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METHODOLOGY REPORT
Research and Development in Sweden

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Contents

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1 Context of the statistics

Research and development statistics describe the financial and human resources invested in research and development (R&D) in Sweden. Surveys of the Business enterprise sector, the Government sector, Higher education sector and the Private non-profit sector provide an overall picture of R&D activities. The statistics are regulated by the EU under the Commission Implementing Regulation 2020/1197. Under this regulation, all member states undertake to produce and deliver R&D statistics in accordance with the guidelines described in the Frascati Manual (FM15) developed by the OECD.

The main users of the statistics are national and international decisionmakers as well as government agencies, interest groups and individual researchers. R&D statistics, together with Statistics Sweden's surveys Government budget allocations for R&D (UF0302), R&D in international enterprises (NV1504) and the Community Innovation Survey (CIS) (UF0315), form the basis of the statistical family *Science, Technology, and Innovation (STI).*

This document outlines the design and implementation of the surveys on the Business enterprise sector, the Government sector, Higher education sector and the Private non-profit sector on which the statistics are based. The document complements the Quality Report for R&D statistics available at www.scb.se/UF0301 under the heading *Documentation*.

2 Survey design

2.1 Target characteristics

The target characteristics of the statistics are regulated by Commission Implementing Regulation (EU) 2020/1197 and defined in the Frascati Manual. For the target quantities to be measurable, the concept of R&D itself needs to be defined. The definition of the term plays a central role in ensuring that statistics are comparable over time and across countries. The definition reads:

Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge and to devise new applications of available knowledge in all fields of science.

For an activity to be defined as an R&D activity, it must be:

Novel: R&D activities undertaken in order to generate new knowledge and to devise new applications of available knowledge.

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Creative: R&D activities based on original concepts or hypotheses.

Uncertain: The final outcome of R&D activities is generally uncertain. There is also uncertainty related to the cost or time needed to achieve the expected results.

Systematic: R&D activities are performed systematically and are planned and budgeted.

Transferable and/or reproducible: R&D activities should lead to results that could be possibly transferable and/or reproducible.

To reflect the activities characterised as described above, the Frascati Manual defines several variables, which are presented in Table 1. These are often divided into economic and personnel variables, which is also partly done in this documentation.

Table 1. Variables in R&D statistics 2023.

Target variables	Unit of measure	Corresponding concept in FM15	Chapter in FM15
Expenditure on intramural R&D	SEK thousands*	Expenditure on intramural R&D	Chapter 4
Expenditure on extramural R&D	SEK thousands*	Expenditure on extramural R&D	Chapter 4
R&D personnel	Full-time equivalents	Full-time equivalent of R&D personnel	Chapter 5
R&D personnel	Head count	Head count of R&D personnel	Chapter 5

* The variable is reported in SEK millions in the Statistical database but is collected in SEK thousands.

2.2 Frame procedure

Business enterprise sector

The Business enterprise sector consists of all private and state-owned financial and non-financial enterprises (including so-called quasi-corporations) operating in Sweden, with the exception of private higher education institutions, which instead belong to the Higher education sector. The main criteria for what constitutes an enterprise are that the unit has its own accounting and can generate added value in the form of profit or return for its owners. Additionally, the

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unit must sell its products at an economically significant price. Branches of foreign enterprise groups are included if they constitute a permanent presence in the market. Finally, certain non-profit institutions that serve the Business enterprise sector, such as research institutes, are also included.

The frame population consists of enterprises that have likely conducted and/or financed R&D activities in the reference year and were registered as active in the Business Register (FDB) in November of the reference year. The frame population is determined in two steps. In the first step, several data sources (other SCB surveys and administrative data sources) are used to identify legal units that have conducted and/or financed R&D activities. Surveys used include previous rounds of R&D in the Business Enterprise Sector, the Community Innovation Survey, ICT Usage in Enterprises, and Foreign Trade in Services. The administrative data sources consist of information on legal units that have utilised the R&D tax deduction and information from research-funding agencies on organisations that received support for research and innovation during the reference year. All enterprises with at least one legal unit identified through any of the data sources are included in the frame population. The legal units identified through these data sources constitute observation units for the enterprises they belong to. Thus, there may be multiple observation units for the same enterprise.

In the second step, all enterprises in SNI 72 (Scientific Research and Development) and enterprises with at least 200 employees that were not identified through any of the previously mentioned data sources are included. For these enterprises, an observation unit (legal unit) is then selected based on a number of criteria (see Table 2). The response from the observation units then represents the entire enterprise.

Table 2. Criteria for choosing a representative legal unit

Criteria for choosing a representative	Description
1. Primary economic activity (SNI)	Primarily, the choice of representative is based on proximity to the enterprise's economic activity. The legal unit whose primary economic activity is closest to the enterprise's economic activity is selected.
2. Number of employees	Secondly, the representative is chosen based on personnel intensity. The legal unit with the highest number of employees is selected.

