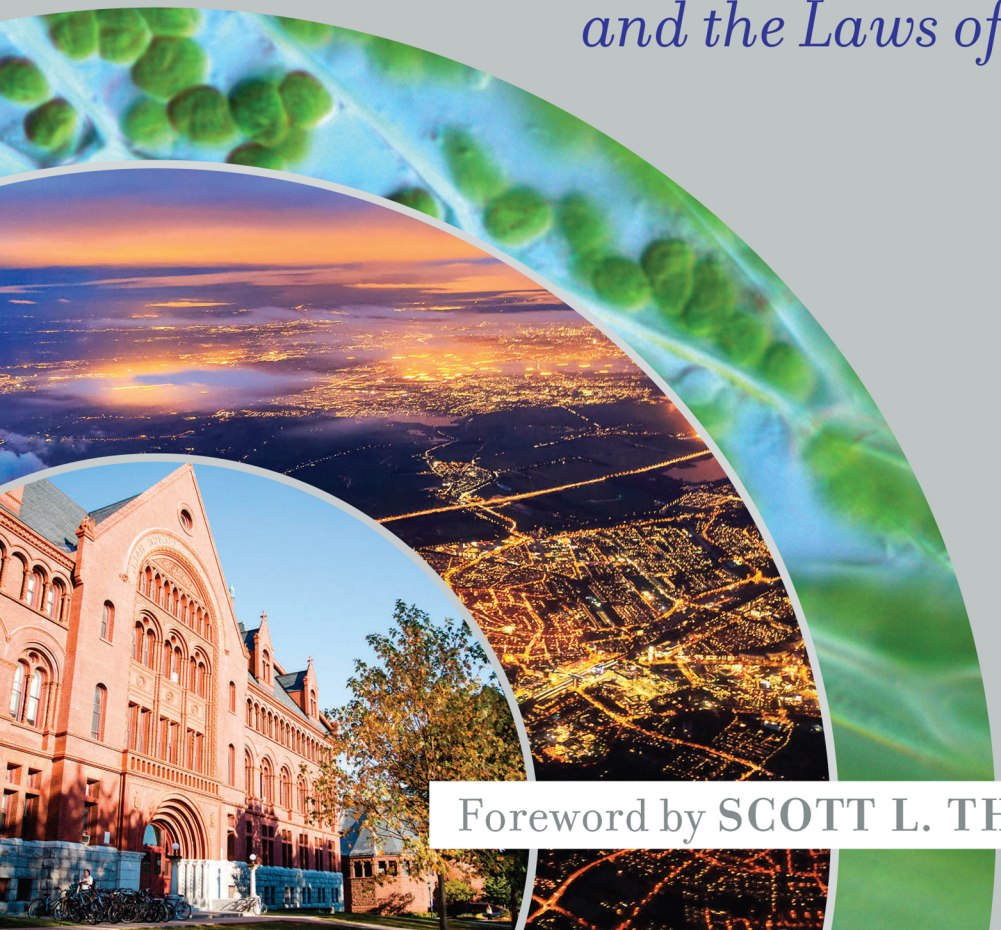
Mario C. Martinez

The SCIENCE *of* HIGHER EDUCATION

State Higher Education Policy and the Laws of Scale



Foreword by SCOTT L. THOMAS

About This Book

Perennial conclusions from state-by-state funding-per-student analyses of underfunding and weak state commitment have become so common that they have diluted the potency of the argument to state policymakers for more higher education funding. In addition, there has been little in the way of testing or questioning the assumptions embedded in traditional funding per student analysis and its accompanying conclusions.

As state legislators balance the competing needs of education, health, transportation, and public safety budgets, they increasingly ask what return on investment (ROI) they get for the funding they provide, including from higher education. The ROI language, while potentially unsettling for its corporate-like and neoliberal connotation, will persist into the foreseeable future. We must ask questions both of adequacy (How much funding should the states provide?) and benefit (What benefits do states receive for the higher education funding they provide?). The focus on traditional funding per student analysis has remained static for over 40 years, indicating the need for new ideas and methods to probe questions of adequacy and benefit.

The Science of Higher Education is an introduction to a new paradigm that explores state higher education funding, enrollment, completion, and supply (the number and type of institutions in a state) through the lens of what are commonly known as power laws. Power laws explain patterns in biological systems and characteristics of cities. Like cities, state higher education systems are complex adaptive systems, so it is little surprise that power laws also explain funding, enrollment, completion, and supply.

The scale relationships uncovered in *The Science of Higher Education* suggest the potential benefits state policymakers could derive by emphasizing enrollment, completion, or capacity policies, based on economies of scale, marginal benefits, and the return state's get on enrollment and completion for the funding they provide.

