

In sample survey statistics, the "difference estimator" **uses auxiliary information known about the population to improve the precision of estimates of a population total or mean, by estimating the difference between the sample estimate and the known population value of an auxiliary variable.** [1, 2]

Here's a more detailed explanation: [1, 2]

- **Purpose:** The difference estimator aims to reduce the variance of estimates by leveraging information about the population that is not directly sampled. [1, 2]
- **Method:** [1]
 - It uses a known population total (X) of an auxiliary variable (x) and a sample estimate (\hat{Y}) of the variable of interest (y). [1]
 - The difference estimator is calculated as: $\hat{Y}_\lambda = \hat{Y} - \lambda(\hat{X} - X)$. [1]
 - λ is a coefficient that can be optimized to minimize the variance of the estimator. [1]
 - The optimum value of λ is calculated as: $\lambda_{opt} = \text{Cov}(\hat{X}, \hat{Y}) / \text{Var}(\hat{X})$. [1]
- **Example:** Imagine you want to estimate the total number of households in a region, but you have data on the total number of registered vehicles (an auxiliary variable). You could use the difference estimator to improve your estimate of the total number of households by using the known total number of vehicles. [1, 2]
- **Advantages:** The difference estimator can be more efficient than using only the sample estimate, especially when the auxiliary variable is highly correlated with the variable of interest. [1]
- **When to use:** This estimator is particularly useful when: [1]
 - You have reliable data on an auxiliary variable that is correlated with the variable of interest. [1]
 - You want to improve the precision of your estimates. [1]
- **Relationship to other estimators:** The difference estimator is related to regression estimators, as it can be seen as a special case of a regression model where the independent variable is the auxiliary variable. [3]

Generative AI is experimental.

[1] <https://www.sciencedirect.com/topics/mathematics/difference-estimator>

[2] <https://www.nature.com/articles/s41598-023-49786-8>

[3] <https://www.sciencedirect.com/science/article/abs/pii/S0377042722000796>