Insight-Statistics 2025, 8(1), 740.
https://doi.org/10.18282/i-s740

Article

Sample selection in social science research: A holistic approach to methodological rigor

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CITATION

Hasan Polas MR. Sample selection in social science research: A holistic approach to methodological rigor. Insight-Statistics. 2025; 8(1): 740. https://doi.org/10.18282/i-s740

ARTICLE INFO

Received: 29 December 2024
Accepted: 15 January 2025
Available online: 7 February 2025

Abstract: The present study investigates the crucial elements of sample selection in social science research, thoroughly examining the nuances of sampling techniques, categories, and factors. The paper offers a thorough overview of the procedures involved in sampling strategies, with a particular emphasis on non-probability and probability approaches. It also discusses the critical role that sample size determination plays, taking into account variables like cost, ethics, statistical power, accuracy, and generalizability in addition to type I and type II errors. The paper also closely examines how several elements, such as research objectives, design, analytical instruments, and resource constraints, affect the choice of the ideal sample size. The topic of choosing the right data analysis software and how it affects choices about sample size is covered in detail. In the last section of the study, the ideas of power, effect size, and minimum sample size in statistical analysis are thoroughly explored, with a focus on partial least squares structural equation modelling (PLS-SEM).

Keywords: sample selection; social science research; methodological rigor; quantitative approach

1. Introduction

Choosing the right sample is an essential part of research technique that affects the validity, reliability, and generalizability of the study's conclusions [1,2]. A thorough review of sample selection methods, procedures, and factors is the goal of this article, which places particular emphasis on probability and non-probability sampling approaches. Furthermore, the research delves into the complexities involved in ascertaining the ideal sample size, taking into account many variables such as statistical power, accuracy, generalizability, expense, morality, and the balance between Type I and Type II shortcomings [3,4]. The influence of research objectives, design, analytical instruments, and resource constraints on determining the appropriate sample size is examined, with particular attention paid to the choice of data analysis software. The notions of power, effect size, and minimum sample size in statistical analysis are explored in the article's conclusion, with a focus on PLS-SEM [5,6].

Research activities are essentially rooted in the hunt for information, comprehension, and significant revelations. The crucial choice of sample selection, which has significant effects on the validity, reliability, and application of study findings, is at the centre of this academic endeavor. Across academic borders and methodology, the careful and deliberate selection of a sample is an essential component of every research study's methodological framework [7].

One can never stress how crucial sample selection is to research. By using a well selected sample, which acts as a microcosm of the broader population, researchers may draw reliable conclusions and make relevant inferences. On the other hand, an improperly chosen sample might introduce biases, jeopardize a study's external and internal validity, and damage the validity of its conclusions. Improving the robustness and dependability of scholarly inquiry is therefore a goal of the road towards optimizing research sample selection [8].

Considering the challenges mentioned above, the objective of this study is to overview of a few of these issues in relation to the following questions:

Research Question No. 1: *What are the most effective and efficient steps of sample selection in social science research, and how can researchers master these steps to enhance the quality of their studies?*

Research Question No. 2: *How to select software for data analysis selection that social science researchers need to use in their studies?*

Research Question No. 3: *What are the effects of resource limitations on sample size determination?*

Research Question No. 4: *What exemplifies the vital relevance of estimating sample sizes?*

This study sets out to do a thorough investigation of the complex field of sample selection, exploring the nuances of the methods, approaches, and factors that support this vital aspect of the research process. Finding the best sample is not only a technical exercise but also a process of strategic and careful decision-making that has a big impact on how research turns out.

2. A deep dive into sample selection processes

Research Question No. 1: *What are the most effective and efficient steps of sample selection in social science research, and how can researchers master these steps to enhance the quality of their studies?*

2.1. How sample and sampling works in a research?

Prior to exploring the nuances of sample selection, it is essential to have a basic comprehension of the words "sample" and "sampling". A sample is a representative portion of a population that is taken so that inferences about the population as a whole may be reached. The process of choosing this subgroup is known as "sampling". To provide an example, consider a situation in which the objective is to determine the opinions of five hundred people in a city. Stratified sampling, random sampling, convenience sampling, and other methods can be used to provide a sample that accurately reflects the diversity and features of the whole population [9,10].

