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The Survey-Based Output Gap and Input Gap

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1. Introduction

The output gap is defined as a deviation rate of actual output from potential. It measures efficiency of utilization of economic resources and thus is thought of as one of indispensable variables for formulating economic policy. A variety of methods are proposed to estimate the output gap, depending on the purpose of economic policy, the availability and quality of relevant data, and economic thoughts. However, they share the core concept of potential output with one another, that is, the maximum sustainable output (e.g., Congressional Budget Office, 2001).[1] The Bank of Japan (BOJ) once defined potential output as the maximum output attainable by utilizing production factors at highest ever rates (Kamada and Masuda, 2001), but later redefined it as the output obtainable by utilizing production factors at average rates (Hara, et al., 2006), so that its output gap became comparable with those of other central banks and international institutions.

The BOJ has long been conducting the *Short-term Economic Survey of Principal Enterprises in Japan* (*TANKAN*) for the purpose of evaluating economic activity in Japan. The TANKAN reports firms' current economic assessments from various perspectives in a quarterly basis. In particular, the BOJ regards the business conditions diffusion index (D.I.) as a top-priority indicator of business cycle in Japan. In the survey, firms are asked how favorable their current business conditions are and answer it with "Favorable", "Not so favorable", or "Unfavorable". The business conditions D.I. is given by a percentage of firms that answer "Favorable" minus a percentage of firms that answer "Unfavorable". The index is in line with our perceptions of how the economy is going, but cannot be used as a gap measure per se, since it does not have the same dimensionality as the output gap.

Recently the BOJ's official output gap has diverged from the business conditions D.I. As shown in Figure 1, the two measures sometimes diverged from each other in the past. For instance, the business condition D.I. was deep in the negative area

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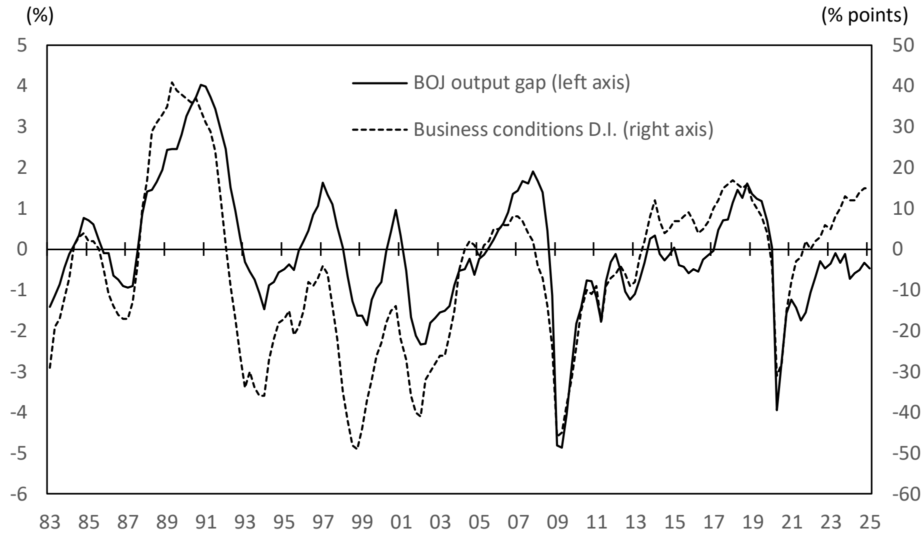
[1] Potential output is sometimes required to have an additional property, that is, consistency with stability of inflation rates. However, the maximum sustainable output may not always be consistent with stable inflation rates.



Source: The Bank of Japan.

Figure 1. The BOJ output gap and the business conditions D.I.

from the early 1990s to the mid-2000s during Japan's lost decade. In contrast, the BOJ output gap fluctuated around zero percent and failed to capture the lost decade. The two business cycle measures have diverged again recently. Since the end of the COVID-19 pandemic, the Japanese economy has experienced severe labor shortage. The business condition D.I. is rising in accordance with it. In contrast, the BOJ output gap remains around zero percent. The divergence of the two measures makes monetary policy hard to implement.

This paper proposes the method of transforming qualitative answers in a survey into a quantitative series of the output gap. Our method is basically an extension of the method proposed by Carlson and Parkin (1975). Their method enables us to estimate inflation expectations from a survey on a direction of a price change: "go up", "go down", "stay the same", or "don't know". We apply their method to estimating potential output from the TANKAN survey on business conditions described above. To do so, we incorporate an additional parameter into their original model, that is, a reference point at which firms perceive business conditions as neither favorable nor unfavorable. We assume that firms answer "Favorable" if their sales are more than the reference point by some amount and "Unfavorable" if their sales are less than the reference point by the same amount. We use this reference point as a proxy for potential output.

Following Kamada and Masuda (2001), the BOJ estimates its output gap from utilization rates of capital and labor. We call it the input gap below. Our method is applicable to the estimation of the input gap. In the TANKAN survey, firms are asked to answer their assessments of production capacity and of employment conditions with "Excessive", "Adequate", or "Insufficient". We transform these qualitative answers into quantitative input gaps of capital and labor. One of the shortcomings of this approach is that in Japan we have no data on capital utilization in the non-manufacturing sector. Kamada and Masuda proposed methods to overcome the problem, but could not reach a definitive solution.[2] The method introduced in this paper will provide a promising solution to the problem.

The remainder of this paper is organized as follows. Section 2 introduces the method for estimating the survey-based output gap. Section 3 addresses theoretical issues for applying our method to the estimation of the input gap. Section 4 applies our method to estimating the output gap in Japan. Section 5 estimates the input gap in Japan. Section 6 compares the output gap and the input gap and discusses why a discrepancy occurs between them. Section 7 concludes the paper.

2. The Survey-Based Output Gap Model

2.1. The Extended Carlson-Parkin Method

There are N firms in the economy. The output of firm i at time t is denoted by x_{it} and distributed normally with mean μ_t and standard deviation σ_t. Firms share reference point x_t^* at which they perceive their business conditions as neither favorable nor unfavorable. In the survey, firms answer "Unfavorable" if their output falls below $x_t^* - \delta$ and "Favorable" if their output exceeds $x_t^* + \delta$. Denote the share of firms that

[2] Economists address the problem of missing data on capital utilization in the non-manufacturing sector by one of the following three ways: (i) the capital utilization rate in the non-manufacturing sector is assumed to be equal to that in the manufacturing sector; (ii) the capital utilization rate in the non-manufacturing sector is always assumed to be 100%; (iii) a proxy for capital utilization in the non-manufacturing sector is created, based on related data. For instance, Kamada and Masuda (2001) proposed to use the data on electricity demands as a proxy for the capital utilization rate in the non-manufacturing sector. The BOJ could not continue this method, however, since the associated data was not updated any longer.

answer "Unfavorable" by A_t and the share of firms that answer "Favorable" by B_t. Then we have the following relationships.

$$A_t = P(x_{it} < x_t^* - \delta) = P\left(\frac{x_{it} - \mu_t}{\sigma_t} < \frac{x_t^* - \delta - \mu_t}{\sigma_t}\right) = \Phi\left(\frac{x_t^* - \delta - \mu_t}{\sigma_t}\right); \tag{1}$$

$$B_t = P(x_{it} > x_t^* + \delta) = P\left(\frac{x_{it} - \mu_t}{\sigma_t} > \frac{x_t^* + \delta - \mu_t}{\sigma_t}\right) = 1 - \Phi\left(\frac{x_t^* + \delta - \mu_t}{\sigma_t}\right), \tag{2}$$

where $P(\cdot)$ indicates probability and $\Phi(\cdot)$ is the cumulative normal distribution. Let $a_t \equiv \Phi^{-1}(A_t)$ and $b_t \equiv \Phi^{-1}(1 - B_t)$. Then we have

$$a_t = \frac{x_t^* - \delta - \mu_t}{\sigma_t}; \tag{3}$$

$$b_t = \frac{x_t^* + \delta - \mu_t}{\sigma_t}. \tag{4}$$

Solving for μ_t and σ_t, we have

$$\mu_t = x_t^* + \frac{a_t + b_t}{a_t - b_t}\delta; \tag{5}$$

$$\sigma_t = -\frac{2}{a_t - b_t}\delta. \tag{6}$$

To estimate potential output and the output gap, we use the data on aggregate output, or gross domestic product, denoted by y_t. By definition, we have $y_t \equiv \Sigma_i x_{it}$ and $\mu_t \equiv \Sigma_i x_{it}/N$. Hence, we have $y_t = N\mu_t$. Let $z_t \equiv (a_t + b_t)/(a_t - b_t)$. Then, with measurement error ε_t, we obtain the following empirical model to be estimated.[3]

$$y_t = \alpha_t + \beta z_t + \varepsilon_t, \tag{7}$$

where

$$\alpha_t \equiv N x_t^*; \tag{8}$$

$$\beta \equiv N\delta. \tag{9}$$

[3] Sekine, et al. (2008) come upon with a similar empirical model in the context of the estimation of inflation expectations. In their model, α_t is assumed to be constant and thus estimable by OLS.

