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Measurement Error Estimation Methods in Survey Methodology

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Abstract

One of the most important topics that are discussed in survey methodology is the accuracy of statistics or survey errors that may occur in the parameters estimation process. In statistical literature, these errors are grouped into two main categories: sampling errors and non-sampling errors. Measurement error is one of the most important non-sampling errors. Since estimating of measurement error is more complex than other types of survey errors, much more research has been done on ways of preventing or dealing with this error. The main problem associated with measurement error is the difficulty to measure or estimate this error in surveys. Various methods can be used for estimating measurement error in surveys, but the most appropriate method in each survey should be adopted according to the method of calculating statistics and the survey conditions. This paper considering some practical experiences in calculating and evaluating surveys results, intends to help statisticians to adopt an appropriate method for estimating measurement error. So to achieve this aim, after reviewing the concept and sources of measurement error, some methods of estimating the error are revised in this paper. Also, the advantages and disadvantages of measurement error estimation methods are discussed and some examples of estimating methods using surveys real data are shown in this paper. It should be noted that if estimating the measurement error with an acceptable accuracy is impossible in practice, it should be ensured based on statistical methods that this error does not have a large value or any increasing trend over time.

Keywords: Statistics; accuracy; measurement error; survey methodology; practical experience; estimation

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1. Introduction

One of the main issues that surveys are concerned with is how to monitor and improve the quality of statistics. For this purpose, the errors that occur during estimating process of statistics must be measured and controlled. These errors depend on the methods used for data collection. Data collection can be conducted by using three main types of survey methods: censuses, sample surveys, and administrative data. Each one of these methods is associated with errors peculiar to itself, but, in general, sources of errors can be grouped into two main categories: sampling errors and non-sampling errors. Sampling error is the difference between an unknown parameter of population and its estimate computed using data from a sample instead of the entire population. Non-sampling error encompasses all the various kinds of errors that may occur during data collection, data processing, and estimation. There are five major types of non-sampling errors: coverage error, frame error, response/non-response error, measurement error, and processing error [Baker (2011)]. Many researches have been done on the concepts and sources of these errors; for example, see the Survey Methodology [Groves et al. (2004)] or Non-sampling Error in Surveys [Lessler and Kalsbeek (1992)].

Measurement error is more complex than all the other types of non-sampling errors. Therefore, much more researches have been done on ways of preventing or dealing with this error. For example, Biemer (2010) proposed the experiment design approach for assessing the effect of various factors on measurement error and Baker (2011) examined the combination of micro data for estimating measurement error. Niny and Pencavel (2008) studied the effect of measurement error on income and welfare distribution indices in the Household Expenditure and Income Survey. Bound et al. (2000) reviewed the researches on measurement error in surveys, in a study plan. Kapteyn and Ypma (2006) assessed the effect of misclassification on measurement error and Alwin (2007) considered ways in which the extent of measurement errors can be detected and estimated in researches.

In this paper, we will discuss the ways of estimating measurement error according to each data collection method in surveys and give the most important advantages and disadvantages of each method. Some examples of estimating methods using real survey data are shown and some recommendations for estimating this error in practice are provided. For this purpose we first point to sources of measurement error in section 2 briefly. Then measurement error models that are widely used in estimating the error will be discussed in section 3. Finally estimation methods of measurement error and their advantages and disadvantages will be reviewed in sections 4 to 6. The conclusion of this paper will be given in Section 7.

2. Sources of Measurement Error

In order to estimate measurement error, the sources of this error must be identified. Groves et al. (2004) introduced four sources for measurement error: design, enumerators, respondents, and data processing. Biemer et al. (1991) added data collection modes (post, telephone or face to face interview) to the above sources.

It seems that these sources are related to censuses and sample surveys. Two other sources, namely, lack of consistency in statistical definitions and concepts, and delays in data recording should be added to the measurement error sources for administrative data.

