Bank of Japan Working Paper Series

Real-Time Analysis on Japan's Labor Productivity

Naoko Hara*
naoko.hara@boj.or.jp

Hibiki Ichiue**
hibiki.ichiue@boj.or.jp

No.10-E-7
July 2010

Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-8660

* Research and Statistics Department, Bank of Japan

** Monetary Affairs Department, Bank of Japan

Real-time Analysis on Japan's Labor Productivity[*]

Naoko Hara[†] and Hibiki Ichiue[‡]

First draft: October 2009
This version: July 2010

[Abstract]

This paper analyzes the revision to Japan's labor productivity, measured using Japan's System of National Accounts (SNA) data. We draw three main findings from our analysis. First, SNA data has been substantially revised in and after the second comprehensive revisions, as well as at the earlier stage of revisions. We find that the past absolute revisions to the annual growth rate of labor productivity often went beyond 1 percentage point. Second, the annual growth rate of labor productivity has been revised upward by 0.4 percentage points on average. We show that part of its upward revisions reflects an underestimation of employment through an increase in 'non-response people,' people who do not respond in the Population Census. Third, revisions to source data such as the Population Census and the Employment Status Survey are helpful to predict revisions to labor productivity growth. Our regression results suggest that labor productivity is likely to be revised upward during expansions or with low real-time estimates of value added. We conclude that the three findings indicate that labor productivity during the 2000s will experience substantial revisions in the future. This conclusion takes into account the fact that the SNA after 2000 has experienced at most one comprehensive revision. The upcoming revisions to labor productivity can be positive rather than negative.

JEL classification: E17, O47

Keywords: Real-time Data; Productivity; SNA; Monetary Policy; Survey Data

---

[*] We thank Ichiro Fukunaga, Keiichiro Inaba, Seisaku Kameda, Kazushige Kamiyama, Tomiyuki Kitamura, Kazuo Monma, Shinya Nakamura, Toshitaka Sekine, and Tomohiro Sugo for their comments. We gratefully acknowledge comments from our discussant Yasuyuki Komaki and participants at the third University of Tokyo – Bank of Japan conference in November 2009, and those from participants at the 16th International Conference on Computing in Economics and Finance held by the Society for Computational Economics in July 2010. We thank the Department of National Accounts of the Economic and Social Research Institute of the Cabinet Office for their response to our questions. We are also grateful to Chie Arai, Daisuke Miyajima, Takanori Nitta, and Tomoaki Tanaka for excellent research assistance. The views expressed in this paper are solely those of the authors and should not be interpreted as reflecting the views of the Bank of Japan.

[†] Bank of Japan; E-mail: naoko.hara@boj.or.jp

[‡] Bank of Japan; E-mail: hibiki.ichiue@boj.or.jp

1. Introduction

Productivity is a fundamental concept in economic analysis. The evolution of mid-to-long-run economic growth—which is a crucial assumption of analyses, on fiscal sustainability, for instance—relies substantially on perspectives on productivity growth. Productivity is also important in the light of short-run economic dynamics. For example, when an economy grows, the desirable policy accompanied by a rise in productivity will be totally different from that without the rise. Considering monetary policy, immediate monetary policy tightening is not necessary if an economy grows with a rise in productivity and labor market conditions are not tight. By contrast, central banks should be cautious about economic growth without rising productivity, because economic bubbles and accelerated inflation are fairly likely to happen through economic overheating.

While it is widely recognized that productivity is conceptually important, measuring productivity is quite difficult. One challenge in measuring productivity is that productivity measured in real time will be revised due to revisions to its source data.

An experience of the Federal Reserve Board (FRB) shows how revisions to productivity can influence monetary policy. In the 1990s, the FRB continued discussions on whether the current productivity growth accelerated under high economic growth. Anderson and Kliesen (2005) use the FOMC transcripts to study what the FOMC members debated based on the FRB staff forecasts of labor productivity. In the 1990s, it is widely said that increased information and communications technology (ICT) investment from the early 1990s was accelerating productivity growth. Data available in real time, however, did not even hint at such a relationship. According to Anderson and Kliesen (2005), the FOMC members' primary concern at that time was whether increased investment in ICT was accelerating productivity growth. They continued to debate whether immediate monetary tightening was needed in response to the rapid economic growth. Eventually, the source data on labor productivity was revised so that the ex-post assessment of labor productivity was higher than its real-time estimates. Thus, the FOMC's decision in the 1990s to avoid an immediate reaction to rapid economic growth was found to be appropriate in terms of uncertainty around real-time data. This episode is often referred to today as an example of proper monetary policy conduct, since it took into account future data revisions[1].

[1] The former Federal Reserve chairman Greenspan later commented in his book, "By not being too quick to raise rates, we helped clear the way for the postwar period's longest economic boom."

With recognition of the importance of data revisions, organizations in the United States and Europe—mainly central banks and international institutions—have been constructing databases collecting real-time data[2]. Progress in developing real-time datasets has led to substantial accumulation of real-time data analysis[3]. Among the series of real-time data analysis, there are various studies on real-time productivity, including Anderson and Kliesen (2005). For instance, Orphanides (2003) points out that a slowdown in productivity growth in the 1970s, which was not observed in real time, led to the Great Inflation via monetary policy that was excessively expansionary. Edge, Laubach, and Williams (2007) measure a learning process for long-run trend of labor productivity of the United States based on real-time data and forecasters' real-time predictions for labor productivity.

In contrast to the United States and Europe, there is only one real-time dataset for Japan that is open to the public and regularly updated. It is provided by the OECD on its website, covering 21 variables collected in the OECD's *Monthly Economic Indicator* from February 1999 onward[4]. Studies on real-time data analysis for Japan are far fewer than those for the United States and European countries. Revisions to Japan's real GDP are studied in Komaki (2005), Kawagoe (2007), and Sekino (2007). Faust, Rogers, and Wright (2005) and Giannone, Henry, Lalik, and Modugno (2010) conduct international comparison on revisions to real GDP. Kamada (2004) and Komaki (2002, 2003) analyze real-time measurement of output gap. As far as we know, however, there is no preceding research on Japan's labor productivity using real-time data.

This paper analyses revisions to Japan's labor productivity based on a dataset we have

---

(Greenspan (2007)). Woodward (2000) and Greenspan (2007) describe the debates at the FOMC meetings during 1990s.

[2] For the United States, Real-Time Dataset for Macroeconomists (RTDSM) by the Federal Reserve Bank of Philadelphia is widely used (Croushore and Stark (2001)). Archival Federal Reserve Economic Data (ALFRED) by the Federal Reserve Bank of St. Louis contains real-time data for about 20,000 variables as of August 2009 (Anderson (2006)). For Europe, the European Central Bank (ECB) has developed a real-time database for the euro area (Giannone, Henry, Lalik and Modugno (2010)). The Bank of England provides a real-time dataset for the United Kingdom (Castle and Ellis (2002)). Aside from these countries, the Reserve Bank of New Zealand has constructed a real-time database for New Zealand (Sleeman (2006)). Concerning international institutions, the OECD provides a real-time database for all OECD countries, the euro area, and several non-OECD countries.

[3] Croushore (2009) provides a comprehensive list of more than 300 papers on real-time data analysis.

[4] Another real-time database for Japan is provided by Yasuyuki Komaki and can be obtained from the following website: http://www.eco.nihon-u.ac.jp/~komaki/RealTimeData-091121.html

recently developed. Although many studies on productivity focus on Total Factor Productivity (TFP), we take labor productivity as the key productivity measure. The main reason is that measured TFP varies among measurement methods and that computing TFP depends on capital stock, which is quite difficult to measure. By contrast, labor productivity employs a simple definition: value added divided by labor input. Thus, the measurement of labor productivity is far less sensitive to measurement methods. In addition, labor productivity does not use the data on capital stock.

We analyze labor productivity at the macro-level, computed as real GDP over labor input, rather than at industry-level. Real GDP can be broken down into nominal GDP and GDP deflator; labor input is broken down into employment and hours worked. In this paper, we investigate revisions to each component of labor productivity.

The remainder of the paper is organized as follows. In Section 2, we introduce our real-time data sets, and show the characteristics of revisions to labor productivity and each of its components. Sections 3 and 4 focus on labor input, which is a denominator of labor productivity. We investigate properties of revisions to components of labor input, namely, employment and hours worked, based on estimation methodology of their source data. Section 5 analyzes value added, which is a numerator of labor productivity. Particularly, we conduct empirical analysis on the relationship between revisions to GDP and business cycle, using regressions for revisions to GDP. Finally, Section 6 concludes our analysis.

2. Revisions to Labor Productivity

Output per hour is one of the most popular measures of labor productivity, and is defined as:

$$\begin{aligned}\text{Labor productivity} &= \frac{\text{Real value added}}{\text{Labor input}} \\ &= \frac{\text{Real value added}}{\text{Employment} \times \text{Hours worked}}\end{aligned} \qquad (1)$$

This paper computes labor productivity based on this definition, and explores the sources of its revisions.

Data for calculating Japan's labor productivity are available from a variety of data sources. As shown in Table 1, preceding papers on Japan's productivity rely on the following: SNA, JIP database (Japan Industrial Productivity Database), KEO database (Keio Economic Observatory Database), Labour Force Survey, and/or Monthly Labour Survey[5].

Among these sources, this paper mainly analyses revisions to the SNA, because it provides sufficient vintages of data on output and employment with a lot of revisions[6].

The exception is hours worked. The SNA has released the data on hours worked per employee for the whole economy only since 2006. Thus, like Hayashi and Prescott (2002), we use total hours worked per regular employee from the Monthly Labour Survey, which is an establishment survey. It covers two employment size classes: establishments with five or more employees, and those with 30 or more employees. We employ the data on the former because of its wider coverage of establishments. However, the data on establishments with five or more employees has been released only since January 1990. Hence, for calculating growth rates of hours worked, we use the data on establishments with 30 or more employees until fiscal year 1990.

The Labour Force Survey is often used as a representative indicator for employment in Japan. We, however, do not take this survey as our main employment statistics. While it has the advantage of timeliness, it is prone to sample bias compared to the Population Census and the SNA, which uses the Census as a data source. Hence, if more accurate statistics become available, the data source for employment should be replaced from timely but less accurate statistics to the more reliable one. Thus, in this section we analyze revisions caused by changing data source for employment from the Labour Force Survey to the SNA, which is thought to be more accurate than the survey.

We take GDP as the measure of value added for the whole economy, which suits our

---

[5] The JIP database was constructed by the Research Institute of Economy, Trade, and Industry (RIETI) and the Institute of Economic Research at Hitotsubashi University. The KEO database was built by the Keio Economic Observatory at Keio University. See Fukao and Kwon (2007), and Makino, Tokui, and Takahashi (2008) for the JIP database, and Kuroda, Shimpo, Nomura, and Kobayashi (1997) for the KEO database.

[6] Industrial classification and estimation methodology applied to capital stock are not shared among the SNA, JIP, and KEO. The methodological dissimilarity matters when we compare the TFP data of an individual industry measured using these databases. By contrast, such dissimilarity is likely to cause little difference in the case of aggregate labor productivity. Concerning industrial classification, JIP and KEO apply adjustment factors to the measured value added and employment to keep consistency with the SNA. In addition, labor productivity does not need any data on capital stock. Therefore, the measured aggregate labor productivity based on the SNA is less likely to clearly differ from that based on either of the other two databases.

analysis on labor productivity at the macro level. We, however, do not use GDP but GNP as output measure when computing labor productivity from the real-time data available before December 1993. It is because a representative indicator for Japan's value added was changed from GNP to GDP when GDP and GNP for 1993Q3 were first released on December 10th, 1993. Therefore, our definition of "revisions" also covers effects of the definitional change in value added from GNP to GDP. This setting is more realistic than a sole use of either GDP or GNP throughout the sample period. In practice, GNP was used in real time when it represented value added, but GDP is used today to obtain labor productivity over history.

Labor productivity of a country is computed as:

$$\begin{aligned}\text{Productivity} &= \frac{\text{Real GDP}}{\text{Labor input}} \\ &= \frac{\text{Nominal GDP}/\text{GDP deflator}}{\text{Employment}\times\text{Hours worked}}\end{aligned} \tag{2}$$

Suppose all of the variables in equation (2) are annual series. By taking the log differences of both sides of this equation, we obtain:

$$\begin{aligned}\mathrm{d}\log(\text{Labor productivity}) &= \mathrm{d}\log(\text{Real GDP}) - \mathrm{d}\log(\text{Labor input}) \\ &= \mathrm{d}\log(\text{Nominal GDP}) - \mathrm{d}\log(\text{GDP deflator}) \\ &\quad - \mathrm{d}\log(\text{Employment}) - \mathrm{d}\log(\text{Hours worked})\end{aligned} \tag{3}$$

$\mathrm{d}\log(\bullet)$ means log difference of annual series. We compute year-on-year growth rates based on the log difference, for the convenience on breaking down revisions following equation (3).

Figure 1 (a) illustrates how labor productivity growth for fiscal year 1991 (April 1991 to March 1992) appeared in real time. The horizontal axis in Figure 1 shows vintages of the data on labor productivity. We calculate labor productivity of the vintage of 1992 by using timely source data released around June 1992, roughly three months after the end of fiscal year 1991. Our source data for this vintage are the preliminary estimate of real GDP, employment from the Labour Force Survey, and the final estimate of hours worked from April 1992 issue of the Monthly Labour Survey. Vintages of 1993 onward use the source data released around March each year. The sources are the first annual revisions of GDP and employment from the SNA, and the final estimate of hours worked from January issues of the Monthly Labour Survey. The latest vintage comes from the data set available in December 2009.

Returning to Figure 1 (a), labor productivity growth for fiscal year 1991 was revised downward by 1 percentage point, from 3.6 percent in the first vintage computed by using the timely statistics to 2.6 percent in the latest vintage. Particularly, comprehensive, or benchmark, revisions of the SNA caused large revisions to labor productivity. A downward and substantial revision was observed in the second comprehensive revision available in the 2001 Annual Report on National Accounts, as well as in the first one published in 1996. Similarly, labor productivity growth for fiscal year 2000 experienced large revisions. As shown in Figure 1 (b), it was revised up from 0.8 percent to 2.8 percent.

We next focus on whether such large revisions have occurred frequently, comparing the real-time and latest estimates of labor productivity. We define "real-time estimates on labor productivity" as those computed when a set of data for the components of labor productivity becomes first available.