Note that potential output, $y_t^* \equiv N x_t^*$, is given by α_t and the output gap is by $\beta z_t/\alpha_t$, excluding measurement errors.

As potential output grows, the output gap defined above declines over time. That is inconvenient if you conduct a long-term analysis. In this case, we recommend to use $\ln y_t$ as a dependent variable instead of y_t and to assume that x_{it} is distributed log-normally. Then we have

$$\ln y_t = \alpha_t + \beta z_t + \varepsilon_t, \tag{10}$$

where

$$\alpha_t \equiv \ln y_t^* ; \tag{11}$$

$$\beta \equiv \delta. \tag{12}$$

See Appendix for details. The log of potential output is given by α_t and the output gap is obtained by βz_t, excluding measurement errors. In this case, the output gap does not decline due to the growth of potential output, as we expect.

2.2. The Estimation of a Time-Varying Model

In equation (7), α_t is assumed to be time-varying and thus the OLS method is not applicable to its estimation. The Kalman filter is a standard method for estimating a time-varying model. We, however, take a much simpler approach in this paper, i.e., the method of augmented least squares inspired by Hirose and Kamada (2003). Here we consider the case in which α_t is time-varying, while β is constant over time. Define loss function $\mathcal{L}$ as follows.

$$\mathcal{L} \equiv \Sigma_t (y_t - \alpha_t - \beta z_t)^2 + \lambda \Sigma_t (\Delta\alpha_t - \Delta\alpha_{t-1})^2. \tag{13}$$

The first term indicates the sum of squared estimation errors. The second augmented term indicates the sum of squared penalties against changes in potential growth. Without βz_t in the first term, the loss function would be the same as the one for the HP filter. In the empirical analysis below, smoothing parameter λ is set equal to 1600, which is recommended by Hodrick and Prescott (1981) for quarterly data.

Our estimators are given by the minimizers of $\mathcal{L}$. We denote them by $\hat{\alpha}_t$ and $\hat{\beta}$. To make mathematical operation easier, we rewrite equation (13) in matrices as

$$\mathcal{L} = (\boldsymbol{y} - \boldsymbol{z}\beta - \alpha)'(\boldsymbol{y} - \boldsymbol{z}\beta - \alpha) + \lambda\boldsymbol{\alpha}'\boldsymbol{D}'\boldsymbol{D}\boldsymbol{\alpha}, \tag{14}$$

where $\boldsymbol{y}$ and $\boldsymbol{z}$ are vectors consisting of y_t and z_t, respectively; $\boldsymbol{\alpha}$ is a vector consisting of α_t; $\boldsymbol{D}$ is a matrix for a second-order difference. For optimization, we differentiate $\mathcal{L}$ with respect to $\boldsymbol{\alpha}$ and β and set the results equal to zero. Then we obtain $\hat{\boldsymbol{\alpha}}$ and $\hat{\beta}$ that satisfy the following equations.

$$-2(\boldsymbol{y} - \boldsymbol{z}\hat{\beta} - \hat{\boldsymbol{\alpha}}) + 2\lambda\boldsymbol{D}'\boldsymbol{D}\hat{\boldsymbol{\alpha}} = 0; \tag{15}$$

$$-2\boldsymbol{z}'(\boldsymbol{y} - \boldsymbol{z}\hat{\beta} - \hat{\boldsymbol{\alpha}}) = 0. \tag{16}$$

Solving for $\hat{\beta}$ and $\hat{\boldsymbol{\alpha}}$, we have

$$\hat{\beta} = \boldsymbol{z}'(\boldsymbol{I} - \boldsymbol{H})\boldsymbol{y}\{\boldsymbol{z}'(\boldsymbol{I} - \boldsymbol{H})\boldsymbol{z}\}^{-1}; \tag{17}$$

$$\hat{\boldsymbol{\alpha}} = \boldsymbol{H}(\boldsymbol{y} - \boldsymbol{z}\hat{\beta}), \tag{18}$$

where $\boldsymbol{H} \equiv (\boldsymbol{I} + \lambda\boldsymbol{D}'\boldsymbol{D})^{-1}$ is the HP filter matrix that extracts a trend component from a time series data. We can rewrite equations (17) and (18) in familiar forms:

$$\hat{\beta} = \frac{\Sigma_t z_t^C y_t}{\Sigma_t z_t^C z_t}; \tag{19}$$

$$\hat{\alpha}_t = y_t^T - \hat{\beta} z_t^T, \tag{20}$$

where superscripts T and C indicate the trend and cycle components of a time series extracted by the HP filter, respectively. Note that the estimators thus obtained inherit some characters both from the OLS estimator as seen in equation (19) and from the HP filter as seen in equation (20).

3. The Survey-Based Input Gap Model

3.1. The Relationship between the Output Gap and the Input Gap

As output is produced from input, the output gap is closely related to the input gap. We begin with the following standard macroeconomic production function.

$$y = \phi k^{1-s} \ell^{s}, \tag{21}$$

where y, k, ℓ, ϕ, and s denote output, capital input, labor input, total factor productivity (TFP), and the income share of labor, respectively. By log-transformation, we have

$$\ln y = \ln \phi + (1-s) \ln k + s \ln \ell. \tag{22}$$

We denote the potentially usable amount of capital and labor by k^* and ℓ^*, respectively. Replacing k and ℓ with them in equation (22), we have potential output y^* as follows.

$$\ln y^* = \ln \phi + (1-s) \ln k^* + s \ln \ell^*. \tag{23}$$

We assume that ϕ is unchanged here. Subtracting equation (23) from equation (22), we have the relationship between the output gap and the input gap as follows.

$$\ln y - \ln y^* = (1-s)(\ln k - \ln k^*) + s(\ln \ell - \ln \ell^*). \tag{24}$$

The left-hand side is called the output gap and the right-hand side is the input gap. The input gap consists of the two input gaps: the capital input gap, $\ln k - \ln k^*$, and the labor input gap, $\ln \ell - \ln \ell^*$.

3.2. The Capital Input Gaps in the Manufacturing and Non-Manufacturing Sectors

In estimation, we treat the manufacturing and non-manufacturing sectors separately. Denote the manufacturing sector by m and the non-manufacturing sector by n. Then the capital input gap is given by

$$\ln k - \ln k^* = r(\ln k^m - \ln k^{m*}) + (1-r)(\ln k^n - \ln k^{n*}), \tag{25}$$

where r is the share of capital stock in the manufacturing sector. We have the data on capital utilization in the manufacturing sector, but no data on capital utilization in the non-manufacturing sector in Japan. Fortunately, we have the TANKAN survey on capital utilization in both sectors. We present how we can exploit the survey for the estimation of the capital input gap in the non-manufacturing sector below.

Manufacturing firm i's capital utilization rate at time t is denoted by x_{it}^m and is distributed normally with mean μ_t^m and standard deviation σ_t^m. Denote the potential rate of capital utilization by x_t^{m*}. Firms answer "Excess" if their actual capital utilization rates are lower than $x_t^{m*} - \delta^m$ and "Insufficient" if they are higher than $x_t^{m*} + \delta^m$. The share of firms that answer "Excess" is A_t^m, while the share of firms that answer "Insufficient" is B_t^m. Let $a_t^m \equiv \Phi^{-1}(A_t^m)$ and $b_t^m \equiv \Phi^{-1}(1 - B_t^m)$. Applying the extended Carlson-Parkin method introduced in the previous section, we obtain μ_t^m and σ_t^m with superscript m on equations (5) and (6).

The data on capital utilization in the manufacturing sector, y_t^m, is given as an index. Denote the capital utilization rate in a benchmark year by μ_0^m. Let $z_t^m \equiv (a_t^m + b_t^m)/(a_t^m - b_t^m)$. Then we obtain the following empirical model, where ε_t^m is a measurement error.

$$y_t^m = \alpha_t^m + \beta^m z_t^m + \varepsilon_t^m, \tag{26}$$

where

$$\alpha_t^m \equiv x_t^{m*}/\mu_0^m; \tag{27}$$

$$\beta^m \equiv \delta^m/\mu_0^m. \tag{28}$$

The index on potential capital utilization is given by α_t^m and the capital input gap is by $\beta^m z_t^m/\alpha_t^m$ in the manufacturing sector, excluding measurement errors.

As mentioned above, we have no data on the index on capital utilization in the non-manufacturing sector in Japan. Thus, we cannot estimate α_t^n and β^n as we did for α_t^m and β^m. To estimate the capital input gap in the non-manufacturing sector, we assume $\alpha_t^n = \alpha_t^m$ and $\beta^n = \beta^m$.[4] We have the survey on capital utilization in the non-manufacturing sector, i.e., the share of firms that answer "Excess" denoted by A_t^n and the share of firms that answer "Insufficient" denoted by B_t^n. Let $a_t^n \equiv \Phi^{-1}(A_t^n)$, $b_t^n \equiv \Phi^{-1}(1 - B_t^n)$, and $z_t^n \equiv (a_t^n + b_t^n)/(a_t^n - b_t^n)$. Then the capital input gap in the non-manufacturing sector is given by $\beta^m z_t^n / \alpha_t^m$.

