Users' understanding of uncertainty measures to describe data quality

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Abstract

The UK Code of Practice for Official Statistics indicates that users must be informed about the quality of statistical outputs against the European Statistical System (ESS) dimensions of quality (relevance, accuracy and reliability, timeliness and punctuality, accessibility and clarity, coherence and comparability). For sample surveys, which form the basis of many outputs produced by the Office for National Statistics (ONS), the typical measures of uncertainty that are recorded are Standard Errors (SEs), Confidence Intervals (CIs), Coefficients Of Variation (CVs) and statistical significance. The Quality Centre at the ONS has begun work to establish a better understanding of how users interpret information on quality, specifically measures of uncertainty, when using official statistics. We have been motivated by a review of current practices for ONS statistical outputs and through exploring the approaches used by other government departments and other National Statistical Institutes (NSIs). Our work has mainly focussed on how data are used based on the quality information that is provided and whether presenting information in a different way, or using some standard definitions, could improve users' understanding. We have identified the CV in particular as a concept to explore with users, as it may be more difficult to understand compared to other measures, but we have also considered the understanding and interpretation of SEs, CIs and statistical significance. Once this project is completed, its findings will help inform how we report on quality in the future. This paper sets out the main stages of this project and presents the main research work that has been carried out by the Quality Centre to date.

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1. Background

The quality of a statistical product can be defined as the 'fitness for purpose' of that product. More specifically, it is the fitness for purpose with regards to the following European Statistical System (ESS) dimensions of quality: relevance, accuracy and reliability, timeliness and punctuality, accessibility and clarity, comparability and coherence [1].

The UK 'Code of Practice for Official Statistics' [2] sets out a number of principles that support the production of official statistics. One of the functions of the Code of Practice is to ensure that official statistics meet the needs of users and are well explained. Principle 4 of the Code concerns 'Sound Methods and Assured Quality', which includes a number of practices such as quality assurance, quality reporting and quality improvement as well as the use of common standards and concepts. In particular, Practice 2 of Principle 4 refers to the need to *'ensure that official statistics are produced to a level of quality that meets users' needs, and that users are informed about the quality of statistical outputs, including estimates of the main sources of bias and other errors, and other aspects of the European Statistical System definition of quality'*.

It is important, therefore, for the Office for National Statistics (ONS) to report on the quality of data, both to meet our obligations under the Code of Practice, but also to provide users with sufficient information on the strengths and limitations of the data so that they can make an informed judgement on what that data are suitable to be used for [3].

The 'Guidelines for Measuring Statistical Output Quality' [1] advise that *'all quality measures and indicators that would be relevant'* to an output should be reported in order to aid user understanding and enable users to determine when an output meets their needs. For sample surveys, which form the basis of many outputs produced by the ONS, the typical measures of uncertainty that are recorded are Standard Errors (SEs), Confidence Intervals (CIs), Coefficients Of Variation (CVs) and statistical significance.

In November 2014, the Government Statistical Service (GSS) Good Practice Team published the *'Communicating uncertainty and change - Guidance for official statistics producers'* [4]. This guidance was prepared for all staff involved in communicating official statistics and provides practical advice about describing uncertainty and change in statistics to enable users to make better use of the findings that are being presented. The guidance provides a number of approaches to aid the communication of uncertainty and change and can be applied to all sources of information, including surveys, censuses, administrative data and other sources, as well as estimates derived from a combination of these. It includes examples of good practice, as well as standard wording to be used when appropriate [4].

However, it should be considered that users may be unfamiliar with statistical concepts [5] and this could mean that they may misinterpret the data quality. Alternative approaches to presenting statistical accuracy include quality grading and suppression. In the former, the outputs are somehow ranked to indicate those that are of poorer quality and those that are of higher quality. Although this may be intuitively easier to understand, there is some information loss as a formal measure of accuracy is no longer

provided [5]. 'Poor' quality results could also be suppressed, meaning that they are no longer published. Quality grading and suppression may be used in addition to the publication of SEs and other measures of uncertainty.