Figure 2 (a) shows the real-time and latest estimates on annual growth of labor productivity. This figure depicts two types of real-time estimates. The first type uses timely source data released about three months after the end of fiscal years, such as the preliminary estimates of GDP and Labour Force Survey. The second type uses the first annual revisions of SNA data. Figure 2 (b) depicts the revisions from the real-time to the latest estimates of both types. This figure shows that the real-time estimates based on timely data lead to larger revisions than those based on the first annual revisions of the SNA. This implies that labor productivity measured with the preliminary estimates of GDP and Labour Force Survey can be substantially revised on the release of the first annual revisions of the SNA. The difference in the type of real-time estimates, however, does not alter the fact that labor productivity has been often revised substantially. As the two figures show, revisions of more than 1 percentage point have often occurred. These figures also illustrate that labor productivity for recent periods seems to be revised less. It does not, however, solely mean that labor productivity will also be revised less in the future. Rather, it reflects the fewer experiences of revisions to the source data for the past several years. Thus, the estimates for recent years can be further revised[7].

---

[7] No comprehensive revision has happened to the latest estimate of real GDP from fiscal year 2005 onward, and only one comprehensive revision to that between fiscal year 2000 and 2004. As shown in Figure 1, even the second comprehensive SNA revision substantially changed labor productivity growth for fiscal year 1991. Therefore, the latest estimate of labor productivity from 2000 can be considerably revised in the future.

We then investigate how revisions to each data source cause the revisions to labor productivity. Henceforth we take real-time estimates of employment from the first annual revisions of the SNA available in real-time. Since our primary interest here is revisions within each data source, we do not study the revisions caused by replacing one source data with another. Equation (3) implies that upward revisions to labor productivity growth are caused by upward revisions to real and nominal GDP growth. Upward revisions to labor productivity growth also come from downward revisions to the growth of labor input, GDP deflator, number of workers, and hours worked.

Figure 3 illustrates revisions to year-on-year growth rates of variables used to compute labor productivity, which are real GDP and labor input (Figure 3 (a)), nominal GDP and GDP deflator (Figure 3 (b)), and employment and hours worked (Figure 3 (c)). The revisions to real GDP have been considerable, and the revisions to labor input have frequently reached about 0.5 percentage points. Concerning signs of revisions, labor input has been often revised downward.

Table 2 shows statistical characteristics of revisions to labor productivity and its components that appear in equation (3). Annual growth of labor productivity is revised upward by about 0.4 percentage points on average: 0.2 percentage points by upward revision to real GDP, and another 0.2 percentage points by downward revision to labor input. Nominal GDP growth shows the largest revision among all of the data sources in terms of MAR (Mean Absolute Revision), RMSR (Root Mean Squared Revision), maximum revision, and minimum revision. GDP deflator and employment are the next largest[8].

In sum, the annual growth rate of labor productivity has been frequently and considerably revised, and has been revised upward on average. This result is largely attributed to revisions to real GDP, but revisions to labor input also substantially contribute to those to labor productivity growth.

---

[8] The measured revisions to hours worked are smaller than those to the other source data. This reflects the use of hours worked from the Monthly Labour Survey, instead of SNA hours worked with insufficient vintages. Since SNA hours worked comes from multiple data sources, it can be revised by revisions to its sources and more largely than the Monthly Labour Survey. According to Cabinet Office (2007), the source data on SNA hours worked include the Monthly Labour Survey and Population Census. The estimation methodology of SNA hours worked, however, is not clearly explained in Cabinet Office (2007). A possibility is that they set the Census, released every five years, as a benchmark, and applies the extrapolation and interpolation to it using the Monthly Labour Survey. If this is the case, SNA hours worked will be revised after the latest Census becomes available. A similar method is used to compute SNA employment, as shown in Section 3.

Based on this result, we will analyze the revisions to each component of labor productivity in the rest of this paper. The revision to employment is in Section 3, hours worked is in Section 4, and GDP is in Section 5.

3. Revisions to Employment

In Section 2, we find that, on average, negative and large revisions to the SNA employment have contributed to the positive revisions to labor productivity. In Section 3, we investigate what has led to the revisions to the SNA employment data. Since the details of SNA estimation methodology are not fully open to public, we employ a two-step approach. First, we approximate official estimates of SNA employment based on the SNA handbooks of methods. Then, we break down revisions to the approximated SNA employment into effects of data sources.

Annual SNA employment data is computed from a variety of source data, according to the official SNA handbooks of methods such as the Economic Planning Agency (2000) and Cabinet Office (2007). The primary data sources for SNA employment are the Population Census, Labour Force Survey (LFS), and Employment Status Survey Results for Japan (ESS). The SNA employment data directly comes from the Census, which profiles Japanese households every five years ending in “0” and “5.” The Labour Force Survey is a sample survey that provides monthly estimates of employment. This survey is used to interpolate the Census data between census years, and to extrapolate the data after the current benchmark year of the SNA. The SNA does not use the latest Census until the current SNA benchmark year becomes the latest census year.

The Employment Status Survey is used to obtain the ratio of multiple jobholders to all jobholders. This ratio is necessary to compute SNA employment, because the Population Census and Labour Force Survey count multiple jobholders only once, while the SNA counts them twice. SNA employment is estimated based on the Census-based employment computed from the Census and Labour Force Survey, and on the multiple-jobholder ratio from the Employment Status Survey. Since the Employment Status Survey is conducted every five years, it is necessary to interpolate and extrapolate the multiple-jobholder ratio to make its annual series. However, the methodology of frequency conversion is not mentioned in the SNA handbooks of methods. Thus, we use assumptions later to estimate the ratio at annual frequency.

This is a brief review of the SNA handbooks of methods. Based on this information, we try to replicate the real-time and latest estimates of SNA employment in census years from fiscal year 1980.

The latest estimates of the SNA employment are computed as the employment data from the Population Census multiplied by the multiple-jobholder ratio from the Employment Status Survey[9]. Since the Employment Status Survey is not conducted in census years, we apply a linear interpolation to calculate the ratio in census years. The latest estimates of SNA employment are represented as:

$$\begin{aligned}&\text{Replicated latest estimates}\\&\quad=\text{Employed persons from Census}\\&\quad\times\left(1+\text{Multiple-jobholder ratio computed by linear interpolation}\right)\end{aligned}\tag{4}$$

By contrast, the real-time estimates of the SNA employment in each census year cannot come from the Census and Employment Status Survey for the year, because the SNA does not incorporate the two statistics in real time. Hence, for the periods not yet covered in real time by these sources, extrapolating the Census employment and the multiple-jobholder ratio is necessary. We estimate the real-time Census-based employment using the previous Census and the five-year growth rate of employment in each census year obtained from the Labour Force Survey[10]. We also extrapolate the multiple-jobholder ratio, assuming the ratio has been unchanged since the most recent year of the Employment Status Survey in real time.

The real-time estimates of SNA employment are represented as:

$$\begin{aligned}&\text{Replicated real-time estimates}\\&\quad=\text{Employed persons from previous Census}\\&\quad\times\left(1+\text{Five-year growth of employed persons from LFS}\right)\\&\quad\times\left(1+\text{Multiple-jobholder ratio from the most recent ESS in real-time}\right)\end{aligned}\tag{5}$$

Figure 4 compares our replication results with the official estimates. Both on a real-time basis and latest basis, the replicated estimates almost follow the official ones. An

---

9 We follow the instruction by the Cabinet Office (2007). Technically, employment in September of every census year is taken from the Population Census. Employment in the rest of months is interpolated or extrapolated by the Labour Force Survey, which is a monthly sample survey. We obtain annual employment data for census years by 12-month averaging.

10 It takes years until the SNA incorporates the latest Census. For example, employment data from the latest Census, which was conducted on October 1st, 2005, was released in January 2007. The SNA is supposed to reflect this Census on the upcoming comprehensive revision in a few years.

exception is the latest estimate for fiscal year 2005: our replication result is lower than the official data by about one million people. That is because the official latest estimate for 2005 does not come from the latest 2005 Census and 2007 Employment Status Survey. Based on the replication result, under the current estimation methodology of the SNA, SNA employment for 2005 is likely to be substantially revised downward in the next comprehensive SNA revision.

From equations (4) and (5), the revisions to the replicated estimates of employment can be written as:

$$\log\left(\frac{\text{Replicated latest estimates}}{\text{Replicated real-time estimates}}\right)$$
$$= \log\left(\frac{\text{Employed persons from Census}}{\begin{array}{c}\text{Employed persons from previous Census}\\ \times\left(1+\text{Five-year growth of employed persons from LFS}\right)\end{array}}\right)$$
$$+\log\left(\frac{1+\text{Multiple-jobholder ratio by linear interpolation}}{1+\text{Multiple-jobholder ratio from the most recent ESS in real-time}}\right) \tag{6}$$

The first and second terms on the right-hand side capture the effects of updating the Population Census and Employment Status Survey, respectively.

Figure 5 plots the revisions to the official estimates and those to the replicated estimates. The latter is broken down into the effects of the Population Census and Employment Status Survey. We obtain three key results from the breakdown. First, the revisions can be replicated except for the latest estimates for fiscal year 2005. Second, SNA employment has been substantially revised by the replacement of the estimates based on the previous Census with those based on the latest Census. A downward revision for fiscal year 2005 is predicted mainly because the SNA will reflect the 2005 Census in the next comprehensive revision. Third, both the Census and the Employment Status Survey have contributed to downward revisions to SNA employment over the most of the periods shown in Figure 5.

Concerning the multiple-jobholder ratio, estimates based on the previous Employment Status Survey are replaced in comprehensive SNA revisions with those based on the latest one. Since the multiple-jobholder ratio has a downward trend as shown in Figure 6, the replacement of its preliminary estimates with the lower revised estimates has induced downward revisions to SNA employment. In the next comprehensive SNA revision, however, the revision to the multiple-jobholder ratio is less likely to influence SNA employment because the ratio almost unchanged from 2002 to 2007.

Regarding the Population Census-based employment, the estimates extrapolated using the Labour Force Survey are replaced in comprehensive SNA revisions with those based on the latest Census. Figure 7 shows that five-year growth rates of the employment from the Census are basically lower than those from the Labour Force Survey. The deviation can be attributed to difference in sample size between the Labour Force Survey for a limited number of households and the Census for whole households. A possible interpretation is that an upper sample bias in the Labour Force Survey is vanished by the replacement with the Census.

There is another reason why the Population Census shows the lower employment growth than the Labour Force Survey. Figure 8 (a) illustrates the number of "employment status not reported" people who do not answer the questions on employment status in the Censuses. Figure 8 (a) shows that the number of those people, which remained at most 0.5 million until 1995, soared to 1.7 million in 2000 and 3.3 million in 2005. In recent years, employment status has not been reported for a larger proportion of people aged 15 and over, as shown in Figure 8 (b). By contrast, the proportion of employed persons in this age group has been decreasing[11]. The Statistics Bureau (2009) points out that one practical problem in the 2005 Census is increased cases in which census workers could not collect completed questionnaires from households. The Statistics Bureau (2009) indicates that it is because of the recent increase in single persons living alone and working parents not staying at home in the daytime. Therefore, a substantial proportion of non-response people is likely to be employed. In other words, the employment data from the Census underestimates the reality. This sort of problem could have happened in the 2000 Census. Consequently, under the current SNA system of estimation methods, SNA employment for 2005 will be revised downward in the next comprehensive SNA revision, as shown in Figure 5. This revision will reflect the deterioration in data accuracy via the large increase in non-response people in the 2005 Census.

In summary, SNA employment has been revised downward in comprehensive SNA

---

[11] The decline in the proportion of employed persons among people aged 15 years and over is also attributed to increased proportions of both unemployment and non labor force in this age group. We, however, are not concerned with this point, because it may not relate to the deterioration of statistical accuracy of the Population Census.

revisions. An important reason is a recent rapid increase in non-response people in the Population Census. In addition, a downward trend in the multiple-jobholder ratio may have contributed to the downward revisions to SNA employment. While the large increase in non-response people led to underestimation of employment in the 2005 Census, the current SNA employment data has not yet incorporated this impact. Therefore, if the estimation methodology of SNA employment is kept unchanged, a downward revision in SNA employment for 2005 will occur in the next comprehensive SNA revision.

4. Revisions to Hours Worked

In Section 3, we analyzed revisions to employment, which is one of two ingredients of labor input. In Section 4, we study another ingredient—hours worked—using its monthly data.

Figure 9 depicts revisions to year-on-year percent changes in total hours worked per regular employee for establishments with five or more employees from the Monthly Labour Survey. The real-time estimates in Figure 9 are the second preliminary estimates, which are officially called “final” estimates, but are revised by subsequent regular sample rotations from Final Reports of the Monthly Labour Survey. The second preliminary estimate for a particular month is released around the end of the following second month. Hence, it becomes available earlier than the real-time estimates mainly used in Section 2, which are available around the time of the first annual SNA revisions[12]. In this section, we also analyze the revisions from the second preliminary estimate to the later vintage available in the first annual SNA revisions.

Hours worked from the Monthly Labour Survey are revised mainly due to regular rotations of a portion of the sample. The sample establishments are supposed to be rotated in January every two or three years, and the sample rotations usually cause revisions over the last two to five years. In this section, we focus on revisions to hours worked for a month before the six sample rotations from January 1993.

Figure 10 (a) exhibits revisions to monthly hours worked from the real-time to the latest

---

[12] This paper focuses on SNA data at quarterly or annual frequency. Concerning the Monthly Labour Survey, hours worked of monthly frequency are revised within a quarter from the first to second preliminary estimates. Hence, we take the second preliminary estimates as the real-time estimates.

estimates for regular, full-time, and part-time employees. In the Monthly Labour Survey, regular employees are defined as the sum of full-time and part-time employees. As shown in Figure 10 (a), the estimates for both full-time and part-time employees have been revised upward in five out of six cases. By contrast, those for regular employees have been revised upward only once. These facts are consistent if the ratio of part-time employees working fewer hours to regular employees has been revised upward. We examine the hypothesis in the rest of this section.

Figure 10 (b) shows that the ratio of part-time to regular employees has been revised upward overall. The upward revision can be attributed to new sample enrollments that hold more part-time employees for some reasons. For example, the sample distribution after a sample rotation first covers new types of business that make more active use of part-time workers.

Based on this fact, we analyze the quantitative impact of revisions to the ratio of part-time employees on those to hours worked. Hours worked for regular employees are written as:

$$h = \left(1 - w\right) h^f + w h^p \qquad (7)$$

This equation shows that hours worked for regular employees h can be computed as a weighted average of hours worked for full-time employees h^f and those for part-time employees h^p. The ratio of part-time employees w is used as weights. With equation (7), we obtain an approximated equation:

$$\Delta h \cong \left(1 - \overline{w}\right) \Delta h^f + \overline{w} \Delta h^p - \left(\overline{h}^f - \overline{h}^p\right) \Delta w \qquad (8)$$

Δ is a function denoting changes from the real-time to the latest estimates. Barred variables denote the average of the real-time and the latest estimates of the variables. Using the approximation, we can break down revisions to hours worked for regular employees Δh into three components on the right-hand side. The three terms are contributions of revisions to hours worked for full-time employees, those for part-time employees, and revisions to the ratio of part-time employees, respectively.