3.3. The Labor Input Gaps in a Country and in Firms

Finally, we consider the input gap of labor. We have the survey on the assessments of labor conditions in firms and the data on unemployment in a country. Based on these data, we can estimate the input gap of labor in a fashion similar to that of capital in the manufacturing sector. Firm i's labor utilization rate at time t is denoted by x_{it}^ℓ, which is assumed to be distributed normally with mean μ_t^ℓ and standard deviation σ_t^ℓ. Denote the potential rate of labor utilization by $x_t^{\ell*}$. Firms answer "Excess" if their actual labor utilization rates are less than $x_t^{\ell*} - \delta^\ell$ and "Insufficient" if they are more than $x_t^{\ell*} + \delta^\ell$. The share of firms that answer "Excess" is A_t^ℓ, while the share of firms that answer "Insufficient" is B_t^ℓ. Let $a_t^\ell \equiv \Phi^{-1}\left(A_t^\ell\right)$ and $b_t^\ell \equiv \Phi^{-1}(1 - B_t^\ell)$. Then we obtain μ_t^ℓ and σ_t^ℓ with superscript ℓ on equations (5) and (6).

We assume that there is a linear relationship between the employment rate in a country, y_t^ℓ, and the average labor utilization rate over firms, μ_t^ℓ.

$$y_t^\ell = \psi + \theta \mu_t^\ell. \tag{29}$$

Let $z_t^\ell \equiv (a_t^\ell + b_t^\ell)/(a_t^\ell - b_t^\ell)$ and substitute μ_t^ℓ in the above equation. With measurement error ε_t^ℓ, we have

$$y_t^\ell = \alpha_t^\ell + \beta^\ell z_t^\ell + \varepsilon_t^\ell, \tag{30}$$

where

$$\alpha_t^\ell \equiv \psi + \theta x_t^{\ell*}; \tag{31}$$

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[4] The same method was proposed informally by Sekine, et al. (2008) in the context of the estimation of inflation expectations.

$$\beta^{\ell} \equiv \theta \delta^{\ell}. \tag{32}$$

The potential employment rate is given by α_t^{ℓ} and the labor input gap is by $\beta^{\ell} z_t^{\ell} / \alpha_t^{\ell}$, excluding measurement errors.

It is worthwhile to pay attention to a conceptual difference between labor conditions in firms and the unemployment rate in a country. The survey concerns the existence of employee who are unproductive in firms. Note that they are employed by the firms and not counted as unemployed in a country. Meanwhile, the unemployment rate in a country measures the share of those who are not employed by any firms. This means that we have two theoretical possibilities about the sign of β^{ℓ}. First, if firms fire idle labor force, it reduces the employment rate in a country, which implies $\theta < 0$ and thus $\beta^{\ell} < 0$. Second, when there exists much labor force idle in firms, the unemployment rate in a country is also likely to be high, which implies $\theta > 0$ and thus $\beta^{\ell} > 0$. We will see which effect is stronger by examining the sign of β^{ℓ} in the empirical analysis below.

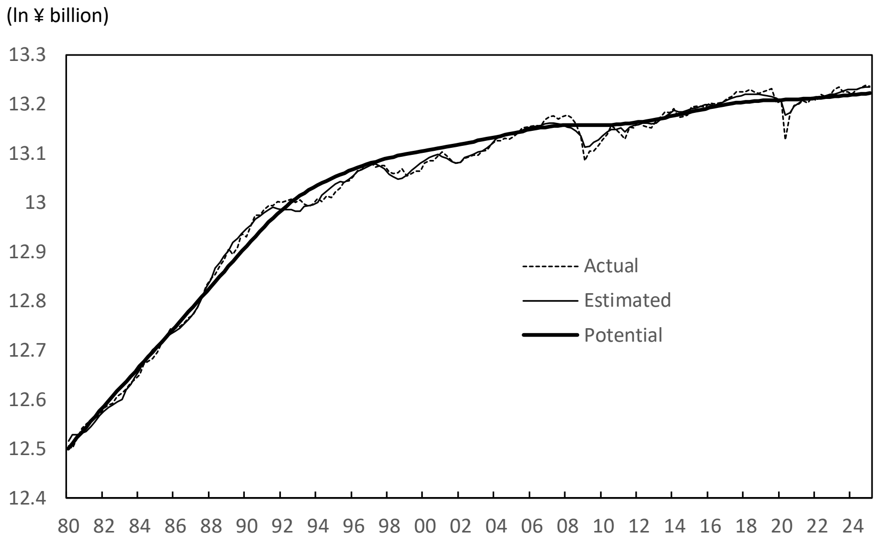
4. Estimation Results of the Survey-Based Output Gap

4.1. The Data for the Survey-Based Output Gap

The data on output is provided by the Cabinet Office as *gross domestic product* (billion yen, real, chained, prices in 2015, seasonally adjusted) in the *System of National Accounts*. The assessments of *business conditions* by firms for all enterprise sizes and all industries are collected by the Bank of Japan in the TANKAN survey. In the survey, firms are asked to answer “Favorable”, “Not so favorable”, or “Unfavorable”. We use the shares of the first and third answers for estimation. Our sample covers the period of 1980Q1 to 2025Q1.

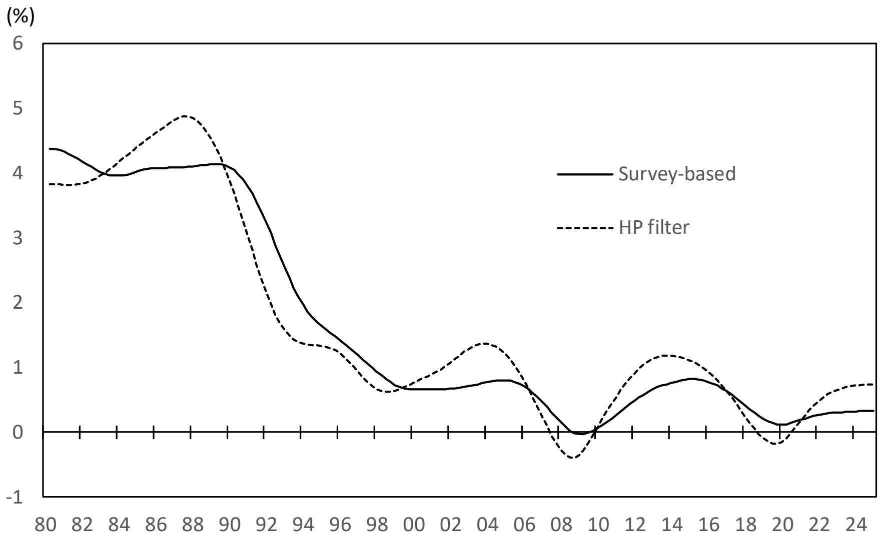
4.2. The Estimated Survey-Based Output Gap

We estimate the survey-based potential output, using the log of gross domestic product and firms’ assessments of business conditions in the TANKAN survey. In doing so, we assume that the output of firms is distributed log-normally. Figure 2 shows the result, which depicts the actual, estimated, and potential output. The estimated output traces



Sourses: The Bank of Japan; the Cabinet office.

Figure 2. Actural, estimated, and potential output

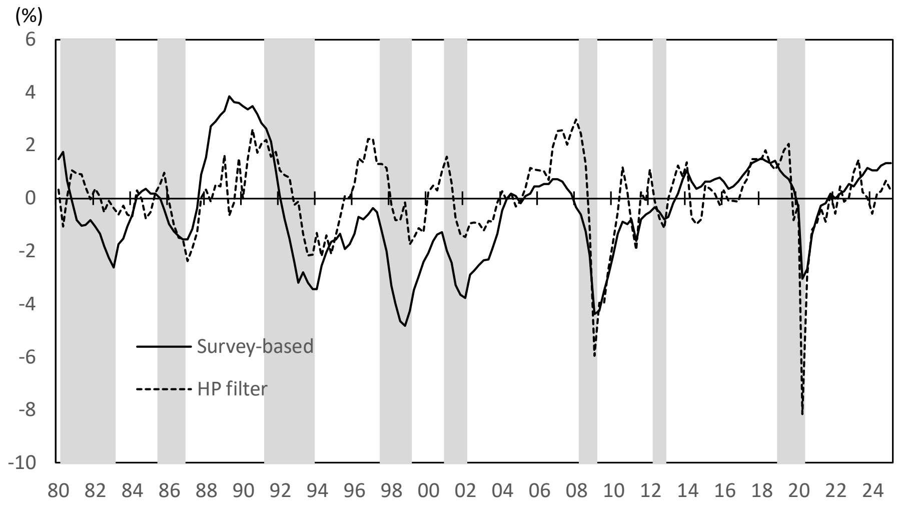


Sourses: The Bank of Japan; the Cabinet office.