Sample: A sample is a representative subset of people or things drawn from a population in order to carry out research and draw conclusions about the features of the sample that apply to the full population [9].

Example: Assume you choose to gather a sample of 500 people in order to research this demographic. Stratified sampling, convenience sampling, random sampling, and other techniques might be used to produce this sample. For the sake of this example, in this manner, without having to conduct surveys or examine every member of the population, you may draw conclusions about the whole population of interest by examining a well selected and representative sample.

Sampling: The act of choosing a subset of people or components from a broader population in order to investigate and make conclusions about that group is referred to as "sampling" in research. Sampling plays a crucial role in the validity and generalizability of your study findings, therefore it's important to do it well [10]. While there are many other sampling strategies, we will discuss two popular ones here: purposive sampling and random sampling, with examples of both.

When doing research, sampling is essential since it guarantees that the results of your study may be applied to a larger population (in the case of random sample) or offer in-depth understanding of a particular subgroup (in the case of purposive sampling) [10]. The goals of the study and the features of the population you are examining should guide your choice of sample technique.

Example: Let's say you wish to research what the city's registered voters think. A random sample of, say, 500 voters might be chosen at random from a list of all the city's registered voters using a random number generator. You may guarantee that the sample is representative of the city's total registered voter population by taking this action.

2.2. Types of sampling techniques

Sampling techniques are broad and heterogeneous fields that include both non-probability and probability tactics. Based on the concepts of randomness, probability sampling guarantees that each individual in the population has a known, non-zero probability of being selected for the sample [11,12]. Conversely, non-probability sampling methods are used in situations where it is not possible to pick respondents fairly. Non-probability sampling techniques frequently have benefits in terms of speed and cost-effectiveness, even if probability sampling provides a strong foundation for statistical results. They do, however, have certain limitations in terms of supporting broad societal generalizations and are susceptible to selection bias [11].

In social science research, sampling strategies may be roughly divided into two groups: non-probability sampling strategies and probability sampling strategies.

Probability Sampling: A strategy in which every member of the population has a known, non-zero chance of being chosen for the sample is called probability sampling. These techniques, which are grounded in the idea of randomness, offer a strong framework for drawing statistical conclusions about the total population [12]. In order to create samples that are both statistically sound and representative of the population from which they are drawn, probability sampling procedures are essential. Probability sampling is frequently used because of its ability to assure a fair representation of the population, even if it cannot guarantee that every sample is an exact mirror of the population. This study emphasizes the relevance and requirement of random sampling in research situations by examining a fictitious scenario involving postgraduate students in 10 private institutions.

Non-Probability Sampling: When the study paradigm does not provide for the option of fair respondent selection, non-probability sampling techniques should be used. When compared to their probability-based equivalents, non-probability sampling procedures often provide the advantages of accelerated data gathering and lower cost expenditure [13]. However, it is important to recognize that these inferential methods are vulnerable to the harmful effects of selection bias, which means they are not appropriate for producing population size estimates that exhibit a high level of objectivity. Furthermore, non-probability sampling techniques are usually insufficient to support the development of comprehensive social generalizations since they depend on the judgment of the researcher or the occurrence of random occurrences [14].

2.3. Steps of sampling techniques

Sample selection is a complicated process that requires a number of well-planned stages to navigate. The population under inquiry, or the group from which significant conclusions are to be derived, must be defined as the first stage. The next step is to create a sample frame, which is a complete list or database of every component in the population, making sure that all pertinent entities are included [14]. Next, a sample strategy is chosen, taking into account the population's features and the objectives of the study. Selecting the right sample size requires careful consideration of a number of variables, including demographic diversity, margin of error, and confidence level [15]. The sample is then drawn at random from the sampling frame, guaranteeing that each element has an equal chance of being included. Data gathering techniques, including surveys, interviews, and observations, are used after the sample has been determined. After thorough research of the gathered data, conclusions regarding the larger population are drawn [16].

