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Methodology for Handling Missing Values in TANKAN

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Abstract

The "***Short-term Economic Survey of All Enterprises in Japan" (Tankan)*** is a sample survey that contains both judgment questions and quantitative items. For the latter, we use a standard stratified sampling procedure, producing an estimate of the population total of each individual stratum. If missing values occur in a stratum, the estimated total for the population of that stratum is obtained by weighting the sum of respondents' values, where the weight used is the ratio of the stratum population to the number of respondents. This method is equivalent to estimating the total for the stratum population by filling in missing values with the stratum mean. However, in Tankan survey, the variance within each stratum is comparatively large, so that we must consider the possibility of large deviations between the stratum mean and the true values of nonrespondents. In light of such problems, this paper conducts experimental simulations in order to discover the most appropriate method for handling missing values in Tankan.

We compare three methods: mean imputation (weighting adjustment); "last value carried forward" (a kind of cold-deck adjustment); and "last value multiplied by respondents' mean growth rate" (a kind of hot-deck adjustment). Simulations are made for three items: sales, current profits, and fixed investments.

Our study shows the following points: the method we are currently using is not as accurate as the alternatives; on the whole, the "last value carried forward" procedure seems to be the most suitable for Tankan's purposes, although this finding does depend upon the item under examination, as well as upon the type of industry and the size classification (large, medium, small) to which an enterprise belongs. These results reflect an important characteristic of our business survey data: namely that the variance observed in the data of a given enterprise over time is smaller than the variance observed within an individual stratum of the survey at a given point in time.

In addition, our work suggests that, because enterprises respond on a semi-annual basis based upon annual projections, when "last value carried forward" is employed, seasonality of the data should be taken into consideration.

Key Words: Business survey, Nonresponse, Imputation, Weighting, Cold-deck, Hot-deck, *Short-term Economic Survey of Enterprises in Japan (Tankan)*

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1 INTRODUCTION

The All Enterprises Tankan (hereafter Tankan) comprises two kinds of surveys. One is a numerical survey of items such as fixed investments and sales; the other (which is more qualitative in nature) asks judgment questions concerning business sentiment. For the numerical survey, population totals are estimated from the sample in accordance with the standard procedure for a stratified sampling survey. In Tankan, the Bank of Japan releases the figures for the actual or projected population totals, the year-on-year growth rates and the revision rates (which are calculated from the population estimates of the present and previous surveys[3]).

If missing values due to nonresponse occur in a stratum in numerical surveys, the population total for that stratum is calculated without estimating nonrespondents' individual values as follows: first the values reported by respondents are summed, then this "respondents' total" is appropriately weighted, where the weight used is the ratio of the number in the stratum population to the number of respondents. This method is equivalent to estimating the population total by filling in all missing values with the stratum mean.

However this procedure will produce a biased estimate unless nonresponse occurs at random. In corporate surveys like Tankan, even if nonresponse occurs at random, some cases are likely to involve substantial deviations between the true and imputed values. For example, if an enterprise situated in the tail of the distribution within the stratum did not respond, imputation of the stratum mean would clearly involve under or overestimation of that observation. In Tankan, enterprises are stratified according to industry and size. Even so, differences among individual enterprises within the same stratum are unavoidably large. If missing values make year-on-year growth rates or 'revision rates'[4] fluctuate significantly, analysts or economists using those indicators to judge business conditions will possibly be confused. For these reasons, and in anticipation of an increase in the non-response rate, we examine more appropriate methods for handling missing values.

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[3] For the qualitative surveys, simple aggregates are prepared. For more details, please refer to "The Methodology of the Sampling and Aggregation of the All Enterprises Tankan" which was released by the Research and Statistics Department [September,1999].

[4] In Tankan, the year-on-year growth rate is calculated by comparing the population estimate of the current survey with the figure reported in the survey for the previous June, since this is when most enterprises report their closing accounts and as such this figure is deemed the most reliable. Consequently, revision rates may be calculated based on different sample sizes because the number of respondents may differ between the two surveys (for the projection for the following fiscal year reported in the March survey and the projection for the current year reported in the June survey, these differences do not occur).

2 HANDLING MISSING VALUES :METHODOLOGY AND EXAMPLES

2.1 A Methodological Overview

In data collection, repeated attempts to contact respondents are fundamental for minimizing nonresponse. Callback is the first reaction in practice. However, once nonresponse occurs, we must try to minimize its impact by making use of the most appropriate handling methods given the purpose and characteristics of the survey.

In our discussion of methods of handling missing values, the focal points of interest are: whether our estimator provides us with an unbiased estimate of the population mean, and whether it preserves the distribution of the population. The main methodologies are as follows:

Method 1. Weighting

When missing values occur, this method applies a weight to respondents' reported values, allowing estimation of the population total without filling in the answers for nonrespondents. We sample n members of a population N. If r is the number of respondents, the sample total for these respondents is described by Y_r, and the usual weighting estimate of the population total is given by $Y_r \cdot \frac{N}{r}$. This method is commonly employed for Tankan and other sample surveys.

The estimated result is the same as that obtained by imputing mean value. Under the assumption that missing values occur at random (See Appendix), this estimator is unbiased.

Method 2. Mean Imputation

Imputation refers to techniques that replace a missing value with an estimate of that value. Mean imputation involves replacing a missing value with the mean within each stratum. Consequently, this method will also produce an unbiased estimate equivalent to that produced by weighting, provided that missing values occur at random.

When mean data are imputed the sample variance will be underestimated, and the degree of variability observed may be distorted. In this sense, mean imputation produces much the same effects as the weighting method without offering any additional advantages.

Method 3. Hot-deck Imputation

Hot-deck imputation refers to techniques that duplicate missing values using values reported by respondents to the survey at the time. There are several means of carrying out hot deck imputation, but the most simple one is to select individual values at random from the set of values reported by respondents without appeal to any specific model. Just as with mean imputation, hot-deck estimates are unbiased provided that the missing values occur at random.

Usually, hot-deck imputation selects data at random not from the full set of all respondents' data, but from those data that are closely associated with the missing values. For instance, personal surveys can conduct hot deck-imputation using data stratified according to sex or academic background.

Hot-deck imputation makes substitutions for each nonresonding unit individually, thus to some extent preserving the essential characteristics of the population distribution. When data are imputed using hot-deck methods the sample variance will still be underestimated, but compared with mean imputation we see some improvement in confidence intervals for our estimates of the population variance.

There are, however, problems of consistency which emerge when using mean imputation or hot-deck imputation for handling missing data. In the case of item nonresponse, when imputation may be performed for some but not all of the item variables for a given sample unit, the relation between the variables for this unit will be affected[5].

Method 4. Cold-deck Imputation

Cold-deck imputation refers to techniques that replace a missing-value with a constant value from an external source. Imputing data realized in previous issues of the same survey is specifically called the "historical data substitution method." Regression estimates or results from other surveys may also be imputed.

The most obvious aim of this method is to reproduce (as far as possible) the distribution of the population by making full use of all available information about missing-values. In this regard it needs to be applied flexibly, taking into account both the individual characteristics and underlying precepts of a particular survey. For instance, cold-deck imputation is appropriate when the trend of the time series data of a unit is stable or fluctuates within a relatively small range. The problem is that, since the values used are drawn from an external source, the results obtained by cold-deck imputation can not be evaluated using sampling theory. In this sense, it can be said that cold-deck imputation is a fairly arbitrary method.

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[5] Problems of consistency among the variables within a given sample unit are referred to by Ford as problems of "internal consistency", whereas problems which deal with the consistency of a given variable across the sample as a whole are termed problems of "external consistency", as in Ford[1993].

Method 5. Multiple Imputation

Multiple imputation is a technique that attempts to improve on the precision of the hot-deck estimator. The multiple imputation procedure involves repeating the hot-deck imputation several times by drawing data at random from subsamples. In theory, it is known that “multiple imputations do result in improvements over single random imputations in that 1. they have reduced the real variance of estimation and 2. they have adjusted partially for the underestimation of variability that follows from performing a single imputation” (Herzog and Rubin [1983] p.219)[6]. In practice, the Federal Reserve Board has applied multiple imputation in its Survey of Consumer Finances (SCF) since 1989[7].

Method 6. Substitution

Substitution is a method which may be applied when a given unit has failed to respond at all (unit nonresonse). The substitution method involves replacing nonresponding units with alternative units, which were not originally selected for the sample. Such substitutions represent the simplest solution to the nonresponse problem. However, just as with hot-deck imputation, selection of substitutes must be carefully conducted so as not to cause bias. Furthermore, practical application of this method will often run into the problem of time restrictions. For a survey where quick release is desirable, it is difficult to go back to the field –work stage to select substitutes after most of the data have already been collected.

2.2 Examples of missing-value adjustment in Japan

A summary of the missing value adjustments used in the main economic surveys in Japan is given in Table 1.

Taking a general overview we see that most of the surveys use a weighting method that obtains estimates of the population total by multiplying the sum of respondents’ values by the ratio of the number in the population to the number of respondents. However, in the case of the Financial Statements of Corporations by Industry, a hot-deck type imputation is conducted, where imputed data are not selected

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[6] See Herzog and Rubin [1983].

[7] The purpose of the SCF is to provide a comprehensive and detailed view of the assets and liabilities of households every three years. The response rate is comparatively low (in 1995 average response rates across regional samples were only 66.3%), so the FRB has grappled with the missing-value problem since the 80s. In its multiple imputation procedure, each variable is imputed multiple times as a function of “shadow” variables with which it is likely to be correlated. See Fries, Starr-McCluer, and Sunden [1998], and Kennickell, A.B. [1998].

at random, but calculated using the data of respondents with characteristics similar to those of nonrespondents. In the Survey on Service Industries, the handling method depends on the kind of nonresponse. While weighting is employed in the case of unit nonresponse, in the case of item nonresponse a hot-deck imputation is applied which makes use of the ratios observed among the items reported by respondents. Lastly, the Survey of Production Forecasts in Manufacturing adopts a procedure in which the seasonally adjusted last value is imputed. This can be classified as a type of cold-deck imputation.

Outside Japan, various methods of handling missing values are employed in accordance with the precepts and characteristics of each individual survey. For example, the United States Census Bureau (USCB) describes its thinking as follows: “In the demographic area, we impute data for some items in a hot-deck procedure based on the use of suitable “donors.” For each item nonrespondent we obtain a donor (respondent) with similar survey characteristics. --- In the economic area, we base imputations on the past records for the same respondent or the same kind of business.”(Bailar and Shapiro [1981] pp.182)

3 NONRESPONSE IN TANKAN AND APPLICABLE METHODS

3.1 An Outline of the sampling method of Tankan[8]

Tankan is a statistical survey which covers private-sector enterprises nationwide using a stratified sampling procedure. The population of the survey comprises the approximately 160,000 enterprises (excluding financal institutions) which have 50 or more regular employees (20 or more regular employees for the wholesaling, retailing, service and leasing industries) based on the Establishment and Enterprises Census of Japan. The sample consists of approximately 9,000 of these enterprises.

Tankan has established a target accuracy relating the actual and projected levels of sales. The ratio of the standard error to the sample mean of sales (hereafter, the error ratio of sales) is set as a target accuracy for each of the six divisions, where enterprises are divided first according to industry (manufacturing and

[8] This paper describes the present sampling method of the All EnterprisesTankan. The Bank of Japan has officially stated that it plans to reexamine Tankan’s sampling method and change its standard for stratification from the number of employees to the amount of capital. For further details, see Research and Statistics Department Bank of Japan [June2001] “A final plan for reexamination of the Short-term Economic Survey of Enterprises in Japan” (in Japanese).

nonmanufacturing) and then according to scale (large enterprises, medium-sized enterprises, and small enterprises). The target accuracy is 3.0% for the manufacturing industry and 5.0% for the nonmanufacturing. Large, medium, and small enterprises within each industry are further divided into 118 strata, thus maintaining a healthy error ratio whilst keeping the sample size as small as possible for practical purposes.