2.1. Design

Many factors can lead to measurement error in questionnaire designing phase. The obscure questions of the questionnaire, inappropriate order of questions, lengthy questionnaires, and deficiency of instruction manuals are the most common factors that cause measurement errors in censuses and surveys. For example, the criteria for distinguishing between people having income without work from employees in Labor Force Survey, or calculation method of loans versus taxes in Household Expenditure and Income Survey (HEIS) may cause measurement errors in these surveys.

2.2. Enumerators

Enumerators play an important role in decreasing or increasing measurement errors. Appropriate explanation of questions, effective interaction with respondents, getting the necessary statistical training, following manuals, and commitment of enumerators greatly affect the measurement error.

2.3. Respondents

Respondents can affect the results of surveys to a considerable degree because the answers they give to questions are the main sources of data that are used for producing statistics. Statistical literacy of respondents, their confidence in the staff members of the executive organization or the statistical system, ensured protection of personal information, fear of revealing correct answers, memory fallibility, misunderstanding of survey concepts and many other similar factors are the issues related to respondents that cause measurement error in statistics.

2.4. Data Processing

Data entry is the main source of measurement error in surveys data processing. Of course, there are some other sources, such as erroneous coding, outliers editing, and non-response imputing, that may cause measurement error in surveys.

2.5. Definitions and Concepts for Administrative Data

Administrative data are produced by some organizations and government agencies activities according to certain rules, regulations and laws, and statistics is a by-product of these activities. Hence, in some cases, the definitions and concepts that are the legal bases of these statistics would not be statistical concepts. For example, in Labor Force Survey, for anyone who has more than one job, the job in which more hours are spent per week, or the job from which more income is derived, is considered as the main job, but, in business registers database, the main job is the one for which a business license has been issued. In the tax organization database, all the taxable jobs are considered as main jobs.

On the other hand, all data recorded in organizations and agencies are not of equal importance for registers administrators. For example, the number of workers of establishments is not of high importance in business databases and may not be completed in accordance with instructions; so, it is possible that an establishment with only one employee as a self-employed worker be recorded as an establishment with one worker in one place and with zero worker in another place in the same situation.

2.6. Delay in Data Recording

Registration activities in organizations and agencies are generally repetitious activities and so have a large volume; hence, data are not usually recorded simultaneously with ongoing events, or the recording process is such that simultaneous registration is impossible. For example, there is a legal deadline as an acceptable delay for registering any new birth or death that affects the population statistics.

Obviously, the above sources have different effects on measurement error of statistics, depending on the type of surveys. For example, the errors formed by delay in recording do not apply to censuses or sample surveys, while the errors made by enumerators or respondents do not apply to, or may be ignorable in administrative data. Of course, the effects of the above sources on censuses are different from sample surveys. For example, publicity and describing how to answer the questions are very effective in reducing incorrect responses in censuses while the problems caused by training too many enumerators for census enumeration, or employing non-professional enumerators, may increase the measurement error.

3. Measurement Error Models

Suppose y_i is the observed (or recorded) value of the attribute of interest Y for i^{th} unit and μ_i is the true value of Y for this unit. Then,

$$y_i = \mu_i + \varepsilon_i, \tag{1}$$

where ε_i is the error of measuring Y for the i^{th} unit. If ε is independent from μ, then the measurement error is considered a classical measurement error. Of course, the independence of $\varepsilon_i s$ is a necessary condition that usually holds true in surveys.

There are some examples of classical measurement error in surveys. For instance, consider the error of measuring literacy level in a sample survey, which could be independent from the true values of this attribute. There are some other examples of this type of errors in surveys, such as memory recall error in reporting age, the year of construction of a building in censuses, or errors made by a delay in registering births or deaths in vital statistics. Although there are some examples of this type of errors, in most cases the measurement error is correlated to the true value of the attribute of interest. For example, low-income households often give more accurate responses to questions on income in HEIS. Gottschalk and Huynh (2006) showed that measurement error of income has a positive correlation with the true value of household income.