Define the Population: Establishing the demographic you wish to examine should come first. This should be the set of people or things about which you plan to draw conclusions from the sample [17].

Example: Let's say you wish to research the academic achievement of every kid in a specific school district. All of the pupils in that school district make up the population in this instance.

Create a Sampling Frame: A complete list or database of every component in the population is called a sampling frame. To make sure that every person in the population is identified and able to be included in the sample, it is critical to have a dependable and current sampling frame [15,16].

Example: Get a list of every student registered in the district in order to establish a sample frame. Included in this list should be each student's name, grade level, and any other pertinent data.

Select a Sampling Method: Select a probability sampling technique based on the population's characteristics and your research goals. Simple random sampling, stratified sampling, systematic sampling, cluster sampling, or multi-stage sampling are examples of common probability sampling techniques [15].

Example: You choose to employ stratified sampling in order to guarantee that the kids from various grade levels are fairly represented. You've selected this approach in order to compare the academic achievements of pupils in elementary, middle, and high school.

Determine the Sample Size: Determine the right sample size by accounting for variables such as the desired degree of confidence, the margin of error, and the variability of the demographic parameters. Software tools and statistical algorithms are available to assist in making this conclusion [16].

Example: You determine that a sample size of 400 students is required to get the appropriate degree of confidence and error margin in your research.

Randomly Select the Sample: Choose a random sample from the sampling frame using a randomization technique, such as a random number generator. Make sure that each component in the sample frame has an equal probability of being selected and that the selection is really random [17].

Example: You choose 150 middle school kids, 150 high school students, and 100 primary students from each of the corresponding strata in your sample frame using a random number generator.

Collect Data: After you have your sample, get the information you need from the people or things you have chosen. Any pertinent approach, including surveys, interviews, and observations, may be used to obtain this data [15,17].

Example: You give the pupils who were chosen at random academic performance assessments and note their results.

Examine and Interpret the Data: Make inferences about the population from the sample's characteristics after analyzing the data that was gathered from it. A sound statistical analysis is essential to drawing reliable conclusions [17,18].

Example: You examine the test results of a sample of children and, using the information gathered, make inferences about the academic achievement of every student in the district.

You may make sure that your sample is representative of the population and that the results of your study can be applied to a wider population by using these probability sampling procedures in your social science research.

2.4. Determinants shaping the deliberations on optimal sample size selection

Selecting the right sample size is a complex procedure that depends on a wide range of variables. The present study examines the different factors that influence the decision-making process when choosing a sample size [19,20]. These factors include the research methodology selected, analytical methods used, complexity of the variables or models, logistical and temporal constraints, response rates, input from advisors, previous sample sizes, and data analysis software utilized. It explores the complex interactions between these variables and how they affect the important choice of sample size [21].

The concept of sample size may be delineated as the subset of a population strategically assembled to ensure a surplus of information, facilitating the derivation of conclusive insights [15,21]. In a comparable vein, Kumar et al. [22] characterized sample size as the 'aggregate count of individuals within the sample', succinctly encapsulating the notion as the count of respondents or observations within a research undertaking. The endeavor of estimating an appropriate sample size necessitates a thoughtful consideration of numerous variables, encompassing the chosen research methodology, analytical techniques, the complexity of variables or models, temporal and logistical constraints, response rates, advisory input, precedent sample sizes from akin studies, and the employed data analysis software [21].

Research Question No. 2: *How to select statistical software for data analysis that social science researchers need to use in their studies?*

3. Software for data analysis selection

The selection of data analysis software is a frequently disregarded factor in determining sample size. In the context of partial least squares structural equation modeling (PLS-SEM) and covariance-based structural equation modelling (CB-SEM), in particular, this study emphasizes the significant influence of the chosen software on sample size decisions. It refutes the fallacy that PLS-SEM is only intended for small sample sizes and promotes a sophisticated comprehension of the advantages and disadvantages of various software programmers [21].