Figure 10 (c) displays results of the breakdown based on equation (8). The results show that the approximation by the equation can fairly replicate the observed revisions. Figure 10 (c) also suggests that upward revisions to the proportion of part-time employees have significantly contributed to downward revisions to hours worked for regular employees.

5. Revisions to GDP

The focus of this section is on revisions to GDP, with more weight given to real GDP. The estimation method of real GDP is more complex than that of SNA employment, and has been often revised. Table 3 compiles the past methodological changes after switching to 93SNA in 2000. The diversity of these changes prevents finding any patterns of revisions to real GDP based on the estimation methods of the SNA. We thus employ regression analysis to study the patterns of revisions to real GDP.

In this section, we use GDP of quarterly frequency, as opposed to annual frequency, used in Section 2, to keep sufficient sample size for regressions. Moreover, we examine revisions from the preliminary to the latest estimates in addition to those from the first annual revisions that were the primary interest in Section 2. The latest vintage in this section is the second preliminary estimates, released in December 2009.

We take the Quarterly Estimates released in March, June, September, and December as the preliminary estimates. This means that we use the first preliminary estimates until 2002Q1 and the second preliminary estimates from 2002Q2 onward[13]. There are two reasons for the mixed use of vintages in this section. First, fixing the timing of release allows us to use the preliminary estimates facing the same availability of the source data throughout the sample period. Second, a new estimation procedure to preliminary estimates introduced in August 2002 has changed the source data and release schedules for the first and second preliminary estimates. Concerning the source data, the demand-side sources play a main role in computation of the first preliminary estimates until 2002Q1, and the second preliminary estimates from 2002Q2 onward. By contrast, the supply-side sources are mainly used to calculate the first preliminary estimates from 2002Q2 onward. Thus, we use the mixed vintages that are mainly based on the demand-side sources.

[13] We collected the preliminary estimates of GDP from various issues of “Economic Statistics Monthly” by the Bank of Japan until 1990, and from press releases by the erstwhile Economic Planning Agency and the Cabinet Office from 1991. It should be noted that these sources provided the estimates mainly for at most the past two years. Thus, we link these estimates with the data from various issues of “Annual Report on National Accounts,” “Report on National Accounts from 1955 to 1969,” “Report on National Accounts from 1955 to 1989,” “Report on National Accounts from 1955 to 1994,” and various issues of “Report on Revised National Accounts” released in comprehensive revisions.

Nonetheless, the drastic methodological change in the SNA may still affect regression analysis. Hence, to examine the robustness of our analysis, we conduct regressions with the first annual revisions instead of the preliminary estimates.

Table 4 (a) reports the major statistics for revisions to real GDP growth by stage of revision. The MAR and RMSR are still large in the later vintages, such as the second annual and comprehensive revisions. The MAR and RMSR for the estimates released after the second comprehensive revision are especially large. This indicates that estimates of real GDP are likely to be revised for years. Since the estimates for 2000Q3 onward have experienced at most one comprehensive revision, estimates of real GDP for the 2000s can be further revised substantially[14]. The gradual introduction of chain-linked volume measures in the SNA, which was applied in December 2004 to GDP from 1994 and in July 2009 to that from 1980, can be thought to influence this result. However, as the statistics in Table 4 (b) show, nominal GDP has a similar pattern of revisions. Hence, the introduction of the chain-linking does not influence this result.

The following equation is used on regression analysis.

$$g_t^f - g_t^r = \alpha + \beta \cdot X_t + \varepsilon_t \qquad (9)$$

g_t^f is the latest estimates of GDP growth rate at the period t. g_t^r is its real-time estimates, either the preliminary estimates or annual revisions. The GDP growth rate is defined as the quarter-on-quarter percent change at an annual rate in seasonally adjusted GDP, which provides the larger sample size with more vintages. X_t is a vector of explanatory variables that have been observable by the release of the real-time GDP estimates for the period t. The revisions to the GDP growth rate are on the left-hand side of equation (9). If the real-time estimates are efficient forecasts of the latest estimates, the revisions should not be predictable by any predetermined variables, including a constant. Thus, we can examine the predictability of the revisions, or inefficiency of the real-time estimates, by testing whether the coefficients in equation (9) significantly deviate from zero.

In the regression analysis of this section, we use demeaned data on explanatory variables for simplifying the interpretation of the constant term. We employ the

[14] The last two comprehensive revisions of SNA were implemented when the preliminary estimates for 2000Q3 and for 2005Q3 were released. Thus, only one comprehensive revision has been implemented to the data from 2000Q3 to 2005Q2, and none to the data from 2005Q3 onward.

Newey-West standard errors, which are corrected for autocorrelation and heteroskedasticity by the methodology of Newey and West (1987).

First, we take the real-time estimates g_t^r as X_t. This type of regression is applied by Mankiw and Shapiro (1986) to the real GDP of the United States, and by Komaki (2005), Kawagoe (2007) and Sekino (2007) to Japanese GDP[15].

Table 5 (a) and (b) show the results of the regressions using the preliminary estimates and the first annual revisions, respectively. In both cases, the coefficient on the real-time estimate is negative and significant at the 1 percent level. This supports the results from the preceding research. This means that the lower (higher) real-time estimates will be more likely to be revised upward (downward). That is, the real-time estimates are not efficient forecasts of the latest estimates[16].

Next, we add the Tankan diffusion index of Business Conditions for all enterprises of all industries to X_t. Preceding papers utilize such survey data to predict revisions to GDP. For instance, for the United Kingdom, Ashley, Driver, Hayes, and Jeffery (2005) report that survey data are significantly helpful to predict the revisions to GDP. Cunningham, Eklund, Jeffery, Kapetanios, and Labhard (2007) construct a state-space model with survey data to predict revisions to GDP[17,18].

---

[15] Kawagoe (2007) and Sekino (2007) are concerned that the past methodological changes affect their analysis, and so they only use the sample after the introduction of new estimation procedure of preliminary estimates. This type of analyses, however, may involve problems. For example, the sample size is too small to run regressions. Moreover, the latest estimate for the whole sample has never experienced multiple comprehensive revisions. Thus, future revisions are very likely to substantially affect their analyses.

[16] Seasonal adjustment can contribute to the inefficiency of the real-time estimates. If the seasonality of the data changes due to structural factors, the measured seasonal factor will reflect the seasonality change only gradually, as the data accumulates. In this case, the latest data show less fluctuation than the earlier vintages because a certain amount of the seasonality change is incorporated in the seasonal factor of the latest vintage. Our regression results from seasonally adjusted series might capture the gradual changes in measured seasonal factors. To eliminate impacts of seasonal adjustment on regressions, we also apply a similar regression analysis on annual data, which seasonal adjustment never affects. The regression results show that the estimated coefficients have the same signs, though not statistically significant, as the case of quarterly, seasonally adjusted series. The lack of significance might be due to insufficient sample size.

[17] The Bank of England provides fan charts for inflation and GDP forecasts in its regular Inflation Reports, which takes the form of probability distribution. Fan charts illustrate probability distributions of future revisions over history, as well as those of projection itself. Cunningham et al. (2007) construct a model used for creating probability distributions of future revisions to the past data. Predicting revisions that are likely to happen in the future is called as "backcasting."

[18] Some studies using real-time data for the United States do not support the usefulness of survey

Table 5 (c) and (d) show that the coefficient on the Tankan diffusion index is positive and significant at the 5 percent level, both with the preliminary estimates and with the first annual revisions. This implies that real GDP growth is more likely to be revised upward during expansions. This pattern of revisions reflects the pattern of information updating on computing estimates of GDP. For example, revised or more comprehensive source data may cover new types of industries that are more likely to grow in expansions, while the earlier release of the source data may not. The addition of those industries can contribute to upward revisions to GDP.

Panels (a) to (d) of Table 5 show that the constant term is positive, but not statistically significant. This result seems to show that the pattern of upward revisions to real GDP does not exist. This, however, can be because the data for the 2000s has experienced few or no comprehensive revisions, and is likely to be substantially revised in the future. If it is true, the constant term is underestimated with the sample from when the second last SNA comprehensive revision was introduced; that is, on the release of GDP for 2000Q3. To examine this hypothesis, we also run regressions with a dummy to the explanatory variables, which takes one from 2000Q3 and zero otherwise. As shown in Table 5 (e) and (f), the constant term is positive and significant at the 10 percent level in the case of the preliminary estimates. This result conditionally supports upward revisions over history. In contrast, the coefficient on the dummy is negative and significant at the 5 percent level. A simple interpretation for these results is that the latest vintage of GDP for the 2000s available in December 2009 has not been sufficiently revised and is more likely to be revised upward. Table 5 (g) and (h) compile the result of the regressions using nominal GDP instead of real GDP as used in Panel (e) and (f). As shown in Panel (g) and (h), the constant terms are positive in both cases of the preliminary estimates and the first annual revisions. The former is significant at the 1 percent level, and the latter is significant at the 10 percent level. Therefore, the regression results using nominal GDP support upward revision over history more significantly than the case of real GDP.

We then break down revisions to GDP by industries to find reasons why GDP was revised upward on average. As shown in Figure 11, however, we cannot see any

data for real-time forecasts of GDP components. Dynan and Elmendorf (2001) report results from regressions of revisions to GDP components on contemporaneous data such as consumer confidence index, interest rates, and unemployment rates. According to Dynan and Elmendorf (2001), these additional data cannot significantly improve the forecast quality of revisions to GDP components. Croushore (2004) reports that indexes of consumer confidence cannot improve real-time forecasts of consumer spending.

common pattern in revisions among industries. Thus, our regression results imply that the upward revision to GDP does not depend on that of any particular industry. Rather, it can be due to the gradual incorporation of comprehensive data to GDP. For example, the later estimates incorporate more comprehensive data like the information on emerging industries. Meanwhile, it can be also true that the pattern of revisions has been actually changed because of technical changes such as an introduction of 93SNA in 2000. We cannot judge the validity of these possibilities, since the SNA has experienced at most one comprehensive revision after the introduction of 93SNA. At the same time, however, we cannot confirm that any of the methodological changes in the 2000s have added a negative tendency to the pattern of revisions. Consequently, GDP growth is more likely to be revised upward than downward in the future.

To summarize, we find that GDP growth has been revised to a large amount even after the second comprehensive revision. This implies that GDP for the recent years, such as for the 2000s, is more likely to face large revisions in the future. Our regression analysis shows that the real-time estimates and survey data can predict revisions to real GDP to a certain extent. Based on the regression results, the latest estimates of GDP for the 2000s are more likely to be revised upward than downward in the future.

6. Concluding Remarks

Labor productivity is computed from its data sources such as value added, employment, and hours worked. Hence, the earlier estimates of labor productivity are revised later due to revisions to these sources. The focus of this paper is on Japan’s labor productivity computed mainly based on the SNA. We explore revisions to the data sources, taking account of the estimation methods for the sources, and conduct regression analysis. The main conclusions are as follows.

First, SNA data has been substantially revised even after the second comprehensive revisions, as well as at the earlier stage of revisions. We find that the past absolute revision to labor productivity often went beyond 1 percentage point.

Second, the annual growth rate of labor productivity has been revised upward by 0.4 percentage points on average. We show that part of its upward revisions reflects underestimation of employment through increasing non-response people in the Population Census.

Third, revisions to the source data such as the Population Census and Employment

Status Survey are helpful to predict revisions to labor productivity growth. In addition, our regression results imply the possibility that labor productivity is likely to be revised upward during expansions or with lower real-time estimates of value added.

Consequently, labor productivity for the 2000s is likely to be substantially revised in the future, because most SNA data for the period has experienced at most one comprehensive revision. Based on the pattern of revisions to the source data, we can conclude that recent labor productivity is more likely to be revised upward in the future than downward. For example, GDP is likely to be revised upward since the average of its revisions is positive. SNA employment, with the current estimation method, is likely to be revised downward, which reflects the rapidly increased non-response people in the 2005 Census. Considering the large revisions to GDP over history, the conclusion is unchanged even without the effect of the deterioration in the accuracy of the Census.

Kameda (2009), which surveys the literature on Japan's productivity, shows that many econometric analyses in the literature point out a rise in productivity in the 2000s. Kameda (2009) argues that few of those analyses cover the period of deep recession since the latter half of 2008. He states that further data accumulation is needed because the data over the most recent recession is indispensable to evaluate productivity in the 2000s. Of course, productivity measurement with the adjustment regarding business cycle, employed in some of the preceding research, can be less prone to data accumulation. Kameda (2009), however, also points out that the accurate adjustment of business cycle is quite difficult. If that is true, a certain proportion of rapid economic slowdown will be identified as a decline in the productivity trend. This will lead to a downward revision to the measured productivity trend.

By contrast, our analysis, which focuses on revisions to the source data, suggests that productivity for the 2000s is more likely to be revised upward in the future. We should note that this paper does not focus on TFP, which the preceding research mainly analyzes, but on labor productivity. Nonetheless, we consider that our analysis can contribute to the debate on recent productivity.

In conclusion, revisions to the source data have substantial impacts on productivity measurement. Economic analysis based on the productivity measured today should take into account the possibility of future revisions to the productivity. On evaluating the recent trend of productivity growth, we need to analyze influences of both data accumulation addressed by Kameda (2009) and data revisions addressed by this paper[19].

[19] Orphanides (2003) concludes that the impact of data accumulation exceeds that of data revision on measuring output gap. This conclusion depends on the measurement method of output gap. Since output gap is a deviation rate of actual output from its measured trend, historical revisions to output will revise output and its trend to the same direction. As a result, the output gap will be revised less. Meanwhile, the measured trend productivity growth discussed in this paper can be substantially revised because of revisions of its source data.

Reference

Anderson, Richard G. (2006), "Replicability, Real-Time Data, and the Science of Economic Research: FRED, ALFRED, and VDC," *Federal Reserve Bank of St. Louis Review*, January/February, 88(1), pp. 81-93.

——, and Kevin L. Kliesen (2005), "Productivity Measurement and Monetary Policymaking During the 1990s," Federal Reserve Bank of St. Louis Working Paper Series 2005-067A, Federal Reserve Bank of St. Louis.

Ashley, James, Ronnie Driver, Simon Hayes, and Christopher Jeffery (2005), "Dealing with Data Uncertainty," *Bank of England Quarterly Bulletin*, Spring, pp. 23-29.

Braun, R. Anton, Julen Esteban-Pretel, Toshihiro Okada, and Nao Sudou (2006), "A Comparison of the Japanese and U.S. Business Cycles," *Japan and the World Economy*, 18, pp. 441-463.