Figure 3. The survey-based potential growth and HP filter trend growth

the actual output closely. It is also notable that the potential output is located at a higher position than the actual output as a whole.

Figure 3 depicts the annualized growth rate of the survey-based potential output. It decelerated from 4 percent to less than 1 percent during the 1990s and is only 0.3 percent in recent years. For comparison, we extract the trend component from the log of gross domestic product by the HP filter (HP filter trend). Its growth rate is 0.7 percent



Note: The shaded areas indicate contraction phases by the Reference Dates of Business Cycle.

Sourses: The Bank of Japan; the Cabinet office.

Figure 4. The survey-based output gap and HP filter output gap

in recent years, more than twice as high as that of the survey-based potential output. Because of its fluctuation, however, the growth rate of the HP filter trend is less reliable than that of the survey-based potential output.

Figure 4 depicts the survey-based output gap and shows its consistency with official peaks and troughs of business cycle. The shaded areas indicate contraction phases defined by the *Reference Dates of Business Cycle* issued officially by the Cabinet Office in Japan. Since the 1990s, the Japanese economy has experienced six contraction phases, due to (i) the burst of the Japanese asset bubble in the early 1990s; (ii) the Japanese financial system unease in the late 1990s; (iii) the burst of the U.S. dotcom bubble around 2000; (iv) the global financial crisis (GFC) in the late 2000s; (v) the recession by the strong yen in the early 2010s; and (vi) the pandemic of COVID-19 in the early 2020s. The survey-based output gap declined in each of these recession phases.

For comparison, we depict the output gap extracted by the HP filter (HP filter output gap) in Figure 4. The HP filter output gap is consistent with the official reference dates as well, but its size is sometimes counterintuitive. Three periods are notable: First, despite the extraordinary boom due to the asset bubble from the late 1980s to the early 1990s, the HP filter output gap was not very high and no higher than it was at the last moment of the Great Moderation in the early 2008. Second, despite Japan's lost decade

Table 1

Estimation results for the survey-based output gap

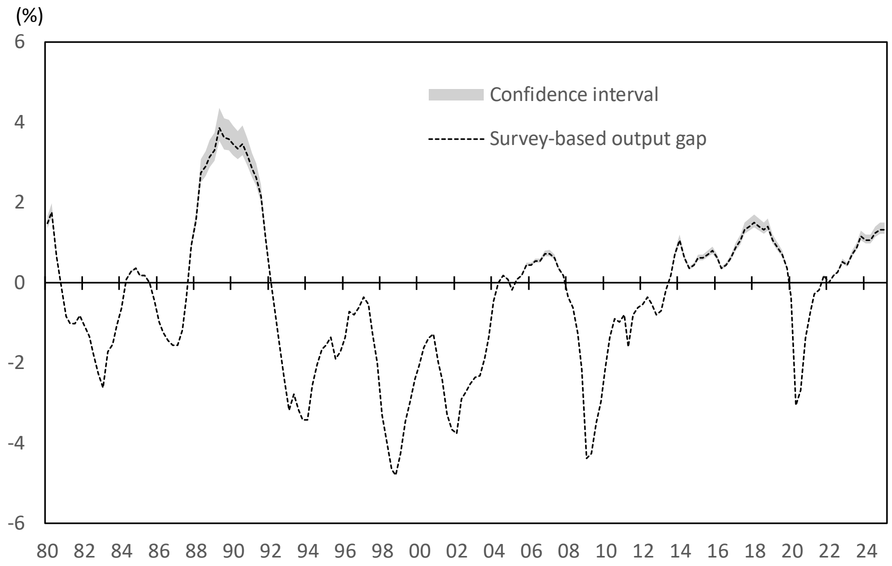
Gross domestic product			
$\hat{\beta}$		0.04	
The t-value of $\hat{\beta}$		18.59	
The 95% CI of $\hat{\beta}$	0.04	$\sim$	0.05
The average width of the 95% CI of $\hat{\alpha}_t$		0.01	
The average width of the 95% CI of the ouput gap		0.31	

due to the burst of the asset bubble from the mid-1990s to the mid-2000s, the HP filter output gap was around zero percent as if the economy had enjoyed calm days. Third, despite the severe labor shortage after the COVID-19 pandemic in 2022, the HP filter output gap remains around zero percent.

4.3. Uncertainty of the Survey-Based Output Gap

Our method of constructing the output gap is based on the estimation of equation (7). Thus, the obtained output gap is stochastic in nature. Here we use the bootstrap method to see the uncertainty of the estimates by constructing the 95% confidence interval (CI). Given $\hat{\alpha}_t$ and $\hat{\beta}$, we calculate estimation errors $\hat{\varepsilon}_t$, from which we draw the same number of errors randomly with replacement to construct a new series of errors, ε_t^0. Given $\hat{\alpha}_t$, $\hat{\beta}$, z_t, and ε_t^0, we calculate a new series of y_t^0. With z_t and y_t^0, we use our estimation method to obtain $\hat{\alpha}_t^0$, $\hat{\beta}^0$, and a new series of the output gap. We repeat this process 10,000 times to obtain 10,000 sets of estimates and pick the 2.5 percentile point and the 97.5 percentile point, which gives us the 95% CI.

Table 1 presents $\hat{\beta}$ and its related statistics. The 95% CI of $\hat{\alpha}_t$ is shown in Figure 5 and its average width is given in Table 1. The table indicates that $\hat{\beta}$ is significantly positive, which is a theoretically collect sign. The 95% CI of the output gap is tight with its average width equal to 0.31 percent point, which suggests that the estimated output gap is reliable enough for the use of business assessment and policymaking.



Sources: The Bank of Japan; the Cabinet office.

Figure 5. The 95% confidence interval of the survey-based output gap

5. Estimation Results of the Survey-Base Input Gap

5.1. The Data for the Survey-Based Input Gap

The data on capital utilization is provided by the Ministry of Economy, Trade, and Industry as the *index on operating ratio* in the manufacturing sector (2010 = 100, seasonally adjusted), which is the ratio of the *index on industrial production* over the *index on production capacity* in the manufacturing sector. There is no corresponding data for the non-manufacturing sector. Firms' assessments of capital utilization are collected by the Bank of Japan in the TANKAN survey as the assessments of *production capacity* in the manufacturing and non-manufacturing sectors. In the survey, firms are asked to answer the question with "Excessive capacity", "Adequate", or "Insufficient capacity". We use the shares of the first and third answers for estimation. Our sample covers the period of 1978Q1 to 2025Q1 for the manufacturing sector and the period of 1990Q4 to 2025Q1 for the non-manufacturing sector.

The data on capital stocks is provided by the Cabinet Office as *gross capital stocks, excluding the construction in progress* (market prices in 2005) in the *Preliminary Quarterly Estimates of Gross Capital Stocks in Private Enterprises*. This data has not been updated since

2016Q1. The share of the manufacturing sector was 32.8 percent on average during the period of 1994Q1 to 2016Q2. We aggregate the capital input gap in the manufacturing sector with weight 0.33 and the one in the non-manufacturing sector with weight 0.67 to calculate the capital input gap of all sectors.

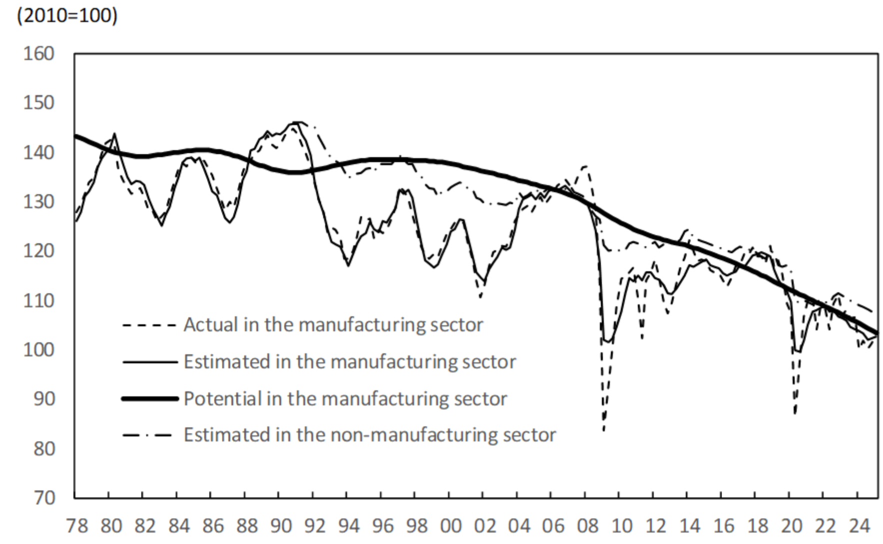
The data on unemployment is provided by the Ministry of Internal Affairs and Communication as the *unemployment rate* (seasonally adjusted) in the *Labor Force Survey*. The employment rate is calculated as 100 minus the unemployment rate. Firms' assessments of employment are collected by the Bank of Japan in the TANKAN survey as the assessments of *employment conditions*. In the survey, firms are asked to answer the question with "Excessive employment", "Adequate", or "Insufficient employment". We use the shares of the first and third answers for estimation. Our sample covers the period of 1974Q2 to 2025Q1.