The choice of an appropriate data analysis program can have a significant impact on the choice of the best sample size [17]. In the academic community, it is widely acknowledged that larger sample sizes are required when using covariance-based structural equation modelling (CB-SEM) platforms, such as AMOS, as opposed to partial least squares structural equation modeling (PLS-SEM) programs like Smart PLS. As shown by Hair et al. [21], Ringle et al. [19], and Ryan [23], this distinction is mostly due to the underlying estimate approaches used by each. It is crucial to remove the false impression that PLS-SEM is a streamlined tool created specifically for models with small sample numbers. Hair et al. [21] noted that despite the target populations being significantly large, research continues to be undertaken with small sample sizes as a result of this false assumption.

Hair et al. [20] have emphasized that "no multivariate analysis technique, including PLS-SEM, possesses any mystical capabilities". This is a crucial point. It is crucial to recognize that a software program's effectiveness depends more on its capability to produce correct results than on its ability to run models with any sample size. Interestingly, both CB-SEM and PLS-SEM may produce consistent results when applied to large datasets with 250 or more samples. In light of these revelations, it is strongly advised that researchers refer to Hair et al.'s [21] thorough analysis of sample size issues in PLS-SEM research [17].

Research Question No. 3: *What are the effects of resource limitations on sample size determination?*

3.1. The impact of resource limitations on sample size determination

Recognizing and navigating the restrictions brought about by time, money, and resource constraints is essential to achieving significant research findings. The study clarifies the difficulties that researchers encounter while physically engaging with dispersed communities, particularly in situations requiring a lot of resources for data gathering. The sample size decision is intricately linked to ethical issues, including the moral consequences of exposing a large number of people to potentially harmful therapies [21].

The idea of sample size—often described as a well-chosen subset of the population—is essential to producing definitive findings. This study emphasizes how significantly sample size affects the validity, reliability, and generalizability of research findings. It emphasizes the necessity for a balanced approach in deciding on the significance level and sample size by highlighting the trade-off between Type I and Type II mistakes. The influence of study objectives, design, and analytic techniques is also covered, acknowledging the dynamic nature of sample size needs in various research contexts [20].

As emphasized by Francis et al. [24], financial, time, and resource restrictions have a significant impact on the careful evaluation of sample size. Researchers frequently struggle with the difficult task of physically interacting with a geographically scattered population, a situation made more difficult by funding limitations [17]. It becomes clear that gathering data requires a labor-intensive and expensive process, such as travelling across several locations or paying enumerators. To use Bangladesh as an example, the existence of gas facilities prevents researchers, especially students, from doing data collection at all of the major places. These include Sylhet, Chattogram, and Bandarban. Attempts to get a sizable and representative sample are further complicated by the problem of subject accessibility [17,24].

Research Question No. 4: *What exemplifies the vital relevance of estimating sample sizes?*

The ideas of statistical power, effect size, and minimum sample size are explored in the research's final parts. Route coefficients and sample size are discussed in relation to statistical power, a metric that indicates a test's capacity to detect a true effect. When determining the minimum sample size required for adequate statistical power, effect size—measured by Cohen's f coefficient—emerges as a crucial parameter that is independent of sample size. The way these ideas interact, especially, when considering PLS-SEM, highlights the complex process of decision-making that researchers go through when trying to determine the ideal sample size [21].

The validity, reliability, and generalizability of study findings can all be strongly impacted by the choice of sample size, making it a key consideration in research. In research, choosing a sample size is crucial for a number of reasons [17,20].

Statistical Power: A study's statistical power is influenced by the size of the sample. The capacity of research to find a real difference or effect, assuming one exists, is known as statistical power. Small sample sizes can result in weak statistical power, which increases the likelihood of missing true effects or correlations in the data. To guarantee that their study has a good probability of identifying important impacts, researchers need to select an adequate sample size [20,21].

Precision: More accurate estimations are often obtained with a larger sample size. The estimations of population parameters (such as means and proportions) often have fewer standard errors when the sample size is larger. As a result, the results are more accurate, and the confidence intervals are smaller, giving a clearer picture of the real features of the population [20].

Generalizability: The sample must accurately reflect the target population. Results that don't generalize effectively to the larger population might be the consequence of inadequate sample sizes or biased sampling. In order to draw conclusions about the total population, researchers must make sure that their sample size and sampling techniques are adequate [25].

