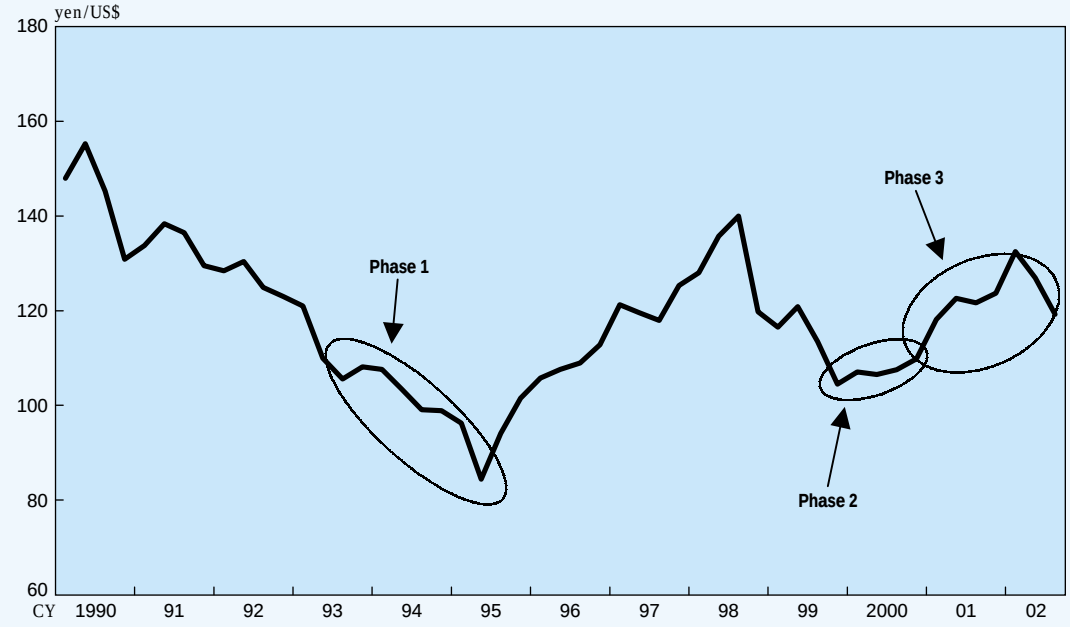
(3) Phase 3 (End of 2000–Present)



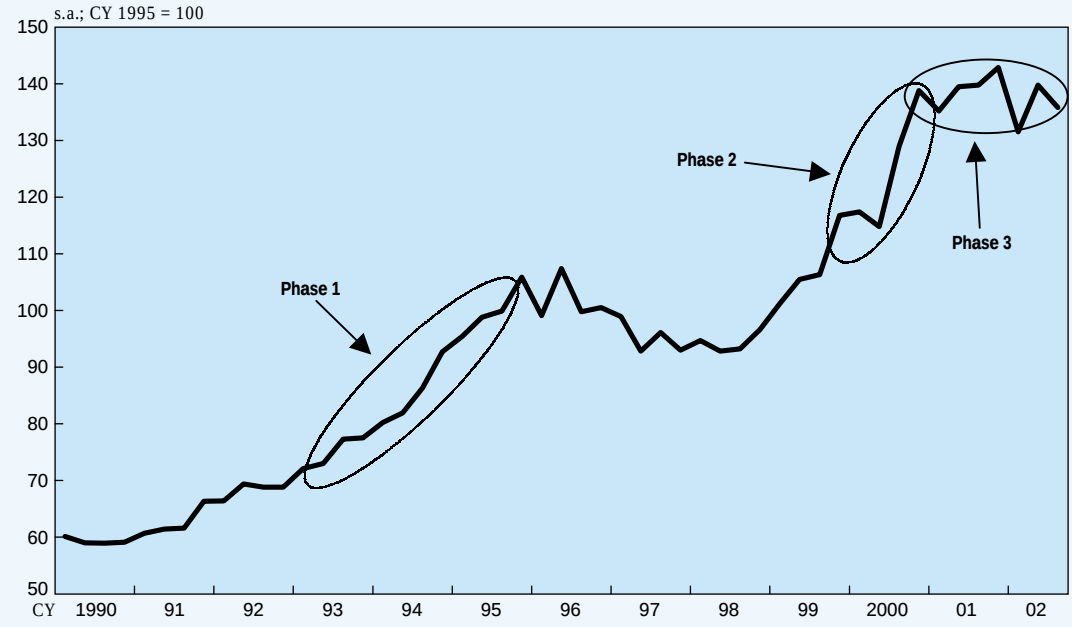
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey";
Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index," etc.