If $E(\varepsilon) = B \neq 0$, then $E(\bar{y}) = \mu + B$ we can rewrite the measurement error model as:

$$y_i = \mu_i + e_i + B, \tag{2}$$

where $e_i = \varepsilon_i - B$ and $E(e_i) = 0$, $\text{Var}(e_i) = \sigma_e^2$ and $\text{Var}(\mu_i) = \sigma_\mu^2$. Given the independence of $e_i s$, we have

$$MSE(\bar{y}) = B^2 + \frac{\sigma_\mu^2 + \sigma_e^2}{n} = B^2 + \frac{1}{R} \times \frac{\sigma_\mu^2}{n}, \tag{3}$$

where $R = \frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_e^2}$ is named as Reliability Ratio by Fuller (1987). This ratio not only affects the measurement error but also reflects all sources of random errors.

Now, if there is an interest to compute the enumerator's effect, the measurement error model could be considered as:

$$y_{ij} = \mu_{ij} + B + b_i + e_{ij}, \tag{4}$$

where y_{ij} is the value of the attribute of interest observed by the i^{th} enumerator for j^{th} unit. Similar to the previous model, we have

$$e_{ij} = \varepsilon_{ij} - B - b_i\ , \quad E(e_{ij}) = E(b_i) = 0, Var(e_{ij}) = \sigma_e^2, \quad Var(b_i) = \sigma_b^2. \tag{5}$$

Given the independence of $e_{ij} s$, we have

$$MSE(\bar{y}) = B^2 + \frac{\sigma_\mu^2 + \sigma_e^2}{n} + \frac{\sigma_b^2}{I}, \tag{6}$$

where I is the number of enumerators and σ_b^2 / I shows the effect of enumerators on the $MSE(\bar{y})$. The reliability ratio is obtained from the following relation,

$$R = \frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_b^2 + \sigma_e^2}, \tag{7}$$

which is a decreasing function of σ_b^2. Biemer et al. (1991) proposed the inter correlation coefficient as:

$$\rho_{int} = \frac{\sigma_b^2}{\sigma_\mu^2 + \sigma_b^2 + \sigma_e^2}. \tag{8}$$

This coefficient measures the correlation between responses of each pair of units gathered by the same enumerator. Of course this could be considered as the ratio of enumerator variance to total variance. Biemer and Lyberg (2003) estimated this coefficient for the US Current Population Survey (CPS) between 0.01 and 0.05.

The $MSE(\bar{y})$ can be rewritten as a function of inter correlation coefficient as:

$$MSE(\bar{y}) = B^2 + \frac{\sigma_\mu^2}{nR}(1 + (m-1)\rho_{int}) , \quad (9)$$

where m is the average number of questionnaires completed by each enumerator. The above relation shows that increasing the $(m-1)\rho_{int}$ leads to the increase of the variance of $\bar{y}$ and design effect as well as the increase of the sample size in repeated sample surveys. The presence of measurement errors causes biased and inconsistent parameter estimates and leads to erroneous conclusions to various degrees in analyses.

Techniques for addressing measurement error problems can be classified along two dimensions. Different techniques are employed in linear errors-in-variables models and in nonlinear models that are nonlinear in the mismeasured variables [Chen et al. (2007)]. Most of the articles that discuss the measurement error of variables focus on linear measurement error models. However, there are some other articles that discuss nonlinear models. For example Chen et al. (2011) provide an overview of recent research papers that derive estimation methods, and provide consistent estimates for nonlinear models with measurement errors.

Measurement error models presented in econometrics and statistical textbooks typically make strong and exceedingly convenient assumptions about the properties of error [Fuller (1987)]. Most frequently, measurement error in a given variable is assumed to be uncorrelated with the true level of that and all other variables in the model, measurement error in other variables, and the stochastic disturbance [e.g., Kmenta (1986); Pindyck and Rubinfeld (1981)]. From these assumptions comes the most elementary version of conventional wisdom about the effects of measurement error on estimates of cross-sectional models [Bound et al. (1989)]:

1) error in dependent variable neither biases nor renders inconsistent the parameter estimates but simply reduces the efficiency of those estimates; and
2) error in the measurement of independent variables produces downward-biased and inconsistent parameter estimates, with the extent of bias and inconsistency dependent upon the extent of the error.