Cost and Resources: Gathering data may be time-consuming and expensive, especially for large samples. The requirement for a larger sample size must be weighed against the resources that are available, say researchers. Occasionally, using a smaller sample size and carefully weighing the costs and benefits of statistical power may be more feasible [25].

Ethics: Using a very large sample size in some studies may not be appropriate or practical. For instance, it could not be moral to subject a large number of people to a possibly damaging intervention in a medical study. Researchers must take ethical issues into account when choosing their sample size [25].

Type I and Type II Errors: The sample size has an impact on the trade-off between Type I (false positive) and Type II (false negative) errors in hypothesis testing. A larger sample size decreases the likelihood of Type II mistakes but may raise the likelihood of Type I errors. To achieve a proper balance, the significance level and sample size should be determined [17,25].

Study Aims: Decisions on sample size are also influenced by the particular study aims and the impact size of interest. A larger sample size could be needed to find it if the estimated effect size is modest. On the other hand, if the effect size is large, a smaller sample could be adequate [25].

Study Design: The choice of sample size may also be influenced by the kind of study design (experimental, observational, qualitative, etc.). For instance, bigger samples may be needed in longitudinal research to take into account attrition over time [25].

Analysis tools: The sample size requirements may be influenced by the statistical tools and techniques employed for data analysis. For reliable findings, certain analyses might need larger sample sizes [25].

3.2. What are power, effect size, and minimum sample size?

Statistical power, sometimes known as "power", is a key idea in statistical analysis [17,20]. It is a measure of the likelihood that a statistical test will correctly identify a real impact, preventing Type II mistakes or false negatives. A specified association coefficient, sample size, a sample taken from a population, and a preset significance threshold are commonly set at a p value of 0.05. These factors are normally taken into consideration when estimating statistical power [17].

Let's think about applying PLS-SEM (Partial Least Squares Structural Equation Modelling) with PLS Mode A and bootstrapping as an example. When a route coefficient is connected to a real impact of magnitude 0.2 at the population level, we presume that the test can properly classify it as statistically significant in this circumstance. What we would refer to as the "true" route coefficient is represented by this 0.2 value. Let's further suppose that when samples of size 160 are randomly chosen from the population, the test correctly identifies the importance of the path coefficient 73 percent of the time [17].

In this setting, we may infer that the test's power, shown by the symbol 0.73, is 73 percent, or the capacity to detect the presence of a real effect under the given parameters.

Effect size is a quantitative measure of the size of an effect that is independent of the size of the sample being studied, as explained by Cohen [26] and Kock et al. [27]. Two main metrics for effect size measurement are frequently used in the context of partial least squares structural equation modelling (PLS-SEM). The most important of them is Cohen's f coefficient [26], which may be calculated as $\Delta R2$ (1-R2). The incremental impact of a predictor latent variable on the related criterion latent variable, to which it is connected, is captured by this coefficient [17].

The effect size associated with the route coefficient under consideration must be taken into account when determining the minimal sample size for a PLS-SEM analysis to achieve an acceptable level of statistical power (usually about 0.8) [17,26]. Notably, a route coefficient's effect size is inversely proportional to its magnitude at the population level. As a result, an associated impact size grows in proportion to the magnitude of a population-level route coefficient.

4. Concluding remarks

The paper concludes by highlighting the critical role sample selection plays in research methods. In order to ensure statistical power, accuracy, and generalizability, it highlights how important it is to take into account a variety of aspects when calculating the ideal sample size. Researchers are given a thorough manual to help them navigate the difficulties of sample selection via the investigation of factors influencing decisions about sample size. The ideas that are shared help to improve research procedures and validate study results across a range of disciplines.

Essentially, this study provides guidance for researchers navigating the complex process of sample selection by providing valuable insights and approaches that may be utilized to improve the validity, impact, and rigor of their research. We recognize the dynamic interplay of methods, procedures, and factors that together enhance scholarly inquiry as we set out on this path of optimizing study sample selection, peeling back the layers of complexity inherent in this decision-making process.

Conflicts of interest: The author declares no conflict of interest.

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