We should note too that the sampling procedure used in Tankan is different from that of a normal random sampling survey in that the sample enterprises are not selected at random but are based on a continuing sample. Thus, once a year it is checked whether or not the distribution of the continuing sample has deviated from that of the population. At that time, if necessary, the sample is supplemented by selecting additional enterprises at random and by stratum from the list of enterprises in the Establishment and Enterprises census of Japan. Consequently, under the condition that all enterprises sampled respond, the distribution of the sample and of the population are kept consistent with each other.

3.2 Facts about missing values in Tankan

Generally, the response ratio of Tankan is fairly high. For large enterprises, the response ratio is about 97 percent and even for small enterprises, the response ratio has recently been over 94 percent (Table 2). However, some numerical items are likely to be missing. Since the March survey is the first survey in which each enterprise is asked about its plans or forecasts for the following fiscal year (April-March), item nonresponse, especially in fixed investments, tends to occur. In practice, repeated callbacks reduce blank items. However, the item nonresponse rate for fixed investments in the March survey is still higher than that in the other quarters (June, September, December).

Table 3 shows the number of nonrespondents of the figures of fixed investment categorized by size and by the pattern according to which nonresponse occurred. The table supports the observation that there are many enterprises where nonresponse occurs only in the March survey. This is especially the case for large enterprises where about half of nonrespondents fall into this category. Table 3 also shows that there are “core nonrespondents”, especially in the medium-sized and small enterprises, who never respond throughout the year.

3.3 Attributes of missing-values

It is often said that enterprises down in business have a tendency not to respond to business surveys. It is probable that they seek to reduce their costs by cutting back on unprofitable reporting like Tankan. Usually, business conditions are reflected in numbers that depict change; for example, the rate of increase in fixed investment. However, if there exists a significant relationship between such a rate of change and the level of the variable under consideration, and if the nonresponse mechanism is also dependent in some way on the relative level of this variable within the stratum, then both mean imputation and hot-deck imputation will result in biased estimation[9]. Thus, here we investigate the occurrence of actual missing values across the categories of fixed investments, sales, and current profits.

Specifically, we test for bias by comparing the mean value of respondents' data with the mean value of an estimated complete data set, where missing values are filled in wherever possible with the realized responses reported in the next survey. Table 4 summarizes the results of t-tests. The statistical null hypothesis is that the mean value of respondents' data is equal to that of the estimated complete data set.

The results show that some strata reject the null hypothesis. Especially in fixed investment, in about 20% of strata we observe mean values of respondents' data that are significantly larger than those of the complete stratum data sets. Most of such strata are classified into large enterprises and small enterprises. This means that there is a tendency for relatively small enterprises within each of these strata to become nonrespondents.

However, no particular tendency is observed in either sales or current profits. And even in fixed investments, in more than 75% of strata the differences are not statistically significant. As a result, we are cautious about making the judgment that missing values do not occur at random. Therefore, it can not be said that either the present weighting procedure or mean imputation produce biased population estimates in Tankan.

3.4 Methods of handling missing values of Tankan

Bearing in mind the features of missing values mentioned above, as well as the underlying purpose of Tankan, the merits and demerits of each available method of handling missing values can be summarized as follows.

(1) Weighting, Mean Imputation

The most important purpose of Tankan's numerical survey is to produce an unbiased estimate of the population mean that reflects the realities of enterprises' economic activities. As described above, there appear to be cases in which we observe a relationship between business' attributes and nonresponse; nevertheless, on the

[9] See Appendix.

whole we cannot make definitive statements about these correlations. As a result, we are unable to conclude that present weighting method should be rejected on these grounds.

However, it is still problematic that the variance within strata is not small[10]. Even if missing values occur at random, if extremely big or small enterprises within each stratum do not respond, population estimates will be far from reality. In this sense, it is worth examining an alternative technique for handling missing values.

It should be noted that, in Tankan, the population is stratified as finely as possible and speedy processing is essential for quick release. Thus, poststratification procedures which make use of new information collected from the sample are both unnecessary and difficult to implement in practice.

(2) Hot Deck Imputation

Although Tankan sample contains approximately 9000 enterprises, which is enough to attain target accuracy, there are not necessarily a large number of enterprises within each stratum, nor is the variance within each stratum small. Under these circumstances, hot-deck imputation, which duplicates missing values using data drawn from the set of actual responses made to the survey at that time, will potentially cause large deviations between the imputed data and the true values that would have been obtained if sample enterprises had responded. Plus, even where the variance within each stratum is comparatively small (as in the case of small enterprises), as a practical problem, there is little time to select a “donor” (suitable respondent) to use for imputation. In this sense, multiple imputation, the applied hot deck procedure, is too complex to be used for Tankan.

Nevertheless, it may be possible to perform a simple hot deck imputation. Tankan is used to observe the cyclical fluctuations of the economy of Japan, and the published year-on-year growth rates and revision rates attract the attention of both economists and analysts. When this is taken into consideration, making use of the mean year-on-year growth or revision rates reported by respondents when imputing missing values (rather than simply imputing the level mean) may provide an appropriate alternative method for dealing with missing values. Such a method would have the further advantage, typical of hot deck procedures, of providing a micro database for analysts which preserves distributional properties.

[10] Target accuracy for Tankan strata is set by the 6 divisions (Large, medium, and small enterprises of the manufacturing and the nonmanufacturing sector) of the sample.

(3) Cold Deck Imputation

It may also be possible to apply cold deck imputation if we have access to external information about missing values. From this point of view, cold deck imputation is particularly suitable for use in Tankan because Tankan possesses a large historical database of responses from the same sample unit.

Because quick release is critical for Tankan, replacing missing data by estimating a sophisticated model like a time series regression model is not well-suited to Tankan's purposes. In this respect, an appropriate cold deck method is the "last value carried forward" method used in the Survey of Production Forecasts in Manufacturing, which makes the assumption that the data of the sample unit does not change from the previous survey.

(4) Substitution

In Tankan it is unrealistic to sample alternative units after data collection because sampling is time-consuming work. Considering the existence of "core nonrespondents" who never respond throughout the year, however, substituting sample units prior to sending questions is quite important for Tankan. As a means of reducing the nonresponse rate, substitution should be used more effectively than it has been hitherto.

4 COMPARISON OF METHODS FOR HANDLING MISSING VALUES

Based on the above considerations, we compare three methods for dealing with nonresponse in Tankan. Specifically, we carry out simulations using data on three items (sales, current profits, and fixed investments) for the following three methods: (**a**) mean imputation (the weighting adjustment method currently in use) [11]; (**b**) "last value carried forward" (a kind of cold-deck adjustment); and (**c**) "last value multiplied by respondents' mean growth rate"[12] (a kind of hot-deck adjustment). For current profits, we exclude (**c**) because the year-on-year growth and revision rates may not be able to be calculated due to negative value.

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[11] Weighting refers generally to methods that use weights to estimate population statistics. Since the weighting method currently in use produces the same results as those produced by mean imputation, for simplicity of exposition, we call the current method "mean imputation" hereafter.

[12] To calculate year-on-year growth rates, only the units that fill in the items in both of the previous and the current survey are used.

4.1 Simulation Method

We conduct two types of simulation: “simulation using experimental data” and “simulation using actual missing data”. These two are mutually complementary. Although ideally we should generate all possible combinations of missing data across our 9000 enterprise sample, this is scarcely a realistic proposition in practice. Thus, in our “simulation using experimental data” we fix the number of missing pieces of data to one per stratum and we then simulate every possible case uniformly. This approach is then complemented by our “simulation using actual missing data, in which we can obtain results more in line with actual situations where some strata are likely to have more than one missing value, while others achieve perfect response rates.

The details are as follows:

Simulation 1. Simulation using experimental data

In our “simulation using experimental data”, assuming that all of the sample units have the same probability of nonresponding, we generate missing enterprises one by one, impute three different numbers from the three missing-value adjustment methods and find the result closest to the realized value. Specifically, for every sample unit $C_1,...,C_n$ within every stratum: (1) assuming that each sample unit $C_1,...,C_n$ takes its turn to perform the role of “missing value”, we replace the missing value with each of the three values obtained in turn by (a) mean imputation, (b) “last value carried forward”, and (c) last value multiplied by respondents’ mean growth rate; (2) we calculate the differences between the imputed values and the correct response; (3) we total the differences (absolute values) from case 1 to case n for each separate method; and (4) we look for the method which marks the smallest total sum of differences in absolute value.

In this simulation, so that we are able to compare imputed values with correct responses, actual nonrespondents are excluded from our calculations.

Simulation 2. Simulation using actual missing data

In our “simulation using actual missing data”, we replace actual missing data from 1999 to 2000 in each stratum with the data estimated using the three methods, (a) mean imputation, (b) “last value carried forward”, and (c) “last value multiplied by respondents’ mean growth rate”; we then look for the method which offers results closest to the “quasi-correct values” realized in the subsequent survey. In the sense that we focus on missing data from specific surveys, this simulation does not attempt to be comprehensive; instead it examines the cases that may be more likely to occur. In this regard it differs from our “simulation using experimental data,” in which we assume that each sample unit becomes missing with the same probability.

In this simulation, we exclude nonrespondents for whom we have no responses realized in the subsequent survey for use as “quasi-correct values”, as well as those for whom we have no historical data for imputation.

4.2 Results of Simulations

Table 5 summarizes our results, giving the number of strata for which each of the three imputation methods attains the closest result to the correct or quasi-correct value. Results for the March surveys are shown separately because it is in these surveys that companies are asked questions about their future plans for the next fiscal year for the first time; as a result there are no corresponding data from previous surveys for “last value carried forward” and “last value multiplied by respondents’ mean growth rate”. We should therefore focus especially on the results of the March surveys[13]. In addition, both alternative methods, “last value carried forward” and “last value multiplied by respondents’ mean growth rate”, may potentially produce biased estimates even if the difference between an estimate and a correct value is the smallest. Thus, to investigate these questions, we create scattered diagrams (illustrated in Figure 1) which plot the differences between the estimated values and the correct values for fixed investment plans for the next fiscal year, calculated from our “simulation using experimental data” from the March 2000 survey.

The results are summarized as follows.

- Mean imputation is inferior to the other methods in most strata regardless of the time of the survey.
- When categorized by industry and scale, the results for fixed investments and current profits tend to suggest that mean imputation is less precise for larger companies’ strata.
- It is difficult to rank the two alternatives to mean imputation. Judging from our experimental simulation, “last value carried forward” seems to be more precise, although this result is sometimes reversed in our “actual data” simulation.
- Neither “last value carried forward” nor “last value multiplied by respondents’ mean growth rate” leads to biased estimates.

[13] In surveys after June, if there is no corresponding data available for imputation from the previous surveys of the fiscal year, then data from surveys of the previous fiscal year are used for imputation in (**b**) “last value carried forward” and (**c**) “last value multiplied by respondents’ mean growth rate”.