The data on the distribution of income is provided by the Cabinet Office as the *generation of income account* in the *System of National Accounts*. The labor share is given by the ratio of *compensation of employees* over *value added, net* (or *net domestic product*) and is calculated to be 66.0 percent on average during the period of 1994 to 2023.

5.2. The Estimated Survey-Based Capital Input Gap in the Manufacturing Sector

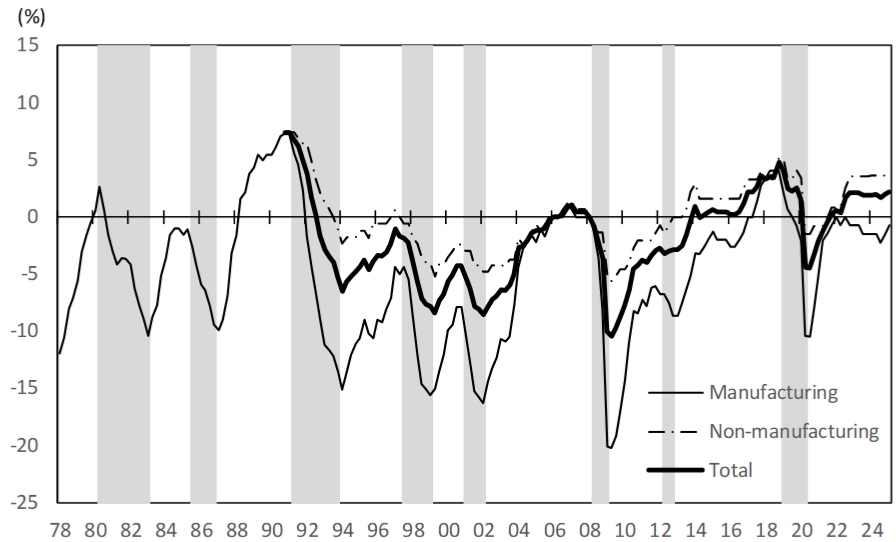
We estimate the input gap for the entire economy by aggregating two measures of input gaps: the capital input gap and the labor input gap. Furthermore, the capital input gap is obtained by aggregating that of the manufacturing sector and that of the non-manufacturing sector. We estimate these input gaps. Let us begin with the estimation of the capital input gap in the manufacturing sector. We use the index on capital utilization in the manufacturing sector and manufacturing firms' assessments of operation capacity in the TANKAN survey. We assume that firms' capital utilization rates are distributed normally.

Figure 6 depicts the actual rate of capital utilization, the estimated rate, and the potential rate in the manufacturing sector. The estimated rate traces the actual rate as a whole. The potential rate was declining over the sample period and its declining speed was accelerated with the emergence of Japan's financial system unease in 1997. One



Sources: The Bank of Japan; the Ministry of Economy, Trade, and Industry.

Figure 6. Actual, estimated, and potential capital utilization rates



Note: The shaded areas indicate contraction phases by the Reference Dates of Business Cycle.

Sources: The Bank of Japan; the Ministry of Economy, Trade, and Industry.

Figure 7. The capital input gaps

explanation for the decline is that the rate of capital depreciation became faster than indicated by the data, for instance, due to technological obsolescence. Our model captures such effective depreciation of capital by a decline in the potential rate of capital utilization. Another explanation is that firms were adaptive and lowered their standard for assessing capital utilization rates in accordance with the actual rate.

The survey-based input gap of capital in the manufacturing sector is depicted in Figure 7. The peaks and troughs are consistent with the official reference dates of business cycle. It is also notable that the graph is in the negative area during most of the sample period with a few exceptions and has climbed up to zero percent recently.

5.3. The Estimated Survey-Based Capital Input Gap in the Non-manufacturing Sector

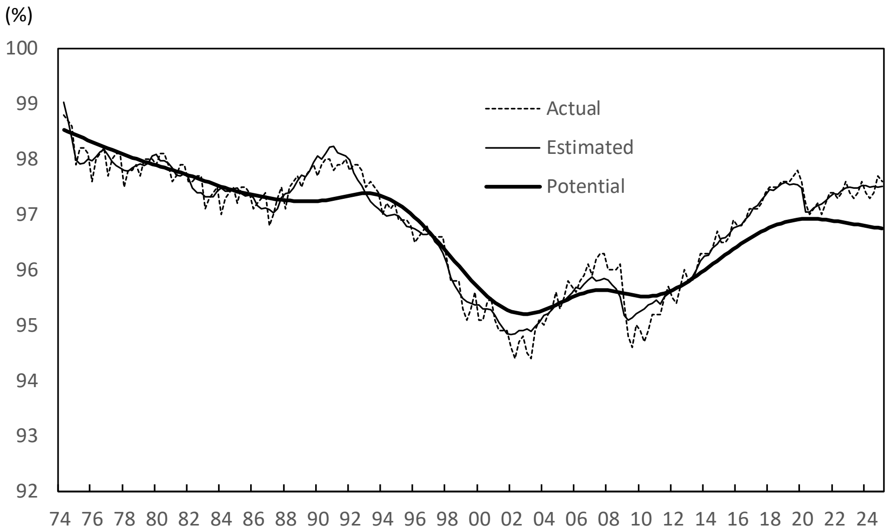
Next, we work on the estimation of the capital input gap in the non-manufacturing sector. We use non-manufacturing firms' assessments of operation capacity collected in the TANKAN survey to obtain the series of z_t^n for the non-manufacturing sector. We cannot estimate $\hat{\alpha}_t^n$ and $\hat{\beta}^n$, however, since we have no data on capital utilization in the non-manufacturing sector. Thus, we borrow $\hat{\alpha}_t^m$ and $\hat{\beta}^m$ from the manufacturing sector to estimate the series of capital utilization rates in the non-manufacturing sector as explained in section 3.

We depict the estimated rate of capital utilization of the non-manufacturing sector in Figure 6. The capital utilization rate of the non-manufacturing sector always exceeds that of the manufacturing sector. Consequently, as shown in Figure 7, the capital input gap of the non-manufacturing sector is always higher than that of the manufacturing sector and in particular has recently floated up beyond zero percent.

We combine the capital input gap in the manufacturing sector and that in the non-manufacturing sector to obtain the capital input gap of the entire economy. The result is presented in Figure 7. The historical high of the capital input gap was recorded in 1990 at the peak of Japan's bubble economy; the historical low was in 2009 near the end of the GFC. Since the end of the COVID-19 pandemic, the capital input gap has restored steadily and has climbed up to 2 percent recently.

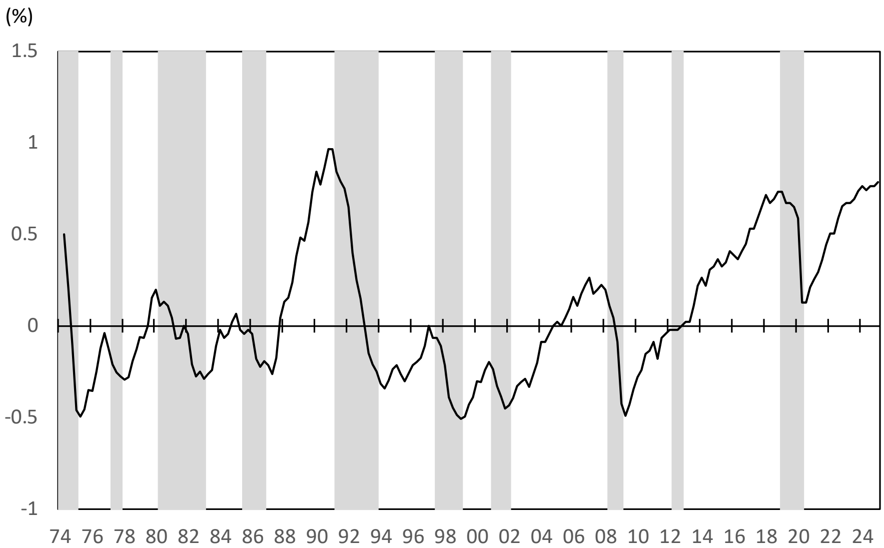
5.4. The Estimated Survey-Based Labor Input Gap

The estimation of the input gap of labor follows the same procedure as the estimation of the capital input gap in the manufacturing sector. We use firms' assessments of employment conditions in the TANKAN survey and the data on the labor employment rate. We apply our estimation method with the assumption that firms' employment rates are distributed normally.



Sources: The Bank of Japan; the Ministry of Internal Affairs and Communication.