The various features of state higher education systems that conform to scale patterns do not alone provide definitive answers for appropriate funding levels, however. As this book addresses, policymakers need to take into account the macro forces, from demography to geography and the economy, that situate the system, as well the interactions between government and market actors that are at the core of every state higher education system and influences the outcomes that system achieves.

THE SCIENCE OF HIGHER EDUCATION

THE SCIENCE OF HIGHER EDUCATION

State Higher Education Policy and the Laws of Scale

Mario C. Martinez

Foreword by Scott L. Thomas

Routledge
Taylor & Francis Group
NEW YORK AND LONDON

First published 2021 by Stylus Publishing, LLC.

First Edition, 2021

Published 2023 by Routledge
605 Third Avenue, New York, NY 10017
4 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

Library of Congress Cataloging-in-Publication Data
Names: Martinez, Mario, 1967- author.
Title: The science of higher education : state higher education policy and the laws of scale / Mario C. Martinez ; foreword by Scott L. Thomas.
Description: Sterling, Virginia : Stylus Publishing, LLC., 2021. | Includes bibliographical references and index. |
Identifiers: LCCN 2021007516 | ISBN 9781642670882 (cloth) | ISBN 9781642670899 (paperback) |
Subjects: LCSH: Higher education and state--United States--States. | Education, Higher--United States--States--Finance. | Universities and colleges--United States--Finance.
Classification: LCC LC173 .M294 2021 | DDC 379.73--dc23
LC record available at https://lccn.loc.gov/2021007516

ISBN 13: 978-1-64267-089-9 (pbk)
ISBN 13: 978-1-64267-088-2 (hbk)
ISBN 13: 978-1-00-344806-8 (ebk)

DOI: 10.4324/9781003448068

To those who question conventions and offer emerging, albeit imperfect ideas, not as contrarians, but as a means to more clearly understand our world as it is so that we may move it toward what we hope it to be.

CONTENTS

FOREWORD

Mario C. Martinez offers a provocative, and likely controversial, approach to our understanding of higher education finance in the 21st century. It is expected that the reader will find some parts of this work compelling and others wanting more development and evidencing. That is unabashedly his point in this volume. At its core, this book shifts our attention from traditional adequacy-based approaches to scale approaches that speak to return on investment (ROI). It is a welcome shift that is responsive to the contemporary dynamics of policy and finance.

The late Hal Hovey (1999) described higher education as the great balance wheel in state budgets. The main idea is that in challenging economic times, state budgets are often balanced with disproportionate reductions to higher education allocations. In good times, states tend to disproportionately overallocate resourcing. At the heart of this concept is a concern over the adequacy of higher education funding. The question of how much we should spend on higher education is fundamentally one of adequacy that is frequently summarized with funding per student or funding per population ratios.

This useful (and well-evidenced) balance wheel framing rests comfortably in the context of higher education finance frameworks born of the 1970s (e.g., Berdahl, 1971). The foundation of our framing of higher education finance rests comfortably in a period defined by the 1972 reauthorization of the Higher Education Act (HEA). The debates leading up to that HEA reauthorization (as part of the Higher Education Amendments of 1972) gave rise to a funding paradigm reestablishing the relationship between states and the federal government. Our traditional (and historically useful) measures of funding adequacy emerge directly from this period.

Since that time, we have witnessed a prolonged period of devolution of federal responsibility to the states, a dramatic shift in our economy's foundations, and inexorable change in the country's demographics. With this has come an upending in the balance of public-private funding for postsecondary education. Building on the work of the Carnegie Commission, Bowen's (1972) guiding questions of "Who Benefits from Higher Education—and Who Should Pay?" are as crucial as ever.

As public postsecondary education costs have outpaced state appropriation, we have shifted the balance to weigh more heavily on the shoulders of students and their families. With that has come the inevitable and necessary narrative of the return on investment for individuals and the increasing privatization of one of America's most transformative public goods. It should be little wonder that ROI has become the focus of individuals and policymakers alike.

The context of higher education has changed, and Martinez is no longer content with incremental approaches to evolving our thinking and work in higher education finance. Adapting methods used to model dynamic systems, he offers scale analysis as a new way of capturing public benefits. His is not a minor attempt to advance our thinking. Throughout the book, Martinez provides a wealth of examples, analyses, and comparisons to demonstrate this approach's utility. While admittedly oversimplified, his approach does represent a genuine shift in our paradigm—one that is likely to cause discomfort and controversy among many in the field.

More important is the work he has put into the conceptualization, the logic, and warrant for reframing our approach to the analysis of finance policy. By design, Martinez is provoking the reader. He is challenging our purchase on traditional assumptions about policymaking and policy analysis. Along with the challenge, we get a well-developed conceptual rationale, a new set of measures, and results to stimulate debate in the field. The framing almost ensures that this debate will necessarily revolve around equity and context.