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3. Net turnover	Thirdly, the representative is chosen based on net turnover. The legal unit with the largest net turnover is selected.

Through information from the Business Register, other data sources, and based on the criteria summarised in Table 3, a frame for the survey is created. The observation unit in the survey is the legal unit.

Table 3. Limitations to the frame population for the Business enterprise sector

Criteria for inclusion	Comments
Enterprises with at least 1 employee.	
Active enterprises	Only active enterprises are surveyed.
In SNI2007 01-63 and 68-99: enterprises in sectors 111000, 112000, 113000 and 114000	Non-financial enterprises.
In SNI2007 64-66: enterprises in sectors 111000-114000, 122100-122500, 122900,125100-125400, 125900, 126100-126200, 127000, 128100-128300, 129100-129400	The handling of financial companies in accordance with FM15 and the Commission's Implementing Regulation (EU) 2020/1197 excludes, among others, the Central Bank but includes other banks and insurance companies.
Enterprises that are excluded:	
- SNI2007 = 68204	Property management of tenant-owners' associations
- SNI2007 = 51 and sector = 113000	Branches of foreign airlines
- Enterprise units with a foreign address	
- SNI2007 = 86, sector = 111000 and ownership code = 30	Hospitals owned by the county
- Enterprise units included in the frame population	

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for the Higher education sector	

For the reference year 2023, enterprises with 1-9 employees (micro-enterprises) that are likely to conduct R&D activities were also surveyed. The same criteria for delimiting the frame were applied to the micro-enterprise population as to the rest of the population.

Government sector

The Government sector consists of national, regional, and municipal institutional units in Sweden, as well as public non-profit organisations. Exceptions to this are state-owned higher education institutions, which instead belong to the Higher education sector. State-owned enterprises and public enterprises are not included in the sector but belong to the Business enterprise sector.

The frame population consists of units classified within the Government sector, with certain delimitations made for government agencies, municipal federations, and public non-profit organisations. Generally, they must have been active during 2023 and have more than zero employees.

For government agencies, a few boards are excluded according to the Swedish National Financial Management Authority's register of agencies, as they have not submitted a complete annual report for 2023 and are not considered to have sufficient economic independence to be an institutional unit. For confidentiality reasons, the National Defence Radio Establishment, the Swedish Security Service. The Royal Court are also excluded as they are not formally considered agencies.

Municipal associations are excluded from the frame if they have fewer than twenty employees unless their primary or secondary economic activity is Scientific research and development. Public non-profit organisations are excluded if they have fewer than five employees or are limited companies. If their primary or secondary economic activity is Scientific research and development, they are always included. Similarly, the public research foundations[1] created

[1] The Swedish Foundation for Strategic Environmental Research, The Swedish Foundation for Strategic Research, The Swedish Foundation from International Cooperation in Research and Higher Education, The Knowledge Foundation, The Foundation for Baltic and East European Studies.

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from the wage-earner funds are included regardless of the number of employees.

The observation unit in the survey is the legal unit and, in most cases, coincides entirely with the source of information. For two municipalities, the respective district administrations respond independently as they are decentralised organisations.

Higher education sector

The Higher education sector includes all universities, colleges, and other higher education institutions. The sector also includes research institutes, experimental stations, and clinics whose R&D activities are directly controlled or administered by a higher education institution. The frame population of the R&D expenditures survey is limited to the institutions that have received funding for research and doctoral education during the reference year, regardless of the source of funding. To identify the institutions that have had funding for research and doctoral education, the Swedish Higher Education Authority's (UKÄ) annual survey of the institutions' finances is used. The units included in the frame for the reference year 2023 are summarised in Table 4.

Table 4. Higher education institutions included in the frame population for the Higher education sector 2023.

Universities	Uppsala university Lund university Göteborg university Stockholm university Umeå university Linköping university Karolinska Institute Royal Institute of Technology Chalmers University of Technology Luleå University of Technology Stockholm School of Economics Swedish University of Agricultural Sciences Karlstad University Linnaeus University Örebro University Mid Sweden University Malmö University Mälardalen University
Collages	Blekinge Institute of Technology Swedish Defence University

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	Swedish School of Sport and Health Sciences University of Borås Dalarna University University of Gävle Halmstad University Jönköping University Kristianstad University University of Skövde University West Södertörn University
Collages of the Arts	Konstfack Royal Institute of Art Royal College of Music in Stockholm Stockholm University of the Arts
Other private education providers	Marie Cederschiöld University Red Cross University College Sophiahemmet University Stockholm School of Theology Academy for Leadership and Theology

The frame population for the time-use survey is limited to the same institutions as the R&D expenditures survey. This means that only positions at institutions that have had funding for R&D during the reference year are included in the frame. To further specify the frame, SCB uses the register of Employees in Higher Education[2]. The register contains all positions that existed at a Swedish higher education institution in October of the reference year.