Cabinet Office (2007), "SNA Suikei Shuho Kaisetsusho: Heisei 19 Nen Kaitei Ban (Estimation Method of Preliminary Quarterly GDP (QE): Revised in 2007)", http://www.esri.cao.go.jp/jp/sna/071011/suikei.html (in Japanese).

Castle, Jennifer, and Colin Ellis (2002), "Building a Real-time Database for GDP(E)," *Bank of England Quarterly Bulletin*, February, pp. 42-49.

Croushore, Dean (2004), "Do Consumer Confidence Indexes Help Forecast Consumer Spending in Real Time?" Deutsche Bundesbank Discussion Paper Series 1 No. 27/2004, Deutsche Bundesbank.

—— (2009), "Literature on Real-time Data Analysis," mimeo.

——, and Tom Stark (2001), "A Real-time Data Set for Macroeconomists," *Journal of Econometrics*, 105, pp. 111–30.

Cunningham, Alastair, Jana Eklund, Christopher Jeffery, George Kapetanios, and Vincent Labhard (2007), "A State Space Approach to Extracting the Signal from Uncertain Data," Bank of England Working Paper No. 336.

Dynan, Karen E., and Douglas W. Elmendorf (2001), "Do Provisional Estimates of Output Miss Economic Turning Points?" Finance and Economics Discussion Series 2001-52, Board of Governors of the Federal Reserve System.

Economic Planning Agency (2000), "93SNA Suikei Shuho Kaisetsu-sho: Zantei Ban

(Estimation Method of 93SNA: a Preliminary Version)”, http://www.esri.cao.go.jp/jp/sna/001115/suikei.html (in Japanese).

Edge, Rochelle M., Thomas Laubach, and John C. Williams (2007), “Learning and Shifts in Long-run Productivity Growth,” *Journal of Monetary Economics*, 54, pp. 2421-2438.

Faust, Jon, John H. Rogers, and Jonathan H. Wright (2005), “News and Noise in G7 GDP Announcements,” *Journal of Money, Credit and Banking*, 37, pp. 403–20.

Fueki, Takuji and Takuji Kawamoto (2008), “Does Information Technology Raise Japan’s Productivity?” Bank of Japan Working Paper Series 08-E-8, Bank of Japan.

Fukao, Kyoji, Sumio Hamagata, Tsutomu Miyagawa, and Konomi Tonogi (2007), “Intangible Investment in Japan: Measurement and Contribution to Economic Growth,” RIETI Discussion Paper Series 07-E-034, Research Institute of Economy Trade and Industry.

——, and Hyeog Ug Kwon (2007), “JIP Database 2006: Sangyo Renkan-hyo Nen-ji Keiretsu no Sakusei ni Tsuite (JIP Database 2006: Estimation of Input-Output Tables),” Research Institute of Economy, Trade and Industry, http://www.rieti.go.jp/jp/database/d05.html (in Japanese)

——, and Tsutomu Miyagawa (2008), *Seisansei to Nihon no Keizai Seicho: JIP Database ni yoru Sangyo to Kigyo Level no Jissho Bunseki* (*Japan’s Productivity and Economic Growth: Industry-level and Firm-level Econometric Analysis Based on JIP Database*), University of Tokyo Press (in Japanese).

Garratt, Anthony, and Shaun P. Vahey (2006), “UK Real-time Macro Data Characteristics,” *Economic Journal*, 116 (February), F119-F135.

Giannone, Domenico, Jerome Henry, Magdalena Lalik and Michele Modugno (2010), “An Area-wide Real-time Database for the Euro Area,” Working Paper Series No. 1145, European Central Bank.

Greenspan, Alan (2007), *The Age of Turbulence: Adventures in New World*, The Penguin Press.

Hayashi, Fumio, and Koji Nomura (2005), “Can IT be Japan’s Savior?” *Journal of the Japanese and International Economies*, 19, pp. 543-567.

——, and Edward C. Prescott (2002), “The 1990s in Japan: A Lost Decade,” *Review of*

Economic Dynamics, 5, pp. 206-235.

Jorgenson, Dale W., and Koji Nomura (2005), "The Industry Origins of Japanese Economic Growth," *Journal of the Japanese and International Economies*, 19, pp. 482-542.

Kamada, Koichiro (2004), "Real-time Estimation of the Output Gap in Japan and Its Usefulness of Inflation Forecasting and Policymaking," Deutsche Bundesbank Discussion Paper Series 1 No. 14/2004, Deutsche Bundesbank.

Kameda, Seisaku (2009), "Wagakuni no Seisansei wo Meguru Ronten — 2000 Nen Iko no Seisansei Doko wo Dono Yoni Hyoka Suruka — (Discussion Points on Japan's Productivity — How to Evaluate the Productivity in the 2000s —)," Paper to be presented at the Introductory Session of the Third Conference held by the University of Tokyo and Research and Statistics Department of Bank of Japan, "2000 Nen Dai no Wagakuni Seisansei Doko — Keisoku, Haikei, Gan-i — (Japan's Productivity in the 2000s — Measurement, Background, and Implication —)" (in Japanese).

Kawagoe, Masaaki (2007), "Keizai Seicho Ritsu no Jigo Shusei ni Kansuru Ichi Kosatsu — Jisshitsu GDP no Real-time Data ni Yoru Bunseki — (An Essay on Revisions to Economic Growth Rate — Real-time Data Analysis on Real GDP —)," *Kikan Kokumin Keizai Keisan*, 134, Department of National Accounts, Economic and Social Research Institute, Cabinet Office, pp. 14-19 (in Japanese).

Komaki, Yasuyuki (2002), "Real-Time Data ni Yoru GDP Gap no Suitei no Fukakujitsu-Sei (Uncertainty around Measurement of Output Gap Based on Real-time Data)," Nihon University Working Paper Series, 02-01 (in Japanese).

—— (2003), "Keiki Shihyo no Fukakujitsu-sei — Real-Time Data ni Yoru GDP Gap no Suitei — (Uncertainty around Business Cycle Indicators — Real-time Measurement of Output Gap —)," Asako, Kazumi and Shin-ichi Fukuda ed. *Keiki Junkan to Keiki Yosoku*, University of Tokyo Press, pp. 311-335 (in Japanese).

—— (2005), "GDP Sokuho-chi ni Okeru Yosoku Gosa to Keisoku Gosa (Forecast Errors and Measurement Errors of the Preliminary Estimates of GDP)," *Kokumin-Keizai Zasshi*, 191, Keizai-Keiei Gakkai, Kobe University, pp. 1-15 (in Japanese).

Kuroda, Masahiro, Kazushige Shimpo, Koji Nomura, and Nobuyuki Kobayashi (1997), "KEO Database — Sanshutsu Oyobi Shihon Rodo no Sokutei — (KEO Database — Measurement of Output, Labor and Capital Inputs —)," KEO Monograph Series No.8, http://www.sanken.keio.ac.jp/publication/KEO-mono/08/index.html (in Japanese).

Mankiw, N. Gregory, and Matthew D. Shapiro (1986), “News or Noise: An Analysis of GNP Revisions,” *Survey of Current Business*, 66 (5), United States Department of Commerce, pp. 20-25.

Makino, Tatsuji, Yoko Takahashi, and Joji Tokui (2007), “Rodo Bumon no Suikei Hoho (Estimation of Labor Input),” Research Institute of Economy, Trade and Industry, http://www.rieti.go.jp/jp/database/d05.html (in Japanese).

Ministry of Health, Labour and Welfare (2008), *Heisei 20 Nen Ban Rodo Keizai no Bunseki* (*White Paper on the Labour Economy 2008*), p. 221 (in Japanese).

Newey, Whitney K., and Kenneth D. West (1987), “A Simple Positive Semi-definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix,” *Econometrica* 55 (3), pp. 703-778.

Orphanides, Athanasios (2003), “The Quest for Prosperity without Inflation,” *Journal of Monetary Economics*, 50, pp. 633-663.

Sekino, Hidemine (2007), “GDP Seicho Ritsu no Kaitei no Yoin Bunseki ― Mankiw-Shapiro no Hoho ni Yoru Bunseki ― (Revision Analysis on GDP growth rate ― Analysis Based on the Procedure of Mankiw and Shapiro ―),” *Kikan Kokumin Keizai Keisan*, 134, Department of National Accounts, Economic and Social Research Institute, Cabinet Office, pp. 20-26 (in Japanese).

Sleeman, Cath (2006), “Analysis of Revisions to Quarterly GDP – A Real-time Database,” *Reserve Bank of New Zealand Bulletin*, 69 (1), Reserve Bank of New Zealand, pp. 31-44.

Statistics Bureau (2009), “Heisei 22 Nen Kokusei Chosa no Jisshi ni Mukete ― Kento Jokyo Hokoku― (Reports on Operations for Coming 2010 Population Census),” Statistics Bureau, Ministry of Internal Affairs and Communications of Japan, http://www.stat.go.jp/data/kokusei/2010/kentouhoukoku/index.htm (in Japanese).

Woodward, Bob (2000), *Maestro: Greenspan's Fed and the American Boom*, Simon and Schuster.

<u>Table 1: Data Sources Used in Productivity Literature</u>

Papers	Employment	Hours Worked	Real Value-Added
Braun, et al. (2006)	Labour Force Survey	Monthly Labour Survey	SNA
Ministry of Health, Labour and Welfare (2008)	Labour Force Survey	Monthly Labour Survey	SNA
Hayashi and Prescott (2002)	SNA	Monthly Labour Survey	SNA
Fueki and Kawamoto (2008)	SNA	SNA, Monthly Labour Survey	SNA
Fukao, et al. (2007)	JIP	JIP	JIP
Fukao and Miyagawa (2008)	JIP	JIP	JIP
Jorgenson and Nomura (2005)	KEO	KEO	KEO
Hayashi and Nomura (2005)	KEO	KEO	KEO

Note: "JIP" and "KEO" denote Japan Industrial Productivity Database and Keio Economic Observatory Database, respectively.

Table 2: Sources of Revisions to Year-on-Year Labor Productivity Growth

	Labour Productivity	Real GDP	Labor Input	Nominal GDP	GDP Deflator	Employ-ment	Hours Worked
Average	0.37	0.17	-0.20	0.19	0.01	-0.19	-0.01
MAR	0.59	0.50	0.22	0.49	0.25	0.20	0.05
RMSR	0.81	0.65	0.32	0.62	0.32	0.28	0.08
Max	1.97	1.89	0.11	1.25	0.79	0.04	0.13
Min	-1.02	-1.00	-0.69	-0.69	-0.64	-0.54	-0.25

Note: The table reports five statistics on revisions to each source used to compute labor productivity. Revisions to a variable are expressed as the latest estimates less the initial estimates using percent changes from the preceding year. The results are obtained from fiscal years 1981 to 2007. MAR denotes Mean Absolute Revision, and RMSR denotes Root Mean Squared Revision.

Table 3: Major Methodological Changes in Real GDP After Introduction of 93SNA

Press Release Date	Change	Schedule of Data Release	Coverage
8/13/2002	Start to use supply-side sources to compute preliminary estimates, as well as demand-side sources	1st preliminary estimate for 2002Q2	1994Q1-
10/18/2002	Assign a part of production of wireless communications equipment to business intermediate purchases instead of gross fixed capital formation	1st preliminary estimate for 2002Q3	1996-
11/18/2004	Introduce a chain-linking of SNA data from 1994	2nd preliminary estimate for 2004Q3	1994-
12/2/2004	Change source data on consumption for some items from Family Income and Expenditure Survey to Survey of Household Economy	2nd preliminary estimate for 2004Q3	2002Q1-
12/2/2005	Discontinue estimations of consumption of farm proprietors' households due to methodological changes to a data source	1st annual revision for fiscal year 2004	Not clear
	Start estimation of investments in pre-packaged software in addition to custom-made software		
	Change the valuation of government consumption of fixed capital from a historical-cost basis to a current-cost basis		
12/1/2006	Revise the estimation method of domestic final consumption expenditure of households on "gross rent," which is space rent for dwellings	1st annual revision for fiscal year 2005	2004-
7/31/2007	Compute the first preliminary estimates of private inventories on raw materials and work-in-process inventories based on an ARIMA model used for seasonal adjustments, instead of assuming unchanged from the previous quarter	1st preliminary estimate for 2007Q2	2007Q2-
9/5/2008	Adjust estimates of the tangible fixed investment and tangible fixed assets of leasing industry to be consistent with the estimates before a revision to business accounting about leasing in March 2007	2nd preliminary estimate for 2008Q2	2008Q2-
7/8/2009	Introduce a chain-linking of SNA data from 1980	7/8/2009	1980-1995

<u>Table 4: Revisions to GDP Growth Rates by Vintages</u>

(a) Real GDP

	Preliminary to Latest	Preliminary to First Annual	First Annual to Second Annual	Second Annual to First Comprehensive	First Comprehensive to Second Comprehensive	Second Comprehensive to Latest
Average	0.12	-0.07	0.25	-0.08	-0.21	0.15
MAR	0.95	0.49	0.42	0.44	0.56	0.60
RMSR	1.19	0.66	0.65	0.57	0.74	0.90
Max	2.77	2.04	2.50	1.16	1.56	3.00
Min	-2.70	-2.12	-1.10	-1.55	-2.76	-2.54

(b) Nominal GDP

	Preliminary to Latest	Preliminary to First Annual	First Annual to Second Annual	Second Annual to First Comprehensive	First Comprehensive to Second Comprehensive	Second Comprehensive to Latest
Average	0.16	-0.04	0.17	0.11	-0.02	0.02
MAR	0.84	0.37	0.30	0.32	0.46	0.53
RMSR	1.10	0.50	0.50	0.43	0.66	0.78
Max	2.67	2.01	2.27	0.98	1.48	2.69
Min	-3.25	-1.47	-0.61	-1.68	-2.78	-2.81

Note: Tables (a) and (b) report five statistics on revisions to real and nominal GDP, respectively. The GDP data used in the two tables are measured by its percent change from four quarters ago, over the period 1981Q1 - 2009Q3. These statistics are computed by vintages, such as from the preliminary estimates to the first annual revisions ("Preliminary to First Annual") and from the first annual to second annual revisions ("First Annual to Second Annual"). "Preliminary to First Annual" includes revisions when estimates experienced the first comprehensive revision no later than the first annual revision. Similarly, "First Annual to Second Annual" includes revisions when estimates concurrently experienced the first comprehensive revision and the second annual revision. MAR denotes Mean Absolute Revision, and RMSR denotes Root Mean Squared Revision.