Do the contents of this book constitute the beginning of a *Science of Higher Education*? I leave that to the reader to decide. Regardless of your opinion on that count, I hope you will agree that this book offers more science than this area has seen since Berdahl and his contemporaries laid the foundation of our current knowledge base in the 1970s.

Scott L. Thomas
John P. "Jack" Ellbogen Dean
College of Education,
University of Wyoming

References

Berdahl, R. M. (1971). *Statewide coordination of higher education*. American Council on Education.

Bowen, H. R., & Servelle, P. (1972). *Who benefits from higher education—and who should pay?* (Report no. AAHE-5). American Association for Higher Education.

Hovey, H. A. (1999). *State spending for higher education in the next decade: The battle to sustain current support* (Report no. #99-3). National Center for Public Policy and Higher Education.

PREFACE

Scale, *power laws*, *flattening of the curve*, *exponential growth*. These terms quickly have become part of our global lexicon with the spread of the coronavirus (COVID-19), and they will gain increasing familiarity in higher education. That is because scale relationships are pervasive in higher education, just as in countless other arenas. Smil (2019) offered such a comprehensive description of growth and scale across so many domains that we should now expect any system involving humans to exhibit characteristics of scale. State higher education systems—the subject of this book—are no exception.

Berdahl's foundational 1971 book *Statewide Coordination of Higher Education* was one of the first publications to comprehensively document state funding and governance characteristics of state higher education systems. As the 1970s growth era in higher education slowed, descriptions of funding gave way to questions of the extent to which states should fund higher education. Higher education leaders and prominent national associations provided funding per student and funding per capita comparisons across the states to help answer these questions.

Funding per student and funding per capita both aim to address funding adequacy (i.e., whether states adequately fund institutions) using two variables, or the technique known as *ratio analysis*. Ratio analysis is common in policy, business, and education fields and assumes the two variables of interest change at the same rate (a linear relationship), unless otherwise specified. Ratio analysis, and its accompanying linear assumption, has two benefits: It is easily understandable, and it simplifies complexity to produce insights into the larger system it models. These benefits become weaknesses when the assumption of linearity is inaccurate.

No single ratio (including those throughout this book) tells an entire story. In policy there are always competing and multiple interpretations for any single ratio. For the last 40 years, funding per student has been interpreted from the perspective of those who study and advocate for higher education (among whom I count myself) as an assessment of a state's funding adequacy or commitment to higher education. Funding per student analyses implicitly assume (a) funding and student enrollment change (or should change) at the same rate, and (b) institutions that raise tuition when funding

decreases are forced to do so, which in turn assumes they operate at maximum efficiency and effectiveness.

Perennial conclusions of state-by-state funding-per-student analyses of underfunding and weak state commitment have become so common, though, that they have diluted the potency of the argument for more funding to state policymakers. In addition, there has been little in the way of testing or questioning the explicit or implicit assumptions of traditional funding per student analysis and its accompanying conclusions.

There is always the risk of straining valued relationships by questioning existing conventions. Hauptman (2020) has been a bold voice and stated that the "frequent assertion of state disinvestment is overstated" (para. 2). He argued that state appropriations tend to focus more on meeting institutional than student needs. Arguments such as this are important to explore, despite the potential to cause divisions.

My motivation for writing this book is two-fold after studying higher education policy the past 20 years: (a) constantly seek new and innovative policy analysis methods and (b) engage in interpretative perspectives from the state policymaker lens, which is different from agreeing with their perspective. *Scale analysis* (Appendix A: Glossary of Terms) provides an alternative to traditional funding per student analyses and works toward these two goals.

Today, as state leaders balance K–12, higher education, health, transportation, and public safety budgets, they increasingly ask what return on investment (ROI) states get from higher education for the funding they provide. The ROI language, while disproportionately asked of higher education (compared to other state functions) and potentially unsettling for its corporate-like and neoliberal connotation, will persist into the foreseeable future.

The exploration of ROI in public higher education is not a promotion of one ideology over another but an acknowledgment of a perspective held by many state policymakers. Enrollment, for example, as a return (benefit) for state higher education funding (investment) asks, from a policymaker perspective: What enrollment benefit does the state receive for the funding it provides? The contrasting traditional funding adequacy question asks, from a higher education institutional perspective: How much funding does the state provide for each enrollment?

