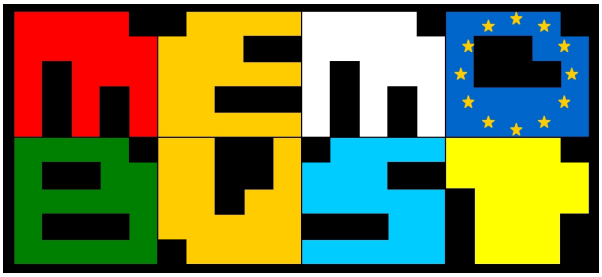

This module is part of the

Memobust Handbook

on Methodology of Modern Business Statistics

26 March 2014

Theme: Quality of Statistics

Contents

General section

1. Summary

Quality may be defined as "the degree to which a set of characteristics fulfils requirements" using the much cited ISO standard 9000 (2005). This is valid also for quality of statistical output. The European Statistical System (Eurostat, 2011, principles 11-15; EU, 2009a) uses nine major quality characteristics of statistical output: *relevance*, *accuracy and reliability, timeliness and punctuality, coherence and comparability, accessibility and clarity.*

Accuracy is generally considered to be a key measure of quality. Total survey error is a conceptual framework describing errors that can occur in a sample survey and the error properties. It may be used as a tool in the design of the survey, working with accuracy, other quality characteristics, and costs. Accuracy is often measured by the mean squared error (MSE) of the estimator. Error sources are considered one by one to estimate the uncertainty and also to obtain some indication of the importance of that source. The errors arise from: sampling, frame coverage, measurement, non-response, data processing, and model assumptions.

Even if statistics are accurate, they cannot be considered as of good quality if, for instance, they are outdated or cannot be easily accessed or there is conflict with other statistics. The quality may be viewed as a multi-faceted concept. Although a major objective of the survey design may be to somehow 'optimise' the accuracy, additional quality criteria such as relevance, timeliness, comparability and coherence, and accessibility and clarity are critical to a survey's quality. There needs to be a balance in line with, for instance, regulations and user needs.

2. General description

There is a lot of literature on quality. Here the emphasis is on quality of the statistical output in the European Statistical System. Some useful references are *ESS Handbook for Quality Reports* (Eurostat, 2009b and 2013c), *European Statistics Code of Practice* (Eurostat, 2011), *Handbook on Data Quality Assessment Methods and Tools* (Eurostat, 2007), and *Quality Assurance Framework of the European Statistical System* (Eurostat, 2012).

The description of managing data quality by Brackstone (1999) gives a somewhat broader perspective. Eurostat (1997) has focus on quality reports and provides examples from business statistics. This module is general rather than focused on business statistics, but there are references to other handbook modules. Some characteristics of business surveys and business statistics are described in the handbook modules "Overall Design – Overall Design", "Repeated Surveys – Repeated Surveys", and "Weighting and Estimation – Design of Estimation – Some Practical Issues" with connections, for instance, to survey design and successive improvements.

2.1 Quality of statistics and its dimensions

Quality of statistics refers to the degree to which the characteristics of statistics fulfil the requirements of users of statistical information.

In the European Statistical System (ESS), the characteristics of statistics are referred to as quality criteria, quality dimensions or quality components. The product quality dimensions defined by

Eurostat in the European Statistics Code of Practice (Eurostat, 2011) principles covering statistical output are mentioned and defined in Table 1.

Table 1. Quality dimensions of statistics, the associated objects and their definitions.

Nr	Quality dimension	Associated object	Definition
1	Relevance	Concept	The degree to which statistical outputs meet current and potential user needs.
2	Accuracy	Data	The closeness of estimates to the true values.
3	Reliability	Data	Closeness of the initial estimated value to the subsequent estimated value.
4	Timeliness	Release of statistical output	The length of time between the event or phenomenon the statistical output describe and their availability.
5	Punctuality	Release of statistical output	The time lag between the date of the release of the data and the target date on which they were scheduled for release as announced in an official release calendar.
6	Coherence	Concepts and methods	The degree to which the statistical processes by which statistics were generated used the same concepts – classifications, definitions and target populations – and harmonised methods.
7	Comparability	Concepts and methods	The degree to which the same data items can be compared but for different reference periods or different sub populations (regions or domains).
9	Accessibility	Statistical output	The ease and conditions under which statistical information can be obtained.
9	Clarity	Metadata	The extent to which easily comprehensible metadata are available, where these metadata are necessary to give a full understanding of the statistical data.

