DIFFERENTIAL BENEFITS OF QUESTIONNAIRE REDESIGN: IMPLICATIONS FOR DATA QUALITY AND STATISTICAL BURDEN ACROSS DIFFERENT RESPONDENT PROFILES[1]

Sabrina Barcherini, Barbara M.R. Lorè, Valeria Mastrostefano, Simona Rosati

Abstract. The aim of this paper is to show how different respondents benefit differently from methodological improvements in the questionnaire design.
When dealing with questionnaires, respondents differ in both the type and number of difficulties they face, depending on structural characteristics, core variables, and response strategies. This leads to differences in completion performance, with some respondents more likely to introduce inaccuracies, especially in quantitative information.
If the questionnaire is one of the main sources of non-sampling error, a good questionnaire design is a primary tool for maximizing accuracy. Data from the survey on Research and Development in business enterprises (RS1), collected before and after major changes to the questionnaire design, have been compared to explore differences in completion behaviour. Both descriptive and logistic model analysis, carried out to assess the impact of design changes intended to facilitate and improve the use of the unit of measurement in expenditure questions, along with the analysis of burden indicators, have shown the existence of different sub-populations, both in terms of accuracy and perceived burden. Profiling respondents has provided valuable insights into further opportunities for improvement.

1. Introduction

A careful design of a questionnaire positively impacts the quality of the data collected and reduces the statistical burden. These effects can vary depending on the respondents' profiles and can influence both response behaviour and perceived burden.

In business surveys, completing a questionnaire can be particularly challenging for a variety of reasons (Willimack *et al.*, 2001). The information necessary to answer the questions has to be retrieved from archives and business documents that are not necessarily interconnected or freely accessible to everyone in the organisation. Enterprises data is not always readily available in the format required by the questionnaire, which must align with the definitions and classifications established in the regulations. Consequently, it often needs to be processed before

[1] This article is the result of the collaboration between the authors. In particular: paragraphs 1 and 4.1 have been written by Simona Rosati, paragraphs 2 and 4 have been written by Valeria Mastrostefano, paragraphs 3 and 4.3 have been written by Sabrina Barcherini, paragraphs 4.2 and 5 have been written by Barbara M. R. Lorè.

the questionnaire is completed, and more than one person may be necessary to perform these operations. Finally, all data entered into the questionnaire must be internally consistent and adhere to quality checks.

The following paragraphs describe the case study of the survey on Research and Development in business enterprises. The analysis performed aims to understand the impact of significant measures implemented during the questionnaire redesign on data quality and statistical burden.

2. Background

Research and Development (R&D) is universally recognised as an engine of economic growth and societal challenges. However, to be a powerful force for socio-economic development, it needs effective policies based on reliable indicators of R&D inputs, namely personnel and expenditure. To this aim, Istat has conducted yearly surveys on R&D since the 1960s, in compliance with the Frascati Manual (OECD, 2015)[2]. The Italian survey provides data on expenditure and personnel involved in R&D activities at time t, as well as preliminary data at time t+1 and t+2. As a census-based survey, the target population comprises around 39,000 Italian active enterprises that could potentially perform R&D[3]. Data is collected through an online self-completed questionnaire, available on the Istat Business Statistical Portal.

The survey's key variables are the personnel and expenditure[4] involved in R&D activities performed within a reporting unit (i.e. intramural activity). Additionally, the survey captures other expenditure aspects such as R&D funding, the functional distribution of R&D resources (basic research versus applied research and experimental development), the industries likely to be making use of the R&D results, and extramural R&D expenditure (R&D performed outside the statistical unit). The measurement of R&D personnel involves two key sets of variables: number of persons involved in R&D in headcounts and in full-time equivalent, since R&D may be a part-time activity and not necessarily involve R&D personnel on a full-time basis[5]. In recent years, the survey has faced significant issues:

- a progressively decreasing response rate;

[2] The Frascati Manual has evolved through seven editions since its initial publication and it is nowadays the de facto R&D reference document across countries at different stages of economic development.

