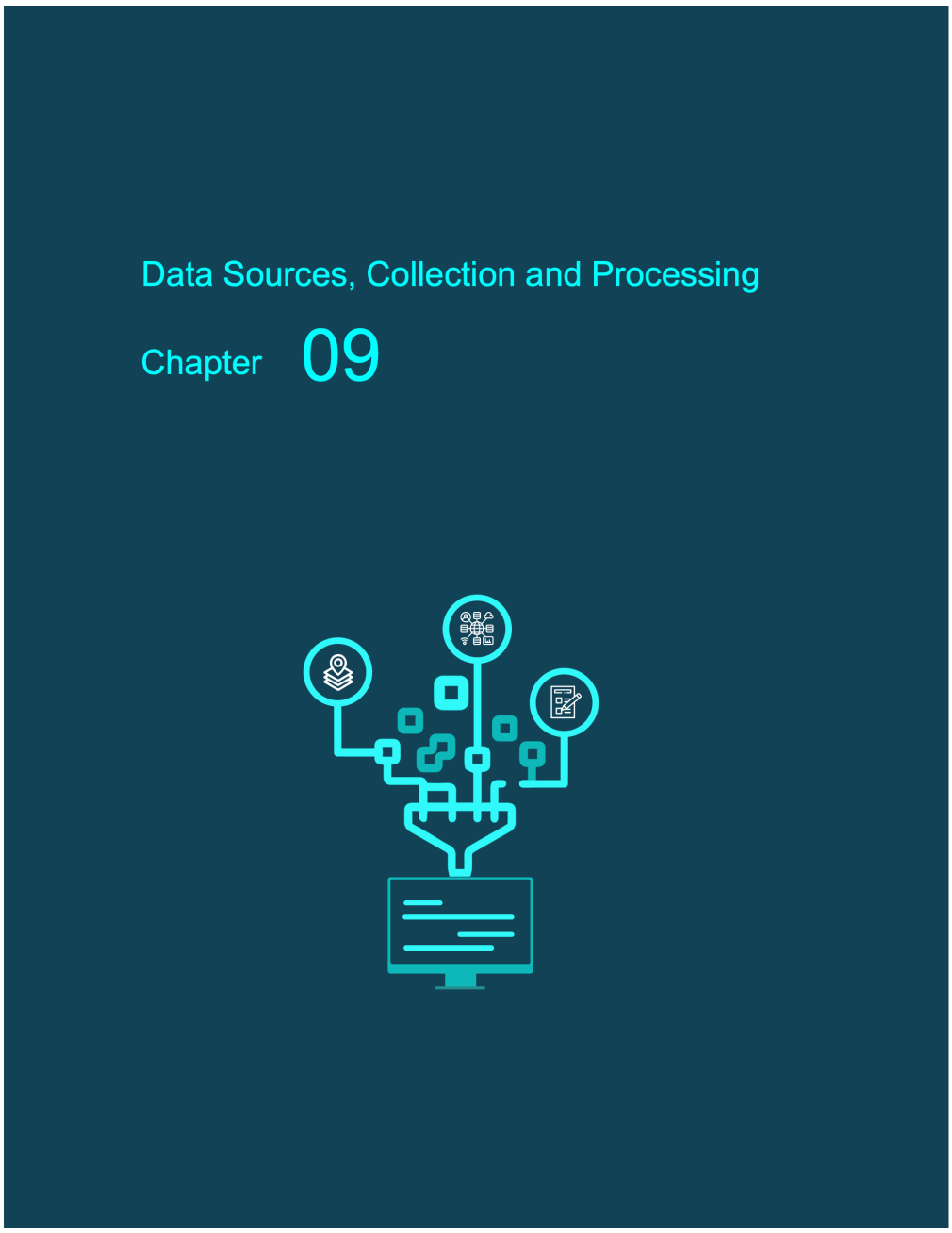
CHAPTER

NINE

DATA SOURCES, COLLECTION AND PROCESSING



9.1 Introduction

Although a chief statistician does not need to know all the details of every statistical activity, a general understanding of statistical concepts and statistical processes is vital for effective decision-making. The starting point is the Generic Statistical Business Process Model (GSBPM) described in *Chapter 6 - The National Statistical Office* and *Chapter 15.4.3 — Generic Statistical Business Process Model (GSBPM)*. The GSBPM describes a statistical process in terms of eight phases, namely, Specify Needs, Design, Build, Collect, Process, Analyse, Disseminate and Evaluate. Chapter 6 covers Specify Needs and this chapter deals with the next four phases, i.e., Design, Build, Collect, and Process, leaving chapters 7 and 9 to discuss the Analyse and Evaluate phases, respectively.

For the purpose of the chapter, statistical processes are divided into four groups according to the input data source, namely:

Survey

Surveys and censuses are the traditional data source and are still very much used. *Chapter 9.2 — Sample surveys and censuses*, the longest section in the chapter, details all aspects of the design, build, collect and process phases. It also includes subsections on respondent relations and staff training, which cross phases.Although well established and precisely targeted to address specified needs, surveys and censuses are time-consuming, labour-intensive and expensive. At the same time, NSOs are having to deal with shrinking budgets and emerging requests for more timely and disaggregated statistics and for indicators covering new domains, in particular in relation to monitoring the 2030 Sustainable Development Agenda and other regional and national development policies. To address these challenges, NSOs and other producers of official statistics are beginning to use the vast amounts of data that have become available in our digital society to supplement existing survey inputs. Indeed, the 'datafication' of society together with cost-efficient storage capacity and a rapid increase in computing performance have opened new opportunities for combining statistical surveys and censuses, and administrative records, and non-traditional data sources such as geospatial information and Big Data.

Administrative data

The most dramatic increase has been in the use of administrative data. Indeed, faced with a new data request, the first step an NSO should take is to check whether the need can be met by the use of an existing administrative data source. *Chapter 9.3 — Administrative sources* describes the particular features of the design, build and collect phases of processes using administrative data that distinguish them from surveys and censuses.

Geospatial data

Geospatial data means data that have a geographic component. The most prolific source of such data is satellite imagery. Geospatial data can be used to greatly enrich other data sources. *Chapter 9.4 — Geospatial data* describes the types of geospatial data, their uses and the challenges faced in such uses.

Big data

Chapter 9.5 — Big Data deals with Big Data, the Internet-of-Things (IoT) sensors, wearables and mobile devices as tools that can complement traditional ways of collecting data due to their potentially high population coverage and use in daily life. The section draws on a vision paper by CBS Netherlands and Statistics Canada entitled Future advanced data collection (🔗), presented at the 62nd ISI World Statistics Congress 2019. It is crucial for NSOs to consider implementing advanced data collection capabilities to increase their value for the societies they serve. Data platforms and other infrastructure usually referred to as the Cloud could be valuable tools in bringing together and processing traditional and non-traditional data from public and private sources.

Box 4: New role for official statistics in Estonia

> Estonia is well known for its innovative practices and the introduction of digital technologies and processes into its public administration. To facilitate more effective use of data sources and prevent duplication of information collected, Statistics Estonia (SE) proposed changes to its statistical law. Through this change, it has taken on the role of national data steward, tasked with coordinating data governance in Estonia. This function of SE will provide an overview, and the possibility to use a central database more efficiently for various statistical analyses since data providers (enterprises, institutions as well as and individuals) do not have to be burdened with responding to multiple questionnaires. The amended law requires all government authorities administering state databases to appoint persons responsible for data governance. It is expected that a data-sharing service will be added shortly to the statistical legislation, allowing SE to better coordinate data sharing of existing state data with other state authorities. This cross-usage of data between state authorities reduces duplication of data. It will enable SE to link data collected from different data sources and produce domain-specific data analyses and statistics while preserving statistical principles and confidentiality of data. SE provides this service only within the public sector and to research institutions. Link to Statistics Estonia, data science competence center (🔗).

9.2 Sample surveys and censuses

The Generic Law on Official Statistics (GLOS), UNECE (2018) defines a statistical survey as 'the primary collection of individual data from respondents of a given population carried out by a producer of official statistics exclusively for statistical purposes through the systematic use of statistical methodology'.

Two approaches used to collect information directly from respondents in different circumstances are sample surveys and censuses. A sample survey is a data collection activity involving only a part (sample) of the total population, while a census is generally a study of every unit (everyone or everything) in a population. Censuses are often referred to as a complete enumeration or a complete count. Both approaches are used to draw conclusions about the whole population. Censuses and sample surveys are complementary in a statistical system. They are each considered to be a special case of a survey.

Censuses are the oldest of statistical activities that serve to make a snapshot of the whole population. Due to their complete coverage population censuses are the most broadly known activities of an NSO and are usually the first association that comes to non-statistician mind when thinking about official statistics. Many materials are available that deal with the management of a census of population, including detailed reports on actual experiences of census-taking. The United Nations Statistics Division has developed a series of handbooks and guidelines to assist countries in their preparation for population censuses. These include:

- *Guidelines on the Use of Electronic Data Collection Technologies in Population and Housing Censuses (2019)* ();
- *Handbook on Geospatial Infrastructure in Support of Census Activities (2009)* ();
- *Handbook on the Management of Population and Housing Censuses, Rev. II (2016)* ();
- *Handbook on Population and Housing Census Editing (2009)* ();
- Measuring the Economically Active in Population Censuses: A Handbook and Collection of economic characteristics in population censuses: technical report (2010) ();
- *Principles and Recommendations for Population and Housing Censuses, Rev. III (2017)* ().

Due to the availability of extensive high-quality and up-to-date UN materials, population and other censuses are not discussed in detail in this handbook.

> Apart from population censuses, NSOs conduct other exhaustive enumeration activities in order to gather characteristics and data on the size and structure of housing, economic units, buildings or farms.

Due to their complete coverage of the target population, those activities are most commonly also called censuses. Economic censuses are particularly useful when other reliable statistics (particularly about the structure of the economy) and reliable register and administrative information are not available. See *Chapter 12.5 — Statistical farm register and other frame sources for agricultural censuses and surveys* for more information on agricultural censuses, and also, on the webpage of the FAO World Programme for the Census of Agriculture ().

> With the advent of the sample theory, censuses have gained additional purposes as they have become a source of information for sampling frames and the basis of estimators for sample surveys. This has led to a reduction of both cost and response burden, thus enabling a more detailed and more frequent data collection. Data from sample surveys are usually more complex than the basic data collected through a census. Surveys are often used to expand on the characteristics of census topics (and add additional topics) and to measure change between censuses. Choosing a right approach may depend on the characteristics of the population and other factors that are discussed below.

The Australian Bureau of Statistics lists the following advantages and disadvantages of Sample Surveys compared with Censuses ().

Pros of a CENSUS	Cons of a CENSUS
- provides a true measure of the population (no sampling error)	- may be difficult to enumerate all units of the population within the available time
- benchmark data may be obtained for future studies	- higher costs, both in staff and monetary terms, than for a sample
- detailed information about small sub-groups within the population is more likely to be available	- generally, takes longer to collect, process, and release data than from a sample
Pros of a SAMPLE	**Cons of a SAMPLE**
- costs would generally be lower than for a census	- data may not be representative of the total population, particularly where the sample size is small
- results may be available in less time	- often not suitable for producing benchmark data
- if good sampling techniques are used, the results can be very representative of the actual population	- as data are collected from a subset of units and inferences made about the whole population, the data are subject to 'sampling' error
	- decreased number of units will reduce the detailed information available about sub-groups within a population

Detailed census information on small area populations is used to design sampling frames and selections for the survey units. While survey programmes may collect different information from the census, several topics are usually common to both. Therefore, to maximize the usefulness of the data from both sources, it is important to standardize concepts and definitions. Standardisation also enables uses of modern approaches, such as small-area estimation which allows the creation of estimates for survey results on spatial levels that are unreliable by using traditional approaches. Small area estimation is a procedure where survey data is combined with census data, or administrative records and survey results are then, according to common characteristics, modelled for every respondent in the entire population. This approach allows the creation of econometric estimates of survey results on otherwise unreliable spatial levels. An example of this approach in official statistics is the estimates of poverty at county level (usually level 3 of the territorial classification) from a survey that is representative at municipal level (usually level 2 of the territorial classification) level.

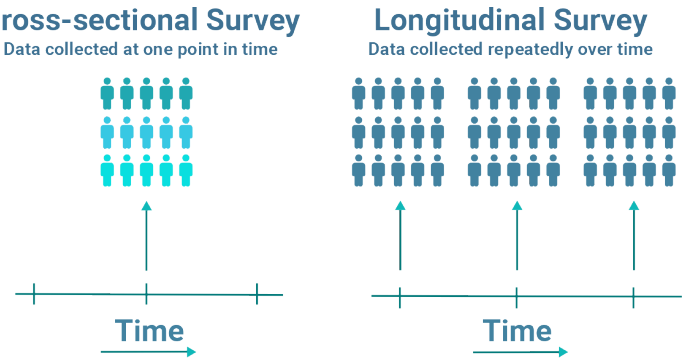
9.2.1 Description of survey functions

A survey is the most commonly used data collection mechanism in official statistics, it is versatile, relatively cheap and fast (at least when compared to the census), can answer a wide variety of questions about various characteristics of a population and is used in almost every statistical area. It is usually motivated by the need to study the characteristics of a population, build a database for analytical purposes or test a hypothesis. Surveys are therefore usually used as a method of decision-making support in private companies and in government, and as an important part of the scientific method in research activities. It is important to note that surveys in official statistics are also used to make international comparisons. NSOs ensure international comparability of survey results by applying a common methodological framework, by using similar methods and procedures and by monitoring the quality of processes and results through quality management systems and quality assurance frameworks (see *Chapter 8 - Quality Management*).

Surveys can be used to provide relevant insights about most questions, but statisticians should clearly communicate that surveys are a tool for aggregating the results from the population and that asking technical questions to the general public may not always give relevant answers. The key to a successful survey is a well-defined set of questions than can be realistically answered by a defined population. When planning a survey, it is important to find a balance between satisfying user needs and avoiding undue burden on respondents.

9.2.2 Survey types

Surveys are versatile instruments that can be used for various purposes. They are the basis of any statistical programme and alongside censuses and processed administrative information form the foundation of official statistics. Surveys can be cross-sectional and longitudinal.



Cross-sectional surveys are those in which a fresh sample of respondents is interviewed each time they are carried out, and they are therefore best served to measure the prevalence of a characteristic within the population. Longitudinal surveys are those that follow the same sample of respondents over time and therefore are best served to measure the incidence of a characteristic.Statistical surveys are usually grouped into statistical domains referring to particular populations. They may also be divided by type of observation unit into two main categories – household surveys and business surveys. Some surveys are a combination of both categories, for example, agricultural surveys, which can be both household and establishment surveys.

Household surveys

Household surveys are the basis of social research and are used to determine the basic characteristics of the population (people). The topics cover many socio-economic areas, including poverty, health, education, employment, gender equality, food security and access to services.

Household is a basic residential unit in which economic production, consumption, inheritance, child-rearing, and shelter are organized and carried out. The classification of 'household' is broader than the classification of 'family' since family refers only to a group of people related by blood or marriage, such as parents and their children only.

> A 'Household Survey' is the process of collecting and analysing data to help us understand the general situation and specific characteristics of individual household or all households in the population.

Two types of questionnaires are usually used for household surveys: a) household rosters; and b) detailed (or individual) questionnaires. A household roster includes listing of all household members and their characteristics, such as each member's age, sex, relationship to the head of household, education and literacy status, employment activity, schooling status (for the population aged 5-24) and marital status.