4.3 Implication of the simulation results

The above results suggest that, in a survey like Tankan in which the variance within the stratum exceeds the variance over time observed in the time series data for individual units, methods which are sensitive to a high within-stratum variance (like the mean imputation method in current use) are likely to produce less satisfactory results than those methods that are more sensitive to variance in the time series data for individual units (like our two alternative methods). In short, both imputation using "last value carried forward" and imputation using "last value multiplied by respondents' mean growth rate" are likely to be more appropriate than mean imputation, given the distributional characteristics of Tankan data.[14].

On the other hand, our simulation does not give us a clear result concerning the ranking of imputation using "last value carried forward" and imputation using "last value multiplied by respondents' mean growth rate" for fixed investments or sales. In our "simulation using experimental data", it is obvious that the former is to be preferred. However, this result is sometimes reversed in our "actual data" simulation, although the difference in precision between the two is not substantial[15]. It is also problematic that the precision of "last value multiplied by respondents' mean growth rate" is sensitive to the phase of the business cycle. The stagnant economic situation in 1999 and 2000 may have had some influence on our simulation results[16].

One thing that we can clearly say, however, is that, in narrow strata divided into 118, some cases are definitely affected by the extreme values that often occur in the rate of change (see Figure 2) [17]. This means "last value multiplied by respondents' mean growth rate" is a rather risky method. Taking into consideration the fact that the diversification of economic activity within a given industry is likely to last into the future in spite of the business cycle, "last value carried forward" may be more appropriate than "last value multiplied by respondents' mean growth rate" for missing-value adjustment, in that it allows us to avoid this risk.

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[14] For small enterprises, while the variance within stratum is small, the time series fluctuation of fixed investment or current profits for individual units tends to be large. We might expect therefore that the precision of mean imputation would be relatively high. However, our simulation shows that even for small enterprises mean imputation is not the best solution.

[15] The scatter diagram, which plots individual differences estimated and correct values for our "simulation using experimental data," also illustrates that, compared with differences between "mean imputation" and "last value carried forward," those between "last value carried forward" and "last value multiplied by respondents' mean growth rate" are extremely small in almost all the case. Please see figure 1.

[16] When the phases of the business cycle are distinct, it is conceivable that there might be a rise in the precision of (**c**) "last value multiplied by respondents' mean growth rate".

[17] Figure 2 shows the distribution of year-on-year growth rates within each stratum, calculated in our simulation using experimental data.

5 HANDLING METHODS FOR MISSING VALUES IN DATA COLLECTED ON A SEMIANNUAL BASIS

In Tankan, quantitative data are surveyed in value terms on a semi-annual basis based upon annual projections. If responses were received in the previous survey, “last value carried forward” may be applied in practice. However, when missing data occur in answer to questions newly posed in the March survey, this method raises another problem in that practitioners must select corresponding semi-annual data from the data set realized in the survey for the previous fiscal year.

5.1 Imputation by semiannual base

Although there are various patterns in which semiannual missing-values can occur, here we take seasonality into consideration and look at the following three imputation methods:[18]

(A) Imputation of each half of the year separately: i.e. replacing the first half of the fiscal year with the value reported in the first half of the previous fiscal year, and the second with the second respectively (“each half method”).

(B) Imputation of bisected data, calculated from the data for the whole of the previous fiscal year (“bisection method”).

(C) Imputation of the most recent prior response, usually the second half of the previous fiscal year (“nearest method”).

While (**A**) is better suited to cases in which there is a certain seasonality in the data, (**C**) would be better if data were sensitive to changes in the business environment. If companies were to act based upon annual projections and we were able to find no clear evidence of seasonality, (**B**) could be the best choice.

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[18] Other possible occurrence patterns for semiannual missing values are for example: a sample unit which consistently responds in only the same given half of the fiscal year; alternatively, a nonresponding sample unit which also fails to respond in either first or second halves of the previous fiscal year.

5.2 Comparison of Handling Methods for Semiannual Missing Values

We compare three methods for handling semiannual missing values, once again carrying out a “simulation using experimental data” for fixed investments, sales and current profits. As above, we select one sample unit at a time to take its turn to be the “nonresponding” unit, make imputations for the missing value using each of the three methods, and then look for the methods that results in an estimate closest to the correct (actually realized) value.

Table 6 shows the results (for evidence of seasonality, see Figure 3).

- For sales, clear seasonality exists and the “each half method” is the most precise.
- For current profits, clear seasonality exists and the “each half method” is the most precise except for the first half of the year for manufacturing, for which the “bisection method” is the best.
- For fixed investments, although there is some evidence of seasonality depending on scale and industry, for the majority the most appropriate method is the “bisection method.” For small enterprises, the “nearest method” is the most precise. The “each half method” also comes out top in the first half of the year for large nonmanufacturing enterprises.

5.3 Interpretation and practical exploitation of the simulation results

From the above results, we may state categorically that the “each half method” is the most appropriate for sales. However, for fixed investments and current profits, it is difficult to draw such firm conclusions.

For current profits, as a whole, the “each half method” seems satisfactory.

The fact that the “bisection method” provides the most precise imputation for the missing data in the first half of the year in manufacturing seems to be influenced by cyclical factors in the period of simulation. Because the year-on-year growth rates of current profits increased greatly from 1999 to 2000[19] and data in the second half of the year displays seasonal rises every year, ”bisecting” the data for the previous year may produce estimates closer to true value than simply imputing the first half response from the previous year (a figure much lower than the “bisected” value over this period). If this inference is true, when business conditions deteriorate, the “bisection method” will cause overestimation. Therefore, since it is not satisfactory to apply the “bisection

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[19] The year-on-year growth rates of current profits for manufacturing industry in fiscal 1999 rose 27.3%, and in fiscal 2000 rose 33.2% (actual result).

method” only for the first half of the year in manufacturing, we may conclude that for practical purposes the “each half method” is appropriate for current profits as well as for sales.

On the other hand, for fixed investments, especially in small enterprises, the “nearest method” is likely to produce estimates closest to the correct response. This may indicate that small enterprises are sensitive to changes in business conditions. However it should be noted that small enterprises have a tendency to respond prudently in the March survey, and then revise their projections upward through the following surveys (Figure 4). Thus, if we impute the figure reported for the second half of the previous fiscal year, which have been revised upward, this will cause overestimation. Besides, aggregating the cases in which the “each half” and the “bisection” methods result in the most accurate estimates produces a total number that exceeds that of the “nearest method” in this simulation, which provides further reason to avoid the risk of overestimation inherent in the latter method. In the first half of the year for large nonmanufacturing enterprises the “each half method” is superior to the others; although, in the second half of the year, obviously the “bisection method” is the best. In conclusion, the “bisection method” is thought to be the most appropriate method for fixed investments.

6 CONCLUDING REMARKS AND FUTURE STUDY

In this paper, we reviewed the methodology for handling missing values and conducted simulations in order to discover the method most appropriate for Tankan. Given that our simulations used only two years’ data (1999-2000), it was undeniable that business conditions during these two years influenced the results in ways that are detailed above. It should also be noted that we simulated only a fraction of the many combinations of nonresponse possible for our sample of enterprises.

However, the simulation provides irrefutable evidence that under certain conditions the stratum mean unmistakably deviates from the actual historical data recorded for the “nonresponding” unit. The problem is not yet serious for Tankan, since response rates are currently high, but it should be born in mind that response rates will likely decline as enterprises seek to reduce their reporting burden. This paper demonstrates that the current method of handling missing values in Tankan should be changed for the better to a more appropriate and simpler method.

Finally, we would like to make one last proposition concerning the practical implementation of the “last value carried forward” method for Tankan. This is that a rule should be established to exclude “core nonrespondents,” (say, sample units which fail to respond for a whole year), and replace them with other enterprises, and that this should be done at regular intervals. Needless to say, it is meaningless to impute a last value that was reported more than one year ago, and exclusion of "core nonrespondents" does not solve the problem either, but merely leads to the same results as mean imputation. Thus, it is desirable to select new sample units to substitute for "core nonrespondents."

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Appendix. What it means to ignore the response mechanism

Let n denote our sample, and let y_i denote the value of the variable for the ith unit in the population N.

The vector $I=(I_1,...,I_N)^T$ indicates sampled and nonsampled units in the survey, where $I_i=1$ if unit i is selected and $I_i=0$ otherwise. The density function for the distribution of I is

$$P(I|Y)=P(I)=\begin{cases}\binom{N}{n}^{-1}, if \sum_{i=1}^{N} I_i=n \\ 0, \quad otherwise\end{cases} .$$

The vector $R=(R_1,...,R_N)^T$ indicates responding and nonresponding units in the survey, where $R_i=1$ if unit i was sampled and did respond and $R_i=0$ otherwise. The probability density function for the distribution of R can be shown by the following form using Bayes' theorem

$$P(R|I,Y)=\frac{P(R|Y)P(I|R,Y)}{P(R|Y)P(I|R,Y)+P(\overline{R}|Y)P(I|\overline{R},Y)} .$$

In the case of random sampling,

$$P(I|R,Y)=P(I|\overline{R},Y)=P(I|Y)=P(I)$$

then

$$P(R|I,Y)=\frac{P(R|Y)P(I)}{P(R|Y)P(I)+P(\overline{R}|Y)P(I)}=\frac{P(R|Y)P(I)}{P(I)}=P(R|Y).$$

However, the above mentioned response mechanism depends on y, and it is difficult to specify when $R=0$. So, assuming independence between R and Y: i.e.

$$P(R|Y) = P(R),$$

$P(R|I,Y) = P(R)$ corresponds to sampling M members at random from a population N $\left(M = \sum_{i=1}^{N} R_i\right)$. Consequently, the probability density function for the distribution of R can be factored in the following form

$$P(R|I,Y) = P(R) = \begin{cases} \binom{N}{M}^{-1}, if \sum_{i=1}^{N} R_i = M \\ 0, otherwise \end{cases} .$$

In practice, we have values only from those units that were sampled and responded, so let D denote the probability variable $D_i = R_i I_i$, $D = (D_1, ..., D_N)^T$. It is equivalent to drawing a random sample m from a population N. And the probability density function for the distribution of D can be factored in the following form

$$P(D|I,Y) = P(D) = \begin{cases} \binom{N}{m}^{-1}, if \sum_{i=1}^{N} D_i = m \\ 0, otherwise \end{cases} .$$

Table 1: Methods of Handling Missing Values Used in the Main Economic Surveys in Japan

Survey	Handling Method	Remarks
Family Income and Expenditure Survey [Ministry of Public Management, Home Affairs, Posts and Telecommunications]	• No handling method is applied except for households involved in farming, forestry, and fishery (missing values are treated as zero). -- The nonresponse rate is regular over time, so missing values are judged to be negligible. -- Mean imputation is applied for all households including those involved in farming, forestry, and fishery. Mean imputation is also applied in the National Survey of Family Income and Expenditure which is implemented once every five years.	• The sample consists of approximately 8,000 households. The purpose of the survey is to clarify the average structure of households, and therefore population characteristics are not estimated. -- Population characteristics are estimated in the National Survey of Family Income and Expenditure.
Labour Force Survey [Ministry of Public Management, Home Affairs, Posts and Telecommunications]	• Weighting adjustment applied in estimating population statistics. • Without altering the sampling rates across individual strata, a correcting weight is applied in order to bring the total for 10 areas in line with the aggregate for the entire country.	• Population characteristics for the labor force and labor market conditions are estimated from a sample of approximately 100,000 Units.
Survey on Service Industries [Ministry of Public Management, Home Affairs, Posts and Telecommunications]	• Weighting adjustment is applied for unit nonresponse, hot-deck imputation is applied for item nonresponse. -- For example, for wages and salaries, the imputed value is estimated by multiplying mean wages and salaries per person within strata by number of employees.	• Population characteristics are estimated for establishments which engage fewer than 30 persons, from a sample of approximately 310,000 (the complete labor survey covers establishments that engage 30 or more persons).
Financial Statements Of Corporations by Industry [Ministry of Finance]	• Handling method varies with capital scale as follows: 600mil.yen or more: sequential hot-deck is applied (sample units are ranked according to capital scale, within stratum; for each missing value, the mean of its nearest neighbours <ten higher, ten lower> is calculated and imputed). 100-600mil.yen: hot-deck imputation is applied (within stratum the average ratio between the item in question and capital holdings is calculated for respondents; missing values are then replaced by multiplying a nonrespondent's capital holding by this ratio). • Less than 100mil.yen: weighting adjustment is applied.	• Population characteristics of corporations with under 1bil.yen in capital are estimated from a sample of approximately 35,000 (For annual and quarterly surveys the sample size is 27,000) Note: see complete survey for corporations with more than 1bil.yen in capital.
Survey of Production Forecast in Manufacturing [Ministry of Economiy, Trade and Industry]	• In principle, cold-deck imputation which imputes flat movement of the sample unit is applied.	• The survey is implemented by purposive selection. The sample consists of enterprises the sum of whose production makes up 80% of the total. • Population characteristics are not estimated.
Monthly Labour Survey [Ministry of Health, Labour and Welfare]	• Weighting adjustments is applied in estimating population statistics. -- Weight used for estimation is the ratio of the number of those registered as employed (at the end of the previous survey) who answered the current survey, to the total number of the population.	• Population characteristics for establishments with 30 or more employees are estimated from a sample of 17,000; for establishments of 5-30 employees, the sample size is approximately 16,500.