Figure 8. Actual, estimated, and potential labor utilization rates

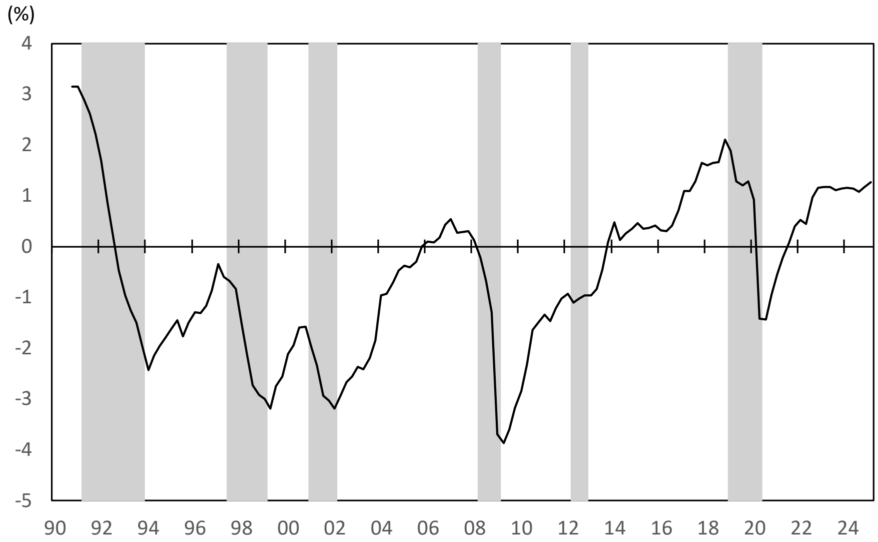


Note: The shaded areas indicate contraction phases by the Reference Dates of Business Cycle.

Sources: The Bank of Japan; the Ministry of Internal Affairs and Communication.

Figure 9. The labor input gap

Figure 8 depicts the actual rate of labor utilization, the estimated rate, and the potential rate. Although the actual rate is noisy, the estimated rate traces it closely as a whole. The potential rate depicts a W-shaped trajectory: It declined gradually after the burst of Japan's asset bubble in the early 1990s; it picked up a little in the early 2000s but declined slightly due to the GFC; it began to climb up again after the end of the GFC in the early 2010s.



Note: The shaded areas indicate contraction phases by the Reference Dates of Business Cycle.

Sources: The Bank of Japan; the Ministry of Economy, Trade, and Industry: the Ministry of Internal Affairs and Communication.

Figure 10. The input gap

The labor input gap is obtained as the deviation rate of the estimated labor utilization from the potential rate, as is shown in Figure 9. Its peaks and troughs are consistent with the official reference dates of business cycle. Recently, it has been boosted up to the same level as we experienced in the bubble economy.

5.5. The Survey-Based Input Gap as the Sum of Capital and Labor Input Gaps

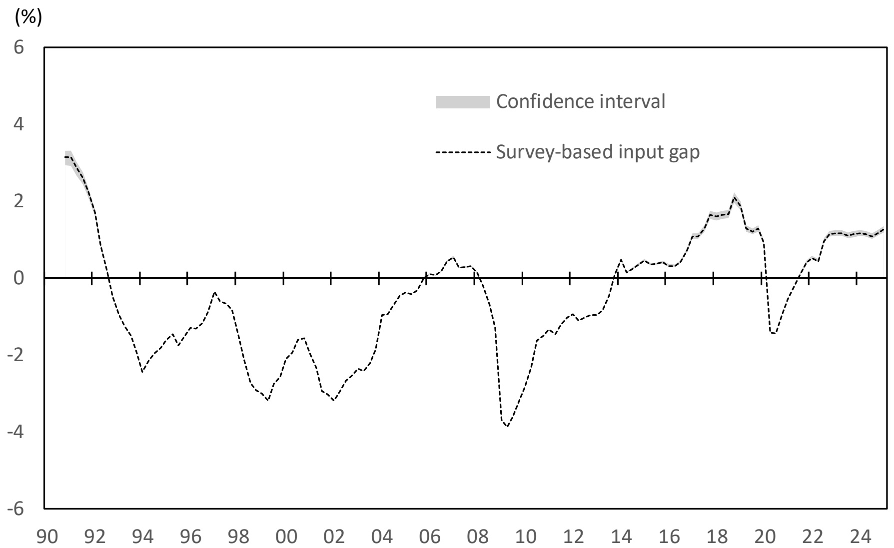
The survey-based input gap is obtained by combining the survey-based capital input gap and the survey-based labor input gap. The result is presented in Figure 10. The survey-based input gap is consistent with the official reference dates of business cycle and gives it quantitative information. The maximum input gap is 3.1% recorded in 1990Q4 at the peak of the Japanese asset bubble; the minimum is -3.9% recorded in 2009Q2 during the GFC; the most recent value is 1.3% in 2025Q1.

We can measure its degree of uncertainty to judge its usefulness in economic assessment. The bootstrap method with 10,000 iteration is used to construct the 95% CI of the estimates. The results are summarized in Table 2. We estimate equation (26) for the capital utilization rate in the manufacturing sector to obtain $\hat{\beta}^m$, which is significantly positive and has a theoretically correct sign. As for the labor utilization rate,

Table 2

Estimation results for the survey-based input gap

Capital utilization in the manufacturing sector	
$\hat{\beta}^m$	34.67
The *t*-value of $\hat{\beta}^m$	28.27
The 95% CI of $\hat{\beta}^m$	31.60 ～ 36.44
The average width of the 95% CI of $\hat{\alpha}_t^m$	2.80
The average width of the 95% CI of the input gap	0.79
Capital utilization in the non-manufacturing sector	
The average width of the 95% CI of the input gap	0.33
Capital utilization in all sectors	
The average width of the 95% CI of the input gap	0.45
Labor utilization	
$\hat{\beta}^\ell$	0.99
The *t*-vale of $\hat{\beta}^\ell$	15.88
The 95% CI of $\hat{\beta}^\ell$	0.91 ～ 1.16
The average width of the 95% CI of $\hat{\alpha}_t^\ell$	0.18
The average width of the 95% CI of the input gap	0.08
Utilization of capital and labor conbined	
The average width of the 95% CI of the input gap	0.17

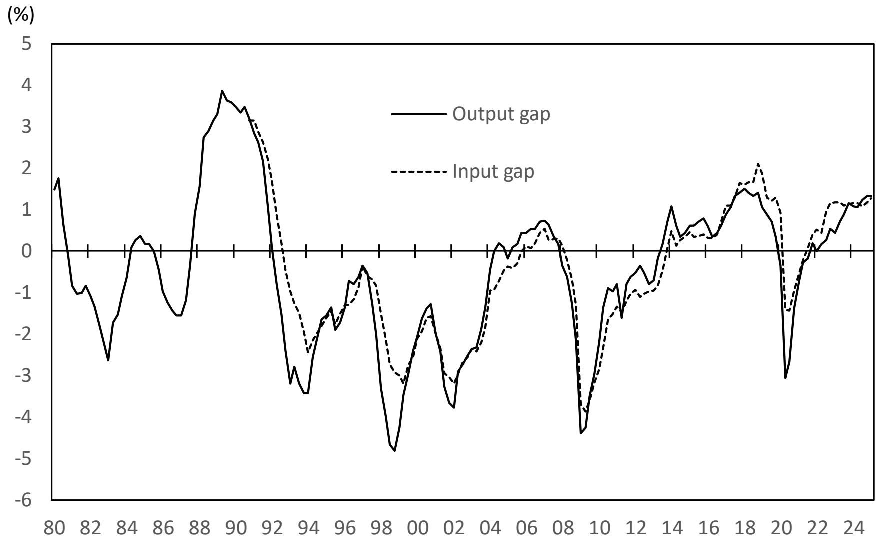


Sources: The Bank of Japan; the Cabinet Office; the Ministry of Economy, Trade, and Industry; the Ministry of Internal Affairs and Communication.

Figure 11. The 95% confidence interval of the survey-based input gap

we mentioned two theoretical possibilities about the sign of $\hat{\beta}^\ell$ in section 3. According to the estimation result in the table, we find that $\hat{\beta}^\ell$ is significantly positive. The rate of idle labor force in firms is positively correlated with the rate of unemployment in a country.

The 95% CI of the total input gap is shown in Figure 11 and, as shown in Table



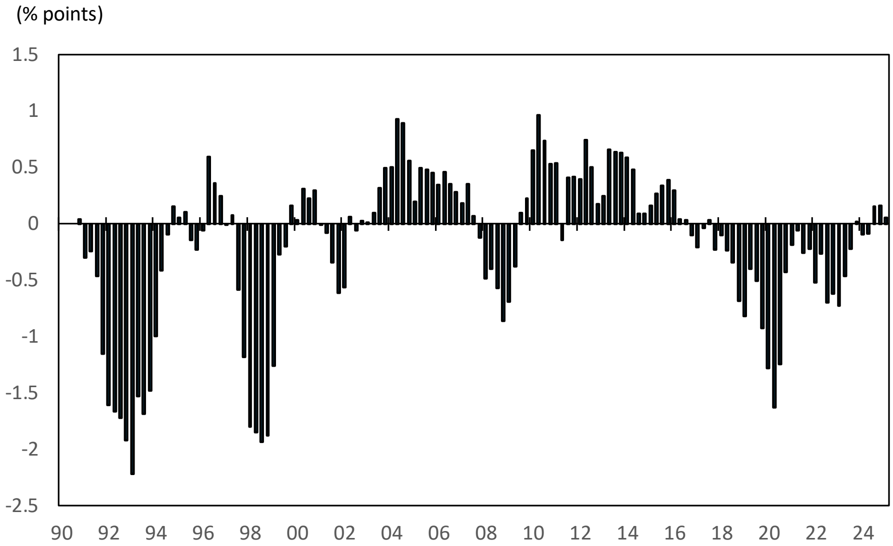
Sources: The Bank of Japan; the Cabinet Office; the Ministry of Economy, Trade, and Industry; the Ministry of Internal Affairs and Communication.