To be included in the frame, the position must have an extent of at least 10 percent. Additional limitations are also made based on personnel category and field of R&D. All positions belonging to the category of research and teaching staff are assumed to work with R&D and are thus included in the frame. For positions belonging to the technical-administrative staff, those with information on field of R&D are included, as this information indicates that they work with R&D.

To obtain more information about those lacking information on field of R&D, a preliminary survey is conducted where the higher

[2] For more information about the register, see Employees in higher education

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education institutions are asked to identify which personnel groups, among the technical-administrative staff, are relevant to include in the survey. Lists are created of job titles at the institution where at least 50 percent of individuals lack a field of R&D. Based on these lists, the institutions indicate which job titles should be included in the frame. The criterion for a job title to be included is that at least 50 percent of the positions should consist of at least 10 percent R&D or direct support to R&D.

Private non-profit sector

The Private non-profit sector consists of non-commercial organisations and private non-profit organisations that serve households, i.e., the general public as well as individuals and households. In addition to non-profit organisations, the sector also includes individuals and households.

The frame population for the survey includes foundations and non-profit associations that are likely to conduct intramural R&D. To identify these likely R&D performers, information about the organisation's purpose, economic activity, and support for R&D and innovation from the research-funding agencies is used. The organisation must also have at least one employee to be included in the frame.

2.3 Procedures for sample selection and exclusion

2.3.1 Sampling method

The sample selection begins once the frame is established. To avoid coverage errors, the samples are coordinated between sectors so that an observation unit does not appear in the sample for multiple sectors. The surveys of all sectors, except the time-use survey of the Higher education sector, are designed as census surveys. This means that no random sampling is conducted, but that all units in the frame are included in the survey.

Higher education sector

The time-use survey is a sample survey. From the positions included in the frame population, a systematic sample is drawn within strata. This means that the frame is sorted by stratum and a starting point is chosen randomly. Then, objects are selected at a fixed interval. Stratification is done with respect to field of R&D, institution or university group, employment category, and gender.

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2.3.2 Exclusion from the survey (cut-off)

Exclusion does not occur in any of the surveys.

2.4 Data collection method

For all sectors in the survey, data is collected through questionnaires. Primarily, web-based questionnaires are used, but the time-use survey within the Higher education sector also uses paper questionnaires to some extent. The assessment is that information about R&D activities cannot be collected from other data sources than questionnaires. To ensure that the costs and response burden incurred by the data collection are justified, impact assessments are conducted before each collection round. The need for the statistics is also checked with the main users.

2.4.1 Data collection

Business enterprise sector, Government sector, and Private non-profit sector

Within the Business enterprise sector, Government sector, and Private non-profit sector, data is collected through questionnaires via web forms. A cover letter is sent to all units included in the survey between two and four months after the end of the reference year. The cover letter contains information about the survey, login details for completing the questionnaire online, and information about any obligation to provide information. If there is a contact person at the unit, the cover letter is sent to them; otherwise, it is addressed to the person responsible for finances.

All units in the Business enterprise sector, as well as government agencies, regions, municipalities, and municipal federations, are obligated to provide information. Foundations and non-profit associations have exemptions from the obligation to provide information for individual variables, while there is no obligation to provide information for other forms of non-profit organisations. Reporting on the questionnaires is done using SCB's tool for web forms, SIV. In cases of non-response, reminder letters are sent out, which largely contain the same information as the cover letters. Three reminders were sent out via email or post. Individual objects considered particularly important for the reliability of the estimates have received additional reminders.

Questions from respondents are primarily handled by SCB's data collection unit, but if the question is of a subject-specific nature, the

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subject unit is often involved. If necessary, such questions can be discussed at weekly coordination meetings.

Higher education sector

For the R&D expenditures survey regarding the Higher education sector, cover letters are sent out via email. The cover letter contains information about the survey, login details for submitting the questionnaire online, and information about the obligation to provide information. The information is sent out approximately four months after the end of the reference year and is addressed to contact persons at the institutions. Information about the contact persons for the survey is obtained from the Swedish Higher Education Authority (UKÄ).

Together with the cover letter, the questionnaire is also sent to the institutions. The questionnaire consists of an Excel template that the institution can upload to Statistics Sweden's tool for web forms, SIV, once they have answered the survey. In the event of non-response, reminders are sent out, also via email. The reminder letters contain largely the same information as the cover letters. Two reminders were sent during the collection regarding the reference year 2023.