4. Estimation Methods of Measurement Error

The measurement error of statistics can be estimated using some various methods. Adapting appropriate method in practice depends on survey method, facilities and limitations. Although modeling the measurement error is one of the most popular methods for better recognition of this error, we can also estimate measurement error with other methods summarized as follows:

1. comparison with administrative data,
2. checking the internal consistency,
3. comparison with previous surveys (for repeated surveys),
4. comparison with external sources (other surveys),
5. conducting a special sample survey for estimating measurement error,
6. repeating a part of a survey, and
7. considering comments of enumerators.

4.1. Comparison with administrative data

A comparison of survey data with administrative data is made in two ways: comparison at micro (record) level and macro (result) level. For example, the households with cars in the population and housing census database can be compared with police database. The number of households with cars in police database that have announced 'don't have any car' in the census provides a benchmark for estimating the measurement error. On the other hand, the number of households with cars in the census database that 'don't have any car' in police database provides a benchmark for estimating the measurement error in police database. Further investigations show that the latter error is caused due to the failure of recording some transactions in the police database.

As an example of comparison at macro level, the number of persons under 10 years of age in the Population and Housing Census must be consistent with the number of births registered over the past 10 years in the National Organization for Civil Registration (NOCR). If these two numbers, taking into account the number of deaths and migrations, are consistent, the census data is verified. The larger number in the census shows a possible error in birth registration and the larger number in NOCR data shows an under-coverage error in the census.

Bollinger (1998) linked the American CPS and Social Security Organization data. He found that only 11.7% of male heads of households and 12.7 % of female heads of households declared their real income and 53.9 % of male heads of households and 56.2 % of female heads of households declared their income within a ± 5 % range of their real income. The main restriction of this method lies in the availability of administrative data that correspond to survey data.

4.2. Checking the internal consistency

Based on the relationship between variables of survey data or administrative data, some criteria can be determined for estimating the measurement error. For example, income under-reporting can be estimated in comparison with household expenditures in HEIS. Checking the number of ages that are multiples of 5 in population censuses, the number of unskilled workers having academic degrees, the number of illiterate men and women, and comparing unemployment rates in rural and urban areas are some other examples of this approach.

In some surveys, control questions are considered for estimating or controlling measurement error. For example, in South Korean Household Income and Expenditure Survey, a 5-level question is asked from the head of household and his/her spouse about their satisfaction with household income. Moreover, some model-based methods use the internal consistency of data. For example, household income measurement error may be estimated by household expenditures using a certain model. Assuming that the measurement error of expenditure is ignorable, a positive relation between household income and non-food expenditures can be considered as follows:

$$\ln(y_i) = \beta(H_i) + e_i \,, \tag{10}$$

where y_i is the real income of i^{th} household, H_i is the non-food expenditures of i^{th} household and e_i is a random error. The Iranian HEIS data for 2008 to 2010 surveys show that there is a relatively strong positive correlation between households' declared income and non-food expenditures. Relying on this fact, a regression model was fitted to HEIS data. The results obtained from using the ordinary least square (OLS) method are illustrated in the table below.

Using this method, household income was adjusted according to non-food expenditures and the following results were obtained for urban and rural areas:

Table 1. Estimates of model parameters

Area	Estimate	Year		
		2008	2009	2010
Rural	$\hat{\beta}$	1.0401	1.0392	1.0388
	R^2	0.9994	0.9994	0.9994
Urban	$\hat{\beta}$	1.0226	1.0232	1.0232
	R^2	0.9997	0.9997	0.9997

Table 2. Results of adjusting income for households in urban areas (in thousand Rials)

Estimate	Year		
	2008	2009	2010
Mean of annual declared income	88,219	93,603	106,156
Mean of annual adjusted income	98,483	103,673	123,135
Measurement Error (average)	10,264	10,070	16,979
Measurement Error (percent)	10	10	14

Table 3. Results of adjusting income for households in rural areas (in thousand Rials)

Estimate	Year		
	2008	2009	2010
Mean of annual declared income	48,424	52,438	59,337
Mean of annual adjusted income	54,437	68,409	73,870
Measurement Error (average)	6,013	15,971	14,533
Measurement Error (percent)	11	23	20

The percent of measurement error for each year is higher in rural areas than in urban areas. The main reason lies in the nature of income from agricultural activities that are often calculated according to agricultural years. The difference between agricultural and calendar years may cause some problems in calculating household annual income at the time of enumeration.