Table 2: The Response Ratio in the Tankan(1999-2000 Survey)

%;Figures in parentheses are %points

		1999survey				2000survey			
		Mar.	Jun.	Sept.	Dec.	Mar.	Jun.	Sept.	Dec.
All Industries	DI	93.9	94.2	94.4	95.1	95.3	95.2	94.9	95.3
	Fixed investments	92.0	93.7	94.0	94.8	94.5	94.7	94.7	95.1
	difference	(1.9)	(0.5)	(0.4)	(0.3)	(0.8)	(0.5)	(0.2)	(0.2)
Large enterprises	DI	96.2	97.2	97.5	97.8	97.1	97.3	96.6	97.0
	Fixed investments	92.0	96.7	97.1	97.5	95.1	96.8	96.4	96.8
	difference	(4.2)	(0.5)	(0.4)	(0.3)	(2.0)	(0.5)	(0.2)	(0.2)
Medium-sized enterprises	DI	94.6	94.9	94.4	95.5	95.7	95.5	95.3	95.6
	Fixed investments	92.5	94.2	94.0	95.3	95.0	94.9	95.1	95.4
	difference	(2.1)	(0.7)	(0.4)	(0.2)	(0.7)	(0.6)	(0.2)	(0.2)
Small enterprises	DI	92.9	92.8	93.4	94.0	94.5	94.3	94.2	94.6
	Fixed investments	91.7	92.5	93.2	93.8	94.1	94.0	94.0	94.5
	difference	(1.2)	(0.3)	(0.2)	(0.2)	(0.4)	(0.3)	(0.2)	(0.1)

Note: Response rates of DI are calculated for business conditions. The data are released in the summary of Tankan as "number of reporting enterprises".

Table 3: Number of nonresponding units by nonresponse pattern (fixed investments)

Unit;figures in parentheses are percentage shares

Period \ Size	All enterprises	Large enterprises	Medium-sized enterprises	Small enterprises
Mar.	210 (25.0)	66 (49.3)	63 (22.7)	81 (18.9)
Jun.	47 (5.6)	2 (1.5)	15 (5.4)	30 (7.0)
Sep.	65 (7.7)	9 (6.7)	29 (10.4)	27 (6.3)
Dec.	67 (8.0%)	7 (5.2)	25 (9.0)	35 (8.2)
Mar./Jun.	49 (5.8)	10 (7.5)	14 (5.0)	25 (5.8)
Mar./Sep.	14 (1.7)	1 (0.7)	6 (2.2)	7 (1.6)
Mar./Dec.	9 (1.1)	1 (0.7)	4 (1.4)	4 (0.9)
Jun./Sep.	17 (2.0)	2 (1.5)	7 (2.5)	8 (1.9)
Jun./Dec.	7 (0.8)	0 (0.0)	3 (1.1)	4 (0.9)
Sep./Dec.	34 (4.0)	1 (0.7)	10 (3.6)	23 (5.4)
Mar./Jun./Sep.	27 (3.2)	8 (6.0)	12 (4.3)	7 (1.6)
Jun./Sep./Dec.	27 (3.2)	1 (0.7)	8 (2.9)	18 (4.2)
Mar./Jun./Dec.	15 (1.8)	2 (1.5)	4 (1.4)	9 (2.1)
Mar./Sep./Dec.	12 (1.4)	2 (1.5)	2 (0.7)	8 (1.9)
Mar./Jun./Sep./Dec.	241 (28.7)	22 (16.4)	76 (27.3)	143 (33.3)
Total	841	134	278	429
Number of sample enterprises	9088	1426	2894	4768

Notes:1. Figures are those for the Mar.,Jun.,Sep.,dec.1999 surveys. For Large and medium-sized enterprises, the sample enterprises at the time of Jun.2000 survey are used, and for small enterprises, the sample enterprises at the time of the Sep.2000 survey are used.
2. Figures in parentheses are percentage shares in total nonresponse of that year.
3. There are no duplications in figures.

Table 4: Attribution of Missing Value t-test for difference rates by strata

Number of strata

Size and item		Plus	Minus	not significant
Large enterprises	Fixed Investments	7	1	22
	Sales	6	1	23
	Current Profits	5	2	23
Medium-sized enterprises	Fixed Investments	2	0	32
	Sales	4	1	29
	Current Profits	3	2	29
Small enterprises	Fixed Investments	16	2	36
	Sales	6	5	43
	Current Profits	2	4	48

Notes:1."Plus" and "Minus" indicates direction of significant difference.
2.t-test were carried out for 7 series as follows:
1998 data surveyed in Dec.1998 survey,
1999 data surveyed in Mar.1999-Dec.1999 survey,
2000 data surveyed in Mar.2000-Jun.2000 survey.
3.Difference rate=((average of respondents' data)-(average of data set after adjusting for missing-values)/(average of data set after adjusting for missing-values)

Table 5: Comparison of Methods Results of Simulations

(1)Fixed Investments

Number of strata

Method which is the closest to the correct answer		Annual projections made in the March survey of the previous year				Forecast for the year made in the Jun., Sep.,and Dec. survey			
		Total	Large ent.	Medium-sized ent.	Small ent.	Total	Large ent.	Medium-sized ent.	Small ent.
(a) Mean imputation	Experimental	18	1	4	13	0	0	0	0
	Actual	33	6	10	17	78	7	25	46
(b) Last value carried forward	Experimental	128	38	35	55	1010	243	298	469
	Actual	41	11	19	11	163	42	57	64
(c) Imputation using last value multiplied by mean growth rates	Experimental	87	21	29	37	46	25	7	14
	Actual	42	18	10	14	152	47	59	46
(b)or(c)	Experimental	1	0	0	1	6	2	1	3
	Actual	17	0	3	14	134	3	37	94
(a)or(c)	Experimental	1	0	0	1	0	0	0	0
	Actual	0	0	0	0	0	0	0	0
(a)or(b)	Experimental	1	0	0	1	0	0	0	0
	Actual	0	0	0	0	0	0	0	0
(a)or(b)or(c) (no difference)	Experimental	0	0	0	0	0	0	0	0
	Actual	0	0	0	0	1	0	0	1
Stratum excluded from simulation		103	25	26	52	534	171	128	235
Total		369	95	110	164	1590	369	484	737

(2)Sales

Number of strata

Method which is the closest to the correct answer		Annual projections made in the March survey of the previous year				Forecast for the year made in the Jun., Sep.,and Dec. survey			
		Total	Large ent.	Medium-sized ent.	Small ent.	Total	Large ent.	Medium-sized ent.	Small ent.
(a) Mean imputation	Experimental	0	0	0	0	1	1	0	0
	Actual	7	1	3	3	22	1	6	15
(b) Last value carried forward	Experimental	157	40	43	74	924	219	267	438
	Actual	60	12	21	27	222	46	67	109
(c) Imputation using last value multiplied by mean growth rates	Experimental	79	20	25	34	134	49	39	46
	Actual	61	23	18	20	242	45	95	102
(b)or(c)	Experimental	0	0	0	0	3	1	0	2
	Actual	1	0	0	1	8	0	0	8
Stratum excluded from simulation		107	24	26	57	568	178	138	252
Total		365	96	110	159	1556	362	474	720

(3)Current Profits

Number of strata

Method which is the closest to the correct answer		Annual projections made in the March survey of the previous year				Forecast for the year made in the Jun., Sep.,and Dec. survey			
		Total	Large ent.	Medium-sized ent.	Small ent.	Total	Large ent.	Medium-sized ent.	Small ent.
(a) Mean imputation	Experimental	22	3	4	15	3	1	1	1
	Actual	45	9	14	22	111	19	30	62
(b) Last value carried forward	Experimental	214	57	64	93	1059	269	305	485
	Actual	97	29	31	37	402	78	140	184
Stratum excluded from simulation		94	22	23	49	549	173	136	240
Total		378	98	113	167	1575	367	476	732

Notes:1."Experimental" in the above table refer to our simulation using experimental data, and "Actual" refer to our simulation using actual missing value.
2."Strata excluded from simulation" occurs in the simulation using acutual missing value.
3. Simulation was carried out for 11 series as follows:
1998 data surveyed in Dec.1998 survey-2000 data surveyed in Jun.2000 survey.

Table 6: Comparison of Handling Methods with Semiannual Missing Value (forecast made in the March survey of the previous year)

(1)Fixed investments

Number of strata

Size		Large ent.			Medium-sized ent.			Small ent.		
The first half of the year	Method which is the closest to the correct answer	Bisection	Nearest	Each half	Bisection	Nearest	Each half	Bisection	Nearest	Each half
	Manufacturing	20	6	12	17	11	6	22	28	18
	Nonmanufacturing	8	3	11	14	14	6	12	18	10
The second half of the year	Method which is the closest to the correct answer	Bisection	Nearest		Bisection	Nearest		Bisection	Nearest	
	Manufacturing	21	17		17	17		33	35	
	Nonmanufacturing	14	8		17	17		21	19	

(2)Sales

Number of strata

Size		Large ent.			Medium-sized ent.			Small ent.		
The first half of the year	Method which is the closest to the correct answer	Bisection	Nearest	Each half	Bisection	Nearest	Each half	Bisection	Nearest	Each half
	Manufacturing	6	2	30	13	1	20	23	6	39
	Nonmanufacturing	4	1	17	6	6	22	10	5	25
The second half of the year	Method which is the closest to the correct answer	Bisection	Nearest		Bisection	Nearest		Bisection	Nearest	
	Manufacturing	6	32		2	32		10	58	
	Nonmanufacturing	7	15		5	29		5	35	

(3)Current profits

Number of strata

Size		Large ent.			Medium-sized ent.			Small ent.		
The first half of the year	Method which is the closest to the correct answer	Bisection	Nearest	Each half	Bisection	Nearest	Each half	Bisection	Nearest	Each half
	Manufacturing	18	9	11	22	3	9	37	12	18
	Nonmanufacturing	7	0	15	16	2	16	13	2	25
The second half of the year	Method which is the closest to the correct answer	Bisection	Nearest		Bisection	Nearest		Bisection	Nearest	
	Manufacturing	4	34		1	33		6	62	
	Nonmanufacturing	4	18		7	27		10	30	

Notes: 1. Simulation was carried out for 2 series: annual projections for 1999 and 2000 made in the March surve of the previous fiscal year.