Chart 14
Exchange Rate and Imports of Consumer Goods

(1) Exchange Rate



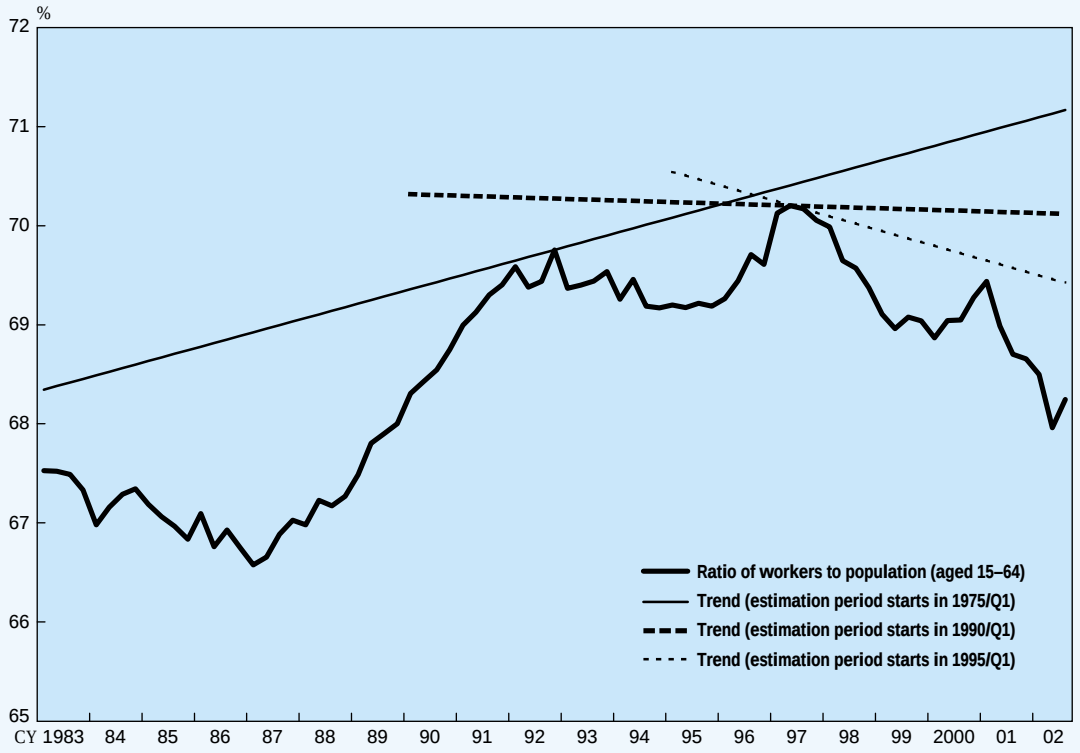
(2) Imports of Consumer Goods



Sources: Ministry of Economy, Trade and Industry, "Indices of Industrial Production," "Indices of Industrial Domestic Shipments and Imports";
Ministry of Finance, "The Summary Report on Trade of Japan";
Bank of Japan, "Wholesale Price Indexes."