More criteria of statistics could be added such as reproducibility, level of detail, plausibility, completeness, periodicity and availability (Van Nederpelt, 2009). However, we will not elaborate these characteristics in this document. These criteria are less current.

2.1.1 Statistics

The term statistics can be subdivided into the following objects or components:

1. The concept of the statistical output (concept) and the methods used to compile the statistical output (method)
2. The values of the statistical characteristics (data)
3. The release of the statistical output (release)
4. Statistical output: a combination of data and metadata (statistical output)
5. The description of the statistical output (metadata)

2.1.2 Focus areas

Each quality dimension is associated with one or more of these five abovementioned objects (Table 1). A combination of a quality dimension and an object is called a focus area, e.g., accuracy of the data (cf. handbook module "General Observations – Quality and Risk Management Models").

The concept of focus areas makes is possible to indicate relationships with or dependencies on other focus areas that are related to other objects such as statistical process, administrative data and methodology. These latter objects have their own set of characteristics or quality dimensions. Focus areas are also, e.g., efficiency of the statistical process, timeliness of the administrative data and soundness of methodology.

2.2 Quality and risk management of statistics

The quality of statistics is managed by taking the right measures, decisions or actions. Most of these measures are taken in the development stage. However, changes could be necessary in the production stage as well. These measures are necessary for each of the nine quality dimensions of statistical output.

According to the OQRM model (see the module "General Observations – Quality and Risk Management Models"), the following steps can or should be taken to manage quality and risk of each quality dimension:

1. Define requirements for each quality dimension
2. Define and implement quality indicators (measurements, evaluation)
3. Define relationships or dependencies with other focus areas or quality dimensions.
4. Analyse possible causes and effects of problems with a quality dimension (risk analysis)
5. Define and implement measures (decisions, actions) to manage the quality dimension

In the module "General Observations – Quality and Risk Management Models", these steps of the OQRM model are further elaborated. Quality indicators of output data (step 2) can be found in the specific section of each module of this handbook. Causes of problems (step 4) with the accuracy of the data are described in section 2.4.1–4 about errors.

2.3 Relevance

The relevance of statistics is the degree to which statistics meet current and potential users' need (Eurostat, 2013a).

2.3.1 Assessment of relevance

Although relevance is not an inherent characteristic of statistical data, it can be evaluated and measured through analysing the data from users' satisfaction surveys, and recording the data requirements of Commission Regulations, and International Organisations (e.g., IMF, OECD). The point of departure of every statistical survey has to do with recording the users' needs and the users' demands on product quality. Maintaining relevance requires keeping in touch with the current and potential users, not only to record their current needs but also to anticipate their future needs. Usually,

data needs are not clearly formulated by users in statistical terms. Thus, a major challenge is to translate data needs in particular topics into likely statistical terms (Brackstone, 1999).

When reporting on relevance, the aim is to describe the extent to which the statistics are useful to, and used by, the broadest array of users. For this purpose, statisticians need to compile information, firstly about their users (who they are, how many they are, how important is each one of them), secondly on their needs, and finally to assess how far these needs are met. There may be information on user satisfaction and possibly on completeness of the statistical information in comparison with regulations. See also the handbook modules "User Needs – Specification of User Needs for Business Statistics" and "Evaluation – Evaluation of Business Statistics".

2.4 Accuracy

The accuracy is defined as the closeness of estimates to the unknown true values (Eurostat, 2009b).

Commonly, the objective of a statistical survey is to estimate a set of target parameters referring to a target finite population. Within the framework of quality, *accuracy* of estimates is generally considered a key measure of quality.

2.4.1 Total survey error and mean squared error

A conceptual framework for accuracy is the *total survey error,* which describes, ideally, the accumulation of all errors that may arise in the design, collection, processing, and analysis of survey data (Biemer, 2010). For quantifying the total survey error, the most common metric approach is the *mean squared error (MSE).* Each estimate computed from the survey data has a corresponding estimated MSE.

The total survey error accumulates all errors, which may arise in the sample design, data collection, processing and analysis of survey data, and it comprises both *sampling* and *not sampling errors*.