[3] The main statistical sources used to define the potential R&D performers are the official Italian business Register and the inventory of the enterprises claiming tax relief for R&D activities and projects (from the Italian Agency for fiscal revenues of the Ministry of Economy).

[4] Intramural R&D expenditures are all current expenditures (including labour and other costs) plus gross fixed capital expenditures (such as for land, buildings, machinery and equipment) for R&D performed within a statistical unit during a specific reference period, whatever the source of funds" (Frascati Manual, 2015).

[5] The survey covers both persons employed and external R&D personnel.

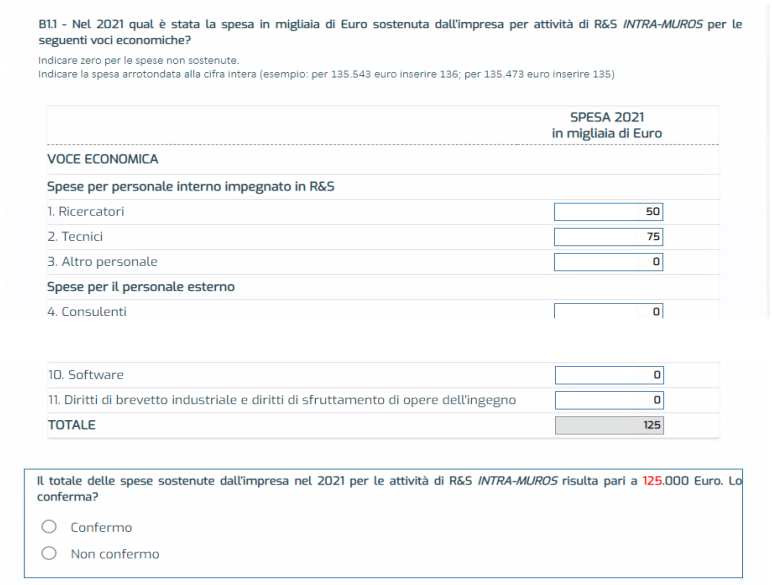
- several sources of inaccuracy, including routing errors, inconsistencies, and outliers. The most concerning issue in recent years has been the misuse of the unit of measurement in the R&D expenditure report, where euros were used instead of thousands of euro;
- a growing response burden, due to an excessively long and demanding questionnaire. Quantitative variables and complex concepts behind the survey make the core questionnaire overly burdensome for respondents, especially for the large and more complex enterprises.

To handle these issues, a huge questionnaire redesign was undertaken.

3. Innovations in the questionnaire design

In 2023, a major redesign of the questionnaire was implemented to address the problem of declining response rates and increasing dropout observed in recent years, as well as to enhance the quality of the data collected. Substantial changes were made to shorten the questionnaire and enhance its user-friendliness. To minimise incorrect responses in quantitative questions, the totals of the main distributions, which are automatically computed, are now submitted to the respondents for validation (Figure 1).

Figure 1 – *Example of quantitative question and validation question from the 2023 questionnaire.*


B1.1 - Nel 2021 qual è stata la spesa in migliaia di Euro sostenuta dall'impresa per attività di R&S *INTRA-MUROS* per le seguenti voci economiche?

Indicare zero per le spese non sostenute.
Indicare la spesa arrotondata alla cifra intera (esempio: per 135.543 euro inserire 136; per 135.473 euro inserire 135)

VOCE ECONOMICA	SPESA 2021 in migliaia di Euro
Spese per personale interno impegnato in R&S	
1. Ricercatori	50
2. Tecnici	75
3. Altro personale	0
Spese per il personale esterno	
4. Consulenti	0
10. Software	0
11. Diritti di brevetto industriale e diritti di sfruttamento di opere dell'ingegno	0
TOTALE	125

Il totale delle spese sostenute dall'impresa nel 2021 per le attività di R&S *INTRA-MUROS* risulta pari a 125.000 Euro. Lo conferma?

- ○ Confermo
- ○ Non confermo

Source: RS1 questionnaire. Year 2023.