A detailed (or individual) questionnaire explores the main theme of the study. This questionnaire is usually only completed by specific respondents, such as the head of household, married couples, and mothers of children under five, out-of-school children, or disadvantaged children, etc. As it has to yield reliable results for the whole population, such a survey requires a substantial number of respondents and therefore tends to be quite expensive to administer. It may be carried out as frequently as monthly, or only occasionally, depending upon how quickly the data being collected are likely to change value and, on the budget, available for conducting the survey.

Business surveys

Business surveys are the basis of economic research and are used to determine the basic characteristics of enterprises and the economy. They can be divided into **short term** and **structural surveys**. Short term business surveys serve to determine the change of output within an industry or phenomena between measurement periods and are used for tracking the business cycle. They are conducted monthly or quarterly if resources permit, otherwise less frequently according to the budget available.

Short term business indicators usually cover production, turnover, hours worked, number of people employed, wages, exports and imports and producer and import prices in various sectors such as industry, construction, trade and services. Structural business surveys, on the other hand, are usually performed annually or less frequently and are aimed at providing detailed information about the structure, type of activity, competitiveness and performance of economic activities within the economy or a sector. While structural business surveys are mainly used for the compilation of the annual national accounts, short term monthly or quarterly business surveys measure change and therefore provide input for assessing volume change in the quarterly national accounts.

Ideally, every business survey uses the statistical business register as the source of the survey frame (as further detailed in *Chapter 12.3 — Statistical Business Register*). According to the statistical unit used a business survey may be an **enterprise survey or an establishment survey**.

- **Enterprise business surveys.** According to Eurostat's glossary of statistical terms (🔗), an enterprise is an organizational unit producing goods or services that has a certain degree of autonomy in decision-making. An enterprise can carry out more than one economic activity, and it can be situated at more than one location. An enterprise may consist of one or more legal units.

  A legal unit may be a natural person or a legal person whose existence is recognized by law independently of the individuals or institutions which may own it or of which it is a member. Examples are general partnership, private limited partnership, limited liability company and incorporated company. Most enterprises consist of one legal unit. However, in many countries, the few enterprises that comprise more than one legal unit account for a huge part of the economy in terms of employment or value-added.

  A legal unit may own a second legal unit and this second legal unit may carry out activities solely for this first legal unit. Both units may even have the same management. In this case, they are seen as one single enterprise. Another example may be that legal unit C employs the staff, and legal unit D owns the means of production like machines and buildings. A third legal unit E may own and manage these two legal units. Only the units C, D and E together can produce something and hence are to be counted as one enterprise. The reasons for splitting the organizational unit enterprise into more than one legal unit can be manifold: avoiding taxes or liabilities, different salaries according to the collective wage agreement or avoiding the publication of annual reports are among them.

  Globalisation has contributed further to more complex structures of enterprises. Being active on the market in a country often requires an enterprise to have a legal unit in that country. The legal units of such an enterprise may be centrally managed from one country; book-keeping may be carried out centrally from another country; research and design may be done in a country with high wages, and; parts of the production in countries with low wages. Multi-national enterprises are often very large enterprises with a huge impact on statistics in terms of employment and value-added. Thus, good quality multi-national enterprise data is crucial for good quality business statistics and necessitates a stepping-up of the collaboration among the various national statistical authorities. This collaboration is often performed via profiling, a process to delineate complex and large enterprises.

- **Establishment business surveys.** An establishment is an enterprise or part of an enterprise that is situated in a single location and in which only a single productive activity is carried out or in which the principal productive activity accounts for most of the value-added. Establishment surveys are any surveys where data is collected from local units. Data collection for each local unit is often difficult as it poses a significant burden for both respondents and the NSO. Due to this fact, the number of establishment surveys is often limited. However, as establishment surveys provide accurate and detailed information on the lowest level, performing them is important for the quality of national accounts. When an establishment survey is not available for a particular statistical area, data from an establishment survey that are available (usually employment and wages) may be used to derive estimates for other variables.

9.2.3 Types of statistical units that can be subject to the survey

The Generic Law on Official Statistics (GLOS) defines **'statistical unit'** as a bearer of statistical characteristics. It is the basic observation unit. According to *UNECE Common Metadata Framework* (🔗), statistical units are entities, respondents to a survey or things used for the purpose of calculation or measurement. They are units of observation for which data are collected or derived. They may be, amongst others, businesses, government institutions, individual organizations, institutions, persons, groups, geographical areas or events. They form the population from which data can be collected or upon which observations can be made.

UNSD publication *Statistical Units* (2007) (🔗) offers a distinction between **statistical, collection and reporting units**. It defines a **collection unit** as the unit from which data are obtained and by which questionnaire survey forms are completed. With this definition, a collection unit is more of a **contact address** than a **unit**. For example, a questionnaire may be completed by a central administrative office or an accountancy firm that provides this service to its client (the observation unit). Such information providing entity is a termed a collection unit.

A **reporting unit** is a unit about which data are reported. Reporting units are those entities for which information is collected by means of questionnaires or interviews. In most cases, reporting units coincide with the units for which statistics are compiled, i.e., observation units.

According to *International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4* (🔗) statistical units in economic statistics can be divided into the following categories:

- enterprise;
- enterprise group;
- kind-of-activity unit (KAU);
- local unit;
- establishment or local kind-of-activity unit;
- homogeneous unit of production.

9.2.4 Survey design

> Survey design is typically an iterative process that identifies the target population and assesses the sources available to provide the survey frame.

The survey frame comprises the list of units that most closely match the target population and the data needed, first, to stratify these units for sample selection and, second, to identify and contact the selected units. Thus, as further detailed in *Chapter 12 - Common Statistical Infrastructure*, the frame contains names, and other data need for the identification (identification data) such as addresses, telephone numbers and e-mail addresses (contact data) as well as other metadata used for stratification and sampling.

Specifying population and constructing sampling frame

The choice of survey frame may lead to a definition of a survey population that is different from the target population – i.e., persons with non-permanent addresses or enterprises with 0 employees being excluded from the survey, but it can also affect the methods of data collection, sample selection and estimation, as well as the cost of the survey and the quality of outputs. Further, the surveyed population might exclude areas with extremely high collection costs (such as a remote island) if they cover an insignificant portion of the target population. There are two main categories of frames: list and area frames. A list frame is a list of all units in the survey population, while area frame is a special kind of frame with a hierarchy of geographical areas as units. A typical household survey uses both types of frames as sources for sample selection (Multi-stage sampling), where first a sample of regions are selected from the area frame and then a systematic sample of dwellings (usually stratified) are selected form each of the selected regions.

> In official statistics, the survey frame (which is called sampling frame in sample surveys) is usually derived from statistical registers or censuses, but various administrative registers are also increasingly used for this purpose (independently or as a method of improving the frame quality).

Using a consistent survey frame is recommendable for surveys with the same target population or a subset of the target population. When the same sample frame is used for different surveys, it is termed a master sample frame or master sample. In this approach, the first stage of sampling (selecting the areas), for household surveys, is often performed once for all conducted surveys, while the final selection of households is performed for each specific survey. This avoids inconsistencies across surveys and reduces the costs associated with frame maintenance and evaluation. More information on master samples can be found in *Chapter 12.7.1 — Household master sample*. Having a reliable survey frame is essential to any survey, and thus the nonexistence of a reliable frame can lead to choosing a census (based on area enumeration) rather than a sample survey.

Types of sampling

The two main types of sampling are probability sampling and non-probability sampling. Probability sampling describes procedures where every unit in the population has a chance of being selected in the sample, and this probability can be accurately determined. Non-probability sampling is any sampling method where some elements of the population have no chance of selection, or where the probability of selection can't be accurately determined. Non-probability sampling is of limited use for surveys conducted by NSOs since the biased selection of units may lead to false conclusions about the survey population as the findings cannot easily be generalized to the population. However, there are statistical areas where a non-probability sample is useful – such as short-term business statistics, where cut-off sampling is often used. Cut off sample is a method in which all units above a certain threshold are surveyed. However, a non-probability sample can be useful for exploratory studies or during the development phase, such as a pilot survey.

Probability sampling should be used when inferences about the population are to be made based on the survey results. In a probability sample, every unit on the frame has a non-zero probability of being selected, and the units are selected randomly. As a result, the selection is unbiased, and it is possible to calculate the probabilities of inclusion, calculate the sampling variance of estimates and make inferences about the population. The main disadvantage of probability sampling is that it requires more time and is more costly than non-probability sampling. It also requires a high-quality sampling frame and at least one sampling specialist within the NSO.

Sampling designs

There are various methods and types of statistical sampling designs.

> Selecting the appropriate and effective design depends on the nature of the available sampling frame and the material costs, time allocated for implementing the survey and the nature of the complexity of the sampling units.

Sample design can also influence the required sample size, and thus it has a significant influence on the total cost of data collection. The simplest probability sample designs are simple random sampling and systematic sampling, which result in equal probabilities of inclusion. More complex designs that can result in unequal probabilities of inclusion and most of which require auxiliary information include stratified, probability-proportional-to-size, cluster, multi-stage and multi-phase sampling. Unequal probability sampling designs are typically used to reduce the cost of sampling and the data collection cost. When deciding between the various possible designs, the first thing to determine is what designs are feasible given the survey frame, units in the survey frame, domains of interest, response burden, data collection method, budget, international experience and support, etc. More information on sample design and sample selection can be found in *Chapter 12.8.2 — Sample design and estimation*.

- Eurostat: Survey sampling reference guidelines (🔗);
- Statistics Canada - Survey methods and practices (🔗);
- Statistics Netherlands - Sampling theory: Sample design and weighting methods (🔗);
- Statistics Netherlands - History of Sampling (🔗);
- UNSD Sampling frames and master samples (🔗).

9.2.5 Data collection and capture modes

Selecting an appropriate method of data collection is essential to the success of the survey. The data collection method should be chosen to achieve a large coverage, high response rate, and gather accurate information while minimising collection burden and having a reasonable cost. All of these cannot be achieved simultaneously and therefore selecting the right approach out of many available options is usually specific to a particular survey. According to *Survey methods and Practices (2003)* – by Statistics Canada (🔗), data collection methods can be divided into Self-completion and Interviewer assisted methods.

Self-completion

With self-completion, the respondent completes the questionnaire without the assistance of an interviewer. There are different ways a questionnaire can be delivered to and returned by a respondent. It can be done by post, facsimile, electronically or by an enumerator. When paper-based, this method is called Paper and Pencil Interviewing (PAPI); when computer-based it is called Computer-Assisted Self Interviewing (CASI); Computer-Assisted or Computer Assisted Web Interview (CAWI).

The main advantage of self-completion over other methods is that it is cheaper than interviewer assisted methods and much easier to administer. Self-completion is also useful for sensitive issues since the questionnaire can be completed in private without an interviewer's presence.

The disadvantage of self-completion is that response rates are usually lower than for interviewer-assisted methods since there is no pressure for the respondent to complete the questionnaire. Also, the quality can be worse than for interviewer-assisted methods since the respondent may misinterpret questions or skip some of them. For this reason, self-completion often requires follow-up after collection to correct errors and omissions.

Three methods of self-completion are commonly used:

- **Self-completion using paper questionnaire**

  Paper questionnaires were up to a few years ago, the most widely used method of data collection. Due to its relatively low cost, a self-completion paper questionnaire was mainly used in large-scale data collection operations, censuses, and recurring surveys such as monthly or quarterly business surveys and household budget surveys. This method is often slow, yields rather low response rates, and requires follow-up reminders and clarifications. Even though NSOs have significantly reduced the number of paper questionnaires in recent years, they are still widely used in less advanced NSSs. Questionnaires can be delivered and sent back via mail, via facsimile, delivered or picked up by interviewers, or a combination of these options. A self-completion paper questionnaire sent and returned via mail is certainly the slowest data collection method. Furthermore, self-completion using paper questionnaire also requires data entry, which must be performed manually or checked manually after optical character recognition (OCR). It can be argued that web interviewing may be cheaper and faster in some cases, but it depends on the access to the internet among the population and in particular among the sub-population-group that the survey aims to target.

- **Self-completion using electronic questionnaire**

  In recent years, many statistical offices have replaced most of their paper questionnaires with electronic questionnaires. Electronic questionnaires are often made available through an encrypted and password-protected access system. This method is often called CAWI (computer-assisted web interview). For statistical offices, the main advantage of CAWI over paper questionnaire is eliminating the manual data entry, since this is done directly by the respondent. Furthermore, electronic questionnaires provide the ability to integrate logical controls to prevent errors and enforce answers.

  A disadvantage of electronic questionnaires is the inability to distribute forms electronically, as countries seldomly possess a comprehensive list of e-mail addresses or official digital mailboxes for every person, household and business. Therefore, the most common way of introducing electronic questionnaires is to mail out the initial login information and require respondents to provide their respective email addresses. Even though the collection process is much faster, and the quality and completeness of the collected data are superior to paper questionnaires, high response rates should not be expected. Follow-up reminders to complete the questionnaire are often neces-

sary but can be foreseen in the design phase of the data collection and automated. Self-completion using electronic questionnaire is currently the most common method of data collection in reoccurring business surveys.

- **Machine to machine transfer**

  Although machine-to-machine transfer may be classified as a new and separate data collection method, it has many self-completion survey characteristics. A machine-to-machine transfer is an automated transfer of information from an IT system of the respondent to the data collection system of the NSO. The initial setup of the recurring data transfer has to be agreed with the respondent, who provides access to predetermined sets of information in predetermined collection periods, through a predetermined communication method. The process is usually done by writing a manually or automatically run script that sends the data through the application programming interface (API) that the statistical office opens. There are examples where accounting software providers have automated statistical reporting for businesses by writing scripts that automatically prepare the requested data, which is then automatically uploaded to the data collection website. This method's main advantage is that it eliminates the reoccurring response burden on businesses and that it is the fastest method of data collection. The main disadvantage is its costs, as preparation and documentation for APIs can be costly. It requires IT staff's direct involvement on both sides and often requires persuasion to be widely deployed among businesses. A machine-to-machine transfer may also be used to transfer information on reporting units from collection units (such as accounting firms) or for accessing Big Data sources.

Interviewer assisted data collection

The interviewer-assisted methods' main benefit is that the interviewer can increase the response rate and the overall quality of the collected information by personalising the interview and interpreting questions and survey concepts.

Interviewer-assisted methods are particularly useful for surveying populations with low literacy rates or when the concepts or the questionnaire are complex, or at any time self-completion would be difficult. Specific cases for which interviewer assisted methods are preferred are surveys to collect information about sensitive topics such as violence against women surveys or gender-based violence surveys. In these cases, special protocols are developed and followed. An interviewer can increase the response rate by showing official identification and stimulating interest in the survey and reassuring the respondent of any concerns he or she might have regarding privacy and confidentiality, and the survey's purpose. The interviewer can prevent errors by immediately identifying and correcting them in the presence of the respondent.

Some disadvantages of interviewer-assisted methods are that they are expensive and difficult to manage. Some of the expenses may include interviewer salaries, interviewer training, transportation and lodging costs for interviewers or office space and telephones in the case of centralised telephone interviewing. The main problem with personal interviews is that it may be difficult to locate the respondent, so the interviewer may be required to make several trips before successfully contacting the respondent. Other disadvantages of interviewer-assisted methods are that poorly trained interviewers can induce response errors, and respondents may be reluctant to answer questions about sensitive topics. If well-trained interviewers are unavailable, other methods of interviewing may be preferable.