Figure 12. The survey-based output gap and input gap

2, its average width is 0.17 percent point, which is half as large as that of the output gap, 0.31 percent point. The 95% CI of the labor input gap is extremely tight and its average width is only 0.08 percent point. The average CI width of the capital input is 0.45 percent point, which is the weighted average of that in the manufacturing sector, 0.78 percent point, and that in the non-manufacturing sector, 0.33 percent point. Therefore, the uncertainty of the total input gap comes mainly from the estimation of the capital input gap in the manufacturing sector. Nonetheless, the uncertainty of the input gap is so small that we can rely on it safely for the assessment of business cycle.

6. Discrepancy between the Output Gap and the Input Gap

Now we have two measures of economic slackness in Japan: the survey-based output gap and the survey-based input gap. We compare them in Figure 12. Although calculated from different data sets, the two gap measures surprisingly coincide with each other as a whole. The root mean squared differences (RMSD) is only 0.71 percent point. Close examination shows, however, that the survey-based output gap and input gap sometimes deviate from each other. The deviation may be caused by various factors. We explore the following possibilities in this section: (i) variations in total factor productivity; (ii) an alternative data on labor supply; (iii) an alternative data on business



Sources: The Bank of Japan; the Cabinet Office; the Ministry of Economy, Trade, and Industry; the Ministry of Internal Affairs and Communication.

Figure 13. The TFP gap

conditions.

6.1. Variations in the Total Factor Productivity Gap

When we construct the survey-based input gap, we exclude the effects of TFP by assuming that it is always on its potential. As Okun (1962) pointed out, however, TFP may vary due to adjustments of production process and thereby actual TFP may deviate from potential. Then equation (24) is rewritten as follows.

$$\ln y - \ln y^{*} = \ln \phi - \ln \phi^{*} + (1 - s)(\ln k - \ln k^{*}) + s(\ln \ell - \ln \ell^{*}). \tag{33}$$

In this case, the survey-based output gap reflects the movement of the TFP gap, while the survey-based input gap doesn't. This allows the two gap measures to divert from each other.

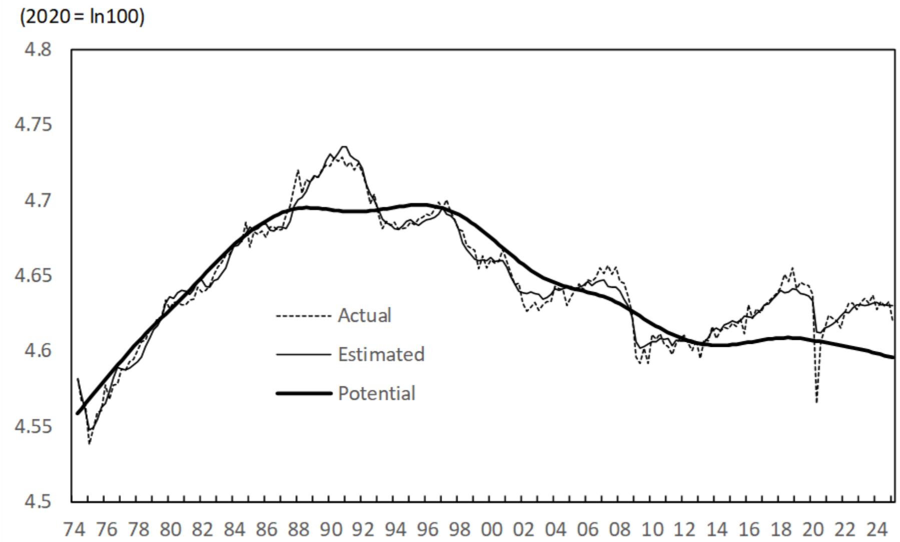
As is clear in equation (33), the TFP gap, $\ln \phi - \ln \phi^{*}$, is obtained by subtracting the survey-based input gap from the survey-based output gap. The result is presented in Figure 13. Interestingly, large negative TFP gaps occurred together with serious recessions, e.g., the burst of Japan's asset bubble in the early 1990s, the emergence of the financial system unease in the late 1990s, and the pandemic of COVID-19 in the early 2020s. When the economy is hit by large shocks, it takes time for firms to make full adjustment to them, which leads to declines in productivity.

6.2. An Alternative Labor Supply Data for the Survey-Based Input Gap

For the estimation of the survey-based input gap, we used the employment rate as the data on labor input, which was given by the ratio of the number of employed people over the labor force population. An alternative way of measuring labor input is to count total hours worked, as the BOJ does in the estimation of its official output gap.

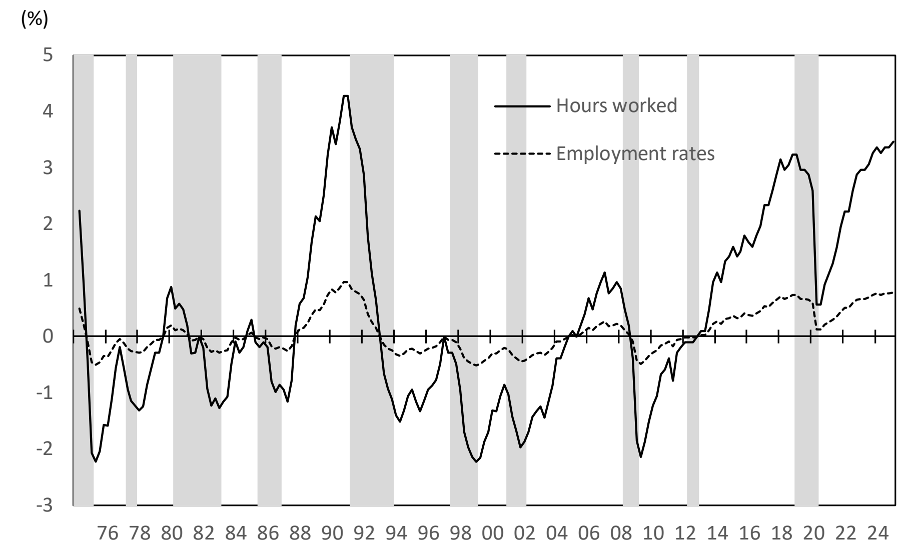
The data on total hours worked is obtained by per capita hours worked times total labor force. The data on per capita total hours worked is provided by the Ministry of Health, Labour, and Welfare as the index on *total hours worked* (2020 = 100, seasonally adjusted) in the *Monthly Labor Survey*, which is transformed into a quarterly data. There are two versions of the index: the one for establishments with 5 employees or more and the other for establishments with 30 employees or more. We use the latter in this paper, since it enables us to conduct empirical analysis which covers a longer period. The data on total labor force is provided by the Ministry of Internal Affairs and Communications as the number of *labour force employed* (total, seasonally adjusted) in the *Labour Force Survey*. We multiply the per capita hours worked by the total labor force and normalize the product with 2020 = 100. Our sample covers the period of 1990Q4 to 2025Q1.

We estimate the input gap of labor, using the total hours worked and firms' assessments of employment conditions in the TANKAN survey, with the assumption that hours worked in the firms are distributed log-normally. The result is presented in Figure 14, which depicts the actual, estimated, and potential hours worked. It is interesting to see that Japan's hours worked peaked in the early 1990s and decreased thereafter by more than 10 percent in 20 years, which is in contrast with the image of workaholic Japanese workers. Figure 15 shows the hours-worked-based labor input gap. Its fluctuation is four times as large as the employment-rate-based input gap obtained in the previous section. Consequently, as shown in Figure 16, the hours-worked-based total input gap fluctuates more widely than the output gap. The replacement of labor force



Sources: The Bank of Japan; the Ministry of Internal Affairs and Communication; the Ministry of Health, Labour, and Welfare.