Requesting an informed response helps reduce mistakes (Barcherini and Lorè, 2022). When data are confirmed as correct, they are captured by the questionnaire and used to populate auto-filled text, which is used as a reminder, and placed within or immediately below the subsequent questions. One of the most challenging issues with the questionnaire is the request for respondents to provide information on expenditure related to intramural R&D activities in thousands of euros, as mandated by EU regulation. In 2019 two versions of the questionnaire were created: one, requiring expenditure in euros, to facilitate the task for units with low economic performance, and another requiring expenditure to be reported in thousands of euros for those expected to have accounting records in thousands (Ceccarelli *et al.*, 2022). However, inconsistent data continued to be reported, with the most prevalent error being the use of euros instead of thousands. Consequently, in the 2023 another innovation was introduced to reduce mistakes in the unit of measurement usage. To make the respondents more aware of their responses, the total submitted to the respondent for validation now includes an auto-filled text that gives the total in full (in euros), even if the data entry is requested in thousands. In this way, any error in the use of the unit of measurement can be immediately identified by the respondent and corrected before continuing with the completion (Figure 1).

4. Assessing the impact of the questionnaire redesign

Descriptive analyses have been conducted to explore the relative variation from 2022 to 2023, in order to understand the impact of major measures implemented during the questionnaire redesign on data quality, completion behaviour, and respondents' perception of statistical burden. Different categories defined by enterprises' size or by the novelty in the survey involvement (first-time respondents vs. experienced respondents) have been compared. Data quality was further investigated by using a logistic model with the aim of examining the effects of the questionnaire redesign on the risk of misusing the measurement unit usage in the R&D expenditure. Additionally, the logistic model has enabled an analysis of the association between enterprise structural characteristics, objective burden, and perceived burden. The main results[6] are reported in the following paragraphs.

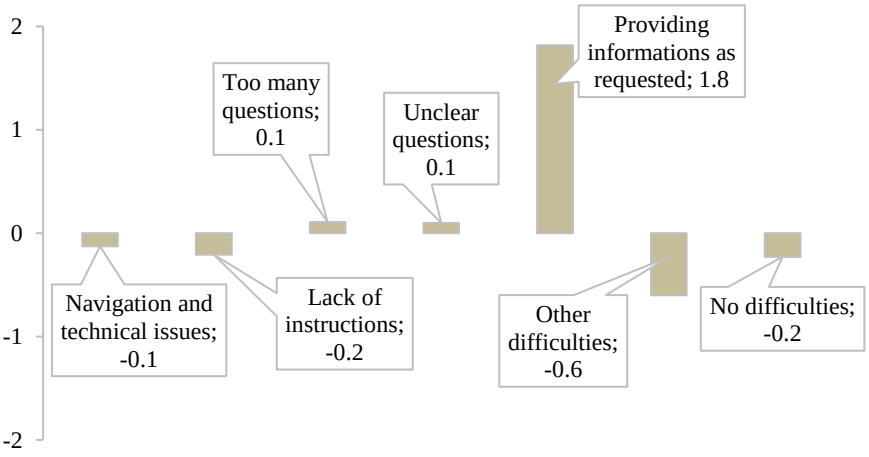
4.1 The impact of the questionnaire redesign on statistical burden

The burden experienced by respondents during questionnaire completion can negatively affect both response rate and data quality (Fricker *et al.* 2019). Responding to a statistical survey is indeed a burdensome task, with the perception of the burden influenced by factors such as questionnaire length, effort required to

[6] Results reported in this paper are elaborations from raw unweighted data.

retrieve information, and question clarity (Bradburn, 1978). Designing a questionnaire is likewise challenging, requiring the management of numerous aspects to minimize respondent stress during the task. The final section of the R&D questionnaire includes a question asking respondents about any difficulties they have experienced during the completion[7]. A comparison of responses to this question from 2022 and 2023 shows a reduction in technical difficulties with the questionnaire: navigation issues decrease from 12.7 percent to 11.1 percent (-0.1) and problems with insufficient instructions decrease from 11.6 percent to 9.2 percent (-0.2). Conversely, difficulties related to the content and structure of the questionnaire have increased. In particular, the difficulty to provide the information required increase from 10 percent to 28 percent (+1.8) (Figure 2).