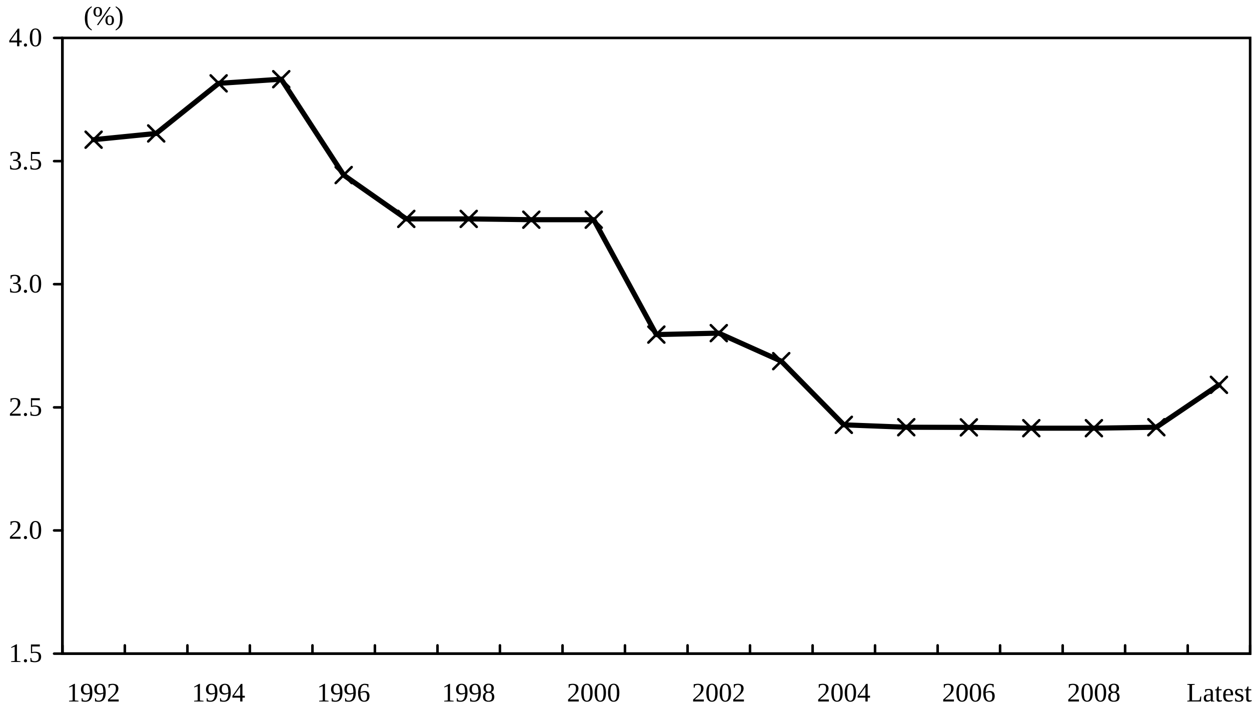
Table 5: Regressions of Revisions to GDP

			Constant	Real-time Estimates	Tankan	Dummy	Adjusted R^2	DW
Real	(a)	Preliminary	0.08 (0.27)	-0.41 *** (0.10)	-	-	0.23	2.36
Real	(b)	First Annual	0.10 (0.23)	-0.31 *** (0.10)	-	-	0.14	2.39
Real	(c)	Preliminary	0.08 (0.26)	-0.46 *** (0.11)	0.032 *** (0.012)	-	0.25	2.37
Real	(d)	First Annual	0.10 (0.22)	-0.36 *** (0.11)	0.026 ** (0.013)	-	0.15	2.40
Real	(e)	Preliminary	0.49 * (0.28)	-0.48 *** (0.10)	0.029 ** (0.013)	-1.30 *** (0.45)	0.27	2.43
Real	(f)	First Annual	0.35 (0.27)	-0.38 *** (0.11)	0.026 * (0.014)	-0.84 ** (0.38)	0.16	2.41
Nominal	(g)	Preliminary	0.91 *** (0.31)	-0.57 *** (0.10)	0.064 *** (0.017)	-2.36 *** (0.57)	0.31	2.40
Nominal	(h)	First Annual	0.58 * (0.30)	-0.41 *** (0.12)	0.047 ** (0.018)	-1.46 *** (0.50)	0.16	2.39

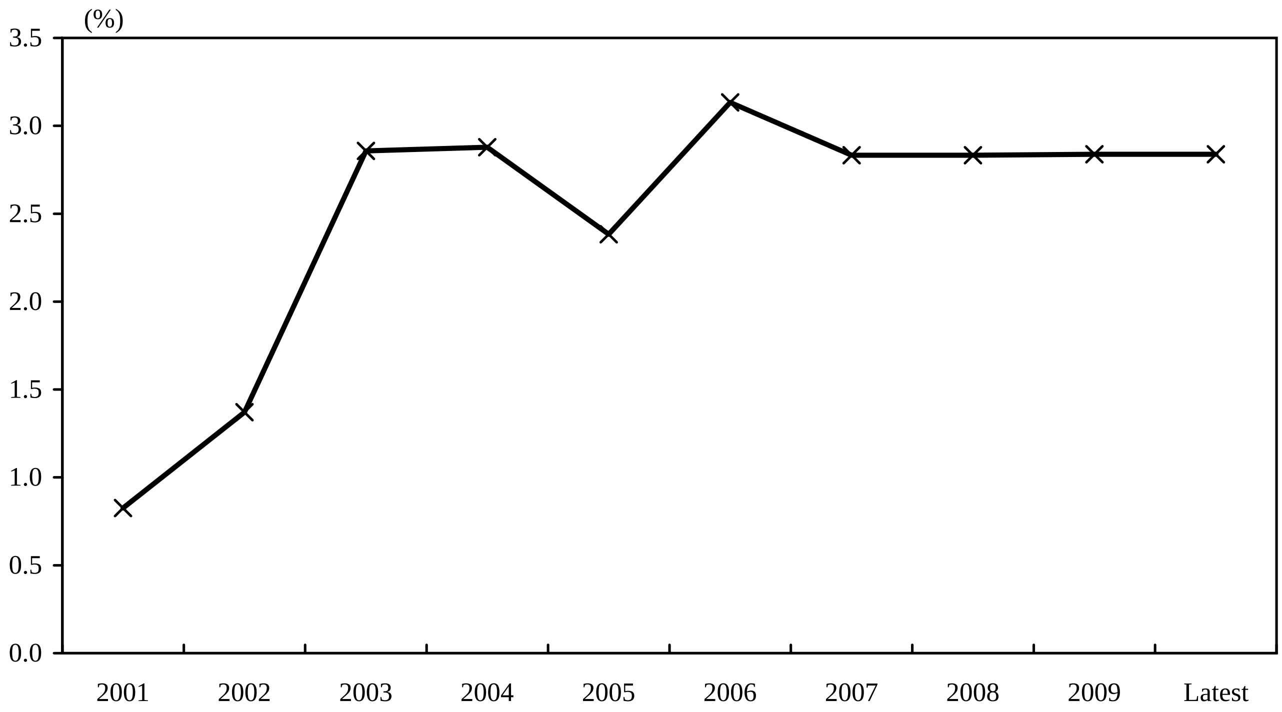
Note: The table reports results from regressions for revisions to seasonally adjusted GDP measured by its annualized percent change from a quarter ago. Revisions to GDP are defined as the latest estimates less the real-time estimates. (a) - (f) are regression results for real GDP, and (g) and (h) are those for nominal GDP. The real-time estimates are the preliminary estimates in (a), (c), (e), and (g), and the first annual revisions in (b), (d), (f), and (h). The estimation periods are 1980Q2 - 2009Q3 for regressions with the preliminary estimates, and 1980Q2-2009Q1 for those with the first annual revisions. All regressions use a constant term and the real-time estimates less their average over the estimation period as explanatory variables. (c) - (h) add the demeaned Diffusion Index of Business Conditions to the explanatory variables. (e) - (h) also employ a dummy as an explanatory variable which takes one from 2000Q3 and zero otherwise. Standard errors corrected by the method of Newey and West (1987) are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The table also reports the adjusted R^2 and Durbin-Watson statistic (DW).

Figure 1: Labor Productivity Growth Rates by Vintages

(a) Fiscal Year 1991



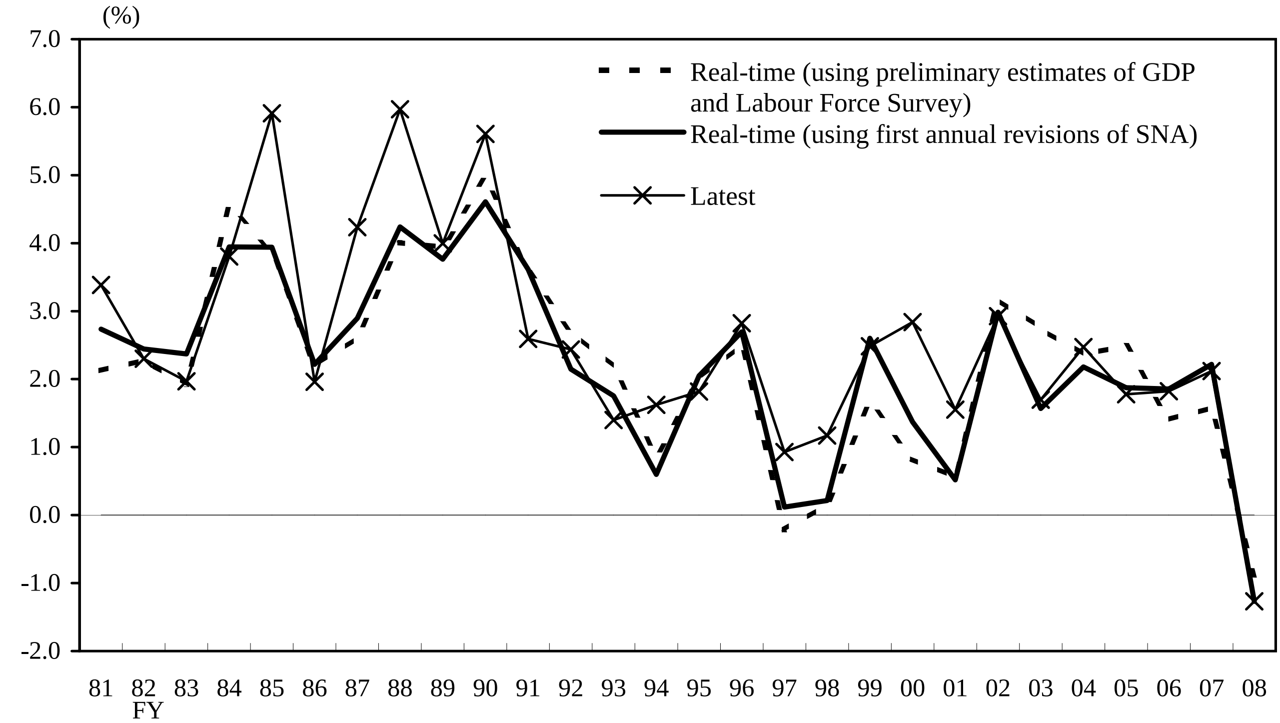
(b) Fiscal Year 2000



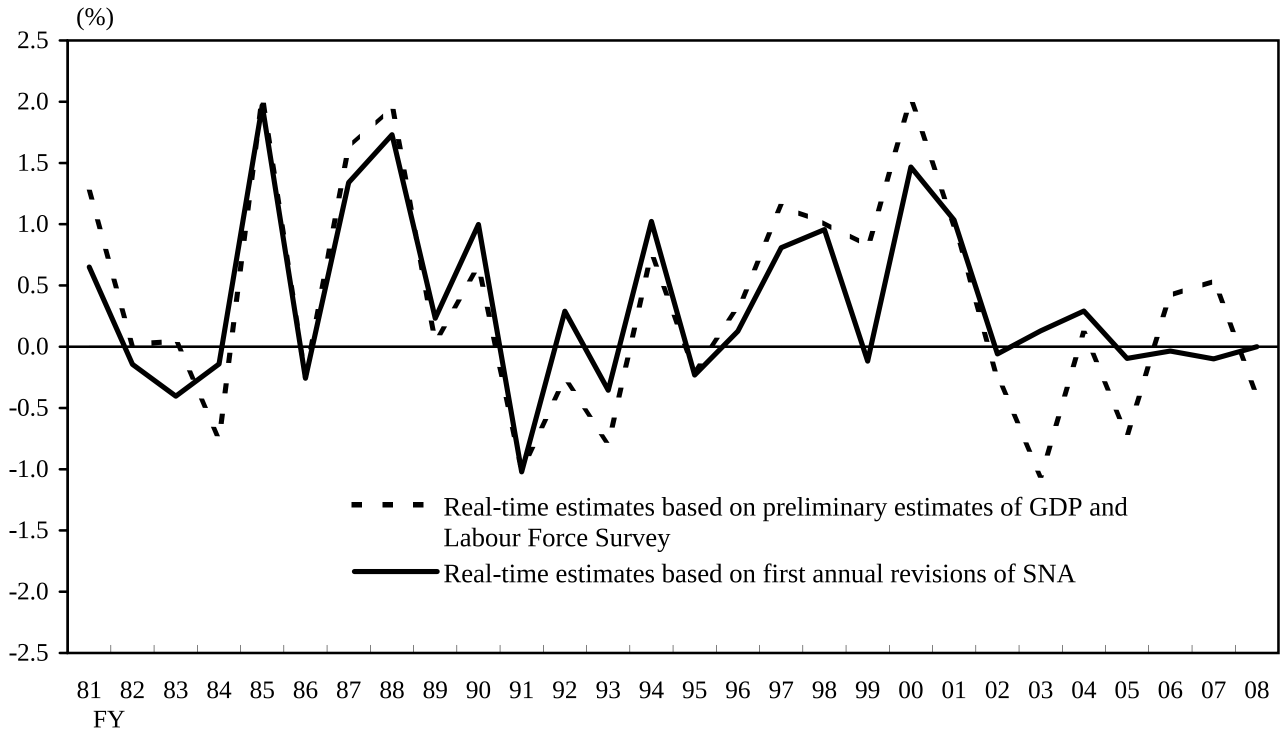
Note: (a) and (b) show revisions from the initial estimates to the latest estimates of labor productivity for fiscal years 1991 and 2000, respectively. These estimates are expressed as percent changes from the preceding year. The estimates are computed from the data which were latest available when the Annual Report of National Accounts for each year—placed on the horizontal axis—was published. An exception is the left values that are computed about three months after the end of each fiscal year by using timely statistics such as the preliminary estimates of GDP and the Labour Force Survey. “Latest” denotes December 2009.