For the time-use survey, cover letters are sent out to all individuals who hold the positions included in the sample. The cover letter is primarily sent out digitally to those who have a digital mailbox. Individuals who do not have a digital mailbox receive the cover letter by post. Since the sample is based on positions and a person can have several positions, there are cases where more than one cover letter is sent to the same person. The cover letter contains information about the survey, login details for answering the questionnaire online, and information that there is no obligation to respond. The letters are sent out approximately three months after the end of the reference year.

The collection is primarily done via an online questionnaire in SIV. In the event of non-response, reminders are sent out, and together with the second reminder letter, the questionnaire is also sent out on paper. Already in the cover letter, respondents are informed that the questionnaire will be sent out by post for those who prefer to answer the survey on paper. Four reminders were sent during the collection regarding the reference year 2023.

For the time-use survey, questions from respondents are primarily handled by Statistics Sweden's data collection unit. For questions of a subject-related nature, the subject unit is often involved. This type of

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question is checked continuously. Questions regarding the economic survey are primarily handled by the subject unit.

2.4.2 Measurement

The questionnaires used in the surveys are attached in Appendix A.

Common to all surveys is that questionnaires in Statistics Sweden's web-based collection tool, SIV, are used as measurement instruments. In the Higher education sector, the online questionnaire is also supplemented with a paper questionnaire and an Excel template. Among the advantages of SIV is that the tool allows the use of controls and filters in the questionnaires. Filters mean that the respondent's answers to certain questions determine whether they should answer specific follow-up questions or not. In cases where the follow-up questions are not relevant to the respondent based on the answer to the filter question, SIV automatically skips the follow-up questions. This reduces the risk of respondents answering the survey in a logically inconsistent way and leads to a reduced response burden.

There are also two different types of controls in the questionnaires in SIV: soft and hard controls. Soft controls mean that a message is displayed to the respondent when a given value is deemed unlikely to be correct based on predetermined criteria. In the message, respondents are asked to check the information and correct it if it is incorrect. Hard controls work in a similar way to soft controls. The difference is that hard controls prevent respondents from proceeding in the questionnaire unless the information is corrected. This type of control is used to prevent logically inconsistent answers.

Business enterprise sector, Government sector, and Private non-profit sector

The questionnaires for government agencies, municipalities, regions, private non-profit organisations, and enterprises are consistent with the exception of certain sector-specific adaptations. To aid the respondent, some information from the previous survey round is pre-filled. The questionnaire begins with a section regarding extramural R&D activities[3]. This is followed by two sections with questions about expenditures and personnel in intramural R&D activities, and

[3] Private non-profit organisations do not get the questions concerning extramural R&D activities as this is not mandatory according to EU regulation.

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finally a fourth section where a forecast for intramural R&D activities for the current year is requested.

All questionnaires end with a couple of voluntary questions where respondents have the opportunity to report how long it took to answer the survey and leave general comments. Otherwise, the obligation to report information applies to all questions in all sections for enterprises, government agencies, municipalities, regions, and municipal associations. For private non-profit organisations, there are exceptions to the obligation to provide information for certain questions. Voluntary questions are clearly marked in the questionnaire.

The questionnaires are implemented in Statistics Sweden's web-based collection tool, SIV, and can only be answered online. In the questionnaires, both filters and controls are designed to facilitate the response process and increase the quality of the information provided. The controls include comparisons with the values given in the previous survey round, expenditures in relation to the unit's total turnover, and suspected unit errors (when respondents have not provided the answer in SEK thousands).

Higher education sector

In the R&D expenditures survey, a web-based solution is used where the respondent fills in and submits a questionnaire in Excel format that is sent out together with the cover letter. The questionnaire contains pre-filled information about the institution's funding for research and doctoral education divided by source of funds. This is information that the institutions have previously provided to the Swedish Higher Education Authority (UKÄ)[4]. The institutions then allocate these funds per field of R&D. Depreciation and investments are only allocated at the 1-digit-level while current costs are allocated at the 3-digit-level of the classification Fields of research and development (FORD)[5]. Information about investments in research and doctoral education is not pre-filled but is provided directly by the institutions in the questionnaire.

The institutions submit their responses by uploading the Excel form to Statistics Sweden's web-based collection tool, SIV. In SIV, there are checks to control that the pre-filled amount per source of funds matches the allocated funds that the institutions have provided. If

[4] Swedish Higher Education Authority
[5] Swedish Standard Research Subject Classificatin 2011

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this does not match, the file cannot be submitted and must be corrected by the respondent. A message is also displayed if the institution has not reported any investments, asking the respondent to check that this is correct. Since not all institutions have investments for research and doctoral education, it is possible to submit the form even if this message is displayed.

In the time-use survey, a questionnaire consisting of four main questions is used. The first question is a filter question where the respondent is asked to indicate if they have been on sick leave, parental leave, or leave of absence from their position full-time during the entire reference year. If this is the case, the respondent does not need to answer the rest of the questionnaire.

