Assessing Organizational Diversity with the Heip Index

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By

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Assessing Organizational Diversity with the Heip Index

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By Salomón Alcocer Guajardo

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This book is dedicated to Dr. Carlo H. Heip (1945 – 2013),
Dr. Mark Oliver Hill, Dr. Stuart H. Hurlbert,
and Dr. Andrew L. Sheldon (1938 – 2017) for their contributions
to the development of diversity indices and to the study of diversity.

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PREFACE

Since Shannon's (1948) development of the index of uncertainty (entropy), researchers have modified the original formula to obtain refined measures of diversity and "species" distribution (i.e., evenness) within a community or environment. Pielou (1966), for instance, created the Shannon (Pielou) index of evenness by dividing the measure of entropy ($H = -\sum p * \ln(p)$) by the maxim level of entropy ($\ln(n)$), which provides a coefficient of the proportion of the maximum amount of variation (i.e., maximum empirical value (EMV)) that is attainable. Briefly, the Shannon index of evenness is represented as follows: $H_E = \frac{-\sum p * \ln(p)}{\ln(n)} = \frac{H}{H_M} = \frac{H}{EMV}$.The Shannon index of evenness (i.e., standardize H) was presented and discussed in the preceding companion book: *Assessing Organizational Diversity with the Shannon Index* (Guajardo, 2023). Other modifications to the Shannon index of uncertainty have been made by Alatalo (1981), Hill (1973), Heip (1974), Hurlbert (1971) and Sheldon (1969). This book focuses on the assessment of Shannon-based indices of evenness when they are applied to demographic employment data to obtain measures of evenness.

Like the preceding and subsequent companion books in the series, this book addresses fundamental analytical and measurement issues and questions that arise when Shannon-based indices of evenness are applied to demographic and employment data to obtain measures of heterogeneity. The issues and questions addressed in this book include the following:

- How is measurement bias addressed by a particular diversity index?
- How is the number of categories used for a demographic (or social) characteristic addressed by a particular diversity index?
- What are the statistical properties of a distribution of scores of a particular diversity index when it is applied to demographic and employment data?
- What is the appropriate statistical method to use based on the distribution of scores obtained by a particular diversity index?
- What is the maximum value of diversity that is obtainable by a particular diversity index?

These issues are addressed throughout this book because little empirical research has been devoted to examining the adaptation and use of diversity indices to measure and analyze demographic (or social) diversity in organizations. Although the issues and questions addressed in this book (and the companion books) are fundamental to carrying out empirical research, practitioners and researchers alike often ignore or take the analytical (or measurement) issues and questions for granted.

As stated in preceding companion books, the book series consists of 9 books. They are the following:

- *Assessing Organizational Diversity with the Simpson Index* applies the Simpson diversity index to demographic and employment data reported by New York City (NYC) departments for fiscal year 2019. This book focuses on the application and analysis of Simpson diversity formulas for calculating biased and unbiased measures of demographic heterogeneity.
- *Assessing Organizational Diversity with the Shannon Index* applies the Shannon diversity index to the same demographic and employment data used in the first book. This book focuses exclusively on the application and analysis of Shannon diversity formulas for calculating biased and unbiased measures of demographic heterogeneity.
- *Assessing Organizational Diversity with the Heip Index* applies the Heip, Sheldon, and other Shannon-based diversity indices to the data used in the first and second books. The Heip, Sheldon, and the other Shannon-based diversity indices presented in the book are modifications of the Shannon index of diversity. From a statistical standpoint, the Heip and Sheldon indices possess statistical properties that are superior to the original Shannon index. Like the first and second books, this book focuses on the application and analysis of the indices with respect to measuring demographic heterogeneity in organizations.
- *Assessing Organizational Diversity with the Smith and Wilson indices* applies the Smith and Wilson (SW) indices to the same data used in the previous books. In addition to applying the SW indices, other Simpson-based indices such as the Ray and Singer (RS) index of concentration are presented in the book. The SW and RS indices are modifications of the Simpson ($D = 1- \sum p^2$) diversity index and assess demographic heterogeneity as well. This book applies the Simpson-based indices to the same data used in previous books to measure demographic heterogeneity in organizations.

- *Assessing Organizational Diversity with the McIntosh Index* applies the McIntosh evenness index to the same demographic and employment data used in the preceding companion books. This book focuses on the analysis of diversity scores obtained by the McIntosh index. Because the index includes the number of groups used to categorize a demographic (or social) characteristic of interest and the size of the workforce simultaneously, the diversity scores contain less measurement bias and have a greater degree of compatibility in comparison to the other diversity indices covered in other companion books.
- *Assessing Organizational Diversity with the Index of Qualitative Variation* (IQV) applies the Mueller and Schuessler IQV to the same demographic and employment data used in the previous companion books. Because the IQV is not invariant to ordering sequences, this book focuses on the application and analysis of heterogeneity scores obtained from the different ordering sequences of the data. Like the McIntosh evenness index presented in the preceding companion book, the IQV includes simultaneously the number of groups used in the categorization of the demographic (or social) characteristic of interest and the size of the workforce.
- *Assessing the Validity of Diversity Indices* compares the indices used in each companion book jointly and uses factor analysis to determine whether they assess the same (or different) aspects of demographic (or social) diversity. Pearson pairwise correlation analyses also are performed to assess the statistical associations amongst the diversity indices. Statistical analyses for equality of means are performed as well.
- *Assessing Organizational Diversity with Quantile Regression* applies quantile regression analysis to each of the diversity indices presented in the book series. This book performs quantile regression analyses at the 25th, 50th, 75th, and 90th percentiles for age, ethnic, and gender diversity.
- *Assessing Organizational Diversity with Structural Equation Modeling* (SEM) focuses exclusively on causal modeling. Specifically, this book focuses on the development and analysis of a structural equation model for specific diversity indices discussed in the series. In so doing, the analyses treat age, ethic, and gender diversity as intervening (or mediating) variables of organizational performance.