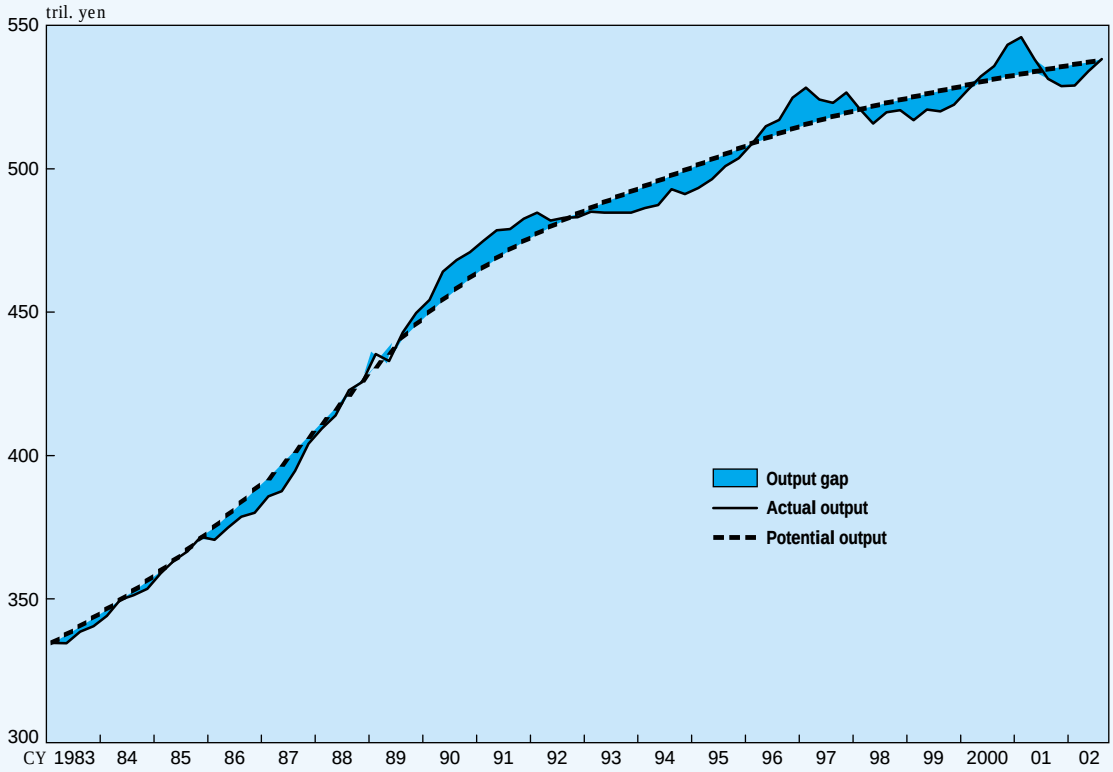
Chart 15

Various Ways of Drawing a Linear Trend for the Ratio of Workers to the Population (Aged 15 to 64)



Source: Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Labour Force Survey."

Chart 16
Estimating the Output Gap Using the HP Filter Approach[1]

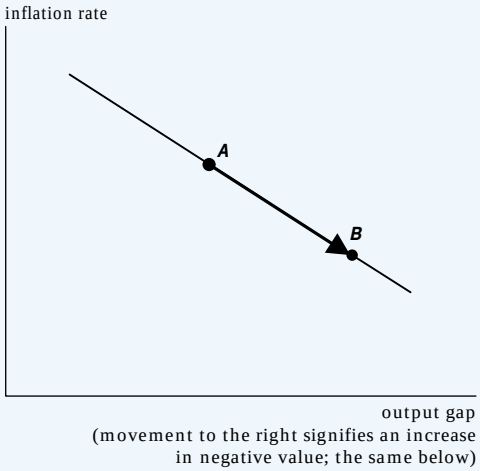


Note: *1.* The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Source: Cabinet Office, "National Accounts."

Chart 17

Shifts in the NAIRU (Conceptual Diagrams)

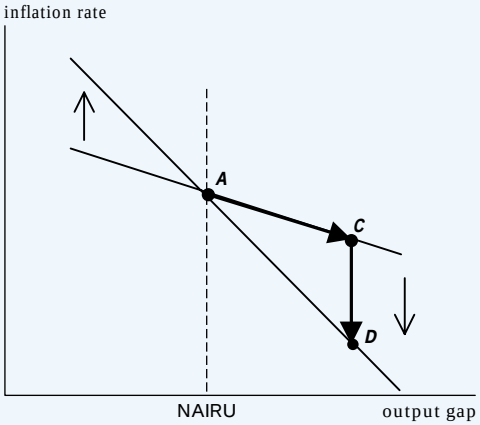
(1) Case 1: Phillips Curve Not Premised on the NAIRU



1. *A* → *B*
   The output gap expands, and the inflation rate falls.

2. Remaining at *B*
   For as long as the output gap remains in the same place, there is no further fall in the inflation rate.

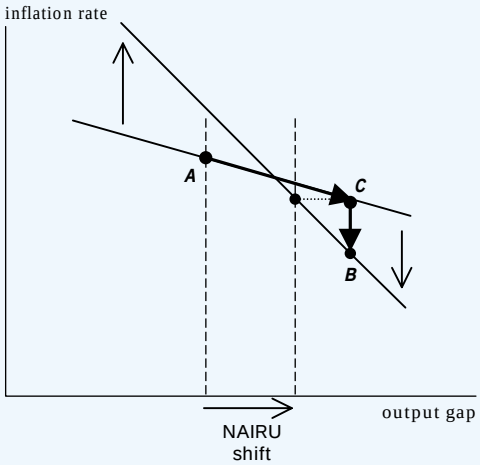
(2) Case 2: Phillips Curve Premised upon a Fixed NAIRU



1. *A* → *C*
   The output gap expands, and the inflation rate falls.