In this context, the use of CVs in ONS general publications has been questioned several times. The Quality Centre has received a number of queries from statistical producers at the ONS regarding whether there is a standard policy or approach that sets out an acceptable level of accuracy for statistical outputs. Although there is a long history of work being carried out in this area at the ONS, there is currently no specific guidance on acceptable levels of CVs, mainly because of the variety of statistical outputs and the need to tailor quality reporting to individual statistics.

In late 2014, the Quality Centre assessed the practices in use at the ONS, at a selection of GSS departments and internationally. This review formed the foundation for some more substantial work to establish a better understanding of how users interpret information on quality, specifically measures of uncertainty, when using official statistics, and to make recommendations for good practice.

This project on uncertainty measures was initiated in 2015 and is mainly focussed on how data are used based on the quality information that is provided and whether presenting information in a different way, or using some standard definitions, could improve users' understanding. Given the queries received by the Quality Centre and the feedback provided by statistical producers at the ONS, the CV in particular has been identified as the most important concept to explore with users, as it may be more difficult to understand compared to other measures. However, we have also considered the understanding and interpretation of other uncertainty measures, such as SEs, CIs and statistical significance.

This paper sets out the main stages of this project on uncertainty measures and presents the main research work that has carried out by the Quality Centre to date.

2. Aims

Statistical producers at the ONS use different uncertainty measures to provide users with the quality information accompanying statistical bulletins. However, there is not a standard approach to how this terminology is defined which could lead to confusion for users. Moreover, in most cases, little feedback has been received from users in relation to their use and interpretation of these measures so it is not clear whether users change how they use the statistics in response to the quality information provided.

The Quality Centre's project has, therefore, aimed to:

- standardise the definitions of uncertainty measures;

- investigate users' understanding and use of uncertainty measures;

- examine the exact boundaries, terminology and presentation for uncertainty measures, in particular CVs.

3. Methodology

3.1   Research steps

This project on uncertainty measures has consisted of three main steps:

- Step 1 *(completed)*: desk research aimed at gathering information about how ONS statistical producers, the GSS and other National Statistical Institutes (NSIs) define, use and present uncertainty measures to users;

- Step 2 *(completed)*: work aimed to define the main uncertainty measures in a clear and simple language that can be understood also by non-technical users. This stage took into account the main findings from step 1;

- Step 3 *(planned)*: investigation into how users understand and use uncertainty measures. In particular, this research step will be useful to determine whether users use data differently dependent on the CV and whether they would find a different measure more meaningful.

Each research step is described in more detail in the following paragraphs. Throughout the project, the Quality Centre has engaged closely with ONS statistical producers and the GSS Good Practice Team.

3.1.1 Step 1: Desk research

In late 2014, the Quality Centre investigated what uncertainty measures are used and how they are defined and presented by a range of statistical producers at the ONS, the GSS and by other NSIs. The main conclusions from this work are reported below.

Approaches used by the ONS

The study found that colour coded CV ranges were in use by some ONS statistical outputs to highlight estimates with higher CVs. There were, however, some differences in the colours used between different statistical outputs and the exact definitions of the ranges. Some outputs published CVs without any colour coding and some outputs used text descriptions of different CV ranges, including an indication of when CVs are too unreliable to be used for practical purposes. There was also an example where the publication of CVs was ceased as it was deemed that CIs would be more meaningful to users.

Approaches used by the GSS and other NSIs

The 2014 study of the approaches taken by a selection of GSS departments showed that generally CIs are provided rather than CVs and they tended to be presented with an appropriate definition.

As part of the same study, international perspectives were explored by contacting a selection of NSIs. The Quality Centre found that:

- the Australian Bureau of Statistics publishes CVs, but these are referred to as relative SEs and, in cases where a value is high, descriptions are provided to explain how the data should be used;

- Statistics Sweden routinely publishes CVs for surveys that are based on probability samples;

- Statistics Canada commonly uses CVs to indicate the quality of estimates. A grading system is used to indicate whether the CV is at an acceptable level of quality.