In the second question, the respondent is asked to estimate how many hours they worked in an average workweek during the reference year. These hours should then, in the third question, be distributed proportionally among different work tasks, including research and development, teaching, and participation in courses within their own doctoral education.

Finally, individuals who have indicated that they have spent part of their working time on R&D are asked to distribute their research time among three different types of R&D (basic research, applied research, and development activities). In addition, the questionnaire contains several questions about stays abroad for work. These are asked on behalf of UKÄ and are not part of the official statistics for which Statistics Sweden is responsible.

The questionnaire in SIV contains controls, such as ensuring that the proportions indicated for different work tasks sum to 100 percent.

2.4.3 Follow-up of non-response

There are two types of non-response: unit non-response and item non-response. Unit non-response means that information from the observation unit is missing, while item non-response means that the observation unit has not answered all the questions in the questionnaire.

The most important systematic work done to prevent both unit and item non-response is to simplify the process for the respondent. Filters and controls in the questionnaires are designed with this in mind. For each question, the respondent is offered the opportunity to leave a comment about the question or the answers they have provided. These comments can provide a basis for imputations

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without contacting the respondent. Several reminders and follow-ups are also made to reduce non-response.

Business enterprise sector

The work to follow up on unit non-response in the Business enterprise sector follows several stages. Three reminders were sent to the enterprises after the final response date, with a few weeks in between. Furthermore, certain specific enterprises were followed up. Since a small number of enterprises can account for a large proportion of the sector's total economic or personnel resources in R&D, special focus is placed on ensuring that these enterprises respond and on avoiding item non-response.

Government sector

Unit non-response is primarily followed up through reminders to the units that have not responded by the final response date. Three reminders were then sent out with a few weeks in between. R&D activities in the Government sector are concentrated in a few units, and great focus is placed on obtaining complete responses from these units.

Higher education sector

To avoid non-response in the economic part of the survey, reminders were sent out on two occasions after the final response date. In cases where an institution did not respond even after two email reminders, contact was taken via telephone.

To reduce unit non-response in the time-use survey, four reminders were sent out via digital post or letter after the final response date for the survey had passed. In the second reminder, the questionnaire in paper format was also included for those who cannot or do not wish to answer the survey online. Since the survey is directed at individuals, no follow-ups were made with respondents in cases of item non-response.

Private non-profit sector

Non-response that occurred after the final response date for the survey was followed up through reminders. A total of three reminders were sent out with a few weeks in between. In cases of item non-response, follow-up contact was made with the respondent to offer the opportunity to complete the information.

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2.5 Processing

Business enterprise sector

Item non-response discovered in the validation process is primarily handled by following up with the enterprises. In cases where enterprises do not have exact information for a certain variable, other information can be used to estimate the value of the variable. These estimates are developed in dialogue with the respondent. For item non-response of the variable doctorate holders, information from registers such as the Occupational Register, the Education Register, and the Register of wages and salaries is used to develop estimates. All processing of item non-response is documented.

Two methods are used to compensate for unit non-response. For enterprises deemed important for the survey, unit imputation is done by adjusting their information from the latest survey round with the GDP deflator to the current reference year's price level. Consideration is given to any changes in the enterprises' R&D activities between the years. For the remaining enterprises that have not responded, non-response compensation is done through post-stratification followed by imputation of the mean values within each stratum. This means that the missing unit is assumed to have the same characteristics as the responding units within the same stratum.

Government sector

Processing in the Government sector is primarily done to avoid logical inconsistencies in the data. For example, variables reported in multiple places in the questionnaire (such as the total intramural R&D expenditures) should be consistent. Variables reported as proportions in the questionnaire are also recalculated in SEK thousands. The steps in the processing are fully traceable, and data are saved in different versions to allow for retraction of processing if new information emerges.

In cases where important units have not responded, unit imputation is also performed. The units that are imputed are those that had significant (and continuous) R&D activities (at least 1 percent of the sub-sector's total expenses for intramural or extramural R&D or approximately 10 million) during the previous odd reference year. Imputation is done by using the latest available information for the unit after assessments regarding the likely development of the activities. The expenses are adjusted with the GDP deflator to account for inflation.

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In cases of item non-response regarding personnel variables for important units, imputations are also made. The imputed value is based on the reported employee renumerations and the average cost of a full-time equivalent for the specific unit during the previous odd reference year.

Two large municipalities have indicated that they cannot respond for the entire municipality's activities, and therefore separate surveys are sent to different parts of the municipal administration. The responses for the municipalities as a whole are then derived from this information by Statistics Sweden.

Higher education sector

In the R&D expenditures survey, data is processed by deducting depreciation and education costs from the funding. This process is described in more detail in section 2.7 Estimation Procedure as it includes estimates of R&D coefficients.

