

Statistical Methods in Valuation Analysis: Review of Principles and Applications (Part One of a Six-Part Series)

In conducting a valuation analysis, a valuation analyst may employ a variety of different statistical methods. This six-part *Health Capital Topics* series conducts a brief overview of the principles and applications of six (6) statistical methodological approaches commonly utilized in valuation reports: (1) descriptive statistics; (2) coefficient of variation; (3) data sets and samples; (4) regression analysis; and, (5) Monte Carlo methods. Each installment of this series will provide the reader with a basic background on these statistical methods, with a focus on: (1) a description of the specific methodology; (2) how valuation analysts use the technique; and, (3) potential pitfalls in utilizing the methodology. This first installment of the series will familiarize the reader with these approaches. A strong understanding of commonly used statistical methods is useful for valuation professionals creating, defending, or critiquing valuation reports. Further, the improper use of statistical methods by valuation professionals may lead to erroneous inferences which may significantly impact the derived value indication. This series aims to serve as a reference guide for the valuation professional, and to serve as a resource when developing, defending, or critiquing valuation reports.

The second installment of this series will provide an overview of descriptive statistics. Typically, statistical research involves quantitative information called *data* (singular *datum*) where statistics “provides methods for organizing and summarizing data.”¹ *Descriptive statistics* present basic information about the dataset in a study.² *Summary statistics*, a type of descriptive statistics, use standard calculations to convey information about a dataset.³ These statistics may measure anything from information on the location of a datum relative to the whole dataset (mean), to measures of variability or dispersion of the dataset (variance).⁴ By employing these statistical methods, a researcher may test the data to answer increasingly complex questions, such as testing a hypothesis (i.e., making a meaningful claim about the data)⁵ or conducting an *analysis of variance* (ANOVA) to gain insights on how an experiment may affect samples from different populations.⁶ However, a researcher should be cautious because potential problems may arise when using descriptive statistics.

The third installment of this series will discuss the coefficient of variance. The *coefficient of variance* (CV)

may be used to assess how different datasets possess more or less variation.⁷ This may be useful for determining the quality of data or data comparison when selecting the appropriate variables to explain phenomena, a task commonly employed in valuation when organizing disparate data sources, e.g., when performing a benchmark analysis.

The fourth installment of this series will focus on datasets and samples more closely. Data can be categorized in two ways: (1) *discrete* (data which can only take particular values, e.g., positive integers); or, (2) *continuous* (data which is able to take on all possible values on an interval).⁸ Often, the size of a population under study is too large or inconvenient to study. Under these circumstances, a *sampling* is the preferred method to develop a representation of the population.⁹ Populations, and the samples drawn from them, may exhibit certain patterns, referred to as *statistical distributions*, some of which occur regularly in statistics and have special names (e.g., normal distribution or Bernoulli distribution) and known properties that can provide convenient analytical tools for understanding the data.¹⁰ Occasionally, certain numbers of the dataset may appear to differ significantly from the remainder of the data, these points, referred to as *outliers*, warrant special attention to obviate any deleterious effects that may arise from their inclusion in the analysis.¹¹

The fifth installment of this series will shift from an overview of general statistics and to a focus on *regression analysis*, which is a rigorous method utilized to determine relationships among different variables in a dataset.¹² There are different types of regressions that a researcher may employ to reach a conclusion about, or estimate, the causal relationship between variables. *Functional form* defines the structural relationship among the variables being analyzed. *Linear regression*, a specific functional form (i.e., the relationship between two variables is constant), is often employed in statistical research. This article will include a review of *single and multivariable linear regression* analysis, as well as, *non-linear approaches*, which exist for data that does not fit a linear model. The regression techniques that will be discussed in this series are *ordinary least squares* (OLS); *generalized least squares* (GLS); *weighted least squares* (WLS); *simultaneous equations*; *vector auto-regression* (VAR); and, *logit/probit* models. An approach using

instrumental variables (IV), a process where another variable is substituted in a model where regression is not otherwise possible,¹³ will also be reviewed. The pitfalls associated with using regression analysis of which a researcher needs to be aware, as well as common errors and techniques for validating results will be reviewed, as well.

