

PARAMETER

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PARAMETER

Primary Disciplinary Field(s): Statistics, Mathematics, Computer Science, Research Methodology

1. Core Definition

The term **parameter** holds distinct, yet related, technical meanings across various quantitative disciplines, fundamentally referring to a characteristic factor that defines or governs a system, operation, or distribution. In its most generalized sense, a parameter serves as a determinant--a value or characteristic that sets the scope, conditions, or properties of an entity. The common thread unifying its application is the concept of a fixed or defined measure that dictates behavior within a specified context, whether that context is a statistical population, a mathematical curve, or a functional routine in programming.

In the realm of **statistics**, a parameter is defined as a fixed, usually unknown, numerical constant that characterizes an entire population with respect to some trait. For instance, the population mean (μ), the population standard deviation (σ), or the proportion of a population exhibiting a certain characteristic are all examples of parameters. These values are considered constant because they describe the entire theoretical or real population, contrasting sharply with statistics, which are variable measures derived from samples. The primary goal of inferential statistics is often to estimate these unknown population parameters based on the data collected from representative samples, thereby using known statistics to approximate the unknown parameters.

Conversely, in **mathematics** and **computer science**, a parameter refers to an argument passed to an operation, function, or subroutine. In this context, the parameter is a variable defined in the function signature that receives the value supplied when the function is called. For example, if a function is designed to calculate the area of a rectangle, the length and width variables defined within the function are its formal parameters. When the function is executed, specific numerical values (e.g., 5 and 10) are passed as arguments, replacing the formal parameters and allowing the operation to proceed under the conditions dictated by those values. This usage emphasizes the parameter's role in defining the specific execution context of a generalized procedure.

2. Etymology and Historical Development

The word **parameter** derives from the Greek roots *para-*, meaning "beside" or "alongside," and *metron*, meaning "measure." Etymologically, it suggests a quantity that is used alongside the primary measure to define or classify something. The term entered scientific and mathematical vocabulary relatively early, notably within classical geometry and physics, where it often referred to

a quantity that remained constant while other variables changed, thus defining a family of curves or relationships.

Its formal adoption into modern **statistics** gained prominence during the early 20th century with the development of inferential statistics by figures such as Ronald Fisher. Fisher's work on estimation theory rigorously established the distinction between population characteristics (parameters) and sample characteristics (statistics). This distinction was crucial for developing the tools necessary to make reliable inferences about large groups based on limited data, solidifying the parameter as the foundational concept targeted by statistical analysis.

The integration of the term into **computer science** and programming followed the conceptualization of modern procedural languages in the mid-20th century. As programming evolved from simple linear execution to modular structures involving functions and subroutines, a precise term was needed to describe the variables used to transfer data into these modules. The parameter, defined as the placeholder in the function definition, became the standard terminology, allowing programmers to write flexible code where the logic remains constant but the inputs (the parameters) can vary with each execution.

3. Key Characteristics and Classifications

Parameters can be classified based on their field of application, leading to specific characteristics in statistics, mathematics, and computing.

In **Statistical Modeling**, parameters are categorized by the distribution they characterize. For example, the normal distribution is defined entirely by two parameters: the mean (μ) and the standard deviation (σ). These are often referred to as location and scale parameters, respectively. A **location parameter**, like the mean, shifts the distribution along the number line without changing its shape, while a **scale parameter**, like the standard deviation, dictates the spread or variability of the distribution. Parameters are considered fixed constants in any given population, though their exact values are typically unknown and must be estimated.

In **Computational Contexts**, parameters are differentiated into two types: **Formal Parameters** (or definition parameters) and **Actual Parameters** (or arguments). Formal parameters are the names specified in the function or subroutine declaration, acting as placeholders. Actual parameters are the actual values or variables passed to the function when it is called. The binding mechanism--the method by which the actual value is assigned to the formal placeholder (e.g., pass-by-value or pass-by-reference)--is a crucial characteristic defining how the function utilizes and potentially modifies the input data.

In **Mathematical Analysis**, particularly in the study of curves and equations, a parameter allows for the representation of complex relationships. For instance, parametric equations use a single

variable (often denoted t) to define the coordinates (x and y) of points along a curve, transforming a single variable relationship into two related equations that trace the path. This use of a parameter facilitates the description of movement, trajectories, or multi-dimensional geometry that would be cumbersome or impossible to describe using standard Cartesian equations.

4. Differentiation from Statistics and Variables

It is crucial to distinguish a **parameter** from a **statistic**, a distinction frequently muddled in colloquial usage. A parameter is a numerical descriptor of a population, while a statistic is a numerical descriptor of a sample. If we were studying the average height of all adults in a country (the population), the true average height (μ) would be the parameter. If we measured the heights of 1,000 randomly selected individuals and calculated their average ($\bar{x}$), that value would be the statistic. The statistic is used as an estimator for the parameter.

Furthermore, parameters must be distinguished from **variables** in both mathematical and research contexts. A variable is a characteristic or quantity that can take on different values within a dataset or experiment (e.g., age, income, test score). A parameter, on the other hand, is a constant value that defines the characteristics of the *distribution* of that variable across the entire population. In experimental design, parameters are often the fixed, controlled boundary conditions or constraints that define the environment of the study, as illustrated by the source content example: "The parameters set are not sufficient enough for the trial to go on." Here, parameters refer to the fixed constraints or conditions (sample size, control limits, resource allocation) established before the trial commenced.

5. Significance and Impact

The concept of a parameter is central to scientific inquiry and computational efficiency because it provides the basis for generalization and control. In **Statistics and Research Methodology**, parameters allow researchers to move beyond the observed data to make generalized statements about the world. Without the theoretical definition of a fixed population parameter, inferential statistics--the backbone of modern empirical science--would be impossible. The ability to estimate unknown parameters informs policy decisions, clinical guidelines, and hypothesis testing.

In **Engineering and Modeling**, parameters are essential for describing and predicting system behavior. Whether modeling climate change, optimizing manufacturing processes, or designing electronic circuits, the defining characteristics of the system are captured by a set of parameters. Sensitivity analysis, a common engineering technique, involves testing how changes in specific input parameters affect the overall output of a complex model, thereby identifying the most critical determinants of system performance.

In **Computer Science**, the use of parameters is foundational to modular programming and

software engineering principles. Parameters enable **abstraction**, allowing developers to treat complex functions as black boxes that perform a defined task regardless of the input values. This promotes code reuse, reduces redundancy, and significantly improves the maintainability and scalability of large software systems. Functions are defined generally, and their specific behavior is customized through the parameters supplied at the point of execution.

6. Debates and Criticisms

The primary area of confusion and debate surrounding the term **parameter** stems from its pervasive misuse in everyday language. Colloquially, "parameter" is often used synonymously with "boundary," "limit," or "constraint" (e.g., "stay within the parameters"). While this usage aligns loosely with the concept of a defining characteristic, it obscures the strict technical distinction required in mathematics and statistics, where a parameter specifically refers to a population constant, not a subjective boundary.

Within statistics itself, debates exist regarding the necessity of parameters in certain methodologies. Non-parametric statistics are techniques that specifically avoid making assumptions about the specific distributional parameters (like mean or variance) of the underlying population. These methods are useful when populations are known to be non-normal or when data is measured using scales where traditional parametric measures (like the mean) are inappropriate. However, even non-parametric methods often rely on parameters of location (like the median) or dispersion (like the interquartile range) in a broader sense.

Further Reading

[Parameter \(mathematics\)](#)

[Statistical parameter](#)

[Parameter \(computer programming\)](#)