2. *C* → *D*
   Since the output gap lies to the right of the NAIRU (in negative territory), the slope of the Phillips curve steepens, and the inflation rate falls further.

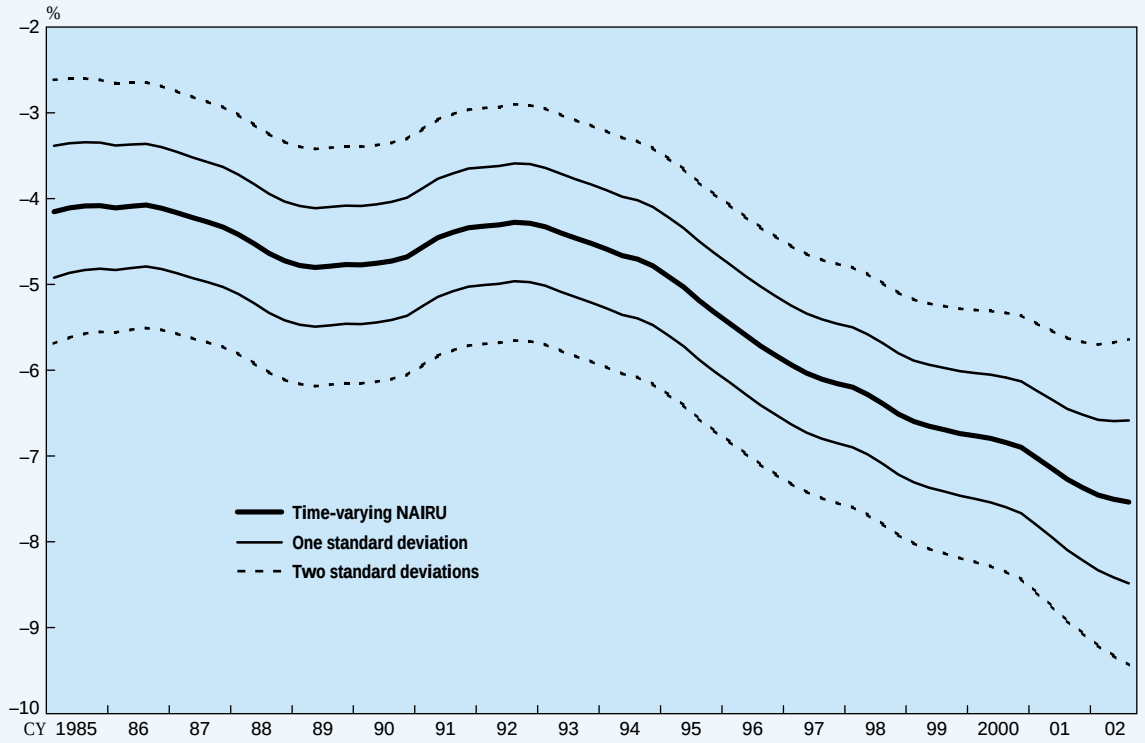
(3) Case 3: Phillips Curve Premised upon a Time-Varying NAIRU



1. *A* → *C*
   The output gap expands, and the inflation rate falls.

2. *C* → *B*
   As in case 2, the Phillips curve steepens; however, since the NAIRU itself shifts, the inflation rate does not fall as far as in case 2.