In the time-use survey, data is processed by correcting logically inconsistent responses. This can include correcting data where individuals have answered the survey in both Swedish and English and where there are discrepancies between the answers, or where proportions that should sum to 100 percent do not. This type of logical correction is done based on predetermined criteria and only where there is auxiliary information that can be used to draw logical connections between the answers.

In cases of item non-response, imputations are also made. The imputed values are based on responses from other units in the same stratum. For item non-response in the variable average weekly working hours, the relationship between the extent of the position and the reported weekly working hours for other units in the stratum is used to impute the missing values. For questions where a percentage distribution is requested, missing values are replaced with the average distribution within the stratum.

Private non-profit sector

Unit non-response is very limited, and therefore it has been assessed that no imputation is necessary to compensate for the non-response. Due to the limited obligation to provide information for foundations and non-profit associations, some item non-response occurs. This primarily concerns personnel variables where it is not mandatory to provide information about the division between internal and external personnel. To compensate for the item non-response, imputations

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have been made. The imputation assumes that all reported personnel are internal.

2.6 Validation

2.6.1 Validation during data collection

The primary purpose of the review during the data collection is to handle cases where controls have been triggered in the questionnaire. How these controls are constructed is described in more detail in section 2.4.2 Measurement. When a respondent has submitted answers where controls have been triggered, an assessment is made of how the issue should be handled. Many cases can be resolved immediately, often through information received via comments from the respondent. In other cases, contact with the respondent is necessary to assess how the case should be handled.

For the Business enterprise sector and the Government sector, a list of units deemed particularly important to review during the data collection has been prepared in advance. These cases are reviewed even if no controls have been triggered because their responses have a significant impact on the final results.

2.6.2 Validation of micro data and collected values

In addition to the validation described above, systematic review of microdata is also performed. The validation focuses on checking figures from respondents that have a significant impact on the statistics, known as selective review. The data is reviewed in such a way that values influential to the statistics for the relevant variables are identified.

The purpose of the validation process is to find outlier values, either in relation to the same respondent's value from the previous round or to the same value among similar respondents in the current round. These values are verified and then treated in different ways depending on whether they turn out to be errors or outliers for other reasons.

Validation of microdata is normally done in parallel with the review of macrodata. If it emerges at the macro level that, for example, municipalities, a certain industry, size class, or code group have developed in an unusual way, this often leads to the identification of new observation units that should be checked and validated in the microdata.

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2.6.3 Validation of macro data

By comparing preliminary results with corresponding results from previous survey rounds, the development of various variables can be monitored. The data serves as input for the validation of microdata.

2.6.4 Control of publication materials

Before each publication and data delivery, data is reviewed to ensure that different sources are consistent. For example, the total for a variable should be the same regardless of the breakdown it is presented with. Reviews are also conducted between different forms of publication.

2.7 Estimation methods

The reporting of R&D in Sweden consists of summaries of estimates for each sector. Preliminary data is estimated in the same way as final data. No seasonal adjustment or fixed price calculation is performed.[6]

2.7.1 Principles and assumptions

Business enterprise sector

The design in the Business enterprise sector is a census survey where all enterprises in the R&D population are surveyed. Therefore, sampling error does not occur in the survey.

To reduce the response burden for the enterprises, they only need to indicate the regional distribution of their R&D expenditures. This distribution is then also used to model the distribution of personnel. Enterprises with fewer than 200 employees in industries where R&D activities are usually of small scale do not need to indicate any regional distribution, either for their expenditures or their personnel. Instead, all R&D expenditures and all R&D personnel reported by the enterprise are attributed to the region where the enterprise is active according to the Business Register (FDB).

Government sector

The design in the Government sector is a census survey, meaning all units in the population are included in the survey. Therefore, there is sampling error. However, uncertainty in the estimates can arise due to non-response.

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[6] In statistical news items, reports, and other publications outside the Statistical database, fixed prices are often calculated. More information about fixed price calculations can be found in the concerned publications.

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To reduce the response burden, it is assumed in some cases that there are correlations between different distributions. The distribution of the Government sector's personnel by occupation and gender per field of R&D is modelled using a template based on the distribution of expenditures between the fields of R&D. For government agencies, the regional distribution of personnel by occupation and gender is also modelled based on the regional distribution of expenditures.

Higher education sector

The R&D expenditures survey within the Higher education sector is designed as a census survey. Therefore, there is no sampling error. However, the estimates made are based on several assumptions that can lead to some bias in the estimates.

A fundamental assumption made when estimating the R&D expenditures is that all funding intended for research and the doctoral programme, except for education costs within the doctoral programme, are utilised and thus correspond to expenditures. In cases where institutions save parts of their funding for the following year or use saved funds to finance their R&D activities during the reference year, there is a risk that the expenses are over- or underestimated.