Three methods of interviewer assisted interviewing are most commonly used:

- **Computer-assisted telephone interview (CATI)**

  Computer-assisted telephone interview (CATI) is a method of interviewer assisted data collection where information is gathered over the telephone and directly imported into the computer system. Telephone interviews offer reasonable response rates at a reasonable cost. Telephone interviews are faster and cheaper than personal interviews since there is no travelling and associated costs. Less time is wasted for contacting the respondent, and quality control of the interviewing process can be easily implemented since telephone interviews can be easily monitored. The disadvantage of telephone surveys is that they are limited by the length of the interview and complexity of the questionnaire, as respondents have less patience for long, complex interviews over the telephone than in person.

  Usage of mobile phones has also influenced telephone interviewing by increasing costs as calls to mobile lines tend to be more expensive than calls to landlines and has made the preparation phase, particularly constructing a survey frame with good coverage much more difficult and complex. Further, it has somewhat decreased the response rates as mobile phone users have the caller ID feature enabled by default and are less likely to answer calls from unknown callers than landline users. This drawback can be mitigated if a communication and awareness campaign

is carried out just before the survey, but a letter announcing a phone call for the survey can also be a good solution. Further, CATI is an excellent data collection method for reoccurring surveys and follow-ups, where the respondent has already provided reliable contact information and has consented to respond. There are many examples where the initial contact is done in person via CAPI, and further data collection is done via CATI (either by the interviewer who performed the initial collection or through a call centre).

Technological developments like speech synthesis and natural language recognition combined with Artificial Intelligence (AI) systems have been tested to collect information from respondents via telephone (example can be found here). Such technologies can be used particularly for simple and recurrent surveys. However, it is expected that more complex surveys could be conducted through fully automated telephone assisted interviews soon. More information on the potentials of AI systems can be found in *Chapter 15.2.15 — Artificial Intelligence*.

- **Personal interviews using paper questionnaires (PAPI)** A significant advantage over self-completion using paper is that, if the interviewers have been properly trained and selected for good quality handwriting, accuracy and completeness of the responses can be significantly improved and more readily captured using optical character recognition (OCR). However, personal interviews using PAPI are being gradually replaced, when possible, with computer-assisted methods. In many countries, in particular less advanced ones, the PAPI is widely used for the population and housing censuses.
- **Computer-assisted personal interview (CAPI)** Computer-assisted personal interview (CAPI) combines the advantages of interviewer and computer-assisted methods by speeding up data collection, enabling more complex skip patterns, automating editing and quality checks, and closely monitoring and managing the interviewing staff. CAPI systems can be designed to generate management reports on the status of the interviews (e.g., response rate, number of interviews completed, number outstanding, length of time per interview, etc.), which help quality monitoring survey management.

  A significant advantage of CAPI methods is automatically collecting additional data (such as geolocalisation) and metadata (such as time of interviewing), which can be used for data linking and controlling the interviewers. The main disadvantage of the CAPI method is the cost of the equipment and the fact that interviewers must be trained and comfortable using the computer and the data collection application. Therefore, using CAPI may not prove to be the ideal solution for surveys with a large number of interviewers or surveys with a high rate of interviewer replacement.

  The computer may be a laptop, tablet, or even mobile phone; the latter two devices are smaller, consume less power, and have a significantly better battery life which are important factors for the interviewers' autonomy. However, input through touch screens is generally slower and less precise than keyboard input to a laptop. Choice of technology is further discussed in *Chapter 15.8 — Questionnaire design tools*.

Appropriate choice of mode

According to Survey methods and Practices (2003) – by Statistics Canada (🔗), the following issues should be considered when selecting an appropriate method of data collection:

- The information available in the survey frame. If the frame does not include mailing addresses, then self-completion questionnaires cannot be mailed to respondents. If up-to-date telephone numbers are not available telephone interviews cannot be conducted.
- The characteristics of the target population influence the data collection method. If the literacy rate of the population is low, or if the language is a consideration (i.e., there are two or more language groups), interviewer-assisted methods may be the only option. If the population and sample are widely dispersed across the country, personal interviews may be too expensive and difficult to manage.
- The nature of the survey may influence data collection. If the subject matter is sensitive, then a collection method that builds in anonymity such as self-completion or telephone interviews may be the most appropriate. If complex questions are asked, an interviewer may be needed to explain questions and concepts. If the interviewer needs to make observations or measurements (e.g., administering a literacy test to children) or showing the respondent material (e.g., graphics or diagrams), personal interviews might be required.
- Available resources heavily influence the choice of the data collection method. These resources include available

budget, personnel, equipment and time. To use an interviewer-assisted method, sufficient budget must be available to pay for the training, hiring and travelling of interviewers. The national statistical office also needs to be able to find the required number of interviewers. If a computer-assisted method is selected, then IT experts are required along with the necessary computer equipment.

- Data quality requirements should be considered when selecting a data collection method. Well-trained Interviewers in the concepts being used in the survey can reduce response errors and nonresponse. Precision requirements should also be considered: larger samples generally yield more precise estimates, but this is the more expensive data collection method.
- Selecting the appropriate method is usually survey specific, and alongside factors mentioned above, often depend on the corporate culture and the survey manager. Some survey managers are reluctant to innovate, while others are actively seeking new methods. It is certainly necessary to promote new practices and encourage the modernisation of survey methods, typically for those representing the highest costs and the highest burden on respondents.

In summary, personal interviews are often the most expensive method and self-completion surveys the least expensive. Using computer-assisted methods increases quality and improves speed, but may sometimes increase costs. The ability to measure quality and implement quality control procedures may also be important. It is easier to monitor the quality of telephone interviews than personal interviews. However, the most efficient solution may be a combination of different methods. This approach is often referred to as the mixed-mode data collection. Mixed-mode is particularly useful for surveys which require multiple interviewing of the same respondents. The mix-mode method may start with the interviewer's visit who informs the respondent, answers the questions, and collects the first set of requested data. After this first visit, further data collection could be processed information could be collected via CAWI or CATI methods. Mixed-mode data collection can also be combined with administrative data to further reduce costs and the response burden.

Questionnaire design

The questionnaire should be designed to minimise possible response errors. This includes standardising the questions, but also standardising the explanations for respondents and interviewers. The questionnaire layout is also important, but it often depends on the method of data collection. The introduction and sequencing of questions starting with questions relevant to the survey topic, but easy to answer can improve respondent participation. Statements that introduce new topics should be used, and the respondent or interviewer's instructions should be clear, short and easy-to-find. The questionnaire's general format and design should be assessed for their impact on the respondent and interviewer; including the font, section headings, colour of the questionnaire, format of response categories, and visual aids, etc. Finally, how the questionnaire is to be processed should be considered: it should be designed to facilitate data collection and capture, which is particularly important for paper-based collection.

A draft version of the questionnaire should be tested and revised thoroughly before finalising the questionnaire. Testing can include informal testing, cognitive testing, focus groups, interviewer debriefings, behaviour coding, split-sample tests and a pilot test – methods of testing are described in detail in links provided below.

> Designing a good questionnaire is a combination of science, experience and sometimes a bit of art. A well-designed questionnaire collects data efficiently with minimum errors and is at the same time easy to answer and administer, without posing an unnecessary burden to the respondent and the national statistical office. Achieving a good balance between those objectives can be achieved through an iterative questionnaire design process, which includes multiple consultations, reviews, testing and revision.

The process usually starts by examining all the information requirements that must be met, followed by an individual review of each question to find an explicit justification for being on the questionnaire. It must be known why each question is being asked and how the information is to be used. The wording of the question must be clear. The questions must follow a sequence that is logical for the respondent. The questions must be designed so that they are easily understood and can be accurately answered by respondents.

Questions can be of two types: open or closed. Open questions allow for self-expression but can be burdensome and time-consuming as well as difficult to analyse. Closed questions may be two-choice questions, multiple-choice and ranking or rating questions. Closed questions are usually less burdensome for the respondent, and data collection and capture are cheaper and easier. However, a poor choice of response categories can cause response distortion. When wording a survey question, the following guidelines should be followed:

- keep it simple;
- define acronyms and abbreviations;
- ensure questions are applicable;
- be specific;
- avoid double-barrelled questions;
- avoid leading questions;
- avoid using double negatives;
- soften the impact of sensitive questions;
- ensure that questions read well.

Questionnaire design is often performed in coordination with various departments of the national statistical office, and it is often wise to appoint a person (or a unit) to be responsible for the final approval of questionnaires. More information on the tools to support questionnaire design can be found in *Chapter 12.8.1 — Questionnaire design*.

- *Statistics Canada - Survey methods and practices* (🔗);
- *Statistics Netherlands - Questionnaire development* (🔗);
- *Statistics Sweden - Design your questions right - How to develop, test, evaluate and improve questionnaires* (🔗).

Minimising response errors

Response errors represent a lack of accuracy in responses to questions. They can be attributed to different factors, including a questionnaire that requires improvements, misinterpretation of questions by interviewers or respondents, and errors in respondents' statements.

> One of the common strategies for reducing the response errors is using terminology that is understandable to the respondent, as the language used by statisticians may not be familiar to the respondent (household or business).

Use of electronic questionnaires can also lead to a significant reduction in the number of response errors, as various conditions can be included in questions (i.e., age limit 0-120 for the question about the respondent age, that revenue must be greater than profit, or that the total must be the sum of its parts).

Response errors should be reviewed in the processing phase, and if a common response error is identified, measures should be taken to minimise it in subsequent data collection.

- Reducing Response Error in Surveys (🔗).

9.2.6 Processing survey

> Once collected, survey data require additional processing before they are analysed and aggregated into statistical results, and the same is true for administrative data used for statistical purposes.

Processing transforms survey responses obtained during collection into a form that is suitable for tabulation and data analysis. It includes all data handling activities – automated and manual – after collection and before estimation. According to the GSBPM data processing phase is divided into sub-processes that integrate, classify, check, clean, and transform the input data. The focus of this chapter will be on editing, coding, imputation and outlier detection, which are covered in more detail in *Chapter 12.8.1 — Questionnaire design*.

Editing

Editing is the application of checks to identify missing, invalid or inconsistent entries that point to data records potentially in error. The purpose of editing is to better understand the data to ensure that the final data are complete, consistent and valid. Edits can range from simple manual checks performed by interviewers in the field or administrative clerks

for administrative data to complex verifications performed by a computer program. The amount of editing performed is a trade-off between getting every record 'perfect' and spending a reasonable amount of resources (time and money) achieving this goal. While some edit failures are resolved through follow-up with the respondent or a manual review of the questionnaire, it is nearly impossible to correct all errors in this manner, so imputation is often used to handle the remaining cases.

- **Point of collection editing**

  Point of collection editing is used to detect mistakes made during the interview by the respondent or the interviewer and to identify missing information during collection to reduce the need for follow-up. Editing during collection is considerably easier to implement when it is automated through a computer-assisted collection method. For self-completion questionnaires, respondents may edit their answers. In most interviewer-assisted surveys, editing is performed during the interview. Interviewers are instructed and trained to review the answers they record on a questionnaire immediately after the interview is concluded – either after leaving the dwelling or after hanging up the telephone. This way they still have an opportunity to detect and treat records that failed edit rules, either because the correct information may still be fresh in their mind or because they can easily and inexpensively follow-up with the respondent to ascertain the correct values.

  Edits can be carried out automatically by software applications in the case of computer-assisted collection methods. For paper questionnaires with manual data capture, it is economical to use data capture as an opportunity to apply rules to clean the data sufficiently to make the subsequent processing stages more efficient. Generally, editing during data capture should be minimal since responding to an editing failure slows down data capture. Edits during this stage of processing are mainly validity edits and simple consistency edits.

  When working with administrative data, it is often useful to suggest to the data provider the inclusion of automated editing rules within the collection systems, as this can lead to a dramatic increase in the quality of the administrative data. Statistical offices should use this as often as possible, as they could directly or indirectly benefit from the increased quality of administrative information.

- **Primary and secondary editing**

  The most comprehensive and complicated edits are usually carried out after data collection is completed, and material reaches the office. In some NSOs this process is performed in multiple phases, most commonly referred to as primary and secondary editing. The first phase is usually performed in regional offices, immediately after data collection, when an interviewer can re-contact the respondent and follow up after performing a basic check and identifying an error or inconsistency. More complex edit rules are generally reserved for the separate edit stage after data capture – along with validity edits, more complex consistency edits are often performed along with selective editing and outlier detection.

  For edit failures after data collection, the usual procedure is to flag the field that failed an edit and then either impute the field or exclude the record from further processing. Most edit failures at this stage are flagged for imputation. Values that fail an edit should be flagged with a special code to indicate that an unacceptable value or invalid blank was reported. These flags are particularly useful when assessing the quality of the survey data. In some cases, the record or questionnaire may fail so many edit rules – or a small number of critical edits – that it is rendered useless for further processing. In such cases, the record is usually treated as a non-respondent, removed from the processing stream and a nonresponse weight adjustment performed.

Coding

Coding is the process of applying numerical values to given responses to facilitate data processing.

Coding can also be done in the phase of survey design when questionnaires are being prepared. This means that every possible answer is given a predefined numerical value before the questionnaire is administered. It is done as a part of the questionnaire design, and it is quite easy to enforce and administer for closed questions and electronic data collection. Application of statistical classifications to the core data is also referred to as coding. GSBPM provides the following example: automatic (or clerical) coding routines may assign numeric codes to text responses according to a pre-determined statistical classification to facilitate data capture and processing. Some questions have coded response categories on the questionnaires or administrative source of data, and others are coded after collection using an automated process (which may apply machine learning techniques) or an interactive, manual process.

Outlier detection and treatment

An Outlier is an observation or subset of observations that appear inconsistent with the remainder of the dataset.

> Outlier detection is performed by analysing the complete dataset and identifying unexpected or extreme values, usually by measuring their relative distances from the centre of the data.

Outliers detected at the editing stage of the survey process can be treated in various ways. In a manual editing system, the outliers are examined or followed-up and corrected if identified as errors. In an automated editing system, replacement values for outliers are often imputed. In some cases, no special treatment of outliers is performed if it is believed that they are not influential.

The following approaches can be used to treat outliers:

- change the value;
- change the weight;
- use robust estimation.

It is also understood that extreme values detected as outliers are not errors - one such example is a sector where there are one large company and many small ones.

More information on outlier determination methods and tools can be found in *Chapter 12.8.1 — Questionnaire design*.

Imputation

> Imputation is a process used to determine and assign replacement values to resolve missing, invalid or inconsistent data.

This is done by changing some of the responses to ensure that a plausible, internally consistent record is created. Imputation is usually performed via a carefully designed automated system, that uses the entire dataset's characteristics and additional data (if available) to propose the replacement value. Good imputation has an audit trail for evaluation purposes. Imputed values should be flagged, and the methods and sources of imputation clearly identified. The original and imputed values of the record's fields should be retained so that the degree and effects of imputation can be evaluated.

Although imputation can improve the quality of the final data, care should be taken to choose an appropriate imputation methodology. Some imputation methods do not preserve the relationships between variables or distort underlying relationships in the data, while a dataset that requires a significant amount of imputed values is usually a result of a failure in the survey design. The adequacy of the method chosen depends on the type of survey, its objectives and the nature of the error. More information on imputation principles, methods and tools can be found in *Chapter 12.8.1 — Questionnaire design*.