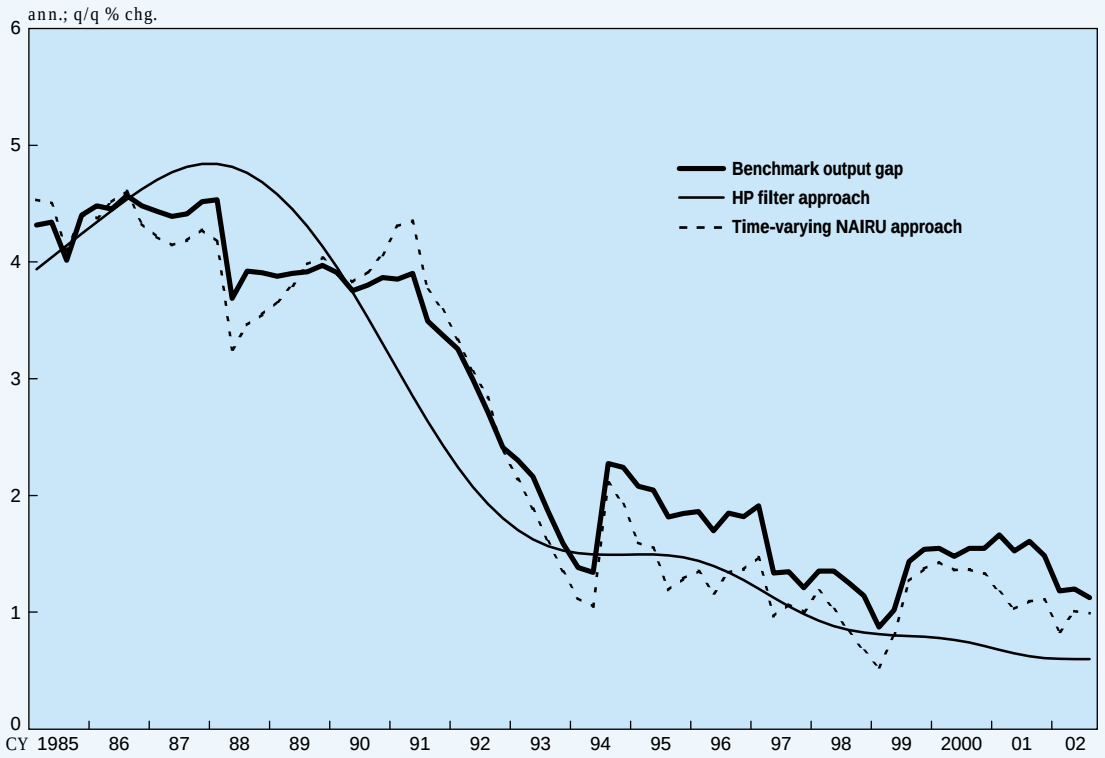
Chart 18
Time-Varying NAIRU[1,2]



Notes: *1.* The scale is the level of the benchmark output gap.
2. The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey";
Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index";
Bank of Japan, "Wholesale Price Indexes," etc.

Chart 19

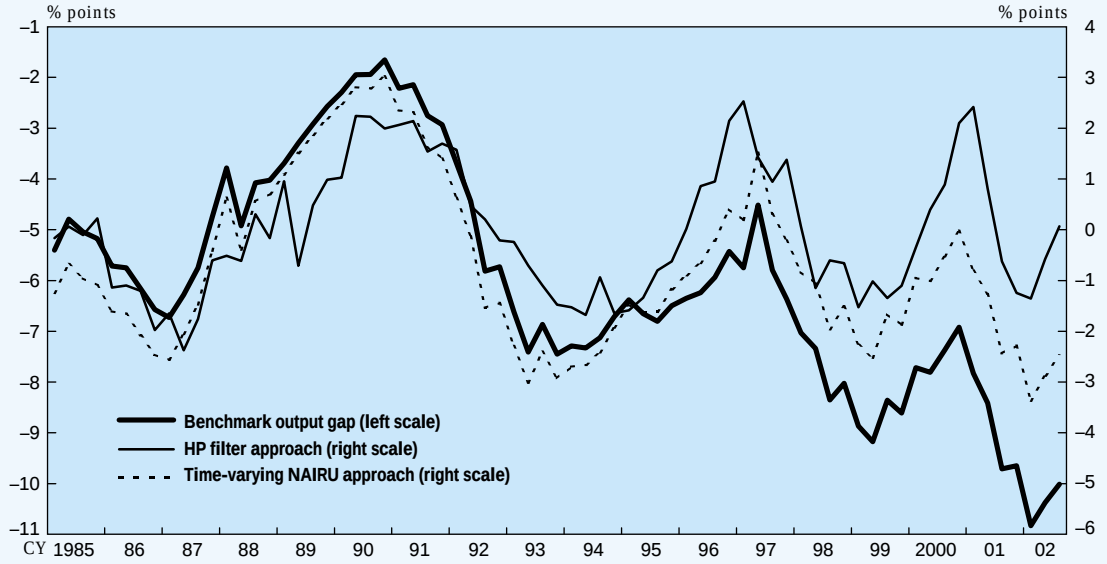
Comparison of Various Measures of the Potential Growth Rate[1]