In accordance with the Frascati Manual, education costs for doctoral education and depreciation costs should not be included in intramural R&D expenditures. To deduct these costs from other expenses, it is assumed that depreciations can be allocated per source of funds according to the same distribution as the funding. Additionally, it is assumed that education costs for doctoral education can be allocated in the same way as the time doctoral students spend on courses within their own doctoral programme.

Investments in R&D are published at the 3-digit level of FORD and per source of funds. However, in the data collection, institutions only report total investments per 1-digit-level of FORD. To allocate the investments, the same assumption is made as for depreciations, i.e., that they can be allocated per field of R&D and source of funds with the same proportions as the funding per institution. Investments are assumed not to be financed with funds from foreign financiers. This can also lead to some bias in the estimates.

The time-use survey is designed as a sample survey with systematic sampling within strata. The purpose of stratification is to be able to make reliable estimates within the reporting groups that are published.

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To compensate for unit non-response, non-response compensated weights are used, based on the assumption that individuals in the non-response and among the respondents do not deviate systematically. This assumption can be difficult to fulfil, especially within strata with very few respondents. Another assumption made is that undercoverage occurs to such a low degree that it does not distort the estimates, which is assessed to be fulfilled for the survey.

Private non-profit sector

The survey within the Private non-profit sector is designed as a census survey, meaning all units in the population are included in the survey. Therefore, there is no sampling error. However, uncertainty in the estimates can arise due to non-response.

2.7.2 Method for point estimations

The statistics estimated in the survey are mainly sums. These include sums per reporting group according to various classifications, as well as total sums per sector and for Sweden as a whole. In the Higher education sector, proportions are also estimated.

Business enterprise sector

Since the Business enterprise sector survey is a census survey, estimator (1) is used to calculate sums. The handling of uncertainty from non-response occurs during the processing stage.

$$\hat{t}_z = \sum_{r_u} z_k \qquad (1)$$

Where:

- $\hat{t}_z$ is the target quantity (sum) to be estimated,
- k is an index of the target objects (k = 1, 2, 3, … K),
- z_k is the value of the variable z for the target object k,
- u is an index of all target objects in the frame population, and
- r_u is all responding units in the frame population

Government sector

Since the Government sector survey is a census survey, there is no sampling-related uncertainty for the sector. There is also no need to consider weighting, for example, to compensate for probability sampling or non-response. All sums are calculated according to estimator (2).

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$$\hat{t}_z = \sum_{r_u} z_k \quad (2)$$

Where:

- $\hat{t}_z$ is the target quantity (sum) to be estimated,
- k is an index of the target objects (k = 1, 2, 3, … K),
- z_k is the value of the variable z for the target object k,
- u is an index of all target objects in the frame population, and
- r_u is all responding units in the frame population

Higher education sector

To estimate personnel variables for the Higher education sector, estimator (3) is used.

$$\hat{t}_z = \sum_{h=1}^{H} \frac{N_h}{m_h} \sum_{r_h} z_k \quad (3)$$

Where:

- $\hat{t}_z$ is the target quantity (sum) to be estimated,
- h is an index of the strata (h = 1, 2, 3, … H),
- k is an index of the target objects (k = 1, 2, 3, … K),
- z_k is the value of the variable z for the target object k,
- N_h is the number of observation units in stratum h in the frame population,
- m_h is the number of responding units in stratum h in the sample, and
- r_h is all responding units in the frame population in stratum h

The variance for the sum denoted as $\hat{V}(\hat{t}_z)$ is estimated using estimator (4).

$$\hat{V}(\hat{t}_z) = \sum_{h=1}^{H} \frac{N_h^2}{m_h}\left(1 - \frac{m_h}{N_h}\right)\frac{1}{m_h - 1}\left[\sum_{r_h} z_k^2 - \frac{\left(\sum_{r_h} z_k\right)^2}{m_h}\right] \quad (4)$$

In addition, proportion estimates are made regarding the distribution of working time across different tasks and the distribution of research time between different types of R&D. Some of these proportion estimates are also used in the estimation process for R&D expenditure variables.

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To estimate the R&D expenditure variables, two reduction steps are carried out. The first step in the reduction is to deduct the depreciation costs of the higher education institutions, while the second step aims to deduct expenses for the educational component within doctoral education.