Macro-editing

Macro editing, namely, editing on the basis of a review of aggregated data, is a set of strategies that aim to reduce the number of micro-edits and manual checks that the clerks have to perform.

> The rational of macro-editing is to provide preliminary results before the editing phase and check the consistency of the results before proceeding to the editing phase.

Macro editing is usually done by performing the dataset analysis and identifying the upper and lower limits of the data that requires verification and perform additional checks based on the importance of the item at the total level. Macro editing can reduce the total cost of editing, as it can be used to prioritise and reduce the verification of the collected data (micro-level).

An overview of macro editing methods can be found here.

Estimation

> Estimation is how an NSO calculates estimates that apply to the overall population based on the sample data.

The principle behind estimation in a probability survey is that each sample unit represents itself and a number of other similar units in the surveyed population. Estimation involves assigning a (final estimation) weight to each unit's response in the sample, where the weight indicates the number of units the sample unit represents in the overall population.

The starting point for determining the appropriate weight of a sample unit is the inverse of the unit's probability of selection. This depends upon the sample design and is commonly referred to as the design weight. Determining this weight is an important part of the estimation process. The total of the design weights is the size of the population from which the sample was selected. In the case of a multi-stage sample design, the probability of selection is taken over all selection stages. The design weight is then adjusted to produce the (final estimation) weight. The two most common reasons for making adjustments are, first, to account for nonresponse and, second, to improve the estimate's reliability by using auxiliary data.

Once the final estimation weights have been calculated, they are applied to the sample data to compute estimates. The total of the weights is the total population size estimated from the sample data. Summary measures of the population such as totals, averages and proportions are typically estimated for the characteristics collected from the sample units. These characteristics often referred to as variables in statistical theory, may be qualitative, for example, sex or marital status, or quantitative, for example, age or income. There are various formulae for estimating summary measures depending on the characteristics being estimated and the sample design.

Information on estimation tools can be found in *Chapter 12.8.2 — Sample design and estimation*.

- ABS - Weighting and Standard Error Estimation for Household Surveys (🔗).
- Memobust Handbook - Weighting and Estimation (🔗).
- Reengineering the Census Bureau's Annual Economic Surveys (2018) – sampling and estimation (🔗).
- Statistics Canada - Survey methods and practices (🔗).

9.2.7 Respondent relations and communications

A key challenge of any statistical organization is continually improving relevance and improving and preserving credibility. As the quality of statistical products in many cases relies on the quality of inputs, ensuring respondent cooperation is essential. Methods of ensuring this cooperation are usually divided into two main approaches, often simultaneously used: using legal instruments to force compliance or discourage disobedience and actively communicate and try to appeal to the sense of morality to encourage cooperation.

A statistical organization must earn public trust by treating respondents with respect, not just to reach its statistical goals. It is important to remember that, even in the presence of laws that make response to one or more data collections mandatory, participation by the public in statistical organization is a largely voluntary process. Even when the survey process is not voluntary, a statistical organization should treat respondents in an ethical manner, minimise their response burden, respect their privacy, and maintain the confidentiality they were promised when they provided the information.

In larger NSOs, respondent relations are often centralized into a specialized unit organized within a user communication department, as respondent relations are often similar to handling difficult users. The unit could manage the following tasks:

- handling the public relations required for potential respondents to understand why they have been selected, what is asked of them and what is the public good that is served as a result of their cooperation;
- exercising special care and taking all the required precautions in cases where the announced survey is either unusually long (for example, surveys of family expenditure) or unusually intrusive (for example, surveys of harmful drug consumption and surveys of fertility);
- keeping a register of respondents contacted and survey interviews completed so that recalcitrant respondents can be identified and persuaded to participate;
- sharing information with respondents, so that they feel not only that they have contributed to the public good but that there is some personal benefit as well;

- accomplishing these tasks requires tact and diplomacy, together with firmness and determination. There will always be people in either the household or the business sector who will refuse to comply, no matter how good a case for cooperation has been put forward.

The following sections will provide examples of good practices in respondent relations and advise how to communicate with respondents.

Use of the law to enforce response

Approaches to this issue differ from country to country. In some, compliance with statistical collection is obligatory - if respondents do not provide information in the form in which it is requested and in a timely fashion, they violate the law. In other countries, some requests for certain classes of information are mandatory and supported by legal requirements, whereas others are made on a voluntary basis. This is probably the most common situation, where the law recognizes a restricted set of compulsory surveys or provides a procedure through which a survey can be made compulsory. If this is the case, statistical agencies usually declare economic inquiries as compulsory and others voluntary. Finally, there are cases where the law is unclear on the subject. When this is true, the statistical organization may be fearful of demanding too much information: if challenged, the court might rule that no information is to be demanded compulsorily, and the resulting publicity might adversely affect response rates. Whatever the legal basis, all agencies find that the most important objective is to secure a cooperative attitude on the respondents, particularly from small businesses and households, as compulsion can rarely alleviate the response problem.

- *The Generic Law on Official Statistics* (GLOS), *UNECE (2016);*
- *The Guidance on modernising statistical legislation* (🔗), *UNECE 2018.*

Respondent policy and charter

As noted earlier, maintaining good relations with respondents is a critical factor of success for any statistical organization. As in other areas, standardized, transparent and uniform approach to respondents usually yields best results. An example of good practice is having a clear and easily accessible document, sometimes presented in the form of a respondent charter, that provides basic information to respondents in order to notify them about the general purpose of official statistics, inform them that data collection is necessary because requested information cannot be obtained through other means, and assure them that the information will be kept secure and will remain confidential. This is usually achieved through a dedicated webpage to which respondents are directed via letters or electronic messages accompanying data collection. Respondent charters are particularly useful for business surveys, as they can be used to ensure businesses that the appropriate method of data collection is used and that the response burden is not excessive. Having a respondent charter is a good way of ensuring commitment, as it can oblige the organization respond to any respondent query within a given time period.

Some NSOs also have a dedicated respondent policy unit, with the objectives of helping to raise response rates and ensure that respondents provide information willingly. The staff of the dedicated unit must be equipped to answer questions about the use of the information, the care with which it is handled and the general attitude of their organization. They must avoid the appearance of annoyance and carelessness in quoting from the law and must be fair and consistent in the way they treat businesses and households. If there is a perceived crisis in relations with respondents, the chief statistician is advised to address the matter at his level. Reporting directly to the chief statistician at this level may be a good way to show reluctant respondents the seriousness with which the organization views the matter.

- UK ONS - Respondent Charter for Business Surveys (🔗).

Managing key respondents and business profiling

- **Managing key respondents**

  Some very large businesses are of particular interest to NSOs due to their large contributions to estimates of the total economy, a particular statistical region, domain, or segment of a classification. Accurate and prompt responses from such businesses are crucial in producing good quality estimates. Assigning a single point of contact within the NSO for a particular business for all surveys can result in big improvements in accuracy and timeliness. For this reason, several NSOs have introduced a special organizational unit, typically called the **Large Case Unit** or the **Large Business Unit**, with the exclusive function of managing relations with large businesses.

  Such units have proven to be useful as they can gather more detailed information from businesses while at the

same time reducing the total burden on the enterprises through a more efficient data collection. Furthermore, such units are particularly appropriate for the conduct of **business profiling**, which (as further described below) involves tracking the boundaries and structure of large businesses and validating or modifying their survey reporting arrangements. As large businesses are subject to quite frequent changes in boundaries and structure, without such action, reported values may become incomparable over time. Large case units are also important for tracking accounting practices, particularly to distinguish internal transfer pricing and market pricing, which is particularly relevant in tracking multinational enterprises and globalization related economic phenomena.

- **Business profiling**

  According to the *Eurostat Business Register Recommendations Manual* (🔗) profiling is 'a method to analyse the legal, operational and accounting structure of an enterprise group at national and world level, to establish the statistical units within that group, their links, and the most efficient structures for the collection of statistical data'. The process requires conducting in-depth interviews with senior company representatives to obtain all the company's relevant financial information, relationships, and structures. Profiling is used to improve the quality of the business register and the quality of all surveys that use it as a survey frame and source of information. More information on business profiling can be found in *Chapter 12.3.4 — Statistical sources to supplement SBR content*. The main benefit of profiling is having clear delineation of activities within a company that are separated into 'virtual' statistical units that can provide a more detailed overview of company activity. Once a company is profiled, it is of paramount importance that data is collected in accordance with the profiled structure, or at least that the procedure of imputing the missing values is defined.

- *Guide to sharing economic data, UNECE 2020* (🔗);
- LCU in Ireland (🔗);
- *Profiling in European Business statistics* (🔗);
- *Profiling in the Netherlands* (🔗);

Minimizing non-response and follow-up procedures

- **Minimizing non-response**

  The key to minimising non-response is to reduce the number of non-contacts and refusals. Causes of non-contact depend on the specific survey design. In face-to-face surveys, non-contact can result from the interviewer's inability to reach the respondent within the prearranged number of contact attempts. Increasing the number of contact attempts not only increases the number of 'contacted' and therefore the response rate, but also increases the costs. Alternatively varying the days and times at which contact is attempted also increases the response rate, without significantly affecting the cost. This is done by defining the follow-up procedures in cases of non-contact, usually, if a respondent is not reached within normal operating hours, the second contact is attempted in the afternoon or during the weekend.

- **Follow-up procedures**

  In self-completion surveys, non-contacts can be the result of errors in the survey frame. As most statistical surveys use statistical registers as a survey frame, the solution would be to keep the statistical registers up to date by using administrative data. Another solution would be to check the information from the enterprises themselves, usually, through a register survey, that is intended to update the information stored in the statistical register. Further information on frame improvements and statistical register can be found in *Chapter 12.3.7 — Producing statistics directly from the SBR*. Tools to reduce refusals also depend on the data collection mode used. For instance, interview surveys may use specially trained interviewers to convert refusals, while mail and Internet surveys rely on incentives or special contacts to counteract explicit refusals. When faced with particularly difficult data collections, such as household budget survey or time-use survey (which both require detailed annotation of activities in diary form) statistical agencies often resort to special incentives offered to respondents. These incentives can be monetary amounts, gifts or participation in a lottery with special prises. Ability to organize incentives may depend on local laws and regulations.

Measuring the response burden, individual and total

Many countries are making efforts to measure and reduce the administrative burden on businesses. Even though providing data for official statistics comprises a small fraction of the total administrative burden, NSOs are giving significant focus to reduce the response burden. The time spent on responding to a questionnaire (including the time needed to retrieve the required data and to fill in the questionnaire) is a quality and performance indicator (QPI) that should be monitored for every survey, as further discussed in *Chapter 8.5.6 — Monitoring quality and applying quality gates*. Even if the questionnaire does not measure the time spent completing the questionnaire, the survey manager can usually provide a reliable estimate based on a desk study or questionnaire testing exercises.

Measurement of the response burden in hours can be translated into monetary terms by multiplying the hours by the average hourly wage in a sector subject to the questionnaire. Multiplying the average response burden by the number of respondents to a survey gives the survey's total response burden. Summing the figures for all surveys within a year gives an overall annual total response burden imposed by the NSO. Having a list of surveys and their response burdens is useful in setting development priorities for the NSO, particularly those that can lead to the modernisation of data collection activities, through which the response burden can be reduced. Examples are (i) modernisation of a paper-based survey to web-based data collection, and (ii) use of administrative data to reduce the total number of questions within a survey questionnaire or eliminate the survey.

Some NSOs also measure the individual burden of each business respondent and/or flag the respondents of each survey in their statistical business register to momentarily exclude them, if possible, from future survey samples. For household surveys, gradually rotating the sample rather than replacing it can be an effective method of spreading response burden equitably and while at the same time having a longitudinal component in what would otherwise be a cross-sectional survey.

9.2.8 Designing integrated survey programmes

> Although continuous improvements in survey taking can be noted throughout the world, improvements have mainly been focused on improving individual surveys rather than integrating different surveys into a modular and unified collection system.

The result is that the speed of development might be unequal, different frames and their update procedures may be used, sampling, collection and processing methodologies may be different – resulting in unnecessary burden for some respondents (usually large enterprises).

Integrated suite of surveys

A solution to the issues mentioned above is to design an integrated suite of surveys. Integration in the context of survey programmes implies linkages between different surveys or between rounds of a single survey. There are three main objectives of integration: enhancement of survey results, reduction of costs, and reduction of response burden.

Integrated surveys have the following common characteristics:

- harmonized concepts and questionnaire content;
- use of a common survey frame, such as statistical register, master sampling frame or master sample, as further described in *Chapter 12- Common statistical infrastructure*; and
- adopting generic sampling, collection and processing methodologies, as also further described in *Chapter 12 – Common statistical infrastructure*.

The approach has been tested in different statistical areas and has proven to be particularly useful, as it leads to a significant reduction in response burden, while at the same time allowing more detailed insights on a lower territorial level. Examples of an integrated suite of surveys can be found in business, social, agricultural and environmental statistics and have been successfully implemented in many countries. Integrated survey programs, particularly those that involve a significant proportion of the overall NSO budget, should be included in strategic plans and carefully planned and evaluated.

- FAO - The Agricultural Integrated Surveys Programme – AGRISurvey.
- Philippines PSA - ISLE Integrated Survey (🔗).
- Statistics Canada - The Integrated Business Statistics Program (🔗).

- *Statistics New Zealand - Integrated household surveys* (🔗).
- *Toward an Integrated Annual Business Survey System* (🔗).

Core survey vehicles and supplementary modules

> A usual approach to an integrated survey programme is to introduce a core set of questions addressed to all respondents together with a set of specific modules and/or rotating supplements containing additional questions.

For business surveys, this enables appropriate tailoring of questionnaires by industry using industry-specific modules as well as rotating supplements on topical questions. By utilising this approach, core information (such as the number of employees or turnover for business statistics, or employment status or sources of income for social statistics) can be gathered coherently from multiple sources, thus allowing representativeness at a lower territorial level than could otherwise be achieved without increasing respondent burden.

A similar approach is also used in household surveys, which are often used for multiple purposes. For example, a labour force survey often has a core module and supplementary (ad-hoc) modules used for more detailed inquiries on sub-topics using the same master sample. There are also examples of surveys designed to collect data on multiple purposes comprising loosely connected modules.

Using supplementary modules also enables imputation of missing variables and construction of estimates using small area estimation methods. This approach is particularly useful in combination with administrative information (both in business and household surveys) used for record linkage and further reducing the response burden. It implies that unique identification numbers that enable record linkage should always be collected as further discussed in *Chapter 15.2.11 — Linked data*.

Responding to urgent requests

One of the comparative advantages of NSOs relative to other data providers is the trust that users have in official statistics. This trust is, amongst other things, built on the accuracy of the data outputs, which, in turn, depends upon the good design and careful execution of statistical processes. Thus, the NSO faces a challenge when confronted with a new and urgent demand for statistics. Being unable to deliver quickly has potentially negative consequences for the NSO. On the other hand, a new and urgent data demand can be an opportunity to gather much-needed resources, tap into a new data source, increase the visibility and/or credibility of the NSO and compete effectively with alternative data providers.

High-profile, urgent requests most commonly come from the government, but may also arrive from international organizations. The NSO should be swift to respond and use the limited window of opportunity to negotiate additional resources allocation. The chief statistician should use his authority to explain to all parties the particularities of statistical data collection.