The mean squared error of an estimator of a population parameter is defined as the hypothetical average of the squared differences between the repeated estimates – when the survey is repeated with sampling, data collection, coding, editing etc. – and the true value of the parameter. In statistical terms, the MSE is the expected squared difference between an estimator and the parameter which is intended to estimate. The mean squared error is equal to the square of the bias plus the variance of the estimator.

2.4.2 Systematic error (bias) and random error (variance)

Accuracy in the general statistical sense denotes the closeness of estimates to the (unknown) exact or true values. Statistics are (nearly) never identical to the true values because of variability (the statistics change from implementation to implementation of the survey due to random errors and effects) and bias (the average of the estimates from each implementation is not equal to the true value due to systematic errors and effects):

- The bias of an estimator equals the difference between its expected value and the true value. Systematic differences may, for instance, be due to systematic measurement errors or systematic effects of non-response that are not overcome in the estimation procedure. The systematic error is the systematic deviation of the estimated value from the true value: the target.

- The variance of the estimator is a measure of the accumulated random errors. The term precision is sometimes used, in general or especially for the square root of the variance.

The total survey error accumulates all errors, which may arise in the sample design, data collection, processing and analysis of survey data, and it comprises both *sampling* and *non-sampling errors*. Both error categories are subject to variability as well as bias.

2.4.3 Sampling errors

Sampling error is that part of the difference between an estimate of a population value and the true value, which is due to the fact that only a subset of the population is selected for the survey.

2.4.4 Non-sampling errors

Non–sampling errors are errors in estimates which cannot be attributed to sample fluctuations. They arise mainly from misleading definitions and concepts, frames that have delays or are inadequate, unsatisfactory questionnaires, defective methods of data collection, non-response, coding, and tabulation. The non-sampling errors appearing to all statistical processes can be categorised as:

- Coverage errors
- Measurement errors
- Non-response errors
- Processing errors

2.4.4.1 Coverage errors

Coverage errors are caused by a failure to cover adequately all units of the target population, which results in differences between the frame population and the target population. We can distinguish the following types of coverage error:

- *Over-coverage* means that units accessible via the frame do not belong to the target population. In business surveys, the *over-coverage* mainly has to do with units (e.g., enterprises) that were included in the business register, they were selected in the sample, but they were not actually existing at the time of the survey (closed enterprises). The decrease of the number of useful sampling units from the initial to the actual size inflates the variance of the parameter's estimate. See the handbook module "Weighting and Estimation – Main Module".
- *Misclassification* is (erroneous) classification of a unit into a category in which the unit does not belong. For instance, a business is classified in Trade instead of Industry. Due to problems of *misclassification*, a number of sampling units turn out to belong to domains of estimation that differ from their design strata. Such units and changes can be handled in the estimation , for instance using post-stratification. See the handbook module "Weighting and Estimation – Main Module".
- The *under-coverage* refers to units which belong to the target population but are not in the frame population. This may, for instance, be due to reporting delays to the business register. Corrections and weighting for *under-coverage* is difficult, because the information cannot be obtained from the sample itself, but only from external sources. See the handbook module "Weighting and Estimation – Main Module".

2.4.4.2 Measurement errors

Measurement errors occur during the data collection, and they mean that the recorded values of variables are different from the true ones.

Their causes are commonly categorised as:

- *Survey instrument:* Questionnaire or measuring device used for data collection may lead to recording of wrong values. Also, the survey mode (CAPI, CATI, CAWI, etc.) can be a potential error source. A wrong mode for a survey could generate, for example, unit or item nonresponse.
- *Respondent:* Respondents may, consciously or unconsciously, provide erroneous data.
- *Interviewer:* Interviewers may influence the answers given by respondents in a way that leads to measurement errors.

Hence, survey results are affected by measurement errors, which occur in the course of the observation of the data. Generally, they can be regarded as random errors, which increase the variance, or as systematic error, which influence the bias. The extra variance (for instance, interviewer variance) due to measurement errors is important to measure in order to assess the effect on the total survey error. See, for instance, the handbook module "Response – Response Process" for the importance and for methods to work with measurement errors.

2.4.4.3 Non-response errors

Non-response errors occur when the survey fails to collect the data as intended, with regard to statistical units and items. The difference between the statistics computed from the collected data and those that would be computed if there were no missing values is the *non-response error*. There are two types of non-response:

- *Unit non-response,* which occurs if there is no information from the statistical unit (respondent) or if the information provided is so limited or possibly erroneous that it is deemed not usable.
- *Item non-response,* which occurs when a statistical unit (respondent) does not provide some of the requested information, or if some of the reported information is not usable.