2. "Bisection":For each missing semiannual value in the March survey, impute a bisection of the respons from the previous December survey.

"Nearest":Impute the response for the second half reported in the previous December survey for each semiannual missing value in the subsequent March survey.

"Each half":For the first half-year missing value in the March survey, impute the first half-year response from the previous December survey.

For the second half-year missing value in the March survey, impute the second half-year response from the previous December survey.

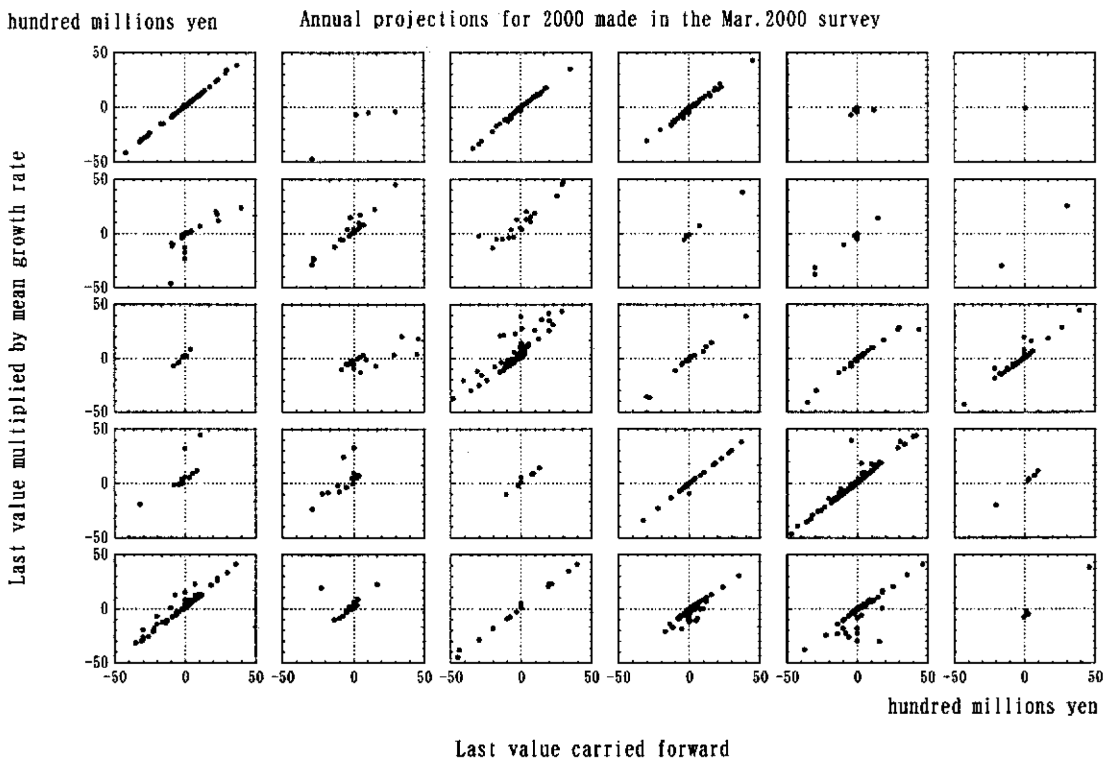
Table 7: The Strata

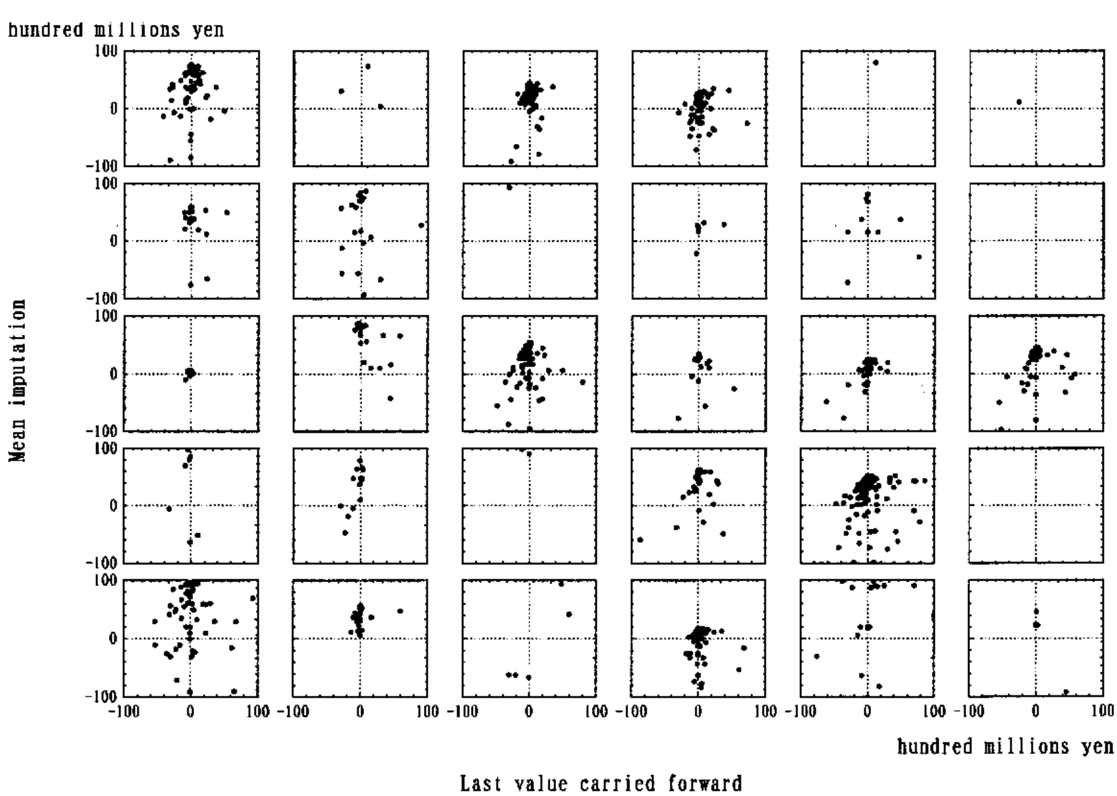
	Electrical machinery, motor vehicles		Wholesaling		Retailing,services, leasing		Other industries	
	Scale	employees(people)	Scale	employees(people)	Scale	employees(people)	Scale	employees(people)
Large enterprises	1	5000-	1	5000-	1	1000-	1	1000-
	2	1000-4999	2	1000-4999				
Medium-sized enterprises	3	300-999	3	300-999	2	300-999	2	300-999
			4	100-299	3	100-299	3	- - -
					4	50-99		
Small enterprises	4	100-299					4	100-299
	5	50-99	5	50-99	5	30-49	5	50-99
	6	- - -	6	20-49	6	20-29	6	- - -

Note:In publication, we classify enterprises as "large", "medium-sized", or "small", but in estimating the populatuon, we utilize more detailed classifications as shown above in order to improve the precision of the statistics.

Figure 1: Differences between correct and estimated values (fixed investments)