Figure 2 – *Percentage variation of reported difficulties in questionnaire completion. Years 2022 and 2023.*



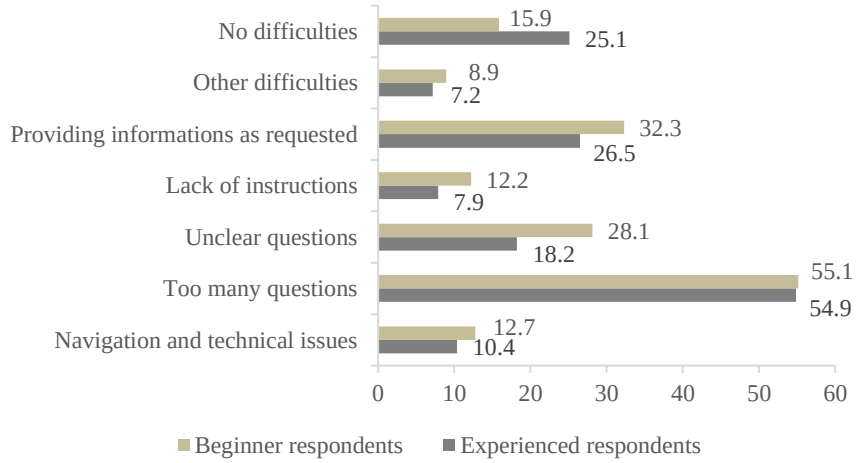
Source: ISTAT, Research and Development in business enterprises (RS1).

Further analysis compared the difficulties reported by first-time respondents with those of experienced respondents in 2023. The findings reveal that beginner respondents encounter more difficulties across all aspects considered (Figure 3), while experienced enterprises more often report no difficulties (25.1 percent vs. 15.9 percent). Previous experience thus seems to be a crucial factor in facilitating the respondents' task. Novice enterprises more frequently report unclear questions (28.1 percent vs. 18.2 percent), difficulties in providing information as required (32.3

[7] The question investigates the following items: difficulty in navigating the questionnaire, high number of questions, unclear questions, lack of instructions to support completion, difficulty in providing information required, other types of difficulties

percent vs. 26.5 percent), and a lack of instructions for completion (12.2 percent vs. 7.9 percent).

Figure 3 – D*ifficulties in questionnaire completion reported by beginner and experienced respondents. Year 2023. (% values).*



Source: ISTAT, Research and Development in business enterprises (RS1).

When enterprises of different sizes are compared, minimal differences in perceived burden are found. In 2023, units with up to 9 employees more frequently report navigation difficulties (13.1 percent compared to 11.1 percent of the total respondents), unclear questions (24.0 percent vs. 21.2 percent) and lack of instructions for completion (12.1 percent vs. 9.2 percent). Enterprises with 250 employees and above more often struggle with providing information as requested (32.3 percent compared to 28.2 percent of the total respondents). Those with 100 to 249 employees more frequently cite the high number of questions (59.5 percent compared to 54.9 percent of the total respondents) as main issue.

4.2 The impact of the questionnaire redesign on accuracy

The quality of data collected through a questionnaire is intrinsically related to the care taken in its design. A well-designed questionnaire can substantially reduce errors and enhance responses consistency (Brown, 2022), as shown by the analysis of changes in the accurate use of units of measurement between 2022 and 2023.

On the whole, the rate of errors in unit of measurement usage has decreased from 13.5 percent in 2022 to 9.2 percent in 2023. However, this overall figure conceals variations among different subpopulations. When focusing on the units that

responded to the survey in both 2022 and 2023, 88.8 percent maintained consistent performance, with 88.1 percent using the unit of measurement correctly in both years and 0.7 percent consistently using it incorrectly. Of those whose performance differed between the two years, 7.0 percent showed an improvement, while 4.2 percent exhibited a decline in their use of the unit of measurement.

Despite the substantial overlap between samples from one year to the next, there are always some new respondents each year (Table 1). Preliminary analyses indicate that units with prior survey experience benefit more from the questionnaire redesign than first-time participants, with experienced enterprises demonstrating a 48.3 percent enhancement in data quality compared to a 40.8 percent improvement among the new ones, regardless of the enterprise's size.