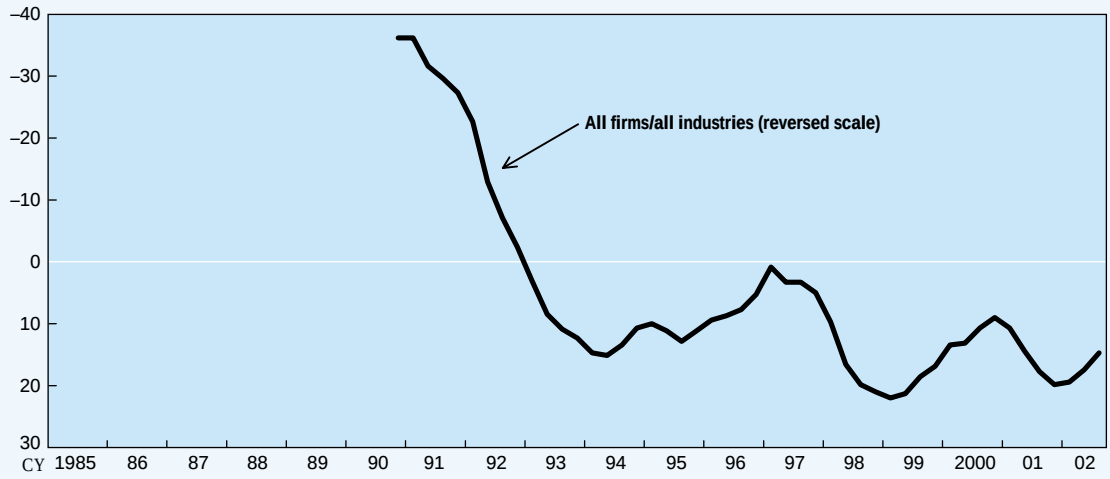
Note: *1*. The figures for real output use "reference series" for 1994/Q1–1999/Q4.

Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey";
Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index";
Bank of Japan, "Wholesale Price Indexes," etc.

Chart 20
Comparison of Various Measures of the Output Gap[1,2,3,4]



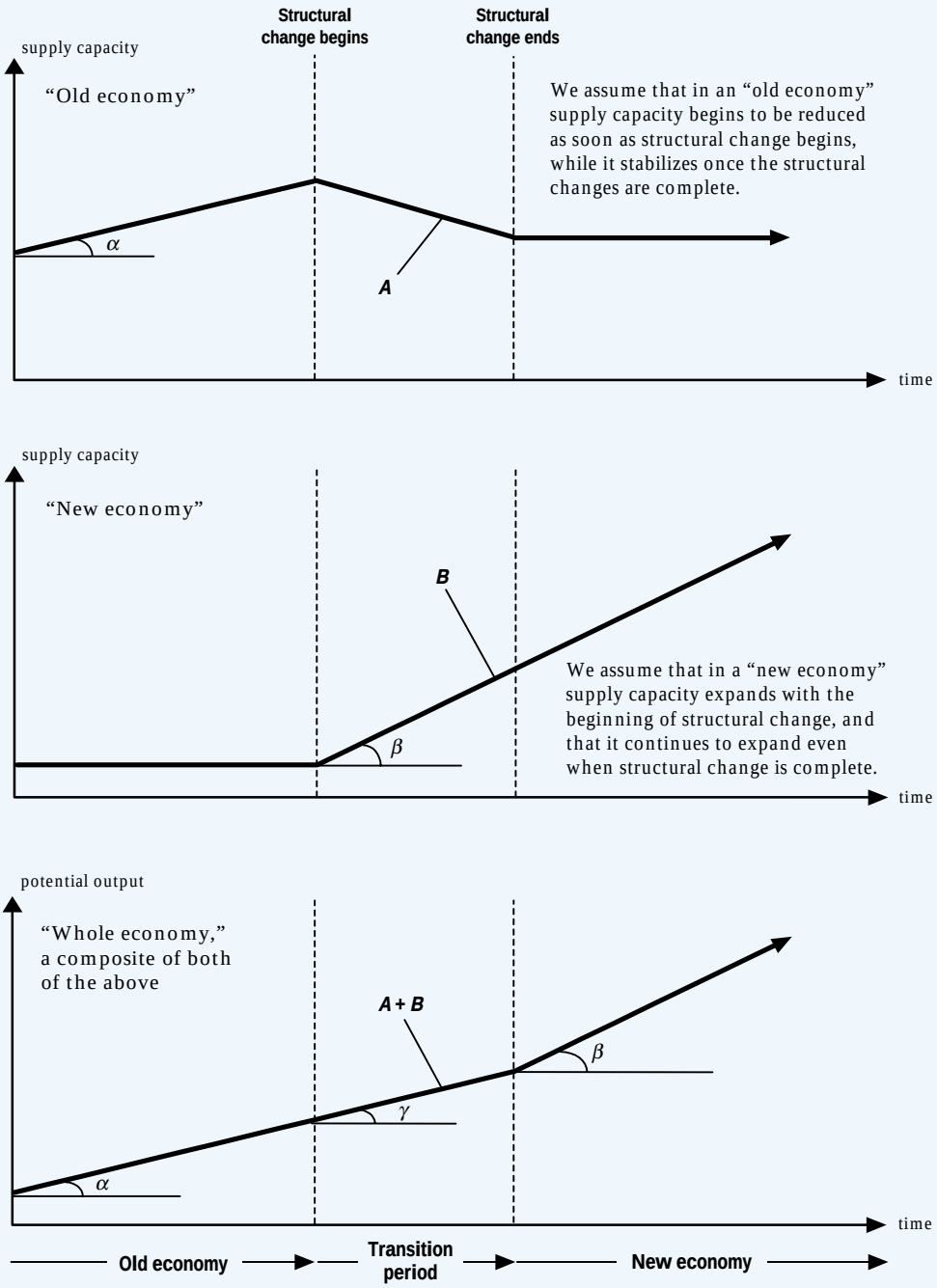
[Reference] Quasi-Output Gap, Based on the *Tankan* Diffusion Index (DI)