> An NSO should not automatically initiate a new survey in response to every new data demand. Rather, it should systematically explore whether the demand could be fully or at least partly satisfied using regularly collected data or administrative data.

The sense of urgency from the users, typically if the user is the Government, may open new opportunities for accessing new data sources. It should be noted that not all requests have to be accepted by official statistics, particularly those that can be easily obtained from private-sector survey companies.

Although the request might be one-time-only, the NSO should bear in mind that periodicity is an important feature of statistical activities and plan and communicate (to ones that are requesting the data) accordingly. Urgent requests may be disseminated under the 'experimental statistics' label if there is no certainty that the effort will be repeated or if the results do not satisfy the usual statistical standards as further elaborated in *Chapter 4.5.5 — User access to confidential data for their own statistical purposes*.

Flexible survey-taking capability

To respond to urgent new data demands, some NSOs have introduced an organizational unit that can design and conduct a quick survey, either as the first cycle of a permanent new survey or as a one-time exercise. The responsibility for feasibility tests can be assigned to such unit, so that its staff become accustomed to launching quick efforts designed to

settle basic questions, prior to what might be a more substantial survey. By developing such a capability and periodically demonstrating its power and scope, an NSO can increase its relevance.

> Integrated survey programmes also increase the capacity of an NSO to respond quickly to new requests, as a module or additional questions may be added more quickly to an existing survey rather than setting up an entirely independent data collection.

9.2.9 Survey staff training and expertise

Successful planning, design, implementation, and evaluation of a survey requires cooperation and coordination of various specialists with different technical skills. Due to their specificities, these skills are often not easy to obtain outside of the statistical system and therefore often have to be developed and maintained internally (more information on options for organizing staff training can be found in *Chapter 13 - Human Resources Management and Development*). As proper training of survey staff is key to ensuring the quality of statistics, it is important to invest time and training resources. Training also enables standardisation of approaches and should promote process optimisation and use of new methods. Organizing efficient training is particularly important for interviewers, as well-educated interviewers can significantly improve the resulting statistics. Subsections below list the staff expertise and skills for efficient survey taking. Survey teams are usually organized interdisciplinary and are typically composed of a survey manager, an expert in the field of study covered by the survey (a subject matter specialist), a methodologist, a computer systems analyst, and a data collection and operations expert. All members of the survey team plan, manage and coordinate activities within their scope of expertise and responsibilities covered within this chapter.

Survey managers

The survey manager is responsible for the management of the survey. He or she is usually a senior expert with extensive experience of participating in multiple phases of multiple surveys. The survey manager ensures that the objectives, budget and schedule are respected. The survey manager is usually responsible for determining the required resources for the survey, developing a preliminary plan, coordinating the preparation, preparing the budget and monitoring resource utilisation and progress. The survey manager presides over team meetings and should understand and represent the interests of the users. The survey manager liaises with and reports progress to senior management and the client. He or she ensures adherence to legal and regulatory commitments and departmental policies, standards, guidelines and regulations.

> The survey manager should be an excellent organizer, with substantial personal authority, that has a deep understanding of the main survey processes.

Survey managers usually come from their respective subject matter units, but sometimes a methodologist or IT specialist can also perform the tasks of the survey manager. Interpersonal and organizational skills should be the main selection criteria for the task of the survey manager, but subject matter knowledge and understanding of processes should not be overlooked, as gaps in those areas may undermine the authority and cause significant problems in survey implementation.

Subject matter specialists

The subject matter specialist is responsible for the content of the survey. He or she conducts or co-ordinates the preparation of definitions and concepts, questionnaire development and testing, preparation of data collection and processing specifications, design of statistical outputs, development and implementation of data analysis and preparation of analytical texts. He or she also co-ordinates the validation of survey results and provides subject matter expertise for the evaluation of data quality and preparation of related documentation.

> Subject matter specialists should have a deep understanding of the subject matter and underlying processes required for a reliable response (such as accounting).

He or she should also fully understand survey processes and results, as he or she is responsible for preparing content and its transformation into statistical output. Subject matter specialists should possess advanced analytical knowledge, that will allow them to prepare and interpret results. Further, subject matter specialists should understand the fundamentals required for questionnaire design, know data manipulation and understand basic programming concepts. Understanding of related methodological and IT issues is necessary as it simplifies the cooperation with methodological and IT experts

and departments. This often includes knowledge of econometrics (at least basic) and understanding of other data manipulation techniques. Finally, language and data visualisation skills are also valuable as they can increase the quality and understanding of the data presented.

Methodologists

A survey methodologist is responsible for conducting and coordinating the design and development of the statistical methodology to be used for the survey.

> He or she is responsible for the sample design, weighting and estimation, quality control design, data quality evaluation designs and measures, the design of edit and imputation mechanisms or strategies, and statistical aspects of data dissemination and analysis.

The survey methodologist also acts as a consultant and adviser to all other survey team members on matters of statistical methodology and ensures adherence to the use of sound and efficient statistical methods.

Survey methodologist should possess advanced statistical knowledge as well as advanced data manipulation knowledge. He or she should understand econometrics (for imputation and modelling) and possess at least intermediate programming skills, as he or she is often forced to write programming code and code modification requests for all aspects of survey processing.

Data collection and follow-up specialists

The data collection specialist is responsible for the development of data collection specifications and procedures. He or she is also responsible for coordinating the recruitment, training, monitoring and control of interviewers and supervisors. His or her responsibilities include developing, implementing, and managing collection operations and preparing material and logistical support. He or she also acts as an adviser to all other members of the survey team on operational matters and ensures the specifications and requirements developed by other team members are properly built into the procedures.

> The role of the data collection specialist may include the coordination of field collection through Regional Offices, as well as the implementation of manual and automated operational activities performed at the Head Office.

Processing specialist is responsible for the development of capture and coding specifications and procedures. He or she is also responsible for coordinating the recruitment, training, monitoring and control of the data input, editing and processing staff. His or her responsibilities include the development, implementation and management of capture and coding activities as well as coordination of logistical support related to data processing.

For smaller projects, the role of the data collection and processing specialist may be combined.

Essential skills for both roles are the ability to effectively coordinate a large team, have the organizational authority and the ability to enforce and observe deadlines. Both data collection and processing specialists should have a deep understanding of the data collection process as well as a basic understanding of all previous and following phases, so he/she can propose improvements if necessary.

Interviewers

Survey methods and practices by Statistics Canada lists the following keys to effective interviewing:

Confidence

The interviewer must have confidence in his or her abilities. This is only possible with a good understanding of the survey and the interviewer's role.

Listening skills

The interviewer should wait for the respondent to finish speaking before they stop listening. The interviewer can indicate that he or she is listening with an occasional 'I hear you'. However, the interviewer should not make assumptions about what a respondent will say or try to finish a sentence. It is better to ask questions if the interviewer feels that the respondent or the interviewer missed the point.

Empathy

The interviewer should be sensitive to a respondent's situation at the time of the call or visit. If the respondent describes a personal incident, the interviewer should show interest (but never pass judgment) and then try to refocus the respondent back to the interview.

Speech

Vocal expression is important, and particularly so in telephone interviews. The interviewer should speak very clearly and try to speak at a moderate speed. If the interviewer speaks too quickly, respondents could miss parts of a question. Speaking too slowly causes respondents to begin answering before the interviewer has finished the question. Lowering the head lowers the pitch of the voice. A lower pitch voice is clearer and carries better, particularly on the telephone. The proper speed and pitch should be demonstrated during training.

Know the Questionnaire

The interviewer must know the questionnaire, concepts and terminology used by the survey. There will not be time to look up definitions or answers to questions in the manual during an interview. Nothing breaks the rapport more quickly than long pauses, especially in telephone interviews.

Data Entry and Editing Clerks

Even though modernisation of statistical processes has reduced the need for manual editing, this activity is still necessary as it significantly increases the quality of official statistics. Data entry and manual editing are often performed by personnel without higher education, but significant benefits can be achieved through education and specialisation. A common skill

needed in both data entry and editing is high levels of concentration, as the tasks are repetitive, and workers need to spend a lot of time on the same task. This kind of job, therefore, requires a very high level of concentration and patience. Lack of this attribute may lead to poor quality of results. Data entry, but also editing clerks are expected to have exceptional typing speed as they will have to input and check huge amounts of data in a very short time. They need to be comfortable with all forms of data entry devices and be comfortable using a mouse, keyboard, scanners, etc. It is also important that they are versed with the use of basic software such as word processing and spreadsheets, but they must also be accustomed to using the specialised data entry and editing software, and hence basic computer usage knowledge is a must.

9.3 Administrative sources

The United Nations' Fundamental Principles of Official Statistics (UNFPOS) state that "Data for statistical purposes may be drawn from all types of sources, be they statistical surveys or administrative records."

The term administrative data refers here to data collected by a government ministry, department or agency primarily for administrative (not research or statistical) purposes. These administrative purposes are related to the corresponding executive or lawful functions such as authorisations, registrations, permits, payments, sanctions, control etc. Administrative data may include both data in administrative registers and data in other administrative sources.

Using administrative data for statistical purposes is not a recent phenomenon – there are examples of compiling statistics from data on the number of births and deaths dating from the early 17th century. However, it has become increasingly widespread during the last two decades as progress in technology and increased computing capacity have permitted statistical agencies to overcome many of the limitations previously associated with the processing of large administrative datasets. This together with advances in data linking methods has provided NSOs with the opportunity to make better use of administrative data in the production of official statistics, both in replacing existing data collection methods, in supplementing statistical survey data and in the creation of new statistical products.

> In 2011, the UNECE published a handbook entitled *Using Administrative and Secondary Sources for Official Statistics – A Handbook of Principles and Practices* (🔗). It gives an overview of administrative data sources and data collection issues, and it is used as a basis for this section. The rapid development during the last decade has increased the common knowledge of administrative sources among statisticians. Further information on the latest experience can be found on NSOs' and international statistical organizations' websites, joint projects and various statistical conferences.

The use of administrative data and the production of register-based statistics are covered in *Chapter 13.2 — Register-based statistics*.

- Statistics Bhutan Guideline for Assessing Quality of Administrative Data for Producing Official Statistics (🔗)

9.3.1 Types of administrative data

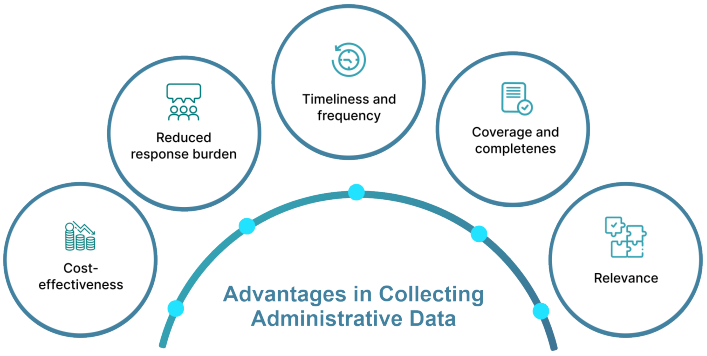
Public authorities in all countries collect a large amount of data as a part of their ongoing operations. Administrative sources cover a wide range of activities such as collecting taxes, social security and health care, employment and unemployment policies, and registration systems for civil events (births, deaths, marriages etc.), businesses, properties and vehicles. This administrative data has become increasingly available to NSOs, and in consequence, there has been a significant impact on how data are collected, and official statistics are compiled.

Administrative data come from many different sources depending on the structure of the public sector in the country. The most common way to utilise administrative data in statistics production is to combine data from different administrative sources with or without data from statistical surveys. In this data integration process, some administrative data sets have a principal role and are widely used by many NSOs. Below, administrative data sources are grouped according to their coverage and content to illustrate their importance and usefulness for the production of official statistics.

- Large and complex administrative data systems contain both registration data and data of transactions. Typical examples are data from population and business registration systems, social security and health care systems, taxation systems, customs systems and building and property registration systems. Usually, these data are complete, exhaustive by nature covering all citizens, enterprises, or the entire stock of properties and buildings. Basic information in the administrative registers in this group may contain identification code, name, address, registration date and other identification and classification information. The authorities responsible for these registers have created systems for continuous (often on-line) updating of the basic content of registers. The authorities keeping these large administrative registers may also have other data systems to carry out their main administrative functions. For example, tax authorities may have basic registers of people and enterprises liable to taxation and separate systems for personal and enterprises' income tax, value-added tax and property tax. Data from the producers of these large data systems are usually used as source material in many different statistical systems varying from population and social statistics to business, economic, and environment statistics.
- Administrative data with a more specific scope include typically registers and data from transport and traffic authorities, justice and electoral authorities as well as education and school systems. Often this data is an important, or only, source, e.g., in production of transport statistics, statistics on justice and crime, statistics on general elections and statistics on education. Administrative data from this group is also used as an additional source for business and economic statistics as well as population and social statistics. This group also belongs to a vast amount of specific administrative data useful in compilation of environment, energy and waste statistics, and administrative data for public sector activities and finances. Some administrative data have the scope and content which may be difficult to obtain through surveys.

9.3.2 Advantages in collecting administrative data

The data collection arrangements and the potential advantages vary from country to country depending on the national circumstance and on the extent to which an NSO plans to use administrative registers and data. The most commonly discussed advantages of using administrative sources in statistics production are presented below.



- **Cost-effectiveness**: an important advantage in using administrative data to compile statistics is that the cost of data collection is relatively small in relation to the costs that are incurred in conducting censuses, creating and maintaining statistical base registers and conducting direct surveys as essentially the costs of data collection have already been covered by the administrative process itself. Use of administrative data, however, is not cost-free to NSOs. There may be a need to invest in ICT- and production systems, coordination mechanisms, and statistical methods and new competences. The NSO may also be obliged to pay data transfer and transmission costs to administrations even though data itself is free of charge.
- **Reduced response burden**: respondents may react negatively to a survey if they feel they have already provided similar information to public authorities. The increasing reluctance of both firms and individuals to participate in statistical surveys, not least surveys of small and medium-sized businesses, may threaten the quality of statistics. Use of administrative data leads to reduced response burden and at the same time may solve the problem of growing non-response rates and increasing the quality of incoming source data and statistics.

- **Timeliness and frequency**: when governments are developing their ICT-systems and moving towards on-line data collection and mobile services, administrative registers are continuously updated, and administrative data are available relatively quickly. Consequently, statistics based on administrative data can be prepared more quickly and can be released earlier than from data collected through statistical censuses and surveys. Due to the continuous on-line or other updating systems of administrative registers, administrative data may also increase the frequency with which statistics are traditionally compiled and published.
- **Coverage and completeness**: administrative sources often give complete coverage of the target population, whereas sample surveys often directly cover only a relatively small proportion of it. Use of administrative data sources may diminish or eliminate the errors due to non-response and other typical errors of sample surveys. Administrative registers and data offer good sources for creating and maintaining statistical base registers, better coverage of target populations for sample surveys, and can make statistics more accurate. Use of administrative data instead of surveys can also improve regional and small-area data and more detailed information.
- **Relevance**: an NSO can improve its ability to respond to new data needs and increase the relevance of statistics by seeking and taking into production new administrative data sources. Administrative registers and data combined with survey data can improve the flexibility of the NSO to react quickly to new statistics demands. Administrative data can play an important role, e.g., in filling data gaps needed to measure progress on the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development that cannot be satisfied through traditional methods alone.