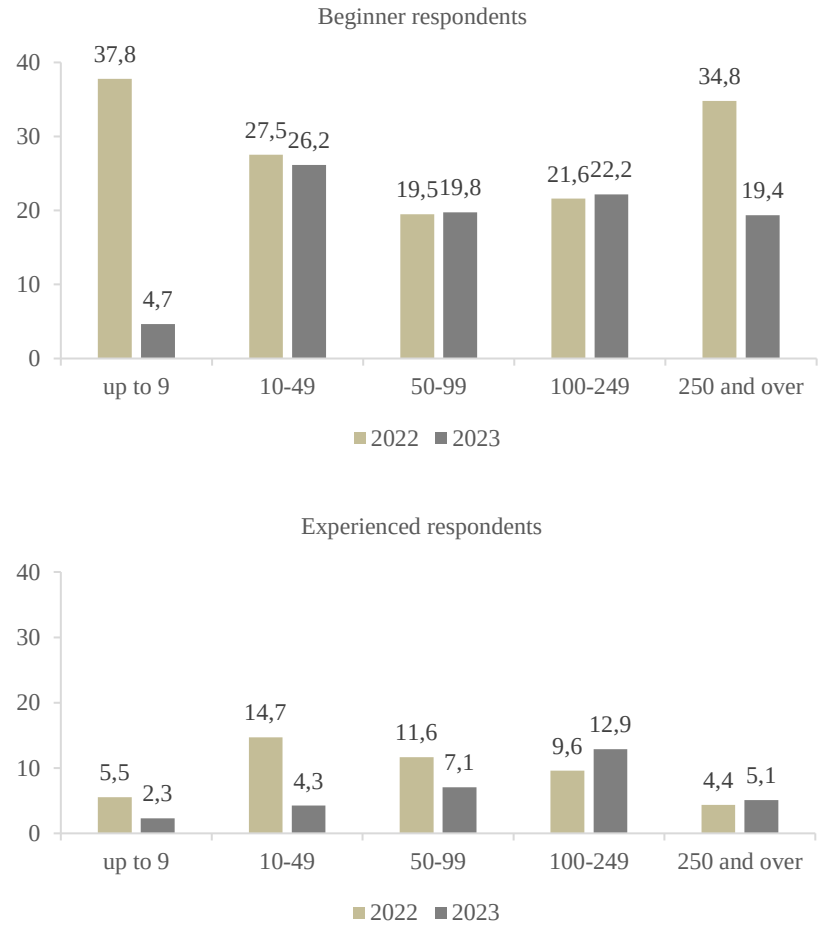
Table 1 – *Respondents in 2022 and 2023 by enterprise size and survey experience.*

Year	Enterprise size					Beginners	Experienced	Total
	Up to 9	10-49	50-99	100-249	250 and over			
2022	2639	5115	1535	1435	1214	1727	10211	11938
2023	3002	5174	1597	1534	1219	3714	8812	12526

However, enterprise size does matter. The redesign of the questionnaire had a different impact across various size classes, depending on whether the units were experts or novices (Figure 4). Under the previous questionnaire design, the smallest and the largest beginner enterprises made the most errors. In 2023, with the new questionnaire, the smallest and the largest newcomers were specifically the ones who outperformed their predecessors in the correct usage of the unit of measurement. Conversely, enterprises in the intermediate size classes, which previously made fewer errors, have maintained their performance largely unchanged. Among experienced respondents, the redesign has had a different effect. The distribution of errors, which previously was right-skewed, has now become left-skewed.