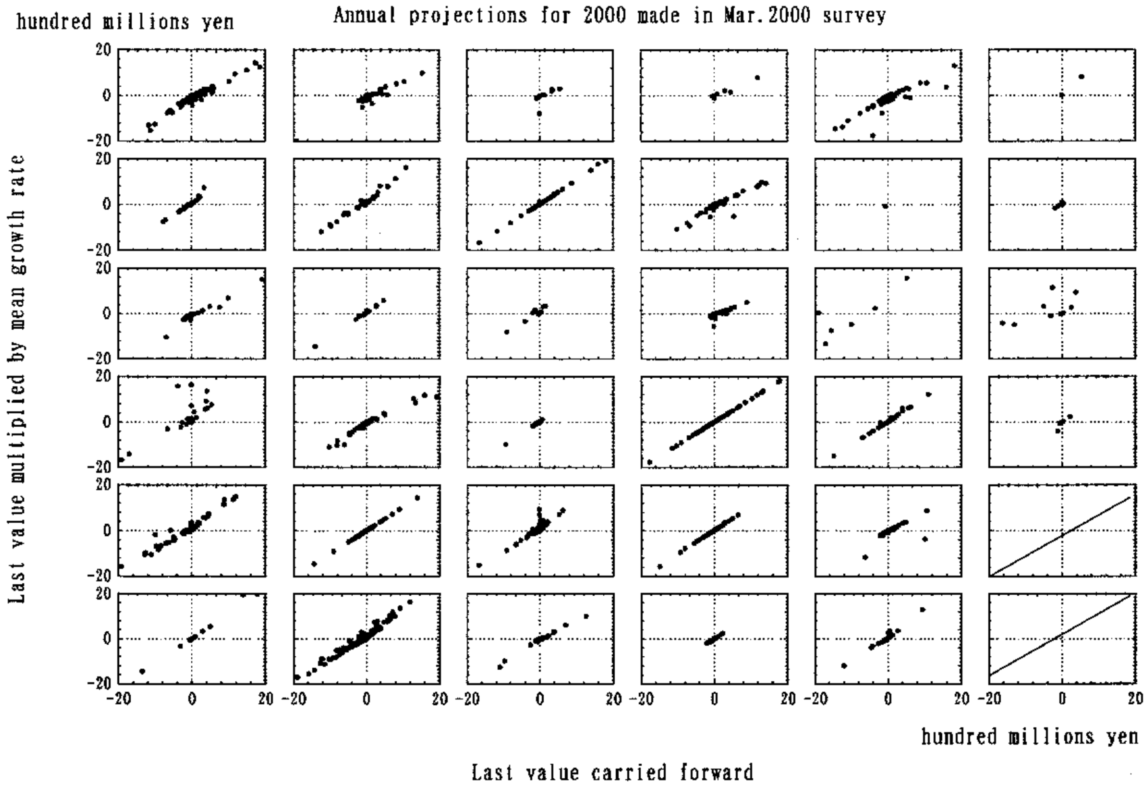
<Large enterprises>

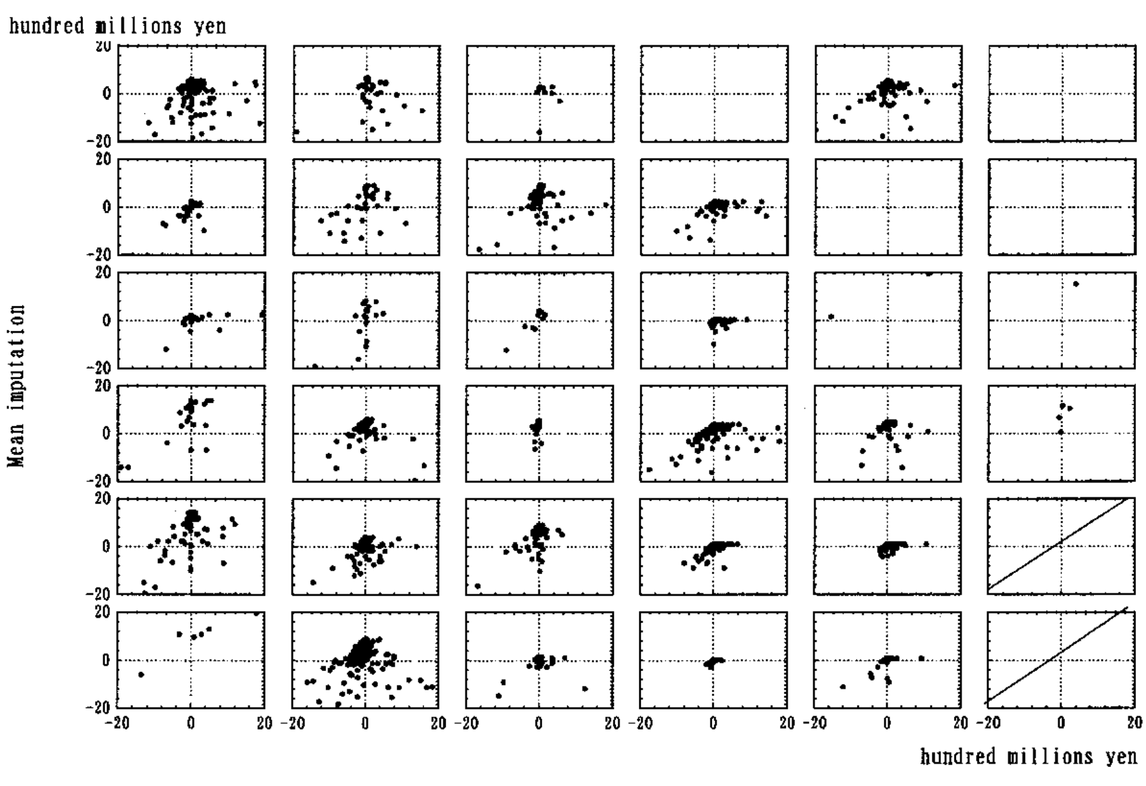




Notes:1. The scatter diagrams plot the differences between correct and estimated values for each enterprises in the simulation, grouped by stratum.
2. The axes plot differences, by imputation method.
3. outliers are omitted.

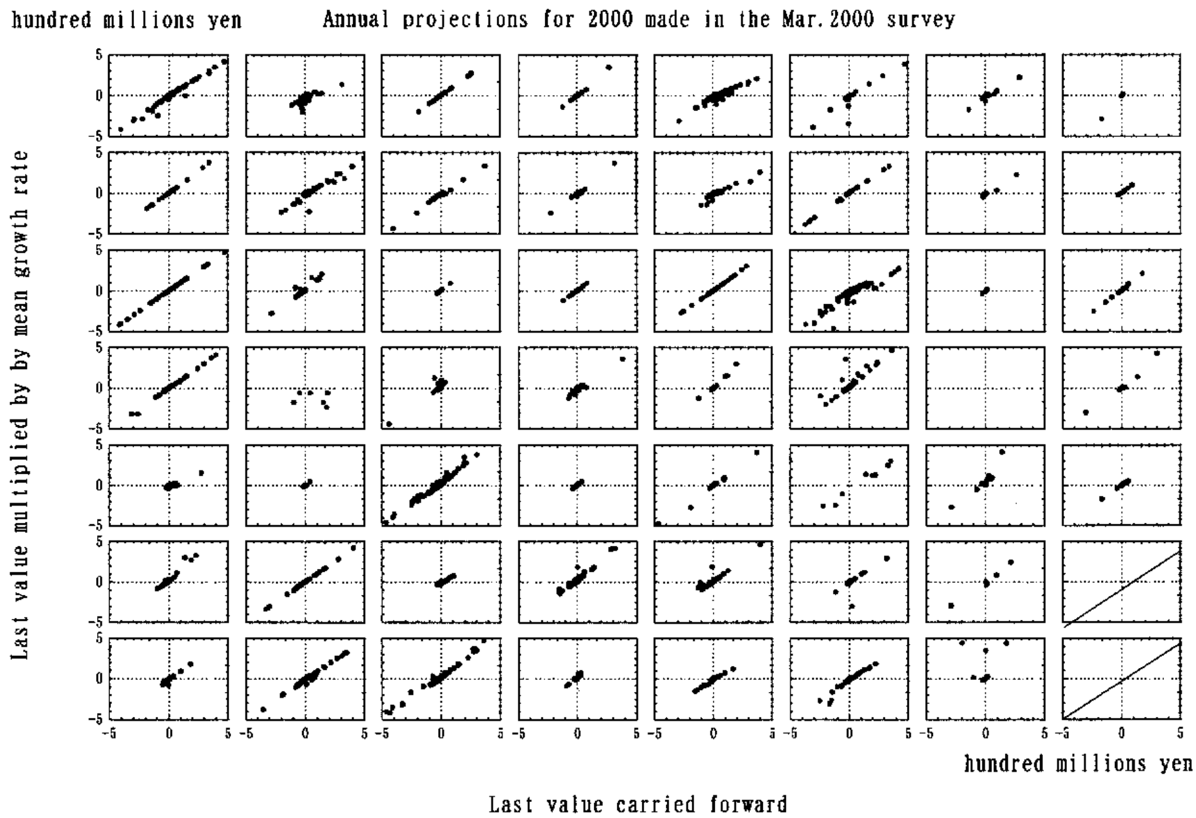
<Medium-sized enterprises>

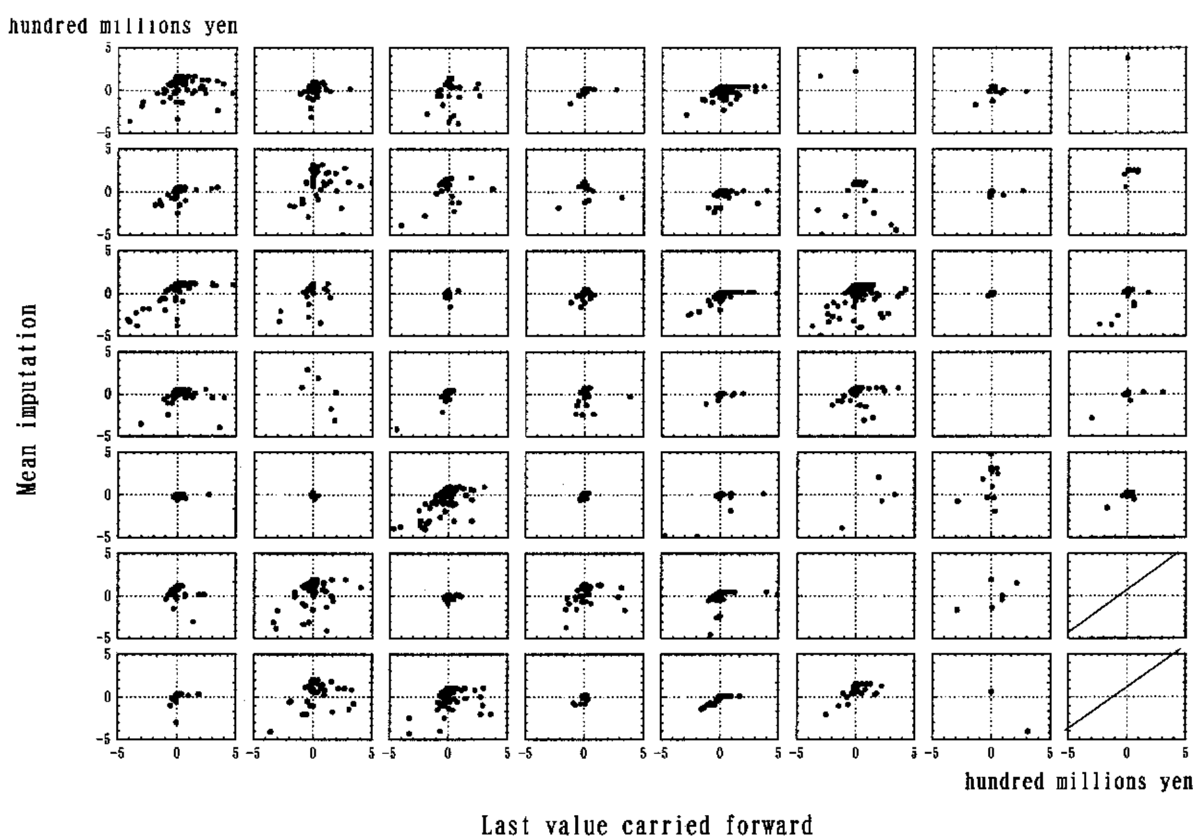




Notes:1. The scatter diagrams plot the differences between correct and estimated values for each enterprises in the simulation, grouped by stratum.
2. The axes plot differences, by imputation method.
3. Outliers are omitted.