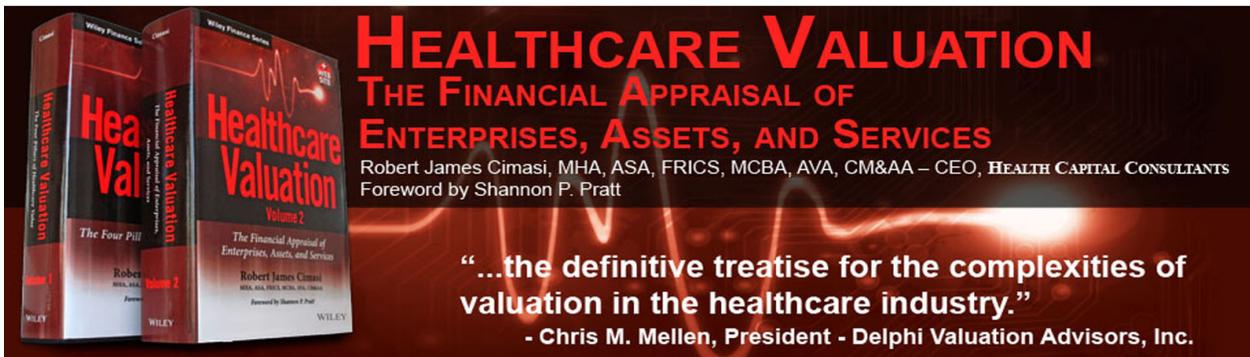
Finally, the sixth installment of this series will explore *Monte Carlo* methods, which harness the power of computers to perform repetitive tasks to understand the statistical properties of a dataset which may not fit neatly into a pre-defined distribution.¹⁴ This simulation-based method can be used to evaluate estimators and goodness-of-fit statistics, which then may be utilized in identifying potential problems with a model or alleviating problems

inherent to the model, such as misspecification or sample size, among others.¹⁵ *Monte Carlo* methods are atheoretical and based solely on empirical evidence,¹⁶ and often serve as a last resort when other analytical methods fail.¹⁷

The next *Health Capital Topics* article in this series will investigate descriptive statistics more closely, as well as, how descriptive statistics are used and how they may mislead a researcher. The following articles will provide a more in-depth view of: (1) *coefficient of variation*; (2) data sets and samples; (3) regression analysis; and, (4) *Monte Carlo* methods. A strong understanding of the basic statistical methods used in valuation reports will only serve to benefit valuation analysts, as well as the end users who rely on information from such reports.

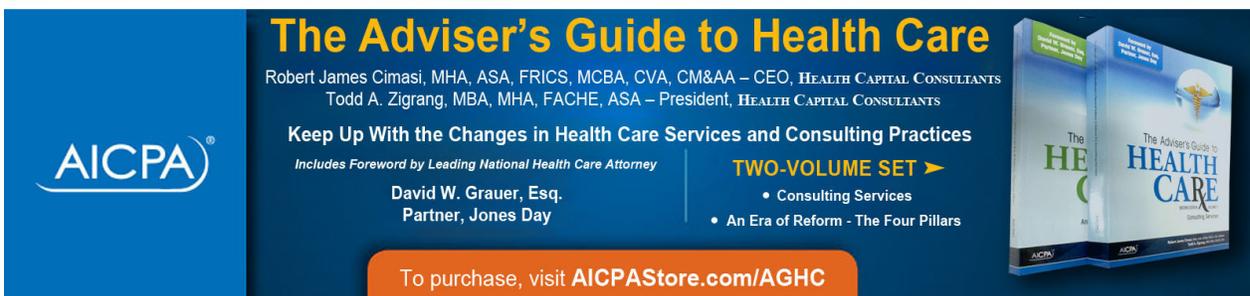
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- 2 "Descriptive Statistics" By William M.K. Trochim, Web Center for Social Research Methods, October 20, 2006, <http://www.socialresearchmethods.net/kb/statdesc.php> (Accessed 7/11/16).
- 3 Devore, 2004, p. 4.
- 4 *Ibid*, p. 28, 36.
- 5 *Ibid*, p. 317.
- 6 *Ibid*, p. 410.
- 7 *Ibid*, p. 48.
- 8 *Ibid*, p. 100.
- 9 *Ibid*, p. 3.
- 10 *Ibid*, p. 104.
- 11 *Ibid*, p. 30.
- 12 *Ibid*, p. 497.

- 13 "A Guide to Econometrics" By Peter Kennedy, 5th ed., Cambridge, MA: MIT, 2003, p. 159.
- 14 "Software Reliability Testing using Monte Carlo Methods" By Harnam Singh and Preet Pal, International Journal of Computer Applications, Vol. 69, No. 4 (May 2013), p. 41; "Monte Carlo Experiments: Design and Implementation" By Pamela Paxton, et al., Structural Equation Modeling: A Multidisciplinary Journal, Vol. 8, No. 2 (August 2001).
- 15 Paxton, et al., August 2001, p. 288.
- 16 *Ibid*, p. 287-88; "Monte Carlo Theory, Methods and Examples" By Art Owen, Stanford University, 2013, <http://statweb.stanford.edu/~owen/mc/> (Accessed 7/11/16), Ch. 1 and 2.
- 17 "Monte Carlo Methods" By Dianne P. O'Leary, University of Maryland, 2008, <https://www.cs.umd.edu/~oleary/c660/660montehand.pdf> (Accessed 7/15/2016).



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