Notes: *1*. Diffusion indices of production capacity, and employment conditions are weighted by capital and labor shares (averages between FY 1990 and FY 2000).
2. The survey target for the production capacity DI was limited to the manufacturing industry before 1990/Q3. For this reason, the above figures are calculated for the period from 1990/Q4, when the survey target was extended to cover the nonmanufacturing industry.
3. Surveys up until December 1998 use the old base, before the revision of sample enterprises; those from March 1999 use the new base.
4. The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey";
Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index";
Bank of Japan, "Wholesale Price Indexes," etc.

Chart 21

Structural Economic Change and Potential Output (Conceptual Diagrams)



Potential growth rate of the old economy $\alpha <$ potential growth rate β of the new economy.
However, it is unclear whether or not γ will be greater than α.

Box Measures of the Output Gap Used Outside the Bank of Japan

Here we provide an outline of the approaches used for estimating the output gap for Japan by three institutions: the International Monetary Fund (IMF), the OECD, and the Japanese Cabinet Office. In each of them the production function approach plays a pivotal role, and in this sense they are similar to the benchmark output gap employed by the Research and Statistics Department of the Bank of Japan (see Chart for Box). However, each also takes the NAIRU or some other neutral point to represent the zero level, with the output gap thus defined to take both positive and negative values, and for this reason it is not possible to compare their levels directly with that of the benchmark output gap.

1. IMF

According to the IMF, potential output is defined as "the maximum output an economy can sustain without generating a rise in inflation" (De Masi [1997] and Bayoumi [2000]), and the output gap for 2001 was then estimated as –2.4 percent (as of November 2002, IMF [2002]). As detailed below, potential output is derived via the aggregation method within a macro production function, where the HP filter is applied to some of the components of the production function. The data for each component of production are adjusted as appropriate, given the economic conditions of the time and their own specific characteristics.

(1) The actual labor input is obtained by compounding three elements: the labor force, working hours, and (one minus the unemployment rate). The potential labor input, on the other hand, is attained by running each of these elements through the HP filter and then compounding the filtered values.
(2) Substituting the actual labor input and the capital stock into a Cobb-Douglas macro production function, the residual is then run through the HP filter and the result taken as TFP.
(3) The capital stock, the potential labor input derived in (1), and TFP derived in (2) are then substituted into the Cobb-Douglas macro production function, thus determining potential output.