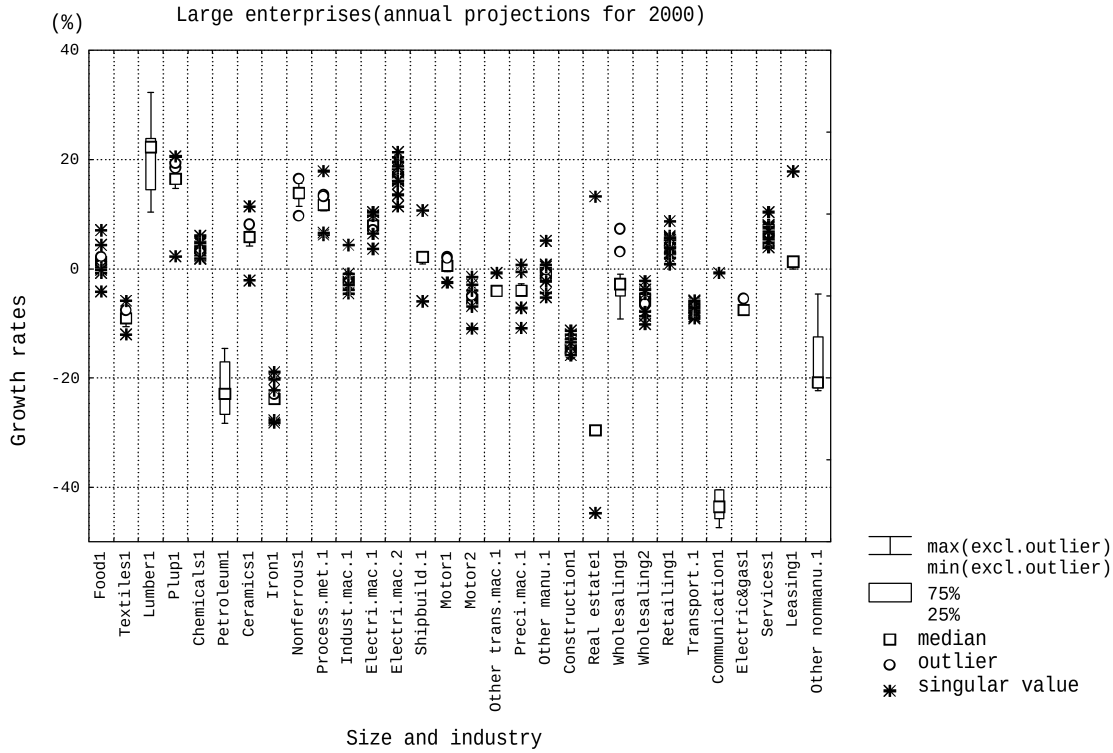
<Small enterprises>

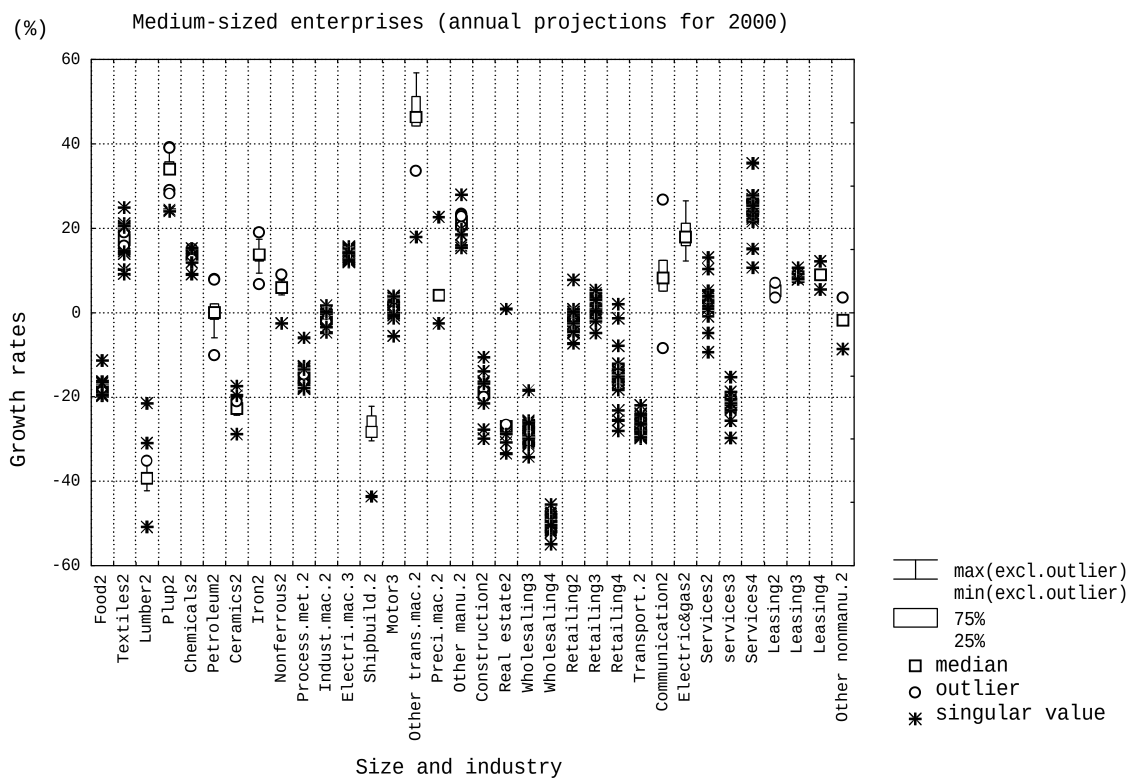




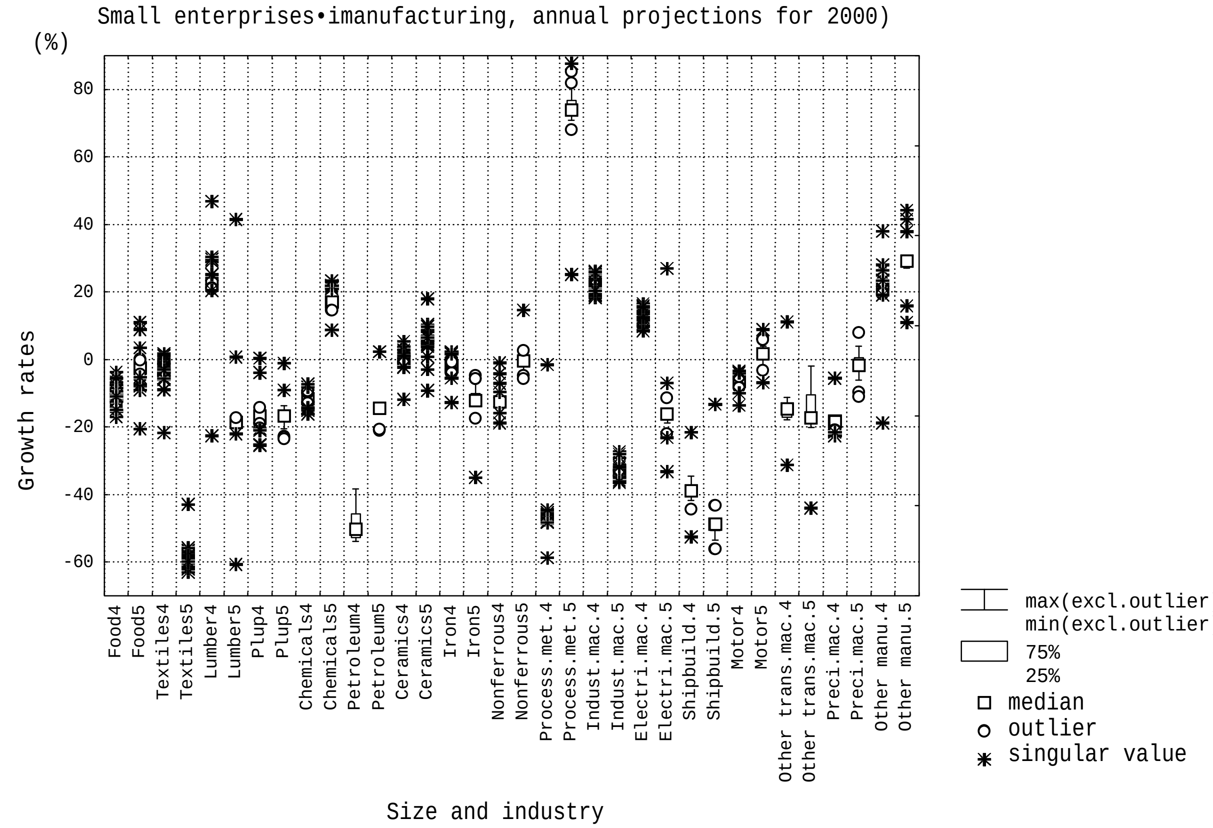
Notes:1. The scatter diagrams plot the differences between correct and estimated values for each enterprises in the simulation, grouped by stratum.
2. The axes plot differences, by imputation method.
3. Outliers are omitted.

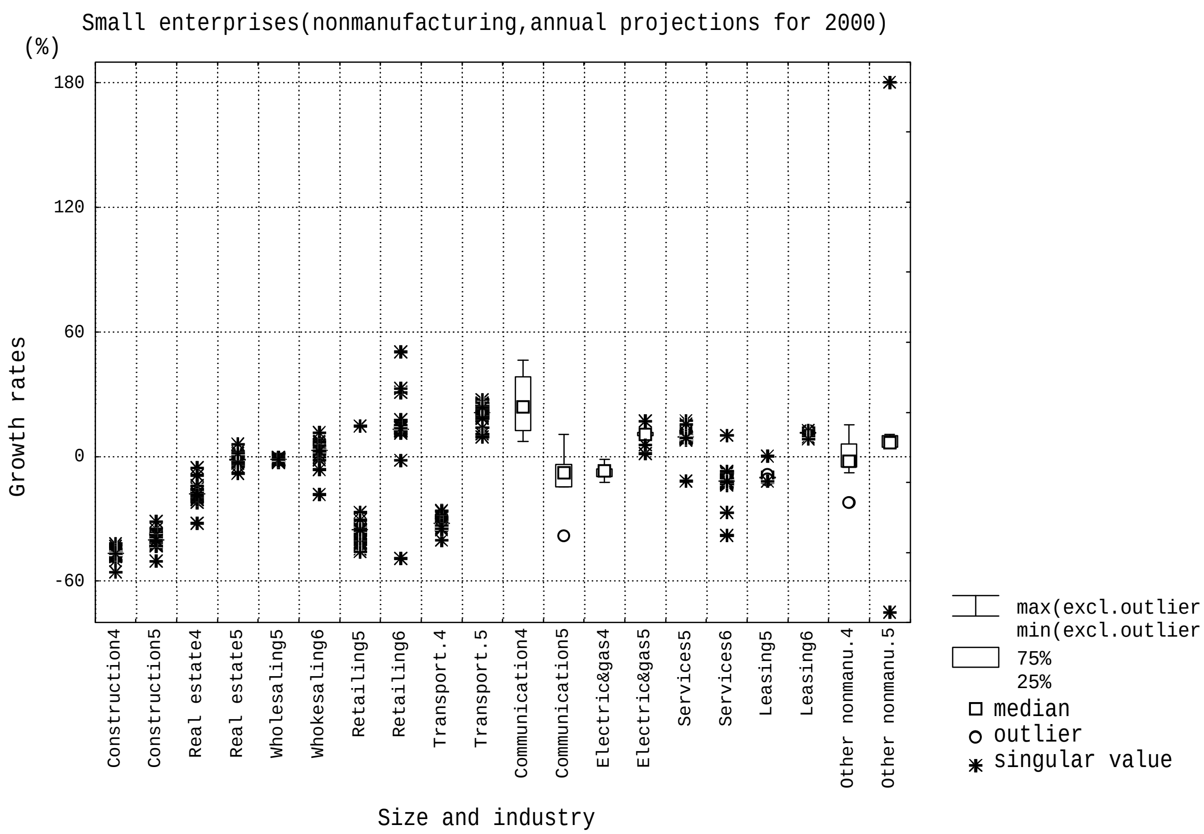
Figure 2: Growth Rates of respondents' values in simulation using experimental data (fixed Investments)





Notes: 1. Outlier: More than 75%point + 1.5 × (75%point - 25%point) or less than 25%point - 1.5 × (75%point - 25%point).
Singular value:More than 75%point + 3 × (75%point - 25%point) or less than 25%point – 3 × (75%point - 25%point).
2. Notation of industries on the horizontal axis is abridged, and the number added at the end indicates stratum. See table7 for more detail.



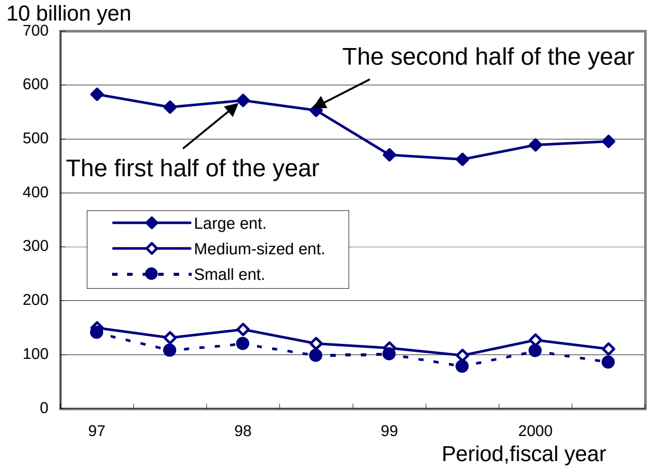


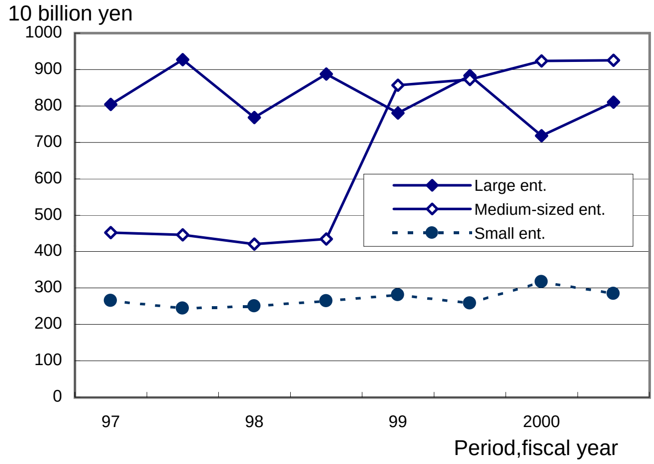
Notes: 1. Outlier: More than 75%point + 1.5 × (75%point - 25%point) or less than 25%point - 1.5 × (75%point - 25%point).
Singular value:More than 75%point + 3 × (75%point - 25%point) or less than 25%point - 3 × (75%point - 25%point).
2. Notation of industries on the horizontal axis is abridged, and the number added at the end indicates stratum.
See table7 for more detail.