<u>Figure 2: Revisions to Year-on-Year Growth Rate of Labor Productivity</u>

(a) Real-time and Latest Estimates



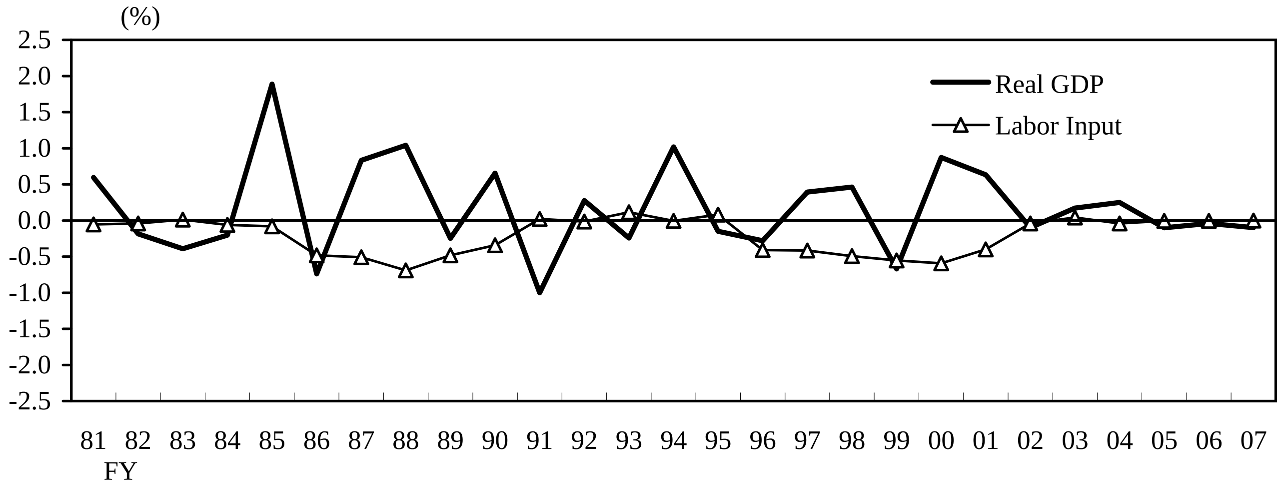
(b) Revisions



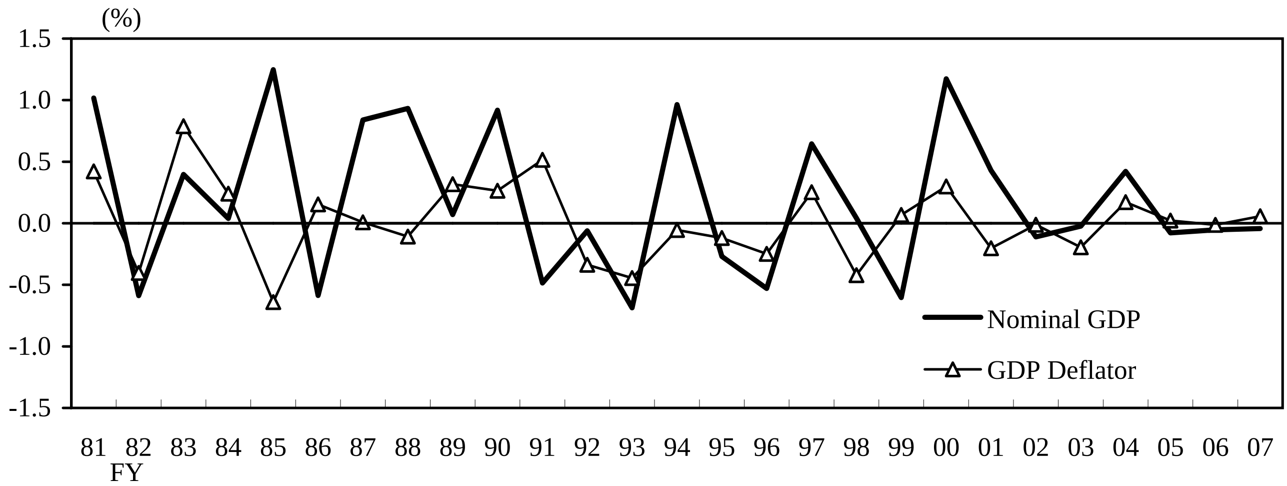
Note: In (a), the two types of real-time estimates of year-on-year labor productivity growth are plotted as thick lines: the one using timely source data as a solid line, and the other using first annual revisions of SNA as a dashed line. The latest estimate is plotted as a thin line. (b) reports revisions defined as the latest estimates less the real-time estimates. A solid line is for the real-time estimates using the first annual revisions of GDP and SNA employment. A dashed line is for those using the preliminary estimates of GDP and the Labour Force Survey.

Figure 3: Revisions to Year-on-Year Growth Rates of Source Data

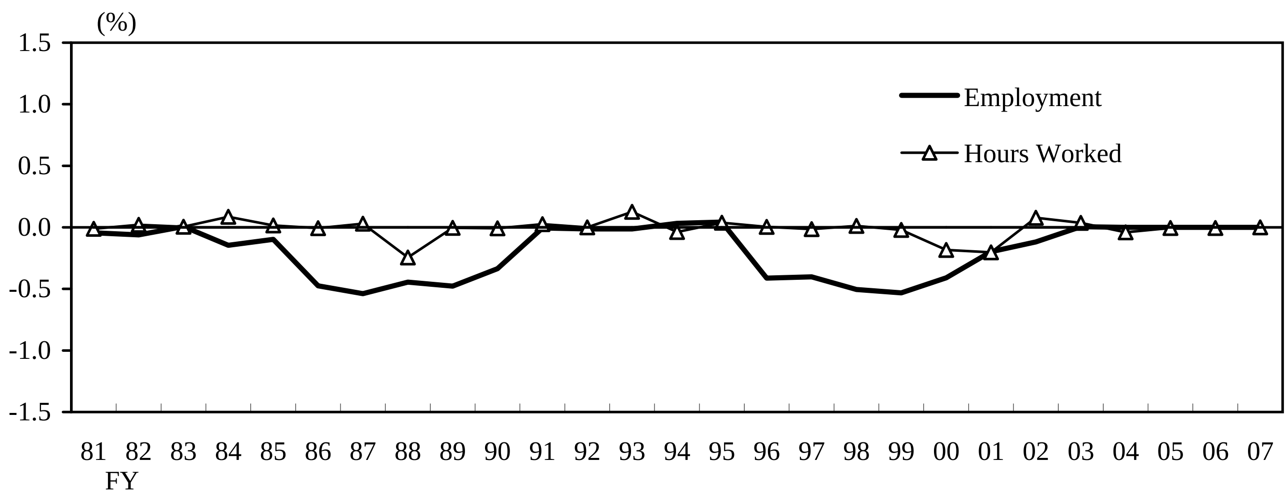
(a) Revisions to Real GDP and Labor Input



(b) Revisions to Nominal GDP and GDP Deflator



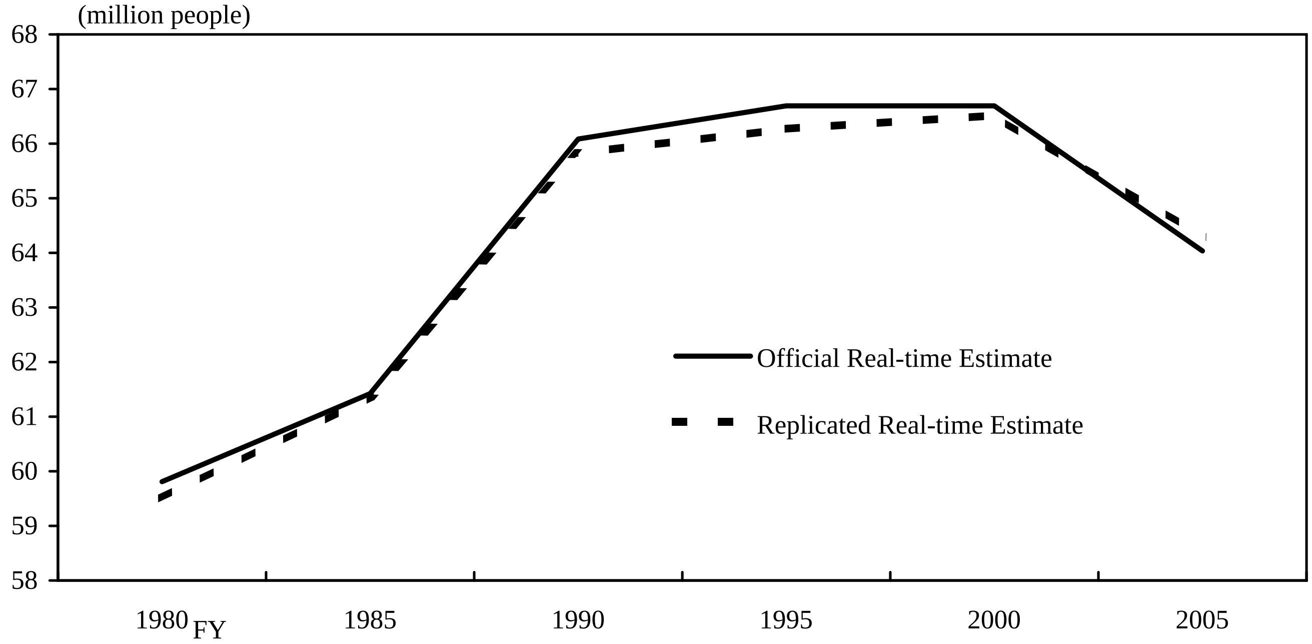
(c) Revisions to Employment and Hours Worked



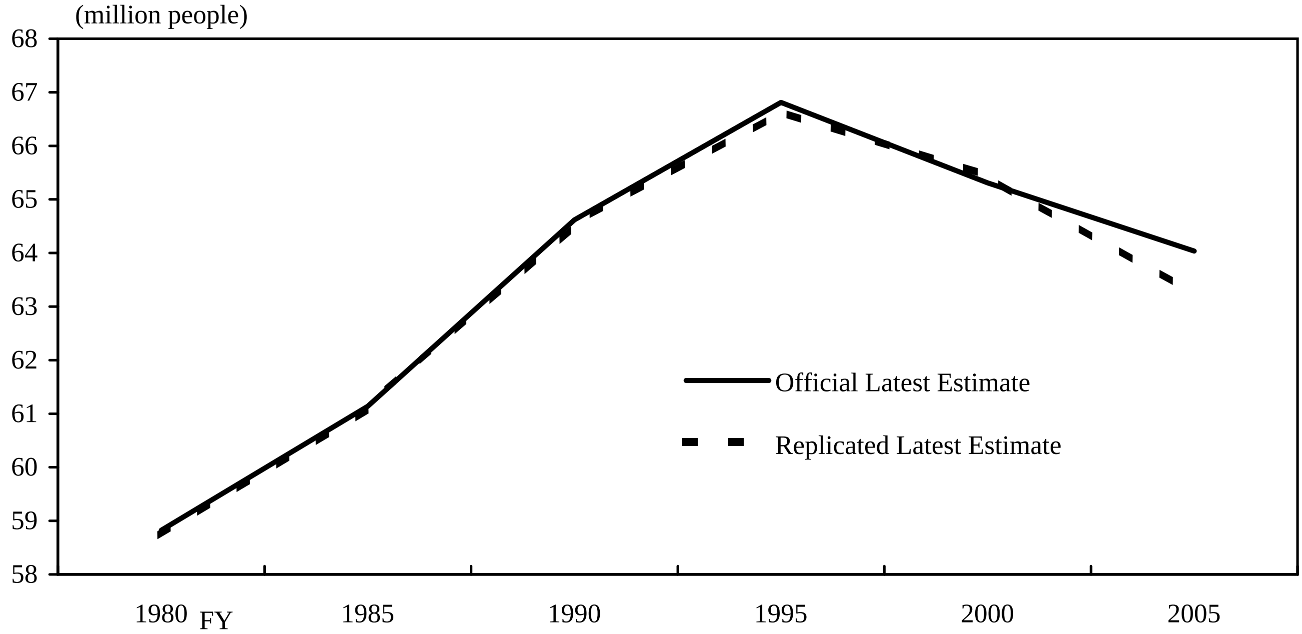
Note: This figure reports the revisions to percent changes from a year earlier in data sources for labor productivity; (a) shows revisions to real GDP (bold line) and labor input (thin line), (b) depicts those to nominal GDP (bold line) and GDP deflator (thin line), and (c) shows those to employment (bold line) and hours worked (thin line).