9.3.3 Challenges and issues in collecting administrative data

Although there are many good reasons to use administrative data, several challenges and problems are associated with data collection. These relate to the data collection arrangements, the preparedness of the data providers and the NSO, and the quality of the data itself. The national statistical legislation usually gives a sound basis to NSOs to collect and process statistical surveys and publish statistics. As to the acquisition of administrative data, legislation is often inadequate and may cause many problems or even prevent acquisition.

The challenges are related to the administrative culture and traditions. Administrative authorities may be reluctant to grant access to "their data" for statistical purposes. This may happen even in a country with appropriate statistical legislation in place. Administrative authorities may have a strong proprietorship regarding administrative registers and data for which they are responsible. In some cases, legal restrictions or confidentiality provisions may be imposed that restrict access to administrative data. In some countries, the desire and proposals of the NSO for minor changes to the administrative data collection arrangements that would improve the usefulness of the data may be impossible to implement in practice.

To meet the common challenges and be better prepared for data acquisition from administrative sources *Chapter 9.3.4 — Requirements for access to and acquisition of administrative data* summarises the basic requirements based on the current knowledge and practice of the countries.

Appropriate data collection arrangements make it easier to assess and respond to the problems relating to the quality of administrative data and the use of these data in statistics production. In each country, the quality of administrative data varies across the sources. Before collecting and using any administrative data set, it is necessary to conduct a thorough quality assessment and plan corrective measures. Often this quality assessment requires that the NSO get access to record-level administrative data. Poor quality administrative data should not be used in the production of statistics.

Box 5: Collaborative on the use of Administrative Data

> Administrative data collected by governments and service providers in the course of their day-to-day business is an increasingly important source for the production of official statistics. There is an urgent need to strengthen the capacity of national statistical systems to leverage administrative data for statistical purposes to fill gaps in the data available to policy and decision-makers to monitor progress and implement the 2030 Agenda and address challenges such as the COVID-19 pandemic.
>
> Responding to this need for increased use of administrative data for statistical purposes, the United Nations Statistics Division (🔗) and the Global Partnership for Sustainable Development Data (🔗) have jointly convened a multi-stakeholder collaborative of more than 25 countries and regional and international agencies.

A key objective of the Collaborative is to strengthen the capacity of countries to use administrative data sources for statistical purposes across thematic areas and throughout the business process. Members of the Collaborative are working together in a coherent and cross-cutting manner to address both urgent and longer-term needs around the access and use of administrative data for statistical purposes, building on advances +made in various sectors and by different partners. Next to building on these advances, the Collaborative aims to fill knowledge gaps and develop tools and other learning resources.

Rooted in the Collaborative's Guiding Principles (🔗), the initiative aims to provide a platform for sharing resources, tools, best practices and experiences. It also contributes to raising awareness among all members of national statistical systems about the benefits of sharing and combining administrative sources to enhance the quality, timeliness, coverage, and level of disaggregation of statistical data.

Among the tangible outputs developed within the last year are an Inventory of Resources on Administrative Data (🔗), four (4) expert clinics on labour statistics (🔗), quality (🔗), interoperability (🔗) and cooperation with data owners (🔗), a self-assessment tool for statistical legal frameworks and a guideline for Memorandums of Understanding. Developing e-learning resources for ministries, departments and agencies that collect and own administrative data is in progress.

Below are listed often mentioned quality problems, doubts and perceived attitudes towards collecting and using administrative data in statistics production together with some solutions used in current practice.

- **Differences in units, concepts and definitions of variables**: units, concepts and definitions of variables used in administrative data often differ from the statistical ones. This is especially a big problem in the field of business and economic statistics. There are many case-by-case studies on how these problems can be solved made by NSOs and international organizations. Sometimes good proxies can be used; sometimes, additional survey data are needed. Differences and possible correction methods should be published together with published statistics.
- **Differences in classifications**: often the classifications used in administrative sources differ from the statistical standards. This may confuse users of statistics. By statistical law, the NSO decides and confirms classifications to be used in official statistics. In some countries, the national classification of economic activities, based on the international statistical standard and confirmed by the NSO, is given an official national standard to be also used by all administrative data producers. This may not entirely prevent wrong coding as the codes used for units may be erroneous. Creating and using link tables is an often-used method to adjust for differences in classifications even though it adds to the NSO's workload.
- **Inadequate data quality**: data included in administrative registers and data files may be incomplete or inaccurate, or data can be missing. In some cases, the staff of an authority responsible for the administrative data may not be properly trained, or methodology for recording appropriate information may be flawed. The corrective measures may include good quality control systems and correction methods of incoming data, training of staff and discussions of quality issues with the administrative authority.
- **Lack of statistical know-how**: the authorities providing administrative data do not generally have the same levels of statistical knowledge and capacities as an NSO. As a result, inconsistent data may occur. For example, some of the data may not be accurately or carefully recorded and could be incomplete or inaccurate for items of secondary interest or value to the primary administrative purposes. In these cases, close co-operation between the NSO and the producers of data in question and training activities of the NSO may help.
- **Need for additional data checking**: depending on the source, administrative data require comprehensive validation checks. Furthermore, a reconciliation process between different data sources may be necessary. This can involve considerable effort and costs to the NSO.

9.3.4 Requirements for access to and acquisition of administrative data

Challenges relating to data collection arrangements are related to the general administrative and legal structure of the country. Access to administrative data, the preconditions for data collection and the possibilities to use these data vary from country to country. Various frameworks are needed to facilitate the access of the NSO to administrative data. These frameworks include legal, policy, organizational and technical dimensions.

All these dimensions should be considered when the NSO is planning data collection from administrative sources. Short descriptions of the main requirements for successful data collection are briefly summarised below.

Legal frameworks

Use of administrative data in the compilation of official statistics requires a firm legal basis. A mandate ensuring the NSO access to administrative data is seen as one of the key issues in modernising statistical legislation. Depending on the national legislation structure, it is important to note that the mandate of the NSO to collect data from administrative sources may also require changes in other legislation. *Chapter 3.4 — Legislative frameworks* gives further guidance on sound statistical legislation. The principal issues are highlighted in the following paragraphs.

> The legislation must provide the NSO with the right to acquire the administrative data free of charge and ensure that the NSO provides the appropriate level of data safeguards such as data protection and confidentiality.

This is vital in gaining and maintaining the public approval of the NSO's ability to properly manage administrative data and for the public to have confidence in the official statistics disseminated.

Simply to be allowed to collect data from an administrative source, or to have access to them, is a rather vague/rough provision and needs more precise interpretation. Ideally, the NSO should have access to record-level administrative data and relevant metadata, it should have the right to combine administrative data with survey and other data, and it should be informed about the administrative data sources and changes in them in due time.

Access and use of administrative data in statistics production have raised important questions regarding whether this increases the probability of violating privacy or breaching business secrets or breaking statistical confidentiality rules. Therefore, it is important to synchronize other legislation with the statistics law. Legislation must ensure the implementation of watertight data security, protection of privacy and statistical confidentiality. These rules should be made known to the administrative authorities and the society at large. It should also be guaranteed that when the NSO acquires administrative data, it is handled strictly according to the statistical confidentiality principles. Data flows go only in one direction, i.e., from administrative authority to the NSO.

Public approval for the government use of administrative data

Even if an NSO is an autonomous organization, it is at the same time part of the governmental sector.

> The NSO cannot operate alone in its efforts to use administrative data in statistics production. Instead, it needs support from other authorities, political masters, the general public, and the society.

Public opinion about sharing data between different government departments varies from country to country. It may be in favour due to the increasing efficiency of administration, and it may be even hostile in fear of diminished privacy and 'Big Brother Syndrome'. It is important to make clear that the use of administrative data for statistical purposes does not mean sharing data within the governmental sector. The NSOs should be active in explaining the protective measures taken in accordance with the confidentiality principles and the law. Open discussion and debate, explaining the rationale and benefits of using administrative data in statistics production should be a key principle of the NSO.

One of the most important users of official statistics is the government sector with its growing needs for new and relevant, high-quality statistics. At the same time in many countries, there is growing pressure for budget cuts. In this situation, the governments may be willing to support NSO's efforts to develop sound infrastructure, lower the costs of statistics and increase conditions to meet the new data needs. In return, NSOs should advocate for getting access to administrative data for statistical purposes as it reduces the costs of the production of statistics without altering the quality of the final products.

Technical frameworks

Technical frameworks refer to the mechanisms by which data and metadata are transferred. The data transfer mechanisms can vary between countries and sometimes between administrative authorities of the same country. This depends mainly on the maturity and sophistication of the ICT-systems of the data providers, on one side, and the NSO on the other side. Data providers may send the data files to the NSO, or the NSO may extract the data directly from the administrative source database. Machine-to-machine access for Big Data sets and on-line access are becoming more common. Broader open data initiatives at the government level may further support direct access in the future.

> From a technical perspective, it is becoming easier for NSOs to access data from administrative sources when governmental organizations are developing IT-systems and digitalizing their processes.

Further, providers of administrative data may also use international statistical standards for data and metadata transmission. In addition, the transmission of data to the NSO may benefit from common national standards applied across the entire government sector.

Cooperation with administrative authorities that are data providers

The use of administrative data for the production of official statistics creates a strong link, or sometimes even interdependency, between the NSO and administrative data providers. Therefore, the NSO needs to follow up on changes in the administrative structures, in legislation relating to administrative data and any e-government initiatives.

> Good co-operation between the NSO and providers of administrative data is needed to ensure that the administrative registers and data are suitable also in the long run as sources of data for the production of official statistics.

In return, administrations can benefit from the know-how and expertise of the NSO in collecting, processing and analysing data and eventually improve the timeliness and coverage of their administrative data. In some countries, NSOs have set up working groups to enhance collaboration and regular dialogue with administrative data providers. These collaborations mechanisms are often governed by memoranda of understanding between the statistical office and the administrative data providers which foresee that the NSO would be informed and consulted well in advance about any changes on the structure, coverage and timeliness of the administrative data set used for statistical purposes.

Such policies and agreements can lead to positive outcomes on both sides. The NSOs can build relationships with administrative data providers by offering expertise in collecting, editing, and storing data by promoting statistical standards and providing guidance in quality issues. These measures, in return, may improve the quality of administrative data. However, the borderline between the producer of official statistics, typically the NSO, and the administrative data providers has to remain clear; in particular when it comes to the principles of confidentiality and professional independence as presented in *Chapter 4.2.2 — Legal frameworks, obligations, and restrictions*.

Preparation and facilities of the NSO

Acquisition from administrative sources needs to be carefully planned and monitored to detect any potential hindrances and issues; in particular when such data is going to replace or has replaced data collection through surveys conducted by the NSO. When administrative data is used for the time, NSO should carefully assess its impact and, when relevant, adapt its internal production processes. These changes may take some time as they require adequate staff, infrastructure and IT technology.

> The NSO with established use of several administrative sources may consider creating a specific functional unit for administrative data in the data collection department through which all data coming from administrative sources should go before they are processed.

This unit would be responsible for checking that incoming data files are acceptable and conducting the first validation and quality checks. The unit may also be responsible for managing the system of data collection agreements (ToR) between the data providers and the NSO. The aims and development of this kind of unit are described in the paper 'The system of collecting administrative data and how it responses to the quality guidelines of the code of practice and the peer review' (🔗) published in 2017.

9.3.5 Processing administrative data

The Generic Statistical Business Process Model (GSBPM) is designed to be applicable regardless of the data source. It can be used for the description and quality assessment of processes also based on administrative data. GSBPM is discussed in *Chapter 6.3.1 — Administrative structure and finance of the national statistical office* and *Chapter 15.4.3 — Generic Statistical Business Process Model (GSBPM)*. Before planning the use of administrative data for statistical purposes, it is recommended to take a closer look at this model which covers all phases of the statistical production process.

At a general level, an NSO should have a clear understanding of what specific administrative data are needed and for which statistical purposes. It is important that for each administrative data set the underlying administrative process and relating legislation have been carefully analysed. A thorough understanding of the content of administrative data, including definitions of units, concepts and variables as well as updating systems is equally of great importance.

There are many variations regarding the use of administrative data in the production of statistics. For example, these data can be utilised to substitute for or supplement survey data, construct statistical registers, generate and update sampling frames, and create integrated statistics such as national accounts and as a part of register-based statistics. Some administrative sources, e.g., the administrative population register, can be used simultaneously for many statistical purposes.

Processing of administrative data is not a specific part or a separate sub-process of the GSBPM, but it is embedded in all process phases. Even though the GSBPM identifies possible steps in the statistical process, it does not require any strict order in which these steps or sub-processes are to be conducted.

> It is important when processing administrative data as one data source for statistics that all necessary steps and sub-processes have been considered and taken into account in the process planning.

An illustrative example of the processing of administrative data in the framework of GSBPM is described in the paper: Methodologies for an Integrated Use of Administrative Data in the Statistical Process (🔗).

Processing administrative data in the context of register-based statistics is further discussed in *Chapter 12.2 — Register-based statistics*.

- *Using Administrative and Secondary Sources for Official Statistics: A Handbook of Principles and Practices, UNECE, (2011)* (🔗);
- *The system of collecting administrative data and how it responses to the guidelines of the code of practice and the peer review, Statistical Journal of the IAOS 33 (2017), Statistics Finland* (🔗);
- *Eurostat - Methodologies for an Integrated Use of Administrative Data in the Statistical Process* (🔗).

9.4 Geospatial data

The term geospatial data refers to data that has a geographic component. This means that the records in a geospatial dataset have implicit locational information such as an address, city, or a postal code. A geographic information system (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present geospatial data.

> GIS data comes from satellite imagery that can create data-rich images with extracted vector features and attribute data. They can be used in mapping applications to achieve a multi-layered result for many types of analysis. Satellite imagery has significant potential to provide more timely statistical outputs, reduce the frequency of surveys, reduce respondent burden and other costs, and provide data at a more disaggregated level for informed decision-making.

The value of linking statistical information to location has long been recognised and implemented by NSOs for many years. This began with the use of GIS by the Canadian statistical office in the 1980s and has evolved over time as

improved infrastructure, tools and skills have facilitated more advanced geospatial analysis. Such data has the potential to reveal new insights and data relationships that would not have been possible by analysing data in isolation.

> It is now readily accepted that integrating statistical and geospatial information can play a key role in providing the data for decision-making processes at local, sub-national, national, regional, and global levels.

In particular, this is vital for measuring and monitoring the targets and global indicator framework for the SDGs. It will also be a vital element for future censuses. Such integrated information will also allow for comparisons within and between countries in a more harmonised manner.

Before using geospatial data, an NSO will need to consider the strategic questions as to what value can it provide, what risks are involved, how to work together with mapping agencies, the ways to improve location coding of statistics and how best to harmonise methods between statisticians and mapping agencies.

9.4.1 UN-GGIM Frameworks

"Geospatial data, methods, frameworks, tools, and platforms are urgently needed, and reliable, timely, accessible and disaggregated geospatial information must be brought to bear to measure progress, inform decision-making and ensure effective and inclusive national and subnational programs that will chart the path towards the 'Geospatial Way to a Better World', to assist in the implementation of the sustainable development goals (SDG's), and transform our world for the better." The UN Secretary General's opening statement at the first United Nations World Geospatial Information Congress, held in Deqing, China, in November 2018.