Shlomo (2010) examined the regression models with errors in dependent and independent variables. Lee (2008) reviewed the results of South Korean Labor and Income Panel Study. He estimated the measurement error of this study using a regression model with variables of household size, proportion of elderly people in household, level of education, sex and age of head of household and whether or not the household head lives in Seoul. He confirmed that employees hide their income less than others.

Figari et al. (2010) computed some inequality indicators such as the Gini coefficient in Austria, Italy, Spain and Hungary using two approaches (1) OECD equivalent scale and (2) income reconstruction approach from taxable income and insurances. They assumed measurement error exist for all income measuring sources in their works including administrative data, tax reports, edited survey data and survey reported data. This means that errors in two approaches are likely to affect results. The results for Gini coefficient are presented in the following table.

Table 4. Estimate of Gini coefficient for selected countries

Approach	Austria	Italy	Spain	Hungary
OECD approach	0.258	0.327	0.324	0.257
Income reconstruction approach	0.239	0.318	0.305	0.265

Gini coefficient obtained from the income reconstruction approach is lower for all the four countries, but the order of countries is the same in both approaches.

4.3. Comparison with previous surveys

Surveys that are conducted for producing statistics are usually repeated in specific time periods. Available data for previous periods can be useful for estimating the measurement errors of these surveys. For example, in manufacturing establishment surveys that are conducted annually, value added of an establishment can be compared with its value added in the last year in terms of quantity and structure. This method has many applications in panel or rotation surveys. Absence of data for new survey enumeration units and the lack of possibility to correspond data from previous surveys to new survey units may lead to some problems in this method as well.

4.4. Comparison with external sources

External sources here refer to all information sources other than administrative data. For example, a comparison of the unemployment rate obtained from the Census of Population and Housing with the same rate obtained from the Labor Force Survey (LFS) is useful for estimating the measurement error of the census. This comparison is made on the basis of the assumption that LFS results are more accurate than population census results for labor statistics. It is because of employing professional enumerators and asking more related questions in the former that lead to better identification of employed and unemployed persons.

In order to study the measurement error of income, Olson and Maser (2010) compared the aggregate income estimates that were published by Statistics Canada based on information on personal income for 2005, derived from four major sources:

1. Survey of Labor and Income Dynamics (SLID), which is a panel survey;
2. Annual Estimates for Census Families and Individuals (T1FF) and the Longitudinal Administrative Data (LAD);
3. Census of Population (questions on income were asked from 20 percent of households); and
4. System of National Accounts (SNA).

Some estimates obtained from these sources are illustrated in the table below.

Table 5. Income estimates from four major sources in Statistics Canada

Estimate (in million dollars)	Source			
	SLID	T1FF	Census	SNA
Aggregate employment income	640,580	635,274	658,064	656,025
Aggregate total income	844,406	847,982	864,163	-

Mantovani and Nienadowska (2007) compared incomes revealed by the Bank of Italy's income budget survey (SHIW) with those incomes declared to the tax authorities. They showed that the average income under-reporting of Italian households is 12 %. Flevotmou (2009) obtained income under-reporting rate of 10% for Hungary, where 24 percent of the employed population are own-account workers and 53 percent are farmers. It should be noted that the tax rate is 21 percent for Italy and 19 percent for Hungary. Hence, the measurement error is less than the tax rate and so, this error could not be related to taxes not being taken into account in household income.

Dixon (2010) linked data from three surveys of the USA, the Consumer Expenditure Quarterly Interview Survey (CEQ), the National Health Interview Survey (NHIS) and the Current Population Survey (CPS), and proposed a criterion for the measurement error of employment rate. Matching in his study was done based on demographic information (family size and age), and households contact information. Dixon (2010) used the differences in estimates between the surveys as an indicator of measurement error. The following table shows the estimates of employment rate for the three different surveys.