Depreciations are deducted by multiplying the funding per higher education institution and research subject group by a depreciation ratio calculated as follows:

$$Deprciations\ quota_{ij} = 1 - \frac{Depretiations_{ij}}{Total\ funding_{ij}} \quad (5)$$

Where:

- i is an index of observation units (i = 1, 2, 3, …, I), and
- j is an index of fields of R&D (j = 1, 2, 3, …, J)

To deduct the costs for the educational component within doctoral education, information is used on how employees allocate their working time between R&D (including direct support to R&D and applications for R&D funding) and courses within their own doctoral education from the time-use survey. Based on this information, an R&D proportion is calculated for all employees according to equation (6) below. For those who did not partake in a doctoral programme during the reference year, the R&D proportion is 1.

$$R\&D\ proportion = \frac{R\&D}{(R\&D + Courses\ within\ the\ doctoral\ programme)} \quad (6)$$

The R&D coefficient is then calculated as the average of the R&D proportions for all employees in the sample per higher education institution and field of R&D over the last three survey rounds. To allocate educational costs to all sources of funding and fields of R&D, the funds are multiplied by the R&D coefficient in the same way as the depreciation quota.

Private non-profit sector

The target variables for the private non-profit sector are calculated according to estimator 2. As the survey is a census, there is no sample error.

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2.7.3 Method for precision estimates

Estimates based on samples always contain sample-related uncertainty, the so-called sampling error. Sampling error refers to the uncertainty in the estimates that arises because only a sample of objects is examined. One way to get an idea of the reliability of an estimate is to calculate a so-called confidence interval. A confidence interval for the total t_z (estimated with estimator 3) with an approximate confidence level of 95 percent is given by estimator (7).

$$\hat{t}_z \pm 1{,}96\sqrt{\hat{V}(\hat{t}_z)} \qquad (7)$$

Where $\hat{V}(\hat{t}_z)$ is the estimation of the variance for $\hat{t}_z$ as seen in estimator (4).

Confidence intervals are published in the Statistical database together with point estimates for the personnel variables for the Higher education sector. As the surveys for all other sectors are census surveys, there is no sample-related uncertainty and thus no confidence intervals are published.

2.7.4 Confidentiality checks

All statistical production must be carried out in such a way that the disclosure of individual observation objects is avoided. Confidentiality checks aim to minimise the risks that individuals or enterprises suffer harm or detriment as a result of information about them being discernible in the presentation of statistics or related information.

Business enterprise sector

For the Business enterprise sector, a perturbative method for disclosure control called the EZS method is used. The method involves adding "noise" to microdata. Each enterprise receives a direction for the noise (positive or negative) and a random magnitude of the noise. By minimising the magnitude of the noise where there is no risk of disclosure, the aggregated noise can be as small and as close to the original sum as possible without risking the disclosure of enterprise information. The method thus enables all statistics for the Business enterprise sector to be published without the specific economic conditions of enterprises being identifiable.

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Government sector

No confidentiality checks are performed for statistics regarding the Government sector. The reason for this is that information about government agencies, municipalities, and regions is not considered to be traceable to an individual's personal or economic conditions and thus falls under the principle of public access. For confidentiality reasons, the National Defence Radio Establishment (FRA) and the Security Service (SÄPO) are excluded from the survey.

Higher education sector

To enable the publication of R&D expenditure statistics for the Higher education sector at the institution level, all private educational providers not covered by the principle of public access are contacted to request consent to waive confidentiality. The information for other institutions falls under the principle of public access, which means it can be published without the institutions' explicit consent. For R&D personnel statistics, confidentiality checks are carried out to minimise the risk of it being possible to identifying an individual. In cases where there is a risk of disclosure, the value is protected through suppression. To prevent the derivation of values that need protection, secondary suppression is also used.

Private non-profit sector

For the Private non-profit sector, the same method as for the Business enterprise sector, the EZS method, is used. The method involves adding "noise" to microdata. Each organisation receives a direction for the noise (positive or negative) and a random magnitude of the noise. The method enables all statistics for the Private non-profit sector to be published without the specific economic conditions of organisations being identifiable.

3 Implementation

3.1 Quantitative information

Business enterprise sector

The frame population consisted of a total of 6 478 enterprises. Of these, 4 578 enterprises have at least 10 employees and 1 900 are micro-enterprises. The response rate for the population with at least 10 employees was 86 percent and for the micro-enterprises 80 percent.

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The total number of observation units, legal units, in the frame population amounted to 7 315. Of these, 5 397 legal units belong to the population with at least 10 employees and 1 918 legal units to the micro-enterprise population.

Government sector

The frame population for the Government sector amounted to a total of 558 units. Of these, 20 are regions, 290 are municipalities, 183 are government agencies, 20 are municipal associations/R&D units, and 45 are public non-profit organisations. The response rate in the government sector was high, amounting to approximately 90 percent.

Higher education sector

In the R&D expenditures survey, all 39 higher education institutions responded. In the sample survey regarding personnel, the frame amounted to 58 769 positions. The sample size was 13 014 positions, and the response rate was 44 percent.

Private non-profit sector

The population for the Private non-profit sector amounted to 94 foundations and non-profit associations. Of these, 85 organisations responded, corresponding to a response rate of 90 percent.

3.2 Deviations from the survey design

No significant deviations from the survey design were made.