Figure 3: Seasonality of semiannual data
(annual projections for next year made in the Mar.survey)

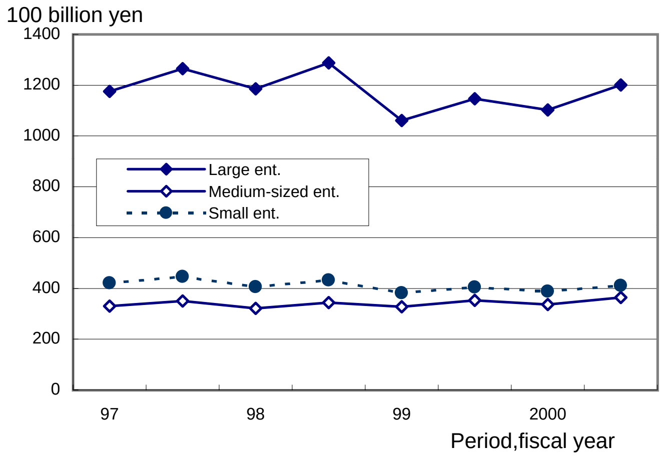
Manufacturing | Nonmanufacturing

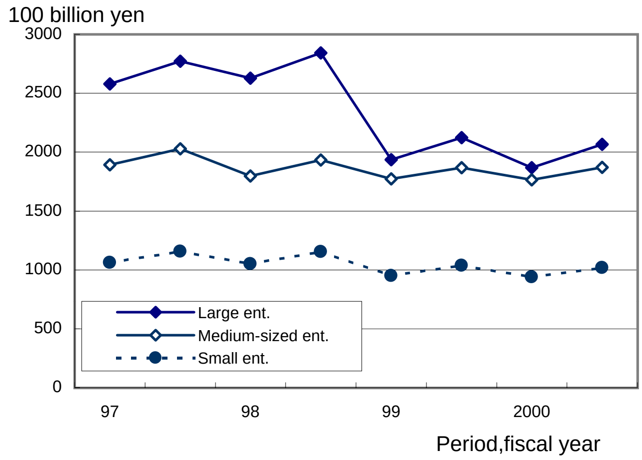
(1)Fixed investments



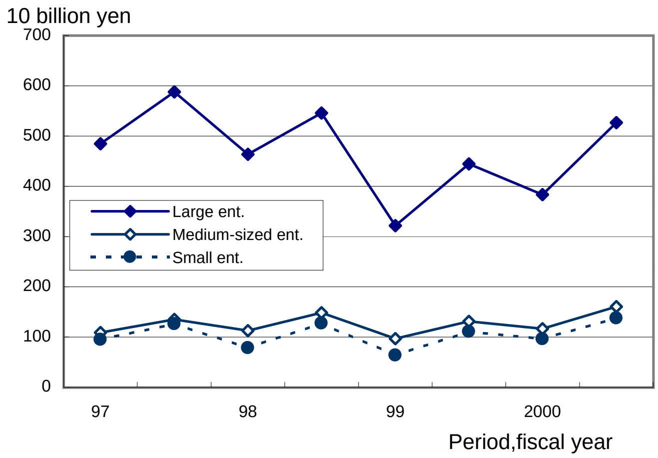


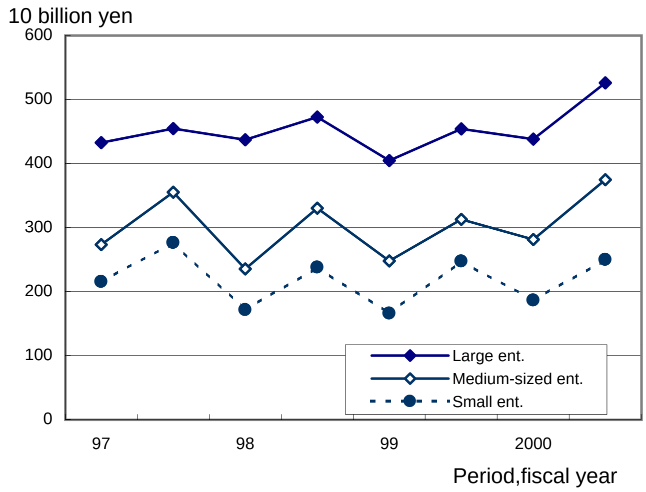
(2) Sales





(3) Current profits



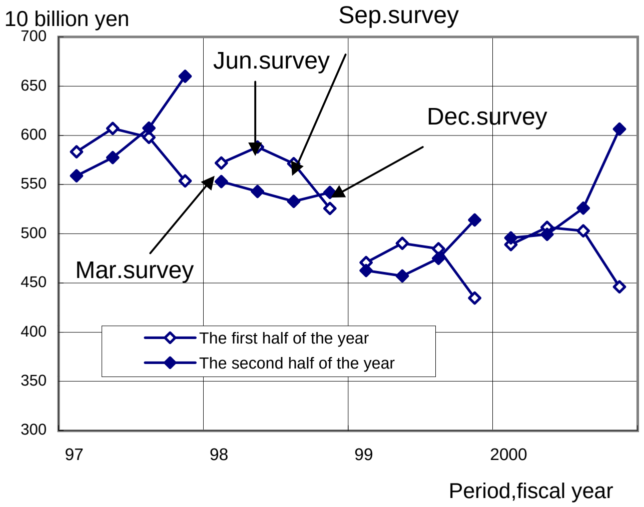


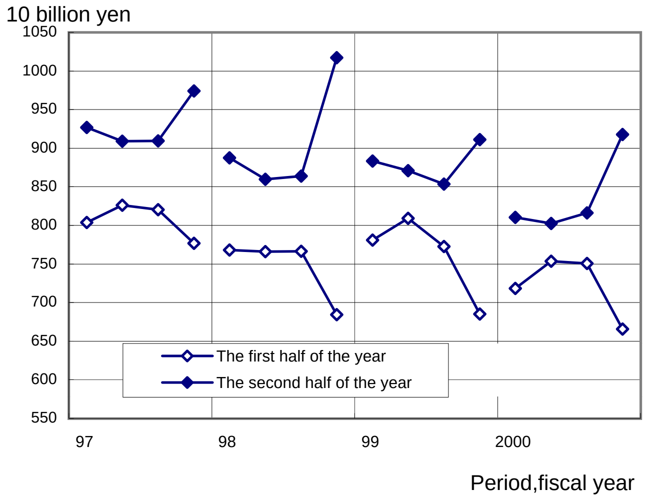
Note:The horizontal axis indicates survey item(fiscal year), and is plotted discretely for the first and second halves of the year, repeating in that order.

Figure 4: Revison of annual projections and forecasts: semiannual data (fixed investments)

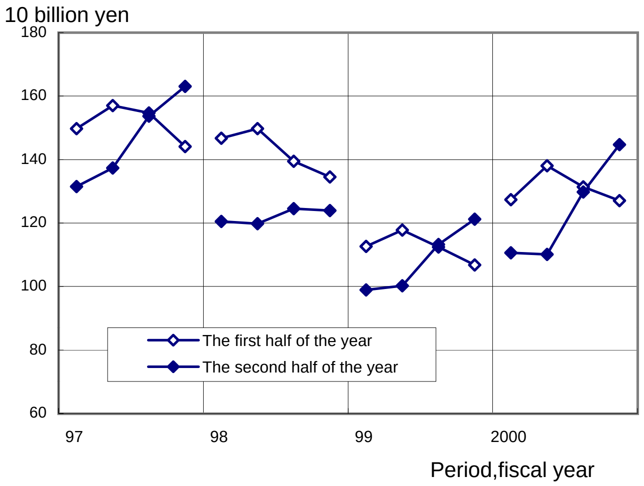
Manufacturing | Nonmanufacturing

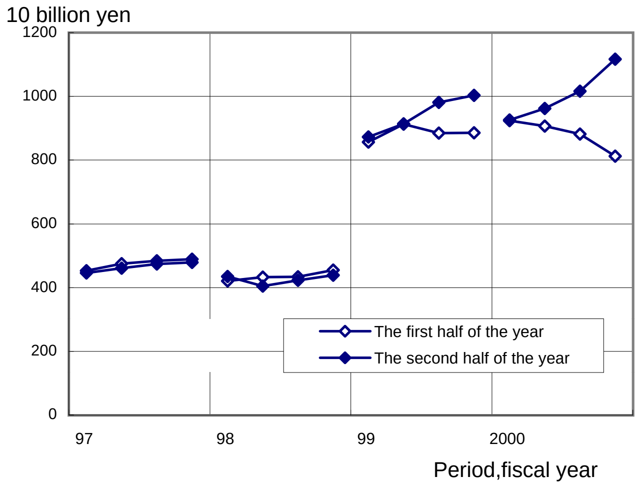
<Large enterprises>



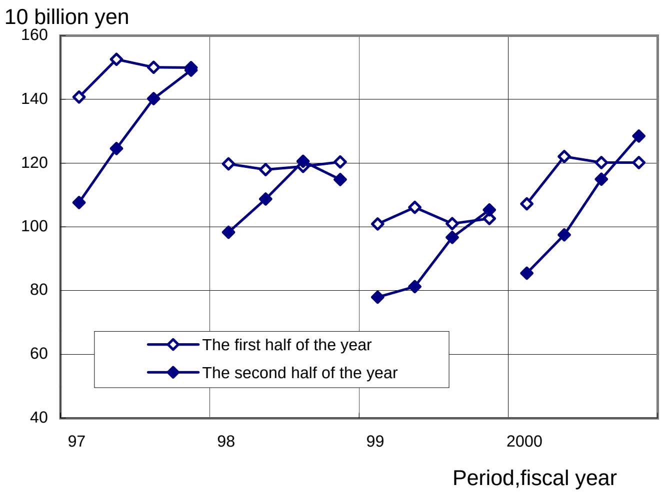


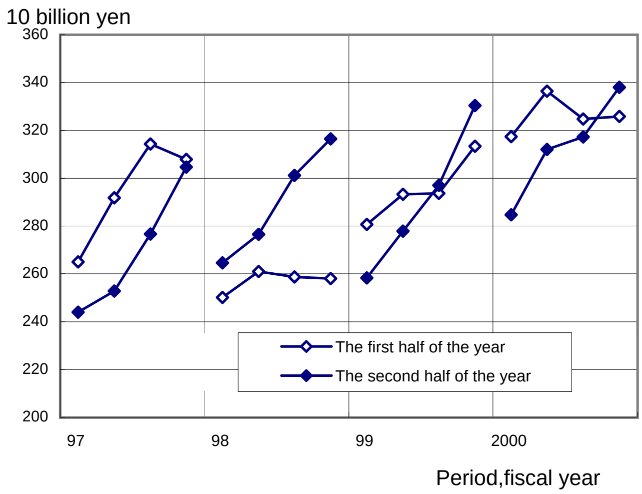
<Medium-sized enterprises>





<Small enterprises>





Note:The horizontal axis indicates survey item(fiscal year), and is plotted discretely for the Mar., Jun., Sep., and Dec. Surveys repeating in that order.