Figure 14. Actual, estimated, and potential hours worked



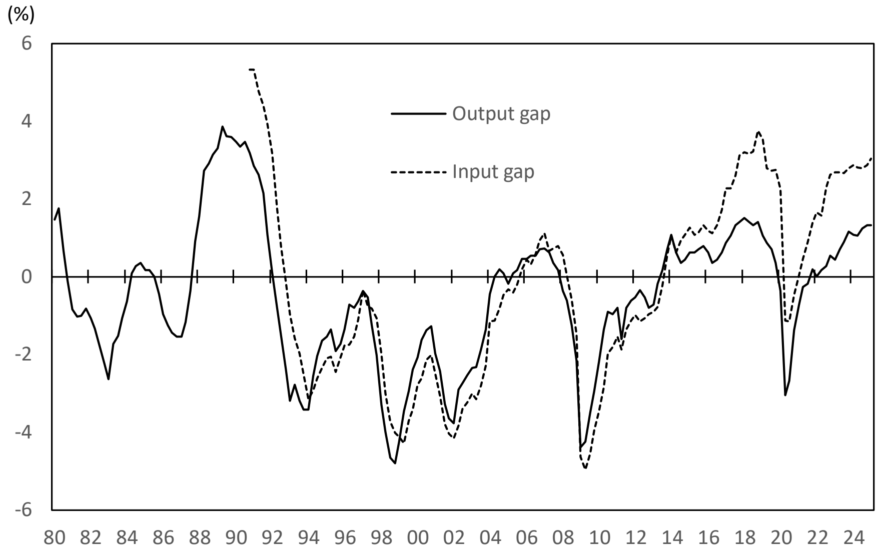
Note: The shaded areas indicate contraction phases by the Reference Dates of Business Cycle.
Sources: The Bank of Japan; the Ministry of Internal Affairs and Communication; the Ministry of Health, Labour, and Welfare.

Figure 15. The labor input gaps by employment rates and by hours worked

measures does not close the discrepancy between the output gap and the input gap.

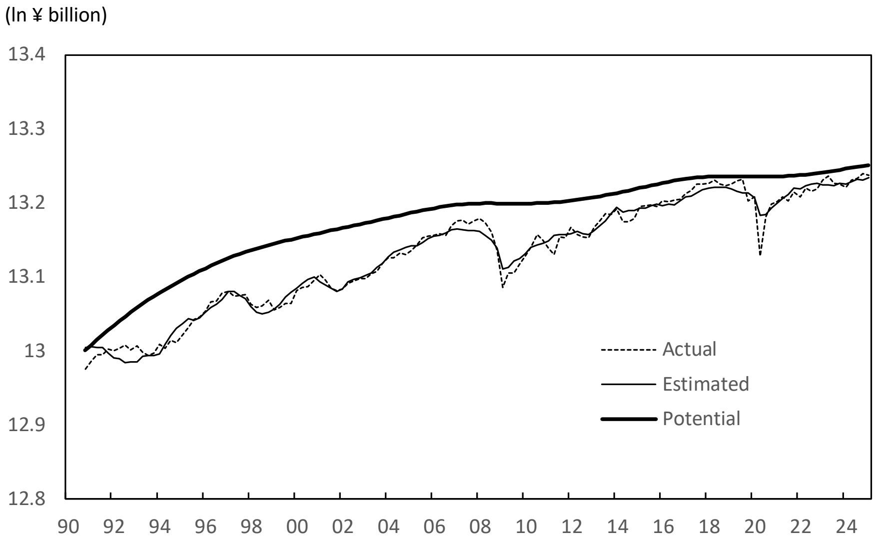
6.3. An Alternative Survey Data for the Survey-Based Output Gap

Lastly, we discuss the choice of a survey data on business cycle. The TANKAN survey has firms' assessments of domestic supply and demand conditions for products and



Sources: The Bank of Japan; the Cabinet Office; the Ministry of Economy, Trade, and Industry; the Ministry of Internal Affairs and Communication; the Ministry of Health, Labour, and Welfare.

Figure 16. The output gap and the input gap by hours worked

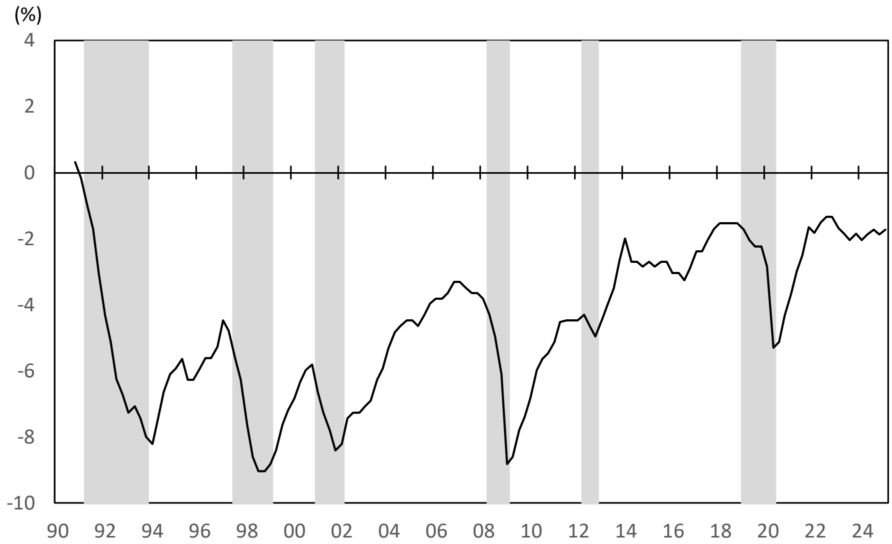


Sourses: The Bank of Japan; the Cabinet office.

Figure 17. Actural, estimated, and potential output by domestic supply and demand conditions

services. Three options are prepared for answering this question: "Excess demand", "Almost balanced", and "Excess supply". This data seems to be a candidate for the estimation of the output gap. We use the shares of the first and third answers for estimation. Our sample covers the period of 1990Q4 to 2025Q1.

The result is presented in Figure 17, which shows the actual, estimated, and potential output. The estimated output traces the actual output closely. Note that the



Note: The shaded areas indicate contraction phases by the Reference Dates of Business Cycle.
Sourses: The Bank of Japan; the Cabinet Office.

Figure 18. The output gap by domestic supply and demand condtions

potential output always exceeds the estimated output. This is interesting, since it shows that in assessing domestic supply and demand conditions, firms think of the maximum producible output, not the maximum sustainable output, as the potential output. Consequently, the output gap always takes negative values, as is shown in Figure 18. The replacement of business assessment surveys does not close the discrepancy between the output gap and the input gap.

7. Conclusion

This paper proposes two measures of economic slackness, the survey-based output gap and the survey-based input gap, which enable us to incorporate firms' assessments of the economy into gap measures. Two ingredients are indispensable in our method: the Carlson-Parkin method of transforming qualitative data into quantitative data and the Hirose-Kamada method of estimating a time-varying model.

The survey-based output gap in Japan is estimated, based on the GDP data and the assessments of business conditions in the TANKAN survey. Our method is also applicable to the estimation of the survey-based input gap in Japan, which consists of the capital input gap and the labor input gap. The estimated survey-based output gap and input gap are consistent with the official reference dates of business cycle and their

95% confidence intervals are tight. Our output gap and input gap are viewed as useful quantitative indicators of business cycle.

The estimated survey-based output gap and input gap surprisingly coincide with each other, but sometimes deviate from each other, particularly in severe recessions. We investigate its causes and conclude that variations in the TFP gap create the discrepancy. We can use the two gap measures appropriately by understanding their contents correctly.

Appendix. Derivation of Equations (10) to (12)

By definition, we have $y_t \equiv \Sigma_i x_{it}$ and $y_t^* \equiv \Sigma_i x_{it}^*$, where x_{it}^* is a reference point of firm i at time t. By the first-order Taylor expansion of $\ln y_t$ at y_t^* and x_{it}^*, we have

$$\ln y_t = \ln y_t^* + \Sigma_i \left\{ \frac{1}{y_t^*} (x_{it} - x_{it}^*) \right\}. \tag{A1}$$

Substituting the approximate relationship of $(x_{it} - x_{it}^*)/x_{it}^* = \ln x_{it} - \ln x_{it}^*$ into equation (A1), we have

$$\ln y_t = \ln y_t^* + \Sigma_i \left\{ \frac{x_{it}^*}{y_t^*} (\ln x_{it} - \ln x_{it}^*) \right\}. \tag{A2}$$

Firms share the same reference point, x_t^*. Thus, we have $x_{it}^* = x_t^*$ and $y_t^* = N x_t^*$. Thus, equation (A2) is reduced to

$$\ln y_t = \ln y_t^* + \frac{\Sigma_i \ln x_{it}}{N} - \ln x_t^*. \tag{A3}$$

We assume that x_{it} is distributed log-normally with parameters μ_t and σ_t. Thus, $\ln x_{it}$ is distributed normally with mean μ_t and standard deviation σ_t. Applying the extended Carlson-Parkin method, we have

$$\mu_t = \ln x_t^* + \frac{a_t + b_t}{a_t - b_t} \delta. \tag{A4}$$

Substitute $\mu_t = \Sigma_i \ln x_{it} / N$ and equation (A4) into equation (A3). Then we have

$$\ln y_t = \ln y_t^* + \frac{a_t + b_t}{a_t - b_t} \delta. \tag{A5}$$

Adding measurement error ε_t to equation (A5), we have equations (10) to (12).

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