Table 6. Employment rate estimates obtained from the three different surveys of the USA

Employment Rate	CE	NHIS	CPS
Without adjustment	0.7453	0.7447	0.7394
CE adjusted rate	0.7453	0.8616	0.8055
NHIS adjusted rate	0.7008	0.7447	0.7474
CPS adjusted rate	0.6502	0.6078	0.7394

The first row of this table includes employment rate estimates from the surveys. The second row shows the estimates of employment rate for CE survey based on data adjusted by the other two surveys. The same procedure is repeated for the third and fourth rows. The results showed the CPS and NHIS have the most difference.

4.5. Conducting an especial sample survey for estimating measurement error

The most common survey of this type is the Post-Enumeration Survey (PES) which is often conducted after each census by choosing a sample of population, enumerating units more accurately, and measuring their characteristics again. The Post Enumeration Survey is conducted mainly to determine how many units of population were missed or counted more than once during the main enumeration. The net undercount that can be estimated by using PES data is the difference between the number of units who were counted in the census and the number of units who should have been counted. Measurement error of some quantitative variables in the census can also be estimated by PES data.

In addition, the accuracy of administrative data for items that are not rare attributes can be estimated by conducting a special survey. Although this method gives acceptable results in most cases, it is not applicable to all surveys in practice.

4.6. Repeating a part of a survey

In some surveys, it may be possible to select a subset of sampling units to be surveyed again by more skilled enumerators. Thus, measurement error can be estimated by comparing the two sets of data. High costs and sensitivity to the time interval between the first and the second survey are the major drawbacks of using this method. Notice that this estimation method is similar to the previous method with the exception that this method is applied for sampling surveys instead of censuses or administrative data.

4.7. Considering comments of enumerators

In this relatively innovative method, some questions are included in questionnaires which make the assessment of the quality of responses possible for enumerators. An estimate of measurement error is obtained by comparing the high quality responses with other responses. For an example, Neri and Zizza (2010) analyzed respondents behavior in reporting their income sources in sample surveys. They used a variable representing the interviewers assessment of respondent level of understanding of the questions in their analysis. Neri and Zizza (2010) used this method for Italian Survey of Household Income and Wealth data and estimated the measurement error of 36% for declared income of self-employed respondents. Obviously, this method is highly influenced by the impacts of enumerators on respondents.

5. A case study

In this section, we briefly give an example of evaluating the measurement error of income in Household Income and Expenditure Survey (HIES) of Iran in 2011-2012. Household Income and Expenditure Survey of Iran is a sample survey that has been implemented annually from about 50 years ago. The main purpose of this survey is the estimation of annual average of household income and expenditure in urban and rural areas of the country.

The Iranian HIES has been taken in rural areas since 1963, and in urban areas as of 1968. The survey was carried out by a sample of 18727 households in urban areas and 19786 households in rural areas in 2011-2012. In order to increase the representativeness of the samples, they are distributed between the months of the year.

The HIES target population is all private and collective settled households in the urban and rural areas. In order to select sample households, a stratified three-staged sampling method is used in the survey. At the first stage, the census areas are classified and selected. At the second stage, the urban and rural blocks are selected and the selection of sample households is done at the third stage. The number of samples is optimized to estimate average annual income and expenditure of households based on the purpose of the survey. Sampling weights are calculated, adjusted for non-responding and calibrated to estimate the total number of target population households.

In this section we endeavor to estimate households' income measurement error in 2011-2012 HIES of Iran. In order to do this, using a linear regression model, as $\ln(y) = \beta(X) + \epsilon$ the expected household income in 2011-2012 HIES is estimated based on location information, facilities and major appliances, characteristics of household members, and some other variables correlated with household income. Then, taking into account the difference between the expected income (estimated from the model) and the household declared income (stated in the survey) as household income measurement error, the household income is adjusted for the impact of these errors. The variables of regression model and their mean values, parameter estimates with standard errors are shown in the table below. Fitting regression model was accomplished using the sampling weights that reflect the sampling design features in the model.