Figure 4: Replication of SNA Employment

(a) Replication of Real-time Estimates

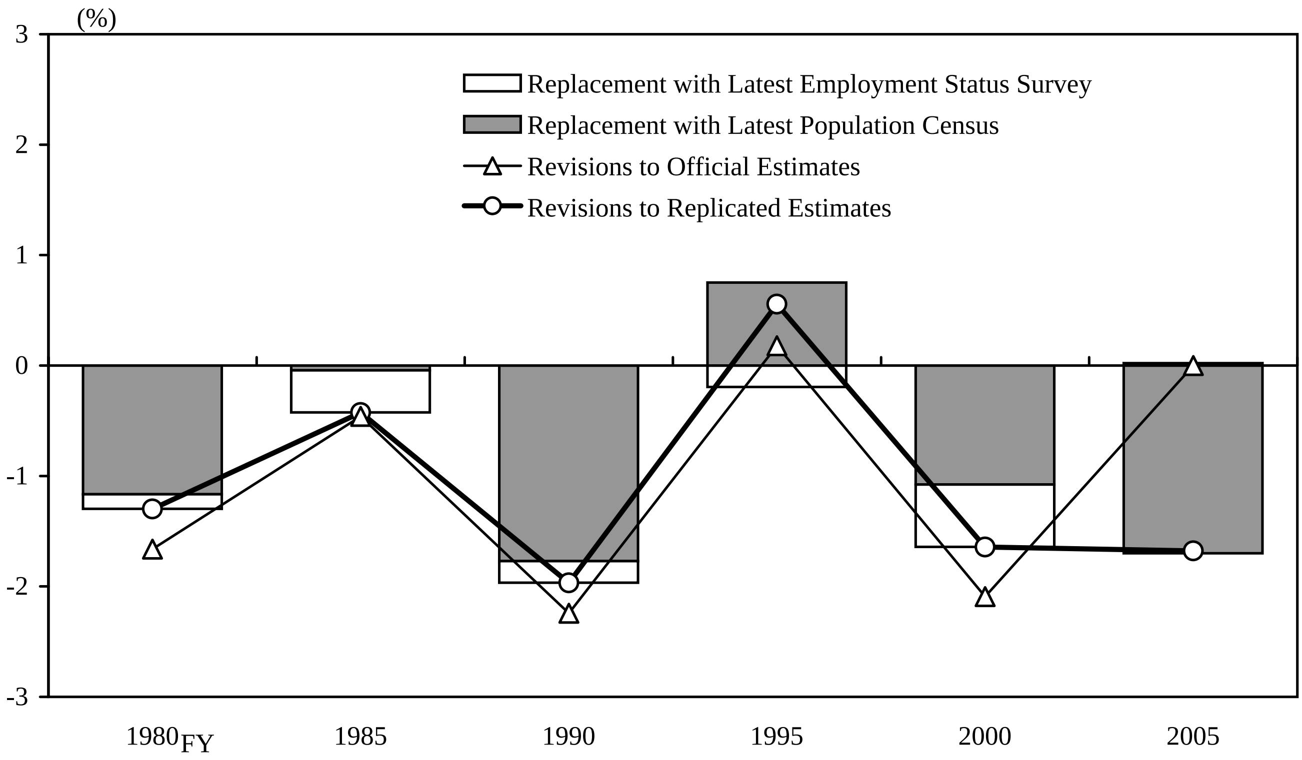


(b) Replication of Latest Estimates



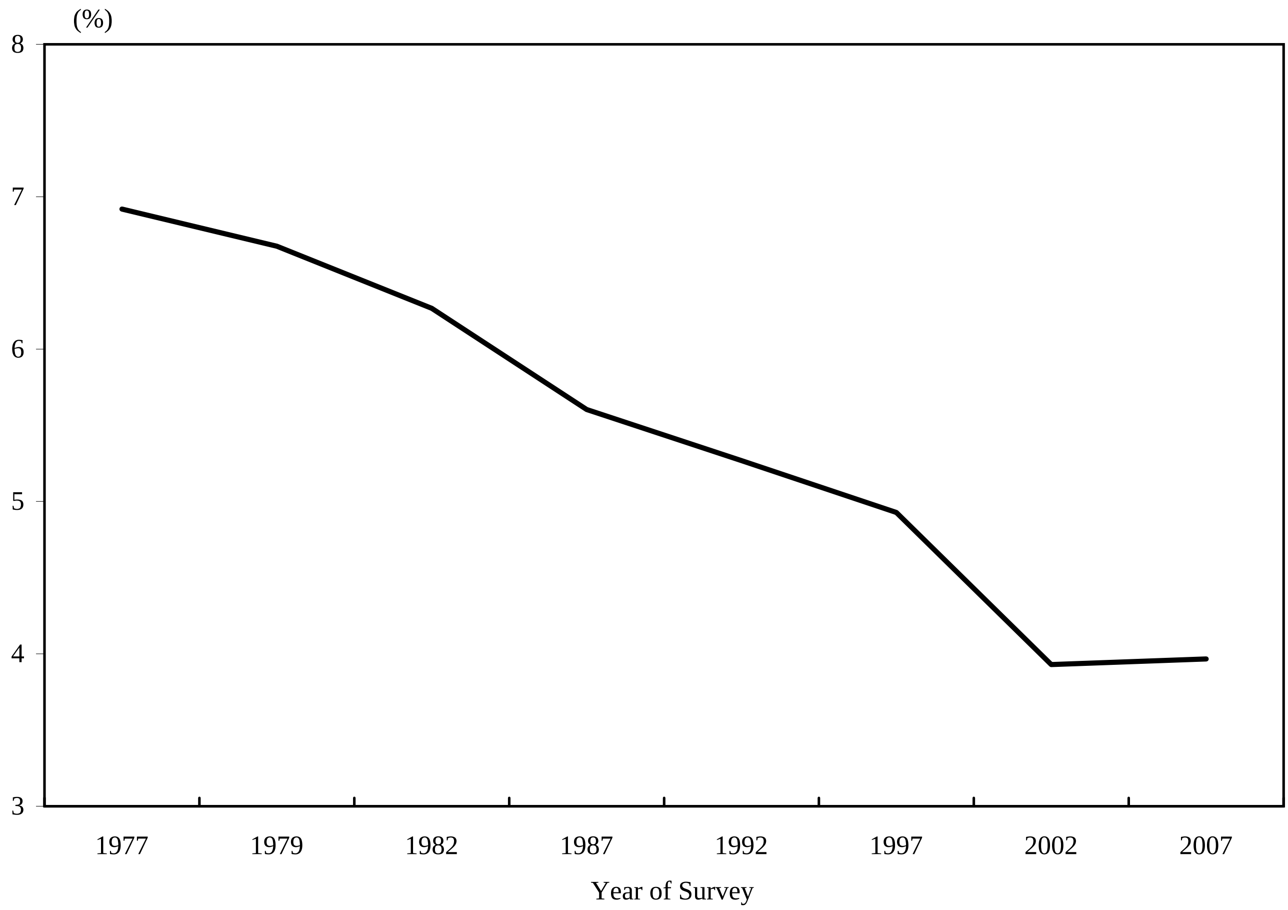
Note: The bold lines are official SNA employment data. The thin lines are replication results of SNA employment computed from the source data with instructions by the SNA handbooks of methods such as Cabinet Office (2007); (a) and (b) correspond to the real-time and latest estimates, respectively. All of the data in the figures are in units of one million people.

Figure 5: Breakdown of Revisions to SNA Employment



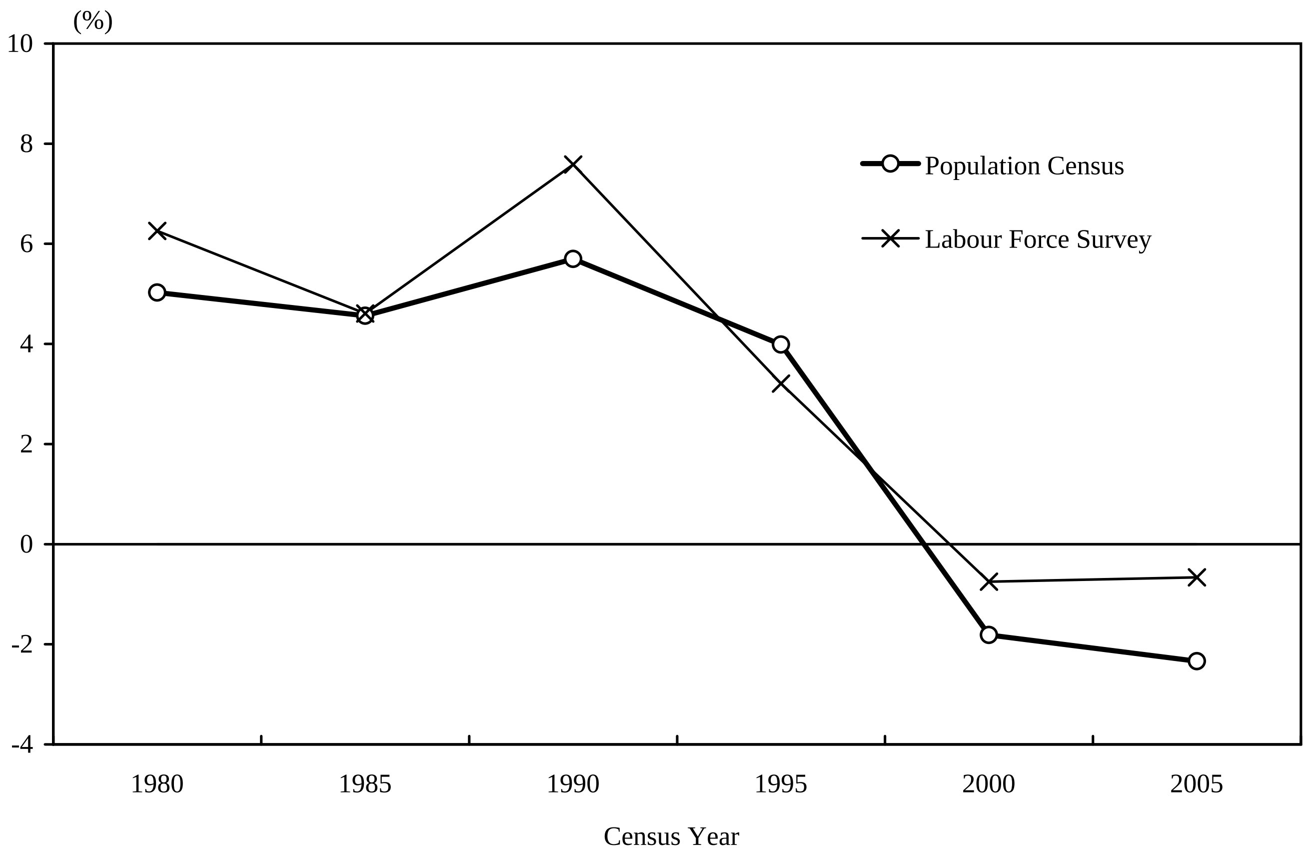
Note: The figure reports percent changes from the real-time to latest estimates of SNA employment for fiscal years placed on the horizontal axis. The thin line shows the case of the official estimates, and the bold line shows the case of the replicated estimates as illustrated in Figure 4. The stacked bar graph shows the decomposition of percent changes in the replicated estimates, computed based on equation (4) in Section 3. The shadow and white bars depict effects of the replacement with the latest Population Census, and those of the replacement with the latest Employment Status Survey, respectively.

Figure 6: Multiple-Jobholder Ratio



Note: The figure reports the multiple-jobholder ratio in units of percent computed as multiple jobholders over all jobholders from the Employment Status Survey Results for Japan. The years on the horizontal axis denote the years of the Employment Status Survey.

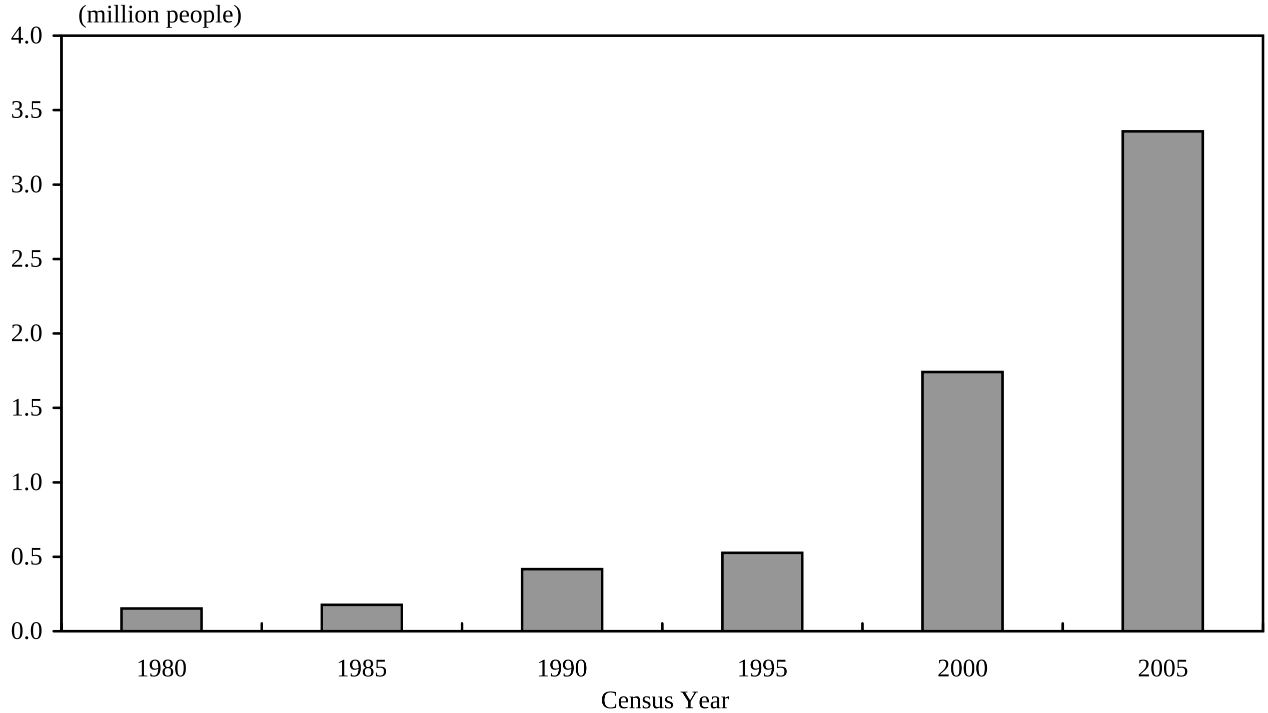
Figure 7: Employment Growth Rates from the Population Census and Labour Force Survey



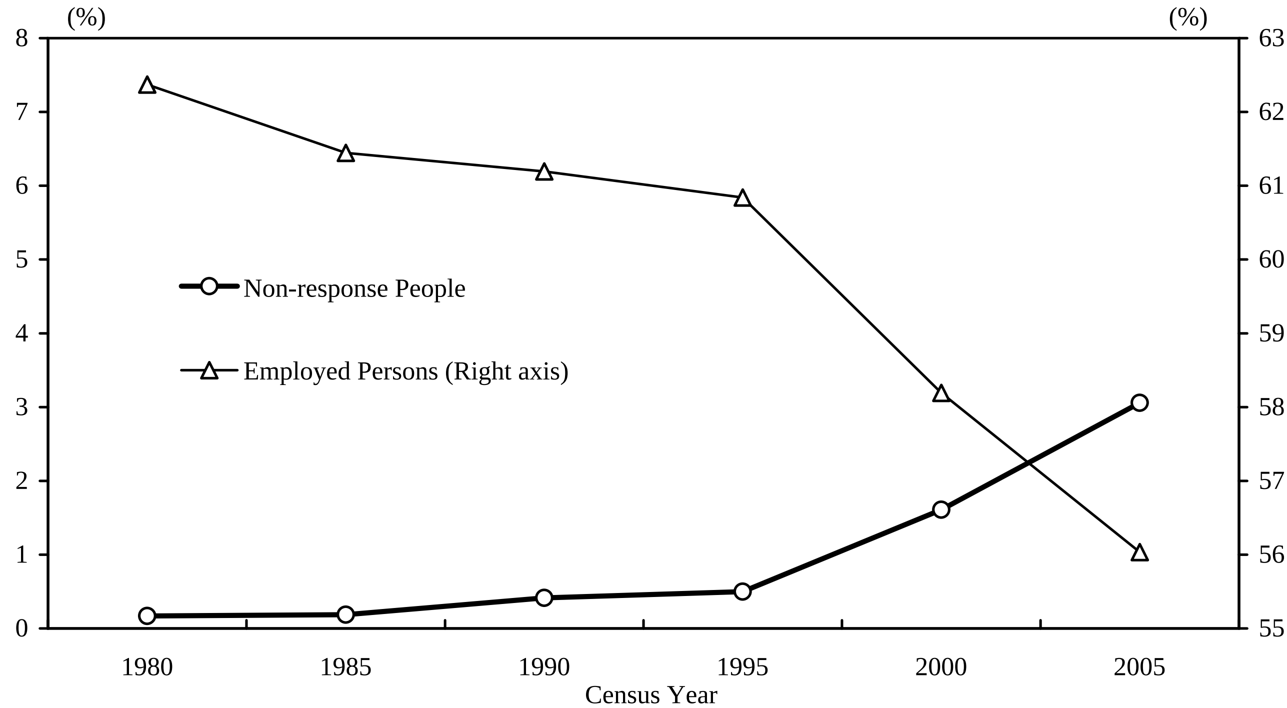
Note: The figure shows percent changes in employment from five years ago computed from the Population Census (bold line), and from the Labour Force Survey (thin line). The data from the Labour Force Survey are for September of the census years shown on the horizontal axis.