The 2030 Agenda for Sustainable Development is an overarching global framework, and oversight for all other frameworks and recognizes the critical importance of geospatial and Earth Observation. Over the past six years, the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) has developed several global geospatial frameworks supporting sustainable development and the integration of statistics and geospatial information. The overarching geospatial framework is the Integrated Geospatial Information Framework the (IGIF) and at the strategic level there are frameworks on disasters, statistical and geospatial integration, and land administration. At the bottom tier, there are frameworks on: Fundamental Geospatial Data Themes, the Global Geodetic Reference Frame, Standards Guides, Licensing of Geospatial Information, and Shared Guiding Principles.

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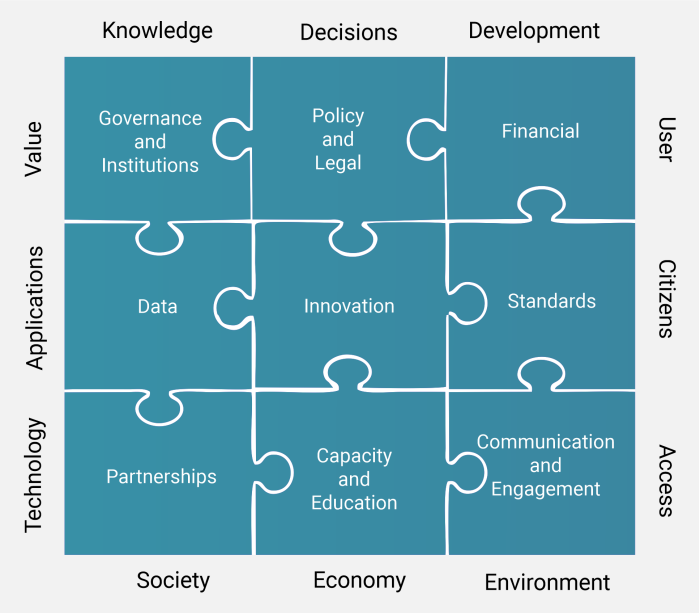
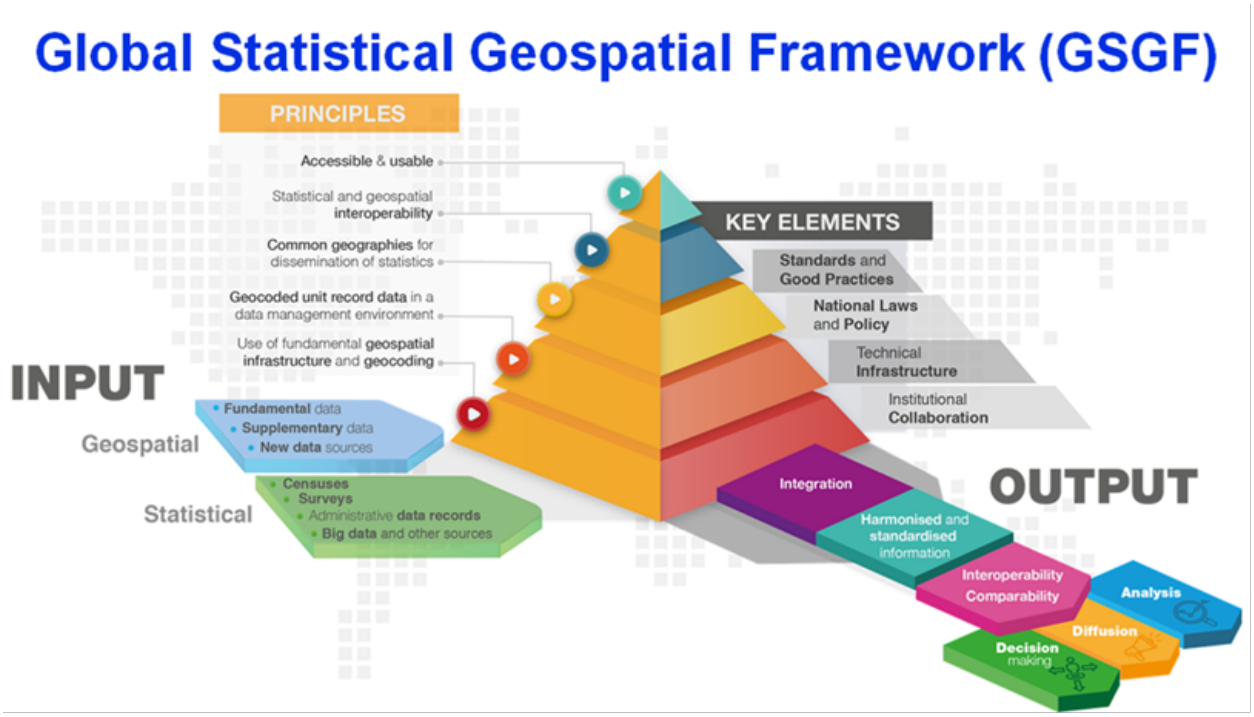
The connection between global development frameworks and UN-GGIM frameworks is the *SDG's Geospatial Roadmap* (🔗), (to be presented for adoption at the 53 Session of the Statistical Commission). The SDGs Geospatial Roadmap is intended to help to "build the bridge" and to promote understanding between the statistical and geospatial actors working with the global indicator framework. It provides simple and actionable guidance for national statistical offices, national geospatial information agencies, custodian agencies and others working within the national Sustainable Development Goal ecosystem. It serves to convey how the Integrated Geospatial Information Framework (IGIF), the Global Statistical Geospatial Framework (GSGF), and other frameworks have an important "integrating" role in advancing the 2030 Agenda.

The Integrated Geospatial Information Framework (IGIF) (🔗) the umbrella geospatial framework provides the specific guidance and recommended actions to be taken by Member States to establish, improve or strengthen their national arrangements in geospatial information management, systems and infrastructures, in particular in developing countries.

The IGIF acts as a catalyst for economic growth and stimulates improved decision-making for national development priorities and the Sustainable Development Goals (SDGs). It has three parts – an overarching strategy, nine implementation guides and country level action plans.



The *Global Statistical Geospatial Framework* (GSGF) facilitates the integration of statistical and geospatial information.



A Framework for the world, the GSGF enables a range of data to be integrated from both statistical and geospatial communities and, through the application of its five principles and supporting key elements, permits the production of harmonized and standardized geospatially enabled statistical data. The resulting data can then be integrated with statistical, geospatial, and other information to inform and facilitate data-driven and evidence-based decision making to support local, sub-national, national, regional, and global development priorities and agendas, such as the 2020 Round of Population and Housing Censuses and the 2030 Agenda for Sustainable Development.

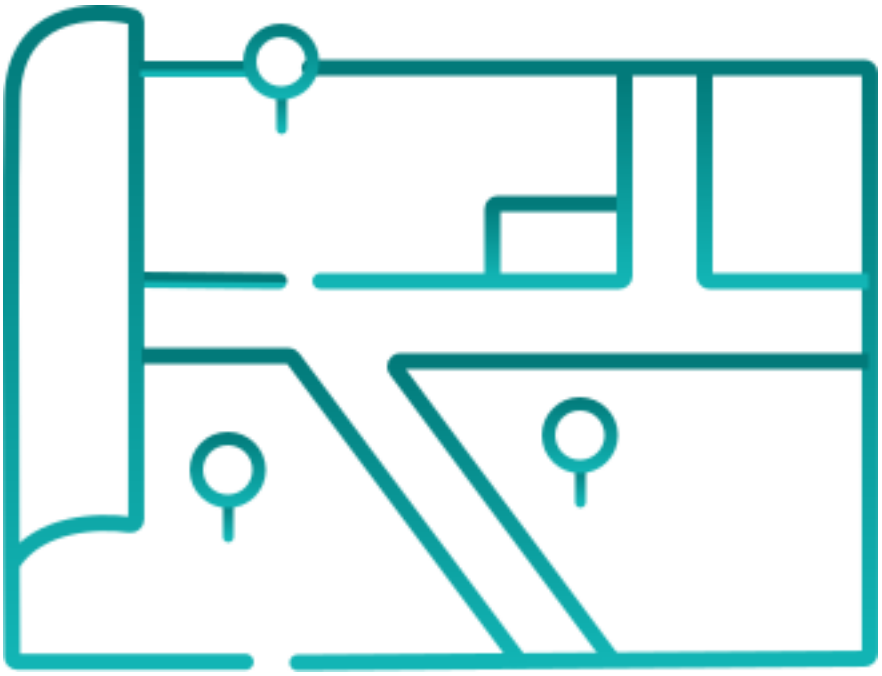
For other frameworks visit https://ggim.un.org/UN-GGIM-publications/

9.4.2 Types of geospatial data

There are two basic types or forms of geospatial data:

Vector

This form uses points, lines, and polygons to represent spatial features such as cities, roads, and streams. Vector models are useful for storing data with discrete boundaries, such as country borders, land parcels, and streets.



Raster

This form uses cells (computer often use dots or pixels) to represent spatial features. Cities are single cells, roads are linear sequences of cells, and streams are collections of adjacent cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface.

- *Eurostat - Geospatial analysis at Eurostat* (🔗) - a set of techniques and tools to study space-time relationships

inherent in data using examples where spatial analysis has been conducted with statistical data of the European Union (EU).

- *FAO - Guidelines on the use of remote sensing products* (🔗) to improve agricultural crop production forecast statistics in sub-Saharan African countries.
- UNSD - Crop Density mapping Land cover and land use statistics Spatial and Statistical Analysis (🔗) of Historic Climate Data Urban-Rural Systems population density distribution map.

9.4.3 Challenges for NSOs in using geospatial data

As for many areas of technology, the main challenge for NSOs in the use of geospatial data is to recruit and retain staff with the necessary skills.

> There is a high demand for GIS specialists and NSOs are often not able to compete with other public bodies and the private sector in the employment market.

An additional challenge is the cooperation with mapping authorities, which lead to the formation of the United Nations Global Geospatial Information Management (UN-GGIM). UN-GGIM aims to ensure that the national mapping and cadastral authorities work jointly with NSOs to contribute to a more effective management and availability of geospatial information, and its integration with other information, based on user needs and requirements.

GIS specialists (also referred to as GIS Analyst, GIS Technician, and Cartographers) are needed to build and maintain GIS databases and to use GIS software to analyse the spatial and non-spatial information they contain. They also analyse GIS data to identify spatial relationships, perform geospatial modelling or spatial analysis, and create thematic maps.

The ideal for an NSO is to have a specialised in-house Cartography or GIS unit, but this is beyond the means of many NSOs, especially in developing countries. However, there are many open-source desktop GIS software products available as well as free GIS data sources.

To enable interoperability of data sources, survey data should where possible be geo-referenced and linked to geospatial data.

Examples of GIS open-source software:

GRASS GIS (🔗) – software suite used for geospatial data management and analysis, image processing, graphics and maps production, spatial modelling, and visualisation.

ILWIS (Integrated Land and Water Information System) (🔗) is a geographic information system and remote sensing software for both vector and raster processing. Its features include digitising, editing, analysis and display of data, and production of maps.

OpenJUMP (🔗) is an open-source GIS that can read and write map files. It can also read from spatial databases and can be used as a GIS data viewer.

MapWindow (🔗) is a set of programmable mapping components for analysis and modelling.

QGIS (🔗) is a cross-platform desktop geographic information system application that supports viewing, editing, and analysis of geospatial data.

SAGA (🔗) is a geographic information system used to edit spatial data.

GIS Data Sources:

Esri Open Data (🔗) provides access to more than 67k open data sets from organizations worldwide. Data can be searched by topic or location and download in multiple GIS formats.

NASA Earth Observations (NEO) can browse and download imagery of satellite data from NASA's constellation of Earth Observing System satellites.

NASA Socioeconomic Data and Applications Center (SEDAC). SEDAC is the Data Center of NASA's Earth Observing System Data and Information System (EOSDIS) and provides libraries of downloadable maps and data.

Natural Earth (🔗) is a public domain map dataset featuring integrated vector and raster data and the means to create maps with cartography or GIS software.

OpenStreetMap (🔗) collects geodata and makes it available free of charge. It is a community of mappers who edit the geography as OpenStreetMap daily.

Open Topography (🔗) provides a portal to high spatial resolution topographic data and tools. Open Topography facilitates access to high-resolution, earth science-oriented, topography data, and related tools and resources.

Sentinel Satellite Data (🔗). The European Space Agency's Sentinel satellite high-resolution spatial data is available to the public for free. The Copernicus Open Access Hub provides complete, free and open access to user products.

Terra Populus (TerraPop) (🔗) incorporates and integrates both census data from over 160 countries around the world, as well as environmental data describing land cover, land use, and climate.

UNEP Environmental Data Explorer (🔗) is the source for UNEP's data sets and its partners in the Global Environment Outlook (GEO) report and other integrated environment assessments. Its online database holds more than 500 different variables, such as national, sub-regional, regional and global statistics or geospatial data sets (maps), covering themes like Freshwater, Population, Forests, Emissions, Climate, Disasters, Health and GDP.

USGS Earth Explorer (🔗) is a source of Geographic Information Systems (GIS) Data. USGS collects, monitors, analyses, and provides science about natural resource conditions, issues, and problems.

- Central Statistical Bureau of Latvia thematic maps (🔗);
- European Forum for Geography and Statistics (EFGS);
- Eurostat - Merging statistics and geospatial information in the European statistical system (ESS);
- Statistical and Spatial Frameworks. Standards and Data Infrastructure, Working paper, Statistics Australia (🔗);
- National Institute of Statistics of Rwanda Geodata Portal (🔗);
- Statistics Korea - GIS, Maps and Statistics (🔗);
- Statistics Poland: Statistical Atlas of Poland (🔗);
- Statistics Sweden - Implementing a Statistical Geospatial Framework (🔗);
- *United Nations Expert Group on the Integration of Statistical and Geospatial Information - Global Statistical Geospatial Framework Linking Statistics and Place* (🔗);
- UN Task Team on Satellite Imagery and Geo-Spatial Data (🔗) provide strategic vision, direction and development of a global work plan on utilising satellite imagery and geospatial data for official statistics and indicators for post-2015 development goals;
- *UNICEF Guidelines on the use of geospatial technologies* (🔗).

9.5 Big Data

The term Big Data refers in general to data generated by business transactions, social media, phone logs, communication devices, web scraping, sensors etc. (see *Chapter 15.2.7 — Big Data*). For a general introduction to the notion of Big Data, see the book Big Data by Viktor Mayer-Schönberger and Kenneth Cukier (2013).

> Big Data has attracted considerable and increasing interest from NSOs regarding the potential to complement traditional statistics. This is particularly important in the context of the need to measure and monitor progress towards the Sustainable Development Goals (SDGs) and other targets.

Big Data has the potential to supplement, complement or partially replace, existing statistical sources such as surveys, or provide complementary statistical information but from other perspectives. It could also improve estimates or generate completely new statistical information in a given statistical domain or across domains.

Big Data is widely used in the commercial sector for business analytics, but there is less evidence of its use thus far in the world of official statistics. Despite the high expectations for using Big Data, the reality is that while the technology needed to process these huge data sets is available and maturing, the biggest obstacle for an NSO is often to gain access to

the data. This lack of access can be due to reluctance of a business to release their data, legal obstacles, costs or concerns about privacy. However, where Big Data is accessible for an NSO, such as websites or sensors administered by public administrations, such as road sensors, it is already successfully used for experimental or even official statistics.

Box 6: Big Data and Data Science - new ways of working in official statistics

At about the time that the UN Secretary-General Ban Ki-Moon released the Data Revolution report (🔗) in 2014, the UN Statistical Commission decided that the statistical community needed to explore in more detail the benefits and challenges of using Big Data for official statistics. The private sector was moving fast in exploiting large amounts of data from digital devices for market analysis and improving business operations, and the statistical community should not stay behind.