The results of estimating the parameters of interest for urban and rural areas in 2011-2012 HIES are shown in Table 8 in thousands Rials. As indicated by this table, the mean of adjusted income (in thousand Rials) is more than the mean of household income in both urban and rural areas of the country. This shows that there is some measurement error in gathering income values in Household Income and Expenditure Survey.

Table 7. Regression model variables and parameters estimates

Variable Label	Description	Parameter Estimate	Standard Error	Mean/ Percentage
I	Intercept	1.16356	0.11086	-
C	Household size	-0.21204	0.00242	3.8
P	Portion of household expenditure allocated to non-food items	0.08309	0.02515	0.7
S	Proportion of household income to expenditure	0.71758	0.00534	1.3
B	Per capita floor area	0.00334	0.00016	30.0
A	Education level of head of household	0.00594	0.00114	4.3
R	Indicator variable of rental housing units	-0.03762	0.00859	0.1
L	Natural Logarithm of given loan value	0.01993	0.00328	15.7
N	Natural logarithm of household total expenditure	0.84330	0.00616	18.4

Table 8. Results of adjusting income for households in urban and rural areas for 2011-2012 (in thousand Rials)

Area	Sample size	Mean of Income	Mean of expected Income
Urban	18716	130328	163311
Rural	19757	79869	101705

6. Advantages and Disadvantages of Estimation Methods

Measurement error estimation methods described in section 4 have some advantages and disadvantages, which are summarized in this section.

6.1. Comparison with administrative data

The most important advantages of this method are:

- The cost of this comparison is very low because there is no need for data collection.
- Results of this method are more accurate because data are mainly recorded and controlled according to formal rules and regulations.

Disadvantages of this method are:

- In most cases, administrative data are different from data needed to be compared with them. For example, tax data usually do not include tax-exempt cases.
- In some cases, statistical reference period is different from administrative data reference time. For example, the financial statements are not to be finalized until July of the next year in Iran.
- Quality of administrative data is not the same for all characteristics. For example, the national identity number is recorded accurately in the registration system, but in the case of postal codes, answers given by respondents may suffice.
- For many of the characteristics included in surveys, corresponding data are not available from administrative data. For example, the number of hours that people spend on reading during a day that is asked in Time Use Survey is never recorded.
- In some cases, the definitions and concepts of administrative data are different from those of the survey data. For example, an unemployed person is not considered as unemployed in administrative data as long as he/she has not applied for a job at an employment agency.

6.2. Checking the internal consistency

The most important advantages of this method are:

- The cost of this method is also very low.
- Data collection requirements are the same for all statistical units.
- It can be combined with other methods of estimating measurement error.
- The shares of all factors contributing to the occurrence of measurement error can be estimated.
- This method allows for including control questions and analyzing the results.

Disadvantages of this method are:

- Some problems may occur in estimating the measurement error when measurements of different characteristics are erroneous. For example, if the household expenditure data are affected by a relatively high rate of measurement error, comparing or modeling the household income on the basis of expenditure data would be difficult.

- When some surveyed characteristics are not relevant with other characteristics included in the survey, it is impossible to obtain a model for the assessment of their measurement error.
- Different results may be obtained by selecting different models and methods as well as expert opinions.

6.3. Comparison with previous surveys (for repeated surveys)

The most important advantages of this method are:

- This method is also low-cost.
- The possibility of studying long-term trends can be reassuring.
- This method can be used for longitudinal panel or rotation surveys, where all or part of the sampling units remain in the sample over time. This provides the possibility for comparing the survey data with data from previous surveys.

Disadvantages of this method are:

- If conditions affecting the survey results change from one period to another, the possibility of comparing survey results may be wiped out.
- In the presence of measurement error in surveys, determining which survey period has been affected by more errors is not always possible.
- Lack of experience creates some problems in using this method for newly designed surveys.

6.4. Comparison with external sources (other surveys)

The most important advantages of this method are:

- The cost is relatively low.
- Several surveys can be used as sources of comparison. For example, the estimated number of unemployed persons in the Labor Force Survey can be compared with the corresponding estimates from Household Expenditure and Income Survey, Time Use Survey, Salary and Wage Survey, the censuses results and even the trends of the mentioned surveys.