Figure 8: "Employment Status Not Reported" People in Population Census

(a) Employment Status Not Reported (Non-response) People



(b) Proportions of Non-response People and Employed Persons to Population 15 Years and over



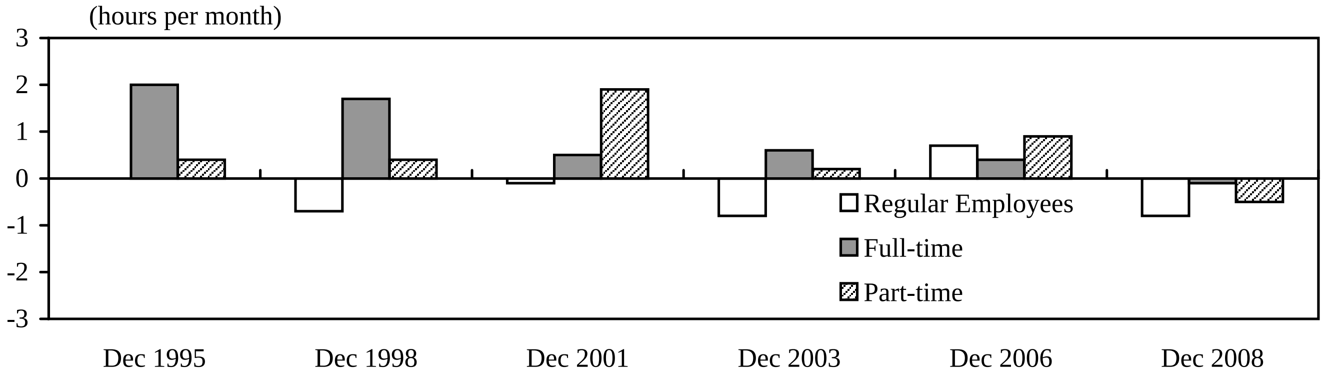
Note: (a) shows the number of people whose employment status is not reported in each census year on the horizontal axis, in units of one million people. Non-response People are computed as "Population of 15 Years and over – Employed Persons – Unemployed Persons – Population not in Labour Force." (b) shows the percent ratios of Non-response People (bold line) and of Employed Persons (thin line) to Population 15 Years and over. The bold and thin lines are assigned to the left and right axes, respectively.

Figure 9: Revisions to Year-on-Year Changes in Total Hours Worked from Monthly Labour Survey

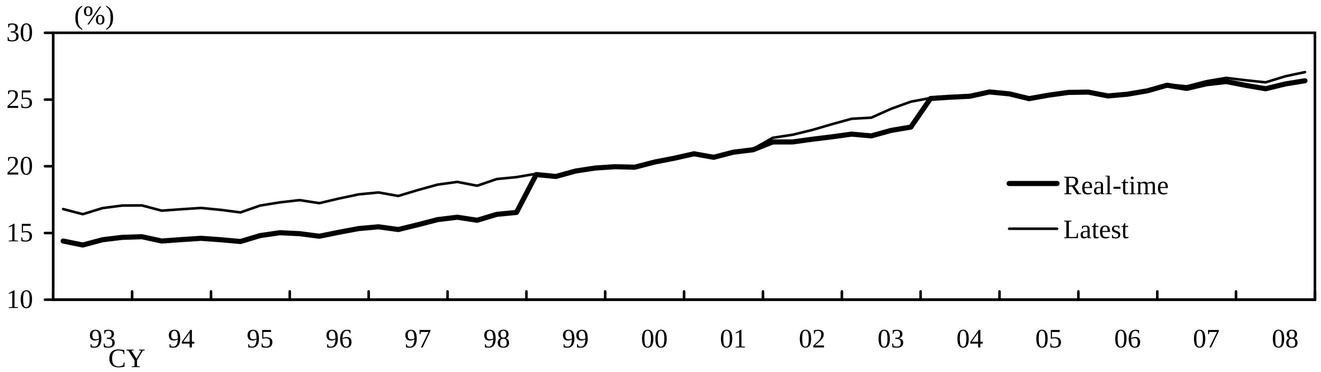
Note: The figure depicts revisions to percent changes in total hours worked from a year earlier collected from establishments with five or more employees from the Monthly Labour Survey. Revisions are computed as the latest estimates less the real-time estimates.

Figure 10: Sources of Revisions to Hours Worked

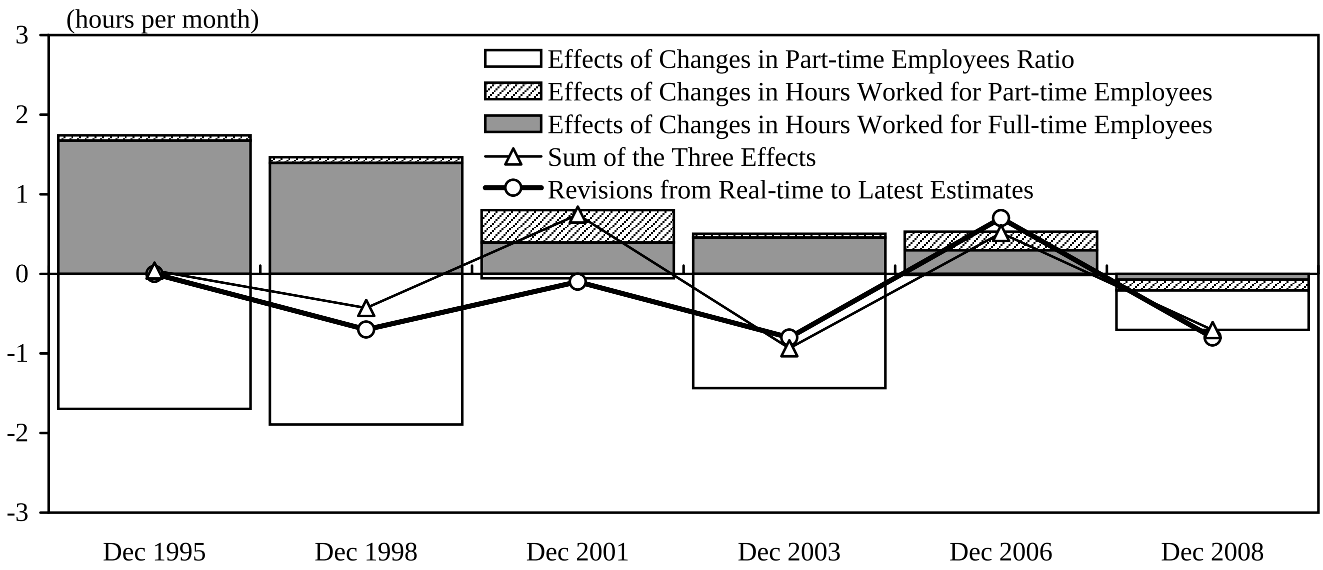
(a) Revisions in Hours Worked from Real-time to Latest Estimates



(b) Real-time and Latest Estimates of Part-time Employees Ratio



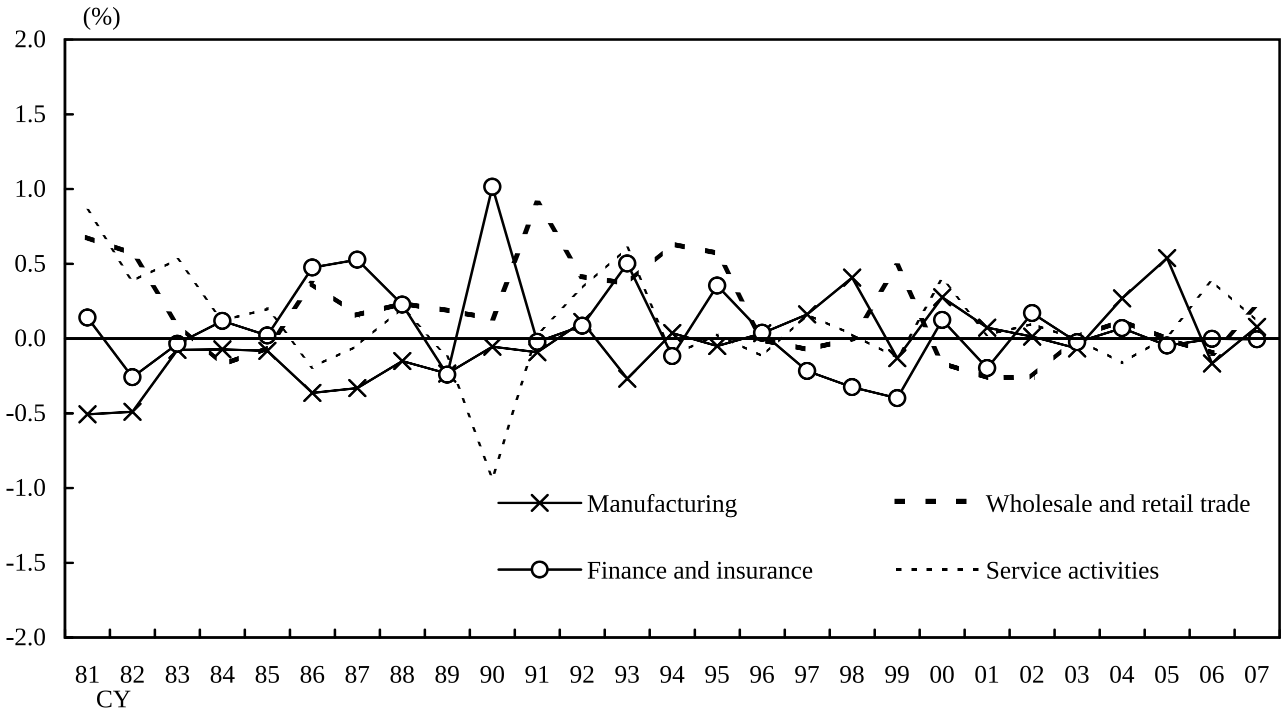
(c) Decomposition of Revisions to Hours Worked



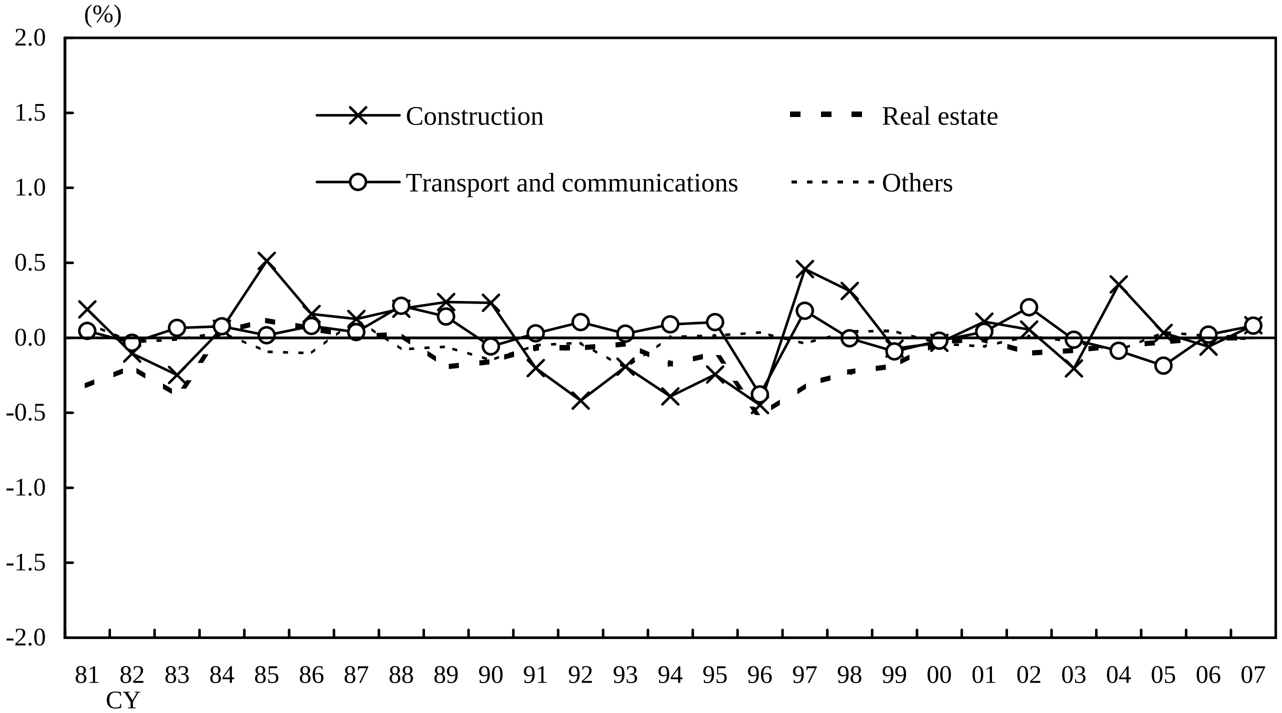
Note: (a) shows revisions from the real-time to the latest estimates of monthly hours worked for the months of the Monthly Labour Survey on the horizontal axis. The white bar depicts revisions to hours worked for regular employees. The shadowed and slashed bars show those for full-time and for part-time employees, respectively. (b) displays the part-time employees ratios of the real-time (bold line) and the latest estimates (thin line). (c) illustrates two types of revisions to hours worked for regular employees. The bold line shows revisions to the official estimates. The thin line shows revisions to the estimates approximated using equation (5) in Section 4. The approximated estimates are broken down into three terms in equation (5). The stacked graph displays effects of the three terms. They are effects of changes in hours worked for full-time employees (shadowed bar), hours worked for part-time employees (slashed bar), and the part-time employees ratio (white bar). (a) and (c) are in units of hours per month, and (b) is in units of percent.

Figure 11: Revisions to Nominal GDP Growth by Industries

(a) Manufacturing, wholesale and retail trade, finance and insurance, and service activities



(b) Construction, real estate, transport and communications, and other industries



Note: (a) and (b) break down revisions from real-time to the latest estimates of year-on-year growth rate of nominal GDP by industries. (a) reports contributions of the revisions of manufacturing, wholesale and retail trade, finance and insurance, and service activities. (b) reports those of construction, real estate, transport and communications, and other industries. 'Others' in (b) is the sum of those of agriculture, forestry and fishing, mining, and electricity, gas and water supply.