3.1.2 <u>Step 2</u>: Definitions of uncertainty measures

Besides having explored the current practices in relation to the use of uncertainty measures, the Quality Centre collated and compared the definitions of SE, CV, CI and statistical significance used by ONS statistical producers, the GSS and other NSIs.

The main conclusions drawn from this desk research were that:

- in some cases, definitions of uncertainty measures were overly technical and did not provide users with sufficient background information to understand why they are needed and how they are useful to explain how accurate and precise estimates are;

- in other cases, uncertainty measures were explained at length; although contextual information can be beneficial to better understand survey processes and uncertainty, the risk with this approach is that users may miss the key points due to the lack of brevity.

Based on these considerations, the Quality Centre has worked with methodologists within the ONS and with the GSS Good Practice Team and prepared:

- an introduction page explaining what sampling means for accuracy and precision and what uncertainty measures can be used in a clear and simple language that can be understood also by non-technical users;

- a standardised set of definitions of SEs, CVs, CIs and statistical significance and examples of how they are used in practice by referring to ONS examples.

The intention is to publish these definitions on the ONS and the GSS websites, encourage their use in statistical bulletins and link these definitions to the ONS Quality and Methodology Information (QMI) reports and the GSS Good Practice Team's guidance on communicating uncertainty and change [4] to ensure that consistent definitions are available for use across the GSS.

3.1.3 <u>Step 3</u>: Investigation of users' understanding and use of uncertainty measures

This research step is at the planning stage and will aim to answer the following research questions:

- How easy or difficult are measures of uncertainty to understand (in general)?

- How easy or difficult are the definitions provided by the ONS to understand?

- Are data used differently depending on the measures of uncertainty provided with estimates? If so, which measure of uncertainty would users find more useful?

- What other measures of uncertainty could be used?

- How can these measures be best presented?

In order to address the above research questions, the Quality Centre is planning to prepare an online survey which will be sent to a list of 'expert' and 'non-expert' users and users of different ONS statistics to ensure that feedback is gathered from a wide range of users. The Quality Centre will be working closely with the ONS statistical producers, the Digital Publishing division and the Stakeholder Management team within the Communications division to select a sample of users.

The online survey will also include a section asking for personal details should users be willing to participate in focus groups. In doing so, the Quality Centre will aim to gather more in-depth information about users' understanding and use of uncertainty measures.

In addition, the Quality Centre will be looking for opportunities to gather feedback from users at ONS user group meetings and to work with other government departments to gather additional feedback from their users.

4. Conclusions and next steps

The UK Code of Practice for Official Statistics [2] indicates that users must be informed about the quality of statistical outputs against the ESS dimensions of quality [1]. For sample surveys, the typical measures of uncertainty that are recorded are one or more of: SEs, CIs, CVs and statistical significance. The Guidelines for Measuring Statistical Output Quality [1] advise that quality measures and indicators should be reported to enable users to determine when an output meets their needs. However, users may be unfamiliar with statistical concepts and, at present, there is not a standard approach to explaining the terminology around uncertainty measures as statistical producers at the ONS and in the wider GSS follow different practices.

In late 2014, the Quality Centre assessed the practices in use at the ONS, at a selection GSS departments and internationally. This review formed the foundation for more substantial work to establish a better understanding of how users interpret information

on quality. This project was initiated in 2015 and this paper has presented its main stages and the main research work that has carried out by the Quality Centre to date. The Quality Centre has worked with methodological experts within the ONS and with the GSS Good Practice Team to prepare standard definitions of uncertainty measures. The intention is to publish these definitions on the ONS and the GSS websites, encourage their use in statistical bulletins and link these definitions to the ONS QMI reports and the GSS Good Practice Team's guidance on communicating uncertainty and change [4] to ensure that consistent definitions are available for use across the GSS. The next stage of the work will be to gather feedback from users of statistics about their understanding and use of uncertainty measures to ensure that the quality information provided is meeting user needs.

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