Disadvantages of this method are:

- Differences between conditions prevailing during the implementation of surveys may lead to some incompatibility.
- Definitions and concepts used in different surveys may differ.
- To provide appropriate conditions for comparison, it should be assumed that the measurement error of the survey considered more accurate is close to zero. This assumption is not always valid.

6.5. Conducting a special sample survey for estimating measurement error

The most important advantages of this method are:

- Measurement error estimation with acceptable accuracy is possible.

- Definitions and concepts of special sample survey match perfectly with those of the original survey.
- Measurement error estimation by various factors such as enumerators, respondents and design is possible.

Disadvantages of this method are:
- Some conditions may change during the time interval between the original survey and the survey conducted for measurement error estimation. For example, some features of population for variable of interest may be changed.
- The cost of using this method is very high in comparison with previous methods.
- In some cases, the answers given by respondents in the original survey may affect their responses in the second survey. For example, if a respondent under-reported his/her income in the original survey, he/she may intend to under-report it in the second survey as well.

6.6. Repeating a part of a survey

The most important advantages of this method are:
- Measurement error estimation with acceptable accuracy for key attributes of survey is possible.
- Definitions and concepts match perfectly with the original survey.
- Measurement error estimation by various factors is possible.
- Conditions of the original and repeated surveys are almost the same.

Disadvantages of this method are:
- The cost of using this method is high.
- Call-back to respondents may increase the respondent burden.
- Studies have indicated that refusal rate is increased in repeated surveys.
- It should be assumed that the measurement error is close to zero in the second survey, but it is not always possible to provide necessary conditions for such an ideal achievement.
- The answers given by respondents in the original survey may affect their responses in the second survey.

6.7. Considering comments of enumerators

The most important advantages of this method are:
- The cost of using this method is less than other methods.
- Measurement error estimation by various factors is possible.
- Comments of well-trained enumerators with sufficient experience are very useful.

Disadvantages of this method are:
- Comments of rather inefficient enumerators can create certain problems.
- It is not always possible for enumerators to provide reasonable comments. For example, the enumerators can comment on the level of a household’s income based on the

residence of the household and give a relatively acceptable judgment, but they cannot judge the answers to such questions as the main activity of the workplace of employed respondents.

- How the respondents interact with enumerator affects the comments of enumerator.

7. Conclusions

Measurement error is one of the most important non-sampling errors that may occur from various sources: design, enumerators, respondents, data processing, lack of consistency in statistical definitions and concepts, and delays in data recording. The first four sources are related to censuses and sample surveys and others are related to administrative data. Estimation of measurement error can be done by various methods in survey methodology. We summarized the most important measurement error estimation methods in 7 categories (excluding modeling the error) that some of them are used only for especial data collection methods (census, sample survey, and administrative data). These estimating methods could not be assigned to sources of measurement error in all cases, and most of the methods could be used for estimating measurement error regardless of its source. So in practice, the most appropriate method should be adopted according to the method of estimating statistics and considering advantages and disadvantages of methods that are discussed in the paper for each case separately. Among these methods, comparison with administrative data, checking the internal consistency, comparison with previous surveys, comparison with external sources and considering comments of enumerators need to cost less than others.

The exact estimation of measurement error is obtainable only if the true value of variable of interest is available for all units in the survey, which will never be achieved in practice. So if estimating the measurement error with an acceptable accuracy is impossible, it must be ensured that this error is an approximately fixed value in repeated implementation of surveys or reporting on the basis of administrative data, or, at least, it should be ensured that this error does not have any increasing trend over time (especially for repeated surveys). In such situations modeling of measurement error can be used for better recognition of this error in practice. Estimating measurement error in surveys enhances the confidence level of planners and researchers and, in the meantime, allows statisticians to evaluate and improve the quality of statistics. For this reason, despite extensive research that has been done in this area, it can be said that estimating, and releasing information on measurement error is still one of the complex issues in national statistical systems.

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