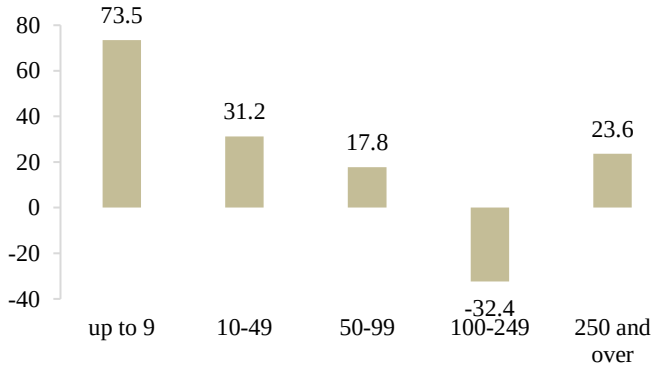
An analysis focusing on the units that responded to both the 2022 and 2023 surveys (Figure 5) reveals that the improvement in the use of measurement unit is the most pronounced among enterprises in the smallest size class. As the number of employees increases, this improvement becomes progressively less significant and disappears entirely in units with 100 to 249 employees. In this size class, a 32.4 percent deterioration was observed. However, the improvement in data quality is regained in the largest size class.

Figure 4 – *Experienced and beginner respondents misusing the unit of measurement in 2022 and 2023 by enterprise size (% values).*



Source: ISTAT, Research and Development in business enterprises (RS1).

Figure 5 – *Percentage variation from 2022 to 2023 in the accurate use of unit of measurement by enterprise size.*



Source: ISTAT, Research and Development in business enterprises (RS1).

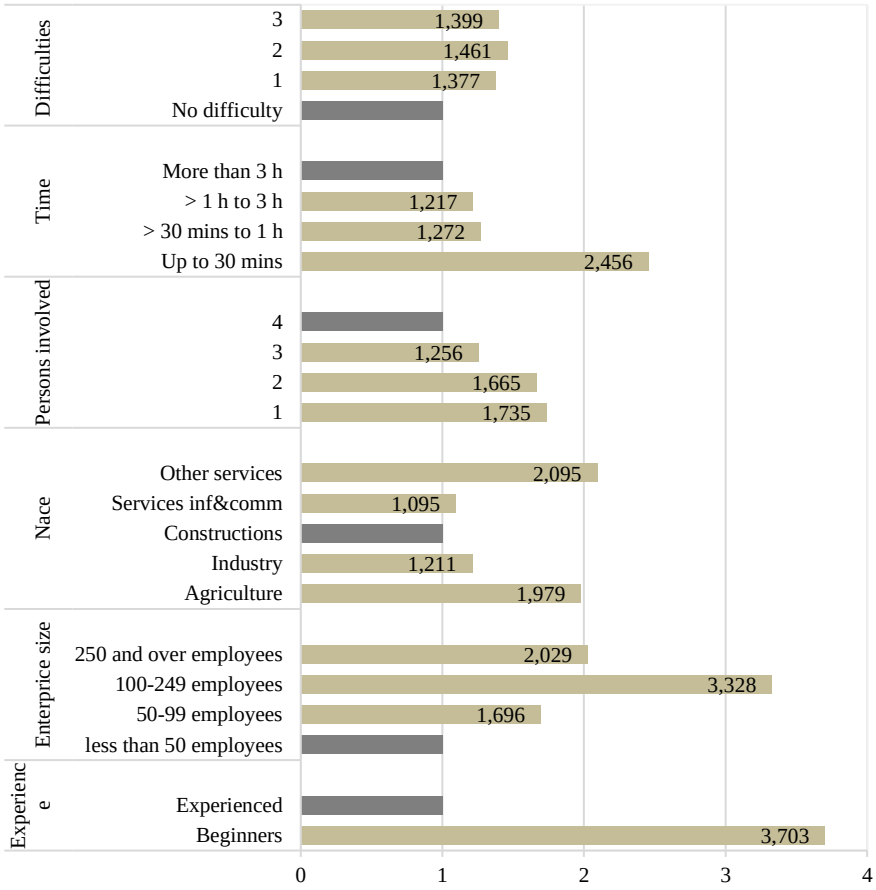
4.3 Factors influencing error occurrence in the unit of measurement usage: a Logistic Regression Analysis

A logistic model has been employed to investigate the quality with which the questionnaire was filled out and the association between enterprise structural characteristics, objective burden and perceived burden (Hosmer *et al.*, 2013).