For purposes of continuity and compatibility, each diversity index is subjected to the same statistical analyses. The IQV, McIntosh evenness, Shannon, Simpson, and SW indices are of special focus in this book series because they have been used in previous research on demographic (or social) diversity in nonprofit, private, or public organizations.

This book series is written for practitioners and researchers in human resources and other fields that are interested in measuring and analyzing demographic, occupational, or social heterogeneity in organizations. The purpose of the book series is to address measurement and analytical issues that practitioners and researchers alike are likely to face when they apply a particular diversity index to demographic and employment data provided by a nonprofit, private, or public organization. As such, this book series should serve as a reference for selecting the diversity index that is best suited for measuring and analyzing heterogeneity in an organizational setting. This book series also should serve as a reference for selecting the statistical method that is best suited for analyzing the distribution of scores obtained by the diversity index of choice.

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CHAPTER 1

INTRODUCTION

As stated in the preceding companion books (Guajardo, 2023a and 2023b), researchers have used diversity (or *integration*) indices to assess the level of demographic (or social) heterogeneity in nonprofit, private, or public organizations since the early 1970s (e.g., Akram, Abrar ul Haq, Natarajan, and Chellakan, 2020; Boehm, Kunze, and Bruch, 2014; Choi, 2010; Gazley, Chang, and Bingham, 2010; Grabosky and Rosenbloom, 1975; Guajardo, 2014; Moon and Christensen, 2020; Nachmias and Rosenbloom, 1973). Of the plethora of indices of diversity that have been developed to assess heterogeneity (or variation), researchers use the Simpson (1949) and Shannon (1948) indices the most frequently. For the most part, the Simpson and Shannon indices have been applied to aggregate demographic employment data to measure age, ethnic, or gender heterogeneity. More recently, diversity indices have been used to assess concepts such as educational and occupational diversity. In most of the previous studies, workforce diversity has served as a dependent variable. More recent studies, however, have treated workforce diversity as an independent variable which influences organizational performance (e.g., Gazley, Chang, and Bingham, 2010; Khan, Khan, and Senturk, 2019; Lee-Kuen, Sok-Gee, and Zainudin, 2017; Pitts, 2005). Like the preceding companion books (Guajardo, 2023a and 2023b), this book takes the position that workforce diversity such as age, ethnic, and gender heterogeneity is an *intervening variable* that influences organizational performance (e.g., Guajardo, 2014; Pitts, 2006).

Shannon-based indices of diversity and evenness

As stated in the Preface, several Shannon-based indices of *evenness* have been developed since Shannon (1948) introduced the index of uncertainty. They include the following:

- Hill index of evenness (Alatano, 1981);
- Heip index of evenness (Heip, 1974);
- Hurlbert index of evenness (1971); and.
- Sheldon index of evenness (1969).

Consistent with the standardized H index of diversity discussed in *Assessing Organizational Diversity with the Shannon Index* (2023b), each Shannon-based index of evenness has a theoretical distribution of scores that ranges from 0 to 1. For an apples-to-applies comparison, the diversity coefficients obtained by the Hill, Heip, Hurlbert, and Sheldon indices of evenness are compared to the standardized H diversity scores (e.g., Pielou, 1981).

Briefly, the evenness (or standardized) H (H_S) diversity scores are obtained by dividing the biased or unbiased Shannon (H) scores by the empirical maximum value (EMV) of the demographic (or social) characteristic of interest. For instance, when ethnicity is categorized into 5 groups, the EMV for the biased and unbiased H index is 1.609 (EMV = H_M = ln(5) = 1.609). The algebraic equation for obtaining biased evenness (or standardized) H scores is written as follows: $H_{E/S} = \frac{H}{H_M} = \frac{H}{EMV} = \frac{-\sum p * \ln(p)}{\ln(n)}$, where H_M represents the maximum possible value of the H index, p represents the percent of individuals in each group, and n represents the number of categories (or groups) for the demographic characteristic of interest. When the standardized H scores are treated as an index of evenness, the scores are interpreted as how well individuals are distributed across the different groups. When the standardized H scores are treated as "normalized" measures, they are interpreted as the proportion of the EMV that is attained. Throughout this book, the diversity scores obtained by the various Shannon-based indices are treated as measures of evenness.

Alatano (1981) developed the modified Hill (1973) index of evenness. As modified by Alatano, the Hill index of evenness combines the Simpson (1949) index of diversity ($S = 1 - \sum p^2$) and the Shannon (1948) index of uncertainty ($H = -\sum p * \ln(p)$) to obtain a coefficient of evenness. The evenness scores are calculated by the applying the following formula: $H_{Hill} = \frac{\frac{1}{D} - 1}{\exp H - 1}$, where D represents the Simpson dominance score ($\sum p^2$), H represents the entropy score ($-\sum p * \ln(p)$), and *exp* (or *e*) represents the antilogarithm of the entropy score (H). The distribution of scores ranges from 0 to 1. In subsequent chapters, H_A is used to represent the modified Hill index of evenness.

As stated in *Assessing Organizational Diversity with the Simpson Index* (Guajardo, 2023a), the Simpson diversity index is used the most frequently to assess demographic (or social) heterogeneity in organizations. Simpson (1949) created the diversity index to obtain the probability that two individuals chosen at random from the same community would share the