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Todd A. Zigrang, MBA, MHA, ASA, FACHE, Publisher • Jessica L. Bailey, Esq., Editor ©

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

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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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Robert James Cimasi, MHA, ASA, FRICS, MCBA, CVA, CM&AA, serves as Chief Executive Officer of **HEALTH CAPITAL CONSULTANTS** (HCC), a nationally recognized healthcare financial and economic consulting firm headquartered in St. Louis, MO, serving clients in 49 states since 1993. Mr. Cimasi has over thirty years of experience in serving clients, with a professional focus on the financial and economic aspects of healthcare service sector entities including: valuation consulting and capital formation services; healthcare industry transactions including joint ventures, mergers, acquisitions, and divestitures; litigation support & expert testimony; and, certificate-of-need and other regulatory and policy planning consulting.

Mr. Cimasi holds a Master in Health Administration from the University of Maryland, as well as several professional designations: Accredited Senior Appraiser (ASA – American Society of Appraisers); Fellow Royal Institution of Chartered Surveyors (FRICS – Royal Institution of Chartered Surveyors); Master Certified Business Appraiser (MCBA – Institute of Business Appraisers); Accredited Valuation Analyst (AVA – National Association of Certified Valuators and Analysts); and, Certified Merger & Acquisition Advisor (CM&AA – Alliance of Merger & Acquisition Advisors). He has served as an expert witness on cases in numerous courts, and has provided testimony before federal and state legislative committees. He is a nationally known speaker on healthcare industry topics, and is the author of several books, the latest of which include: "*Adviser's Guide to Healthcare – 2nd Edition*" [2015 – AICPA]; "*Healthcare Valuation: The Financial Appraisal of Enterprises, Assets, and Services*" [2014 – John Wiley & Sons]; "*Accountable Care Organizations: Value Metrics and Capital Formation*" [2013 - Taylor & Francis, a division of CRC Press]; and, "*The U.S. Healthcare Certificate of Need Sourcebook*" [2005 - Beard Books].

Mr. Cimasi is the author of numerous additional chapters in anthologies; books, and legal treatises; published articles in peer reviewed and industry trade journals; research papers and case studies; and, is often quoted by healthcare industry press. In 2006, Mr. Cimasi was honored with the prestigious "*Shannon Pratt Award in Business Valuation*" conferred by the Institute of Business Appraisers. Mr. Cimasi serves on the Editorial Board of the Business Appraisals Practice of the Institute of Business Appraisers, of which he is a member of the College of Fellows. In 2011, he was named a Fellow of the Royal Institution of Chartered Surveyors (RICS).

Todd A. Zigrang, MBA, MHA, ASA, FACHE, is the President of **HEALTH CAPITAL CONSULTANTS** (HCC), where he focuses on the areas of valuation and financial analysis for hospitals, physician practices, and other healthcare enterprises. Mr. Zigrang has over 20 years of experience providing valuation, financial, transaction and strategic advisory services nationwide in over 1,000 transactions and joint ventures. Mr. Zigrang is also considered an expert in the field of healthcare compensation for physicians, executives and other professionals.

Mr. Zigrang is the co-author of the "*Adviser's Guide to Healthcare – 2nd Edition*" [2015 – AICPA], numerous chapters in legal treatises and anthologies, and peer-reviewed and industry articles such as: *The Accountant's Business Manual* (AICPA); *Valuing Professional Practices and Licenses* (Aspen Publishers); *Valuation Strategies; Business Appraisal Practice*; and, *NACVA QuickRead*. In addition to his contributions as an author, Mr. Zigrang has served as faculty before professional and trade associations such as the American Society of Appraisers (ASA); the National Association of Certified Valuators and Analysts (NACVA); Physician Hospitals of America (PHA); the Institute of Business Appraisers (IBA); the Healthcare Financial Management Association (HFMA); and, the CPA Leadership Institute.

Mr. Zigrang holds a Master of Science in Health Administration (MHA) and a Master of Business Administration (MBA) from the University of Missouri at Columbia. He is a Fellow of the American College of Healthcare Executives (FACHE) and holds the Accredited Senior Appraiser (ASA) designation from the American Society of Appraisers, where he has served as President of the St. Louis Chapter, and is current Chair of the ASA Healthcare Special Interest Group (HSIG).

John R. Chwarzinski, MSF, MAE, is Senior Vice President of **HEALTH CAPITAL CONSULTANTS** (HCC). Mr. Chwarzinski's areas of expertise include advanced statistical analysis, econometric modeling, as well as, economic and financial analysis. Mr. Chwarzinski is the co-author of peer-reviewed and industry articles published in *Business Valuation Review* and *NACVA QuickRead*, and he has spoken before the Virginia Medical Group Management Association (VMGMA) and the Midwest Accountable Care Organization Expo.

Mr. Chwarzinski holds a Master's Degree in Economics from the University of Missouri – St. Louis, as well as, a Master's Degree in Finance from the John M. Olin School of Business at Washington University in St. Louis. He is a member of the St. Louis Chapter of the American Society of Appraisers, as well as a candidate for the Accredited Senior Appraiser designation from the American Society of Appraisers.

Jessica L. Bailey-Wheaton, Esq., is Vice President and General Counsel of **HEALTH CAPITAL CONSULTANTS** (HCC), where she conducts project management and consulting services related to the impact of both federal and state regulations on healthcare exempt organization transactions and provides research services necessary to support certified opinions of value related to the Fair Market Value and Commercial Reasonableness of transactions related to healthcare enterprises, assets, and services. Ms. Bailey is a member of the Missouri and Illinois Bars and holds a J.D., with a concentration in Health Law, from Saint Louis University School of Law, where she served as Fall Managing Editor for the *Journal of Health Law & Policy*.

Kenneth J. Farris, Esq., is a Research Associate at **HEALTH CAPITAL CONSULTANTS** (HCC), where he provides research services necessary to support certified opinions of value related to the Fair Market Value and Commercial Reasonableness of transactions related to healthcare enterprises, assets, and services, and tracks impact of federal and state regulations on healthcare exempt organization transactions. Mr. Farris is a member of the Missouri Bar and holds a J.D. from Saint Louis University School of Law, where he served as the 2014-2015 Footnotes Managing Editor for the *Journal of Health Law & Policy*.