The presence or absence of errors in the measurement unit usage has been defined as a binary dependent variable. The explanatory variables encompassed: i) structural characteristics, including enterprise size, NACE (Nomenclature of Economic Activities), and previous experience with the survey; ii) objective burden, measured by the time spent and the number of individuals involved in the data preparation before the questionnaire completion; iii) perceived burden, indicated by the number of difficulties reported during the questionnaire completion, and iv) core information, represented by intensity of research and development activities, namely the ratio between the expenditure incurred and the number of researchers involved (Figure 6).

A stepwise procedure has been applied. The only non-significant variable is the intensity of research and development activities. The variable most predictive of errors occurrence is the lack of experience, that is participating in the survey for the first time, whereas NACE is the least predictive variable.

Figure 6 – *Probability of misusing the measurement unit. Odds ratio. Year 2023.*



Source: ISTAT, Research and Development in business enterprises (RS1).

Beginner enterprises are 3.7 times more likely to misuse the unit of measurement than experienced ones, indicating that experience in completing the questionnaire facilitates accuracy and that recent changes have not negatively affected this gained experience. Regarding enterprise size, using the class with less than 50 employees as a reference category, the highest risk of inaccuracy is observed in enterprises with 100 to 249 employees, which have a 3.3 times higher risk. As the time spent collecting and preparing data to enter into the questionnaire increases, the risk of error decreases. Respondents who take less than half an hour to perform these operations have a 2.5 times higher risk of error compared to those who take more than 3 hours, while those who take 1 to 3 hours have a 1.2 times higher risk. Taking enterprises in the construction sector as the reference category, those in the

agriculture sector have a 1.9 higher risk, and those in the industrial sector have a 1.2 higher risk.

5. Discussion

When designing the methodological features of a questionnaire, the respondent must be the primary focus. By paying attention to the content, wording and format of questions, we can reasonably ensure a reduction in statistical burden, an improvement in data quality, and potentially an increased willingness of respondents to participate in surveys (Barcherini *et al.*, 2022). However, each questionnaire is unique (Convers and Presser, 1986) and presents its own challenges, particularly quantitative ones, which can be demanding for both respondents and designers.

Likewise, respondents are not homogeneous; they vary in structural characteristics and response strategies. Unlike prior studies that evaluated the overall performance of the responding companies without examining underlying differences (Ceccarelli *et al.*, 2022), the case study discussed highlights this variability, showing that design choices can improve the experience for some respondents while worsening it for others. For instance, the accuracy of measurement unit use varies with enterprise size. As enterprise size increases, this accuracy improvement diminishes and then plummets in the 100-249 size class. This trend suggests that performance depends on the balance between the task difficulty and the resources available to address it. As the size of an enterprise increases, the complexity of the calculations required to complete the questionnaire also increases. However, the ability to manage this complexity does not scale proportionately, resulting in a gradual decline in accuracy improvement. The sharp decline in performance in the 100-249 size class indicates a breakdown in the balance between task difficulty and the respondents' ability. Larger firms regain this balance thanks to better resources and expertise, which allow them to cope with extreme complexity.

Therefore, continuing to think generically in terms of business questionnaires, or generalising questionnaire design based on the simplistic dichotomy (short forms for small enterprises and long forms for medium and large ones) that is often used to reduce the burden of the business surveys (Istat, 2024) does not seem to be the most effective strategy.

It is reasonable to assume that each questionnaire has a unique breaking point in terms of the difficulty-ability balance, which depends on both its features and respondents' characteristics. Identifying this breaking point is crucial for optimizing design choices to accommodate most respondents. At the same time, it is essential to envision differentiated design solutions tailored to respondents' diverse needs. This requires testing and integrating quantitative methods with qualitative techniques to understand the challenges faced by different respondents and to create increasingly customized solutions.

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Sabrina BARCHERINI, Istat, barcheri@istat.it
Barbara Maria Rosa LORÈ, Istat, lore@istat.it
Valeria MASTROSTEFANO, Istat, mastrost@istat.it
Simona ROSATI, Istat, srosati@istat.it