The effect of non-response on the produced statistics is that it increases variance and bias. Bias is introduced by the fact that non-respondents may be different than respondents in their values of some survey variables in a systematic way that the estimation procedure does not account for. Variability increases due to decreased effective sample size possibly due to the adjustments made. See the handbook module "Weighting and Estimation – Main Module".

2.4.4.4 Processing errors

Once data have been collected, a range of processes is performed before the production of final estimates, e.g., coding, editing, checks and corrections, imputation of microdata, and later weighting and tabulating etc. Errors that arise at these stages are called processing errors. For example, in coding open-ended answers, wrong codes may be assigned to occupations or economic activities of enterprises. This applies to manual, semi-automated as well as automatic coding. There may also be mistakes in computer programs and when "moving" data and results. Manual handling under time pressure is risky.

There are both systematic and random processing errors.

2.5 Reliability

Reliability is the closeness of the initial estimated value to the subsequent estimated value. The subsequent estimated values relate to the same reference period. It regards revisions of data. There may be several revisions. Hence there may be several measures of reliability, due to different combinations of estimated values. See the handbook module "Quality Aspects – Revisions of Economic Official Statistics".

Reliability is related to accuracy. However, it does no refer to the true value but to a later estimate. It is also related to the coherence between provisional and final data. The revision size depends on both random errors and possible systematic differences between the estimators. See, for instance, the handbook module "Weighting and Estimation – Main Module" for possible early estimates and also references there.

2.6 Timeliness

The timeliness of statistical outputs is the length of time between the event or phenomenon they describe and their availability. This is a quality dimension, which is obvious, and there may be user requests. For example, monthly data must not be available too many months after the reference month.

2.7 Punctuality

Punctuality is the time lag between the actual delivery of the data and the target date when it should have been delivered.

2.8 Coherence

The coherence of two or more statistical outputs refers to the degree to which the statistical surveys and processes by which they were generated used the same concepts – classifications, definitions, and target populations – and harmonised methods. Coherent statistical outputs have the potential to be validly combined and used jointly. An example of joint use is where the statistical outputs refer to the same population, reference period, and region, but where they comprise different sets of data items (say, employment data and production data).

Comparability may be regarded as a special case of coherence where the statistical outputs refer to the same data items and the aim of combining them is to make comparisons over time, or across regions, or across other domains.

When bringing together statistical outputs, the errors occurring (i.e., lacks of accuracy) in the surveys and processes have the potential to cause numerical inconsistency of the corresponding estimates. This can easily be confused with a lack of coherence/comparability. In some cases the estimation procedure eliminates such numerical inconsistencies, for instance through calibration or benchmarking. See the handbook module "Weighting and Estimation – Main Module".

Different categories of coherence are distinguished:

- Coherence of provisional and final statistics (see also reliability above).
- Coherence of short term and long term statistics

- Coherence of statistics in the same domain
- Coherence of statistics of business statistics with national accounts

2.8.1 Coherence of short term and annual statistics

In business surveys, an essential point of quality assessment is the coherence between short term and annual statistics. When comparing the annual growth rates of annual and short-term statistics (STS), divergent trends sometimes appear, provoking inconvenience to the users, especially when the target populations and the definitions of the variables coincide between annual and short-term statistics (e.g., turnover and employment between Short Time Statistics and Structural Business Surveys). Reasons for deficiencies in coherence – influential differences in definitions and methodology – need to be studied. Their effects should be assessed.

2.8.2 Coherence of statistics in the same domain

Frequently, a group of statistics, possibly of a different type (e.g., in monetary value, in volume or constant price, price indicators) measures the same phenomenon, but from different approaches. It is very important to check that these representations do not diverge too much in order to anticipate users' questions and prepare corrective actions.

2.8.3 Coherence of business statistics with national accounts

Finally, in order to advise users on the information source best suited to their needs, it may also be useful to compare survey statistics with national accounts. The methodology used for compiling national accounts would need to be taken into consideration as well the primary data source used and the adjustments made. Divergences in the concepts should also be taken into account.