2. OECD

According to the OECD, potential output is defined as "the level of real GDP, and associated rates of growth, which are sustainable over the medium term at a stable rate of inflation" (Giorno *et al.* [1995]), and the output gap for 2001 was estimated as –1.4 percent (as of November 2002, OECD [2002]). The method of estimating potential output is as follows:

(1) The actual labor input is obtained by multiplying the employable population (the number of those between the ages of 15 and 64) by the labor force participation ratio. In determining the potential labor input, first of all the rate of unemployment consistent with a rate of change in the wage level that is neither increasing nor decreasing is obtained using a Phillips curve. This value is then subtracted from one, and the resultant figure is multiplied by the employable population to get the potential labor input.
(2) Substituting the capital stock and the actual labor input above into a CES macro production function, the residual is then run through the HP filter and the result taken to represent TFP.
(3) The capital stock, the potential labor input derived in (1), and TFP derived in (2) are then substituted into the CES macro production function, thus determining potential output.

3. Cabinet Office

According to the Cabinet Office, the potential growth rate is defined as "the rate of economic growth realizable when the capital stock and labor force are neither over- nor under-utilized," while the zero point of the output gap is obtained by estimating the structural unemployment rate.[1] The output gap for 2001 was estimated as –3 to –4 percent, while the potential growth rate over the next 2–3 years will be around 1 percent (as of December 2001, Cabinet Office [2001]). The estimation methodology for potential output is as follows:

1. Based on an economic white paper, the method of estimating the output gap used by the Cabinet Office has been changed since FY 2001.

Box (continued)

(1) The actual capital input is obtained by multiplying together the capital stock and the capacity utilization rate for the manufacturing and nonmanufacturing industries, respectively. For capacity utilization in the manufacturing industry, the industrial capacity utilization rate is used; while for nonmanufacturing the *Indices of Tertiary Industry Activity* is divided by the nonmanufacturing capital stock, detrended, and then the resulting detrended series is used. Next, the above capacity utilization rates for manufacturing and nonmanufacturing industries are separately regressed on the Bank of Japan's *Tankan* diffusion index of business sentiment regarding levels of production and operational capacity to obtain the potential capacity utilization rate; the latter is then multiplied by the capital stock to give the potential capital input.

(2) The actual labor input is calculated by multiplying together working hours and the number of workers. Meanwhile, the structural rate of unemployment is calculated by estimating a Beveridge curve from the unemployment and vacancy rates. Subtracting this from one, the resulting figure is then multiplied by the total population of the labor force to get the potential number of workers. At the same time, having removed from regular working hours the noise associated with the shortening of working hours, the resulting figure is added to the past average of overtime to get potential working hours. Finally, the product of these two quantities (the potential number of workers and potential working hours) is taken to represent the potential labor input.

(3) Substituting the actual capital input derived in (1) and the actual labor input derived in (2) into a Cobb-Douglas macro production function, the residual is then run through the HP filter and the result taken as TFP.

(4) The potential capital input derived in (1), the potential labor input derived in (2), and TFP derived in (3) are then substituted into the Cobb-Douglas macro production function, thus determining potential output.

Chart for Box Comparison between Measures of the Output Gap Used by Other Institutions[1]

%

		CY 1996	97	98	99	2000	01
IMF		**0.9**	**1.0**	**–1.7**	**–2.2**	**–1.1**	**–2.4**
OECD		**0.5**	**1.3**	**–1.0**	**–1.5**	**0.0**	**–1.4**
Research and Statistics Department of the Bank of Japan	**Benchmark output gap**	**–6.0**	**–5.6**	**–7.7**	**–8.8**	**–7.5**	**–8.9**
	HP filter approach	**1.0**	**1.6**	**–0.6**	**–1.2**	**0.8**	**0.3**
	Time-varying NAIRU approach	**–0.3**	**0.5**	**–1.3**	**–2.1**	**–0.6**	**–1.7**

Note: *1.* The figures for real output use "reference series" for 1994/Q1–1999/Q4.
Sources: Cabinet Office, "National Accounts," "Capital Stock of Private Enterprises Statistics";
Ministry of Economy, Trade and Industry, "Indices of Industrial Production";
Ministry of Health, Labour and Welfare, "Monthly Labour Survey";
Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index";
Bank of Japan, "Wholesale Price Indexes";
International Monetary Fund, "World Economic Outlook";
Organisation for Economic Co-operation and Development, "OECD Economic Outlook."

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Symbols and Abbreviations Used in This Article

CY	Calendar year	tril.	Trillions
FY	Fiscal year	ann.	Annualized
Q	Calendar quarter	s.a.	Seasonally adjusted
%	Percent	q/q % chg.	Percentage changes from the previous quarter
% points	Percentage points		
mil.	Millions		