In March 2014, the Committee of Experts on Big Data and Data Science for Official Statistics (🔗) was created. It distributed its work over about a dozen task teams (🔗) looking into the use of earth observations, mobile phone data, scanner data, social media data and AIS vessel tracking data, as well as cross-cutting issues regarding data access, privacy-preserving techniques, IT infrastructure, communication and awareness-raising, and capacity development. Since its inception, the Committee released guidelines on all the mentioned areas, developed training materials and conducted numerous seminars and workshops.

The achievements of the Committee were not only reported to the Statistical Commission (🔗) but also exhibited at annual Big Data Conferences in Beijing (2014), Abu Dhabi (2015), Dublin (2016), Bogota (2017) and Kigali (2019). Due to the Covid-19 pandemic, the planned conference in Seoul (2020) was conducted as a virtual event.

In Bogota (November 2017) (🔗), the Committee decided that a Cloud-based collaborative environment should be developed for the statistical community to conduct joint Big Data projects and to share data, methods, applications and training materials. The Office for National Statistics of the United Kingdom took the lead and built the UN Global Platform (🔗) in the period 2018-2020, then handed it over to the UN community in June 2020. National statistical institutes could now use satellite data or AIS vessel tracking data with corresponding Cloud, method, and developer's services to run big data projects. However, necessary skills in data engineering and data science and the use of various new data sources were lacking. Therefore, four Regional Hubs for Big Data (🔗) in support of the UN Global Platform were established in Brazil (Rio de Janeiro), China (Hangzhou), Rwanda (Kigali) and UAE (Dubai). Through these hubs capacity building activities were brought to all world areas.

The Expo2020 event in January 2022 in Dubai (🔗) not only showcased the ceremonial launch of the Regional Hub for Big Data in the UAE, but also highlighted the other regional hubs as well as the strong commitment of the hubs to collaborate with each other for the benefit of building capacity in the use of Big Data and Data Science in all countries. Some reflections on new ways of working in official statistics can also be found in a December 2021 article (🔗) by the UN Statistics Division in the Harvard Data Science Review.

9.5.1 Types of Big Data

There are several categories of Big Data.

Structured data

All the data received from sensors, weblogs and financial systems are classified under machine-generated data. These include medical devices, GPS data, data of usage statistics captured by servers and applications and the huge amount of data that usually move through trading platforms, to name a few. Human-generated structured data mainly includes all human input data into a computer, such as his name and other personal details. When a person clicks a link on the internet, or even makes a move in a game, data is created.

Unstructured data

While structured data resides in the traditional row-column databases, unstructured data is the opposite- they have no clear format in storage. The rest of the data created, about 80% of the total, account for unstructured Big Data. Until recently, there was not much to do to it except storing it or analysing it manually. Unstructured data is also classified based on its source, into machine-generated or human-generated. Machine-generated data accounts for all the satellite images, the scientific data from various experiments and radar data captured by various facets of technology. Human-generated unstructured data includes social media data, mobile data and website content. This means that the pictures we upload to Facebook or Instagram the videos we watch on YouTube and even the text messages we send contribute to the mass of unstructured data.

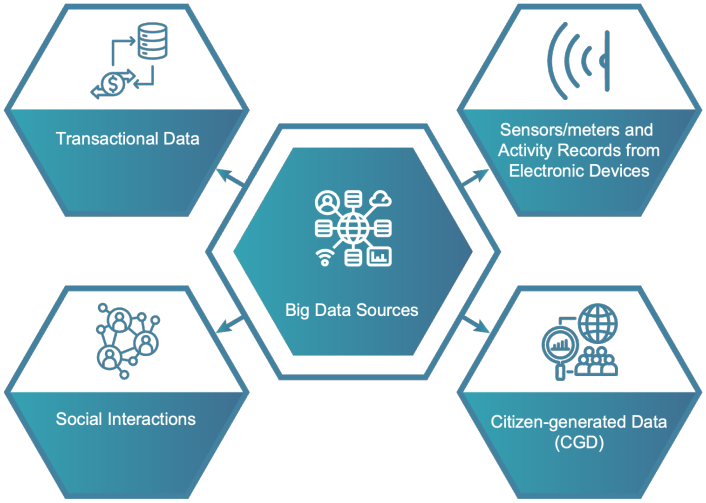
Semi-structured data

Information that is not in the traditional database format as structured data but contains some organizational properties that make it easier to process is included in semi-structured data. For example, NoSQL documents are considered semi-structured since they contain keywords that can be used to process the document easily.

9.5.2 Big Data sources

There are broadly four sources of Big Data.

- **Transactional data** is generated from all the daily transactions that take place both online and offline. Invoices, payment orders, storage records, delivery receipts – all are characterized as transactional data. However, data alone is almost meaningless, and most organizations struggle to make sense of the data they are generating and how it can be put to good use. Business transactions: Data produced from business activities can be recorded in structured or unstructured databases. With a big volume of information and the periodicity of its production (because sometimes this data is produced at a very fast pace), thousands of records can be produced in a second when big companies like supermarket chains are recording their sales.



- **Sensors/meters and activity records from electronic devices**: the quality of this kind of source depends mostly on the sensor's capacity to take accurate measurements in the way it is expected. Machine data is defined as information generated by industrial equipment, sensors installed in machinery, and even web logs that track user behaviour. This type of data is expected to grow exponentially as the Internet of Things (IoT) grows ever more pervasive and expands around the world. Sensors such as medical devices, smart meters, road cameras, satellites, games, and the rapidly growing Internet of Things will deliver high velocity, value, volume, and data variety shortly.
- **Social interactions**: this covers data produced by human interactions through a network. The most common is the data produced in social networks. This kind of data relies on the accuracy of the algorithms applied to extract the meaning of the contents commonly found as unstructured text written in natural language. Some examples of analysis made from this data are sentiment analysis, trend topics analysis, etc. Social data comes from the Likes, Tweets & Retweets, Comments, Video Uploads, and general media uploaded and shared via the world's favourite social media platforms. This data provides invaluable insights into consumer behaviour and sentiment and can be enormously influential in marketing analytics. The public web is another good source of social data, and tools like Google Trends can be used to improve the volume of Big Data.
- **Citizen-generated data (CGD)** is data produced by non-state actors under the active consent and participation of citizens to primarily monitor, demand or drive change on issues that affect them directly. CGD can be an innovative data source (secondary data source) for the production of official statistics and be leveraged to support the effective tracking of progress on the Sustainable Development Goals (SDGs).

UNECE has developed a multi-layer classification of Big Data sources (🔗) with 24 categories at the lowest level.

9.5.3 Challenges accessing and processing Big Data

Accessing Big Data

According to the GLOS guidance. Article 6.1 'Producers of official statistics shall be entitled to access and collect data from all public and private data sources free of charge, including identifiers, at the level of detail necessary for statistical purposes. In the longer term, the goal is to regulate this access in the statistical law.

There are several potential barriers an NSO has to overcome in gaining access to Big Data sources. These include the following:

- concerns on the part of private companies about losing their competitive advantage;
- legal constraints concerning privacy and confidentiality of client information;
- businesses have recognised the value of their data and are not prepared to just give it away;

- the costs of setting up the necessary infrastructure and training staff for a non-core business-related activity.

NSOs need to overcome such legal requirements and seek agreement with businesses to gain access to Big Data for statistical purposes. If agreements can be struck with the businesses that own the data, several business models can enable data exchange between private corporations and an NSO. The PARIS21 paper "*Access to New Data Sources for Statistics: Business Models and Incentives for the Corporate Sector*" (🔗) lists the following models:

- **In-house production of statistics**: the in-house production of statistics model is, in many ways, the most conventional or standard model. It is used by most NSOs today and, as such, comes with a known set of risks and opportunities. On the positive side, the model allows the data owner to maintain total control over the generation and use of its raw data. User privacy can be protected through deidentification, and generated indicators can be aggregated sufficiently to be considered safe for sharing. From a safety or security point of view, the in-house production of statistics is the preferable option.
- **Transfer of data sets to end users**: in this model, data sets are moved directly from the data owner to the end-user. The model gives the end-user significantly more flexibility on how the data is used. In general, raw data is de-identified, sampled and sometimes aggregated to avoid possible re-identification. Efforts to de-identify need to ensure that data cannot be re-identified by crossing it with external data. Because de-identification is never absolute, even when the most sophisticated anonymizing techniques have been deployed, data in this model is generally released to a limited number of end-users, under strict non-disclosure and data usage agreements ensure a level of control and privacy.
- **Enabling remote access to data**: in the remote access model, data owners provide full data access to end-users while maintaining strict control on what information is extracted from databases and data sets. In this model, personal identifications are anonymized, but no coarsening is made on the data. The data does not leave the premises of the data owner; rather, the end-user is granted secured access to analyse the data and compute the relevant metrics. The end-user is then permitted to extract only the final aggregated metrics once the data analysis has been completed. This method is often used in research, in specific partnerships between the data owner and a group of researchers, under very strict non-disclosure and data usage agreements. Strict monitoring of the input and output traffic on data storage devices is carried out to ensure no data is removed. The main incentive in this type of model is that users benefit from free research resources on their data.
- **Using trusted 3rd parties (T3Ps)**: in the Trusted 3rd party (T3P) model, neither the data owner nor the data user supports the security burden of hosting the data themselves. Instead, both parties rely on a trusted third party to host the data and secure access to the data source. The data is anonymized in the sense that hashing techniques protect personal identifiers. In addition, the end-user does not have direct access to the raw data. Instead, end-users must make a request for reports or other intermediate results to the T3P, which ensures protection of the data.
- **Moving algorithms** rather than data. In this model, shared algorithms allow the reuse of software by several private data owners wishing to perform similar analytical functions on one or several data sets. For example, such a model may be effective when several national telecoms operators wish to estimate population density (or other population patterns) based on their collective data. The data sets from different operators do not need to be necessarily merged. Instead, while the analytical functions performed on each data set may be identical, the data sets themselves can remain separate and under separate control. Results can be arrived at independently by each operator, and the aggregated results can later be merged to arrive at a comprehensive national or regional analysis.

To gain reliable and sustainable access to Big Data sources, NSOs need to form strategic alliances with the data producers, which can be a lengthy process with no guarantee of success. Private corporations are aware of the value of their data, are unwilling to expend resources on activities that are not mission-critical, and that carry potential risks of business information and confidentiality breaches. Governments must enact legislation obliging corporations to make their data available to NSOs to use for the public good. However, this can take many years to put in place.

The issue of gaining access to privately held Big Data sources needs to be addressed at a supranational level, particularly as many of the companies generating Big Data are multinational concerns. The legal aspects are complex and difficult to solve legally at the country level. Moreover, NSOs are not the only organizations interested in gaining access to Big Data for public purposes. In the EU, for instance, a broad expert group (🔗) is looking into this issue. The EU has also provided some guidance (🔗), specifically mentioning statistics.

Challenges in processing Big Data

Data privacy

With Big Data, the biggest risk concerns data privacy. Enterprises worldwide make use of sensitive data, personal customer information and strategic documents. A security incident can not only affect critical data and bring a downward reputational effect; it can also lead to legal actions and financial penalties. Taking measures for data privacy is vital - as recent high-profile cases have shown, if not sufficiently protected this information can be used to profile individuals and be passed on to third parties leading to loss of consumers' trust. Thus, NSOs need to ensure that data sources and indicators used are obtained without violating privacy or confidentiality regimes.

Costs

NSOs must also invest in security layers and adapt traditional information technology techniques such as cryptography, anonymisation, and user access control to Big Data characteristics. Even though that the access to data for NSO should ideally be free of charge as with access to administrative data, it may be necessary to pay the one-off cost of preparing the data transfer system such as an API.

Data quality

Big Data is often largely unstructured, meaning that such data sources have no pre-defined data model and does not fit well into conventional relational databases. Diverse structures also cause data integration problems as the data needed for analysis comes from diverse sources in various formats such as logs, call-centres, web scrapes and social media. Data formats will differ, and matching them can be problematic. Unreliable data: Big Data is not always created using rigorous validation methods which can adversely affect quality. Not only can it be inaccurate and contain wrong information but can also contain duplications and other contradictions.

Methods

Using Big Data may require new methods and techniques. For instance, new modelling techniques may be called for, especially if Big Data is used for producing early indicators or even nowcasting. Artificial Intelligence and deep learning techniques may be used for processing unstructured text messages or satellite images.

Data impermanence

An NSO cannot guarantee that a data source will be reliable as it has no control over or relationship with the data owner as with traditional data sources. Formats can change at any time without warning that can render data capture and subsequent processes that have been put in place by the NSO unworkable. Data sources can even disappear completely if the business rules generating the data are changed.

Data gaps

The SDGs have a fundamental commitment to leave no-one behind. Vulnerable populations may not be covered by Big Data if using sources such as mobile phones are not available to the poorest and most marginalised groups of society.

A *vision paper CBS Netherlands and Statistics Canada on future advanced data collection* (🔗), presented at the 62nd ISI World Statistics Congress 2019 in Kuala Lumpur, discusses how sensor data and data originating from data platforms (public or private) hosted outside NSOs can play an increased role in the future of data collection and to maximize the benefit of these data sources to produce “smart statistics”.

Smart Statistics can be seen as the future extended role of official statistics in a world impregnated with smart technologies. Smart technologies involve real-time, automated, interactive technologies that optimize appliances and consumer devices’ physical operation. Statistics would then be transformed into a smart technology embedded in smart systems that would transform “data” into “information”.

Some of the main challenges and opportunities outlined in the vision paper are as follows:

- **Methodology**: linking different data sources and validating data that were not collected specifically for official statistical purposes (administrative and sensor data) requires completely new and advanced methodological concepts. Changing from a survey methodology toward a data methodology is key.
- **Quality**: timeliness will become an important characteristic of the quality of statistical products and, of course, timeliness might influence the accuracy of statistical information. Accuracy is not a synonym for quality, but it is one characteristic that determines the quality of statistical products. As long as the accuracy of information is known and specified to the end-user, this will not be a problem. Research into reducing the potential trade-off between timeliness and accuracy would, of course, be of interest.
- **Data access with respect to social acceptability and legal frameworks**: social acceptability is key to gaining access to privately-held data. This means that NSOs need to be transparent and able to demonstrate and explain the value proposition to society (public good) and address society's concerns about trust, confidentiality and privacy. At the same time, legal frameworks need to be developed to ensure that NSOs can use all these new data sources to their maximum extent and make sure that society can benefit from the added value NSOs can potentially provide.
- **Data access with respect to technology and methodology**: The keywords for future data access are collect, connect and link. Technology to obtain secure data access, in conjunction with the appropriate methodology and algorithms to guarantee privacy and confidentiality, is one of the main technological development areas for the near future. Multi-party computation, privacy-preserving data sharing (PPDS) and privacy-preserving record linkage (PPRL) are potentially promising technological advancements that need to be further developed into a robust set of methods.
- *Big data in official statistics* (), *CBS (2020);*
- *Bucharest Memorandum on Official Statistics in a Datafied Society* (), *104th DGINS Conference, Bucharest (2018)*;
- *Recommendations for access to data from private organizations for official statistics* (), *Global Working Group on Big Data for Official Statistics (2016)*;
- *Scheveningen memorandum on the use of Big Data in official statistics* (), *Eurostat (2013)*;
- UN Global Working Group on Big Data ().