2.9 Comparability

Comparability is the degree to which the same data items can be compared but for different reference periods or different sub populations (regions or domains). Statistics should be coherent in order to be comparable. Three types of comparability are distinguished:

- *Comparability over time:* It refers to the degree of comparability between two or more instances of data on the same phenomenon measured at different points in time.
- *Comparability between geographical domains:* It refers to the degree of comparability between similar surveys measuring the same phenomenon for different geographical domains.
- *Comparability between non-geographical domains:* It refers to the comparability between different surveys results which target similar characteristics in different statistical domains.

2.10 Accessibility

Accessibility of statistics is the ease and conditions under which statistical information can be obtained (Eurostat, 2013a). It depends on the physical conditions by means of which users obtain data: where to go, how to order, delivery time, pricing policy, marketing conditions (copyright, etc.), availability of micro- or macrodata, various formats and media.

To achieve the accessibility of information, the following three principal aspects need to be fulfilled (United Nations, 2003):

- A catalogue system, which allows the users to find out what information is available and assist them to locate it.
- A delivery system, which provides access to information through distribution channels, and in formats, that suit users.

The traditional printed catalogue has given way to on-line catalogues of statistical products, linked to metadata bases in which the characteristics of the information can be found. Access to the catalogue system can be through the Internet, and users who find what they want can immediately place an order to request the desired information or retrieve the information themselves. On-line databases, accessible by internet are the dominant component of the delivery system.

2.11 Clarity

Clarity is the extent to which easily comprehensible metadata are available (for the user), where these metadata are necessary to give a full understanding of statistical data (Eurostat, 2013a). It is determined by the information environment within which the data are presented, whether the data are accompanied with appropriate metadata, whether use is made of illustrations such as graphs and maps, whether information on accuracy and other quality aspects are available (including any limitations on use) and the extent to which additional assistance is provided by the producer

According to the United Nations (2003), the clarity of statistical information is primarily achieved by providing users with metadata, which help them to properly interpret the produced statistical information. The information needed to understand statistical data has to do with (United Nations, 2003):

- The concepts and classifications that underlie the data (what has been measured).
- The methodology used to collect and compile the data (how it was measured).
- The accuracy measures of the data (how well it was measured).

Quality information and indicators for other dimensions than accuracy could be added to this list. For instance, some information on comparability and coherence may be important.

These elements could be compiled in a quality report (EU, 2009b; Eurostat, 2009a) or as explanation of a statistical table.

3. Design issues

4. Available software tools

The *ESS Handbook on Precision Requirements and Variance Estimation for Household Surveys* (Eurostat, 2013b*)* presents variance estimation and many software packages (in its Appendix 7.5) available which can calculate variance estimates for linear and non-linear statistics under simple and complex sampling designs. Its focus is household statistics having sampled individuals, but there are general texts and useful information also for business statistics.

5. Decision tree of methods

6. Glossary

For definitions of terms used in this module, please refer to the separate "Glossary" provided as part of the handbook.

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Interconnections with other modules

8. Related themes described in other modules

1. General Observations – Quality and Risk Management Models
2. User Needs – Specification of User Needs for Business Statistics
3. Overall Design – Overall Design
4. Repeated Surveys – Repeated Surveys
5. Response – Response Process
6. Weighting and Estimation – Main Module
7. Weighting and Estimation – Design of Estimation – Some Practical Issues
8. Quality Aspects – Revisions of Economic Official Statistics
9. Evaluation – Evaluation of Business Statistics

9. Methods explicitly referred to in this module

1.

10. Mathematical techniques explicitly referred to in this module

1.

11. GSBPM phases explicitly referred to in this module

1.

12. Tools explicitly referred to in this module

1.

13. Process steps explicitly referred to in this module

1.

Administrative section

14. Module code

Quality Aspects-T-Quality of Statistics

15. Version history

Version	Date	Description of changes	Author	Institute
0.1	10-03-2012	first version	Ioannis Nikolaidis	ELSTAT
0.1.1	25-10-2013	reviews Norway, Italy, Sweden and the Netherland processed	Peter van Nederpelt	Statistics Netherlands
0.1.2	20-01-2014	reviews Sweden and Hungary processed.	Peter van Nederpelt	Statistics Netherlands
0.1.3	01-03-2014	reviews EB processed	Peter van Nederpelt	Statistics Netherlands
0.1.4	11-03-2014	preliminary release		
1.0	26-03-2014	final version within the Memobust project		

16. Template version and print date

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