With these different perspectives and questions, it is entirely possible that traditional analysis shows a state does not adequately fund higher education while the same state shows a positive return on enrollment (enrollment ROI) using scale analysis. A positive enrollment ROI indicates institutions in a state make good use of the funding they receive, even if they need more. However, some states may rank favorably on the traditional funding

per student metric but show a negative enrollment ROI. A negative ROI indicates that institutions in such states may not be using funding resources as efficiently as those in other states.

Colorado and Vermont are examples of states that rank low on traditional funding per student metrics that assume a linear relationship between the two variables but rank high on ROI metrics that rely on the empirical scale relationship between the two variables described throughout this book. Though such results may raise alarm, the ROI interpretations say nothing about the adequacy of state funding in Colorado or Vermont, only that institutions in these states appear to make good use of the funding they do receive.

The conventional interpretation that links funding per student with funding adequacy is so strong that alternative methods of analysis, and in turn competing results and interpretations, using the same two variables, are likely to raise objections. Admittedly, the scale analysis throughout this book relies on two variables, just as is true for the traditional analysis, and does not claim to go beyond that. In this sense, the scale analysis also simplifies the complex reality of higher education systems, though there is a groundswell of evidence from other fields that the simple power law reveals much more about such systems than linear analysis.

I should note up front that none of the chapters incorporate tuition. One of my book reviewers and some colleagues from national organizations who viewed the initial analysis in 2018 suggested I account for both tuition and state revenue in the scale analysis, since both contribute to public institutional operational revenues. The link between tuition revenue and state support does indeed merit a separate analysis. Public tuition setting is a function of many drivers including state support, administrative motivations, and pressures to legitimize institutions through growth.

The research necessary to disentangle institutional and state drivers from tuition revenues (and tuition rates), while worthy, is beyond the scope of my initial effort to establish a foundation for a science of higher education. I do not assume that if state funding goes down, for example, that institutions are forced to increase tuition to make up the exact amount. This assumption rests on other assumptions: that institutions are operating at maximum efficiency and effectiveness (some may, some may not), that there are no other administrative motivations that influence tuition, and so on.

Numerous reports that show institutions in the United States have raised tuition largely independent of state funding and that tuition has consistently outpaced inflation legitimately raise questions about these assumptions. It is, of course, ideal to consider multiple perspectives that will propose different reasons, or drivers, for these results.

It is also fair to state my assumption that one driver on tuition setting by institutional administrators and their boards is the inescapable pressure of capitalism. Institutions of higher education, like organizations in business, philanthropy, government, and the nonprofit (NFP) world, are on a continual quest to validate their existence by demonstrating growth. Presidents and chancellors get hired by promising to expand institutions, not reduce them. My assumption about capitalism and its effect on institutional administrators aligns with the prominent economist Branko Milanović's (2019) description of capitalistic pressures on all types of institutions and organizations in advanced economies.

I took the feedback from my reviewers and for diligence purposes ran an analysis combining state funding and tuition revenue relative to state population. The results of that analysis are not the basis of this book but appear in Appendix J, are briefly discussed in chapter 5, and do not vary drastically from analysis that omits tuition revenues.

Whatever refinements and debates ensue about existing or new models for examining state funding, enrollment, and completions, state policymakers will continue to confront funding tradeoffs. The concepts of benefits, investment, and ROI already apply to state higher education policy from a policymaker perspective. For better or worse, the COVID-19 pandemic and future unforeseen emergencies will elevate ROI questions over funding adequacy questions for public higher education.

No one questions that higher education funding produces public benefits for the entire state and private benefits to the individual receiving the education. But many of the public benefits—more productive citizens in the tax base, increases in civic responsibilities, fewer people who require government assistance—are difficult to articulate, prove, prioritize, and actualize in the short-term. In addition, the emphasis by all stakeholders, from community college and university administrators to policymakers, on employment and wages (another capitalistic tendency) elevates the private benefit narrative over the public one and, in turn, emphasizes returns.

Book Purpose and Chapter Previews

The Science of Higher Education creates a starting point to address the question of what benefits states receive for their higher education investment. This book explores state higher education policy issues using state-level population, enrollment, completion, funding, and institutional (number and type of institutions) data from the 50 states. (Refined views of the data throughout this book make adjustments when possible, such as state cost of living differences.)

None of the analyses in this book that include funding as a variable directly address how much policymakers should fund higher education (*funding adequacy*). State funding analysis, using scale methodologies, addresses how states fund higher education relative to each other, for a given year. These patterns of funding across the states are consistent over time.

This new approach—or new paradigm—models the two-variable relationships between various higher education system features (e.g., funding and enrollment) that conform to what are known as *power laws*. The *power law* shows when two variables change at different rates (scale), which contrasts with an assumption in most ratio analysis that they change at the same rate (linear). The two examples in Table P.1, detailed in chapters 7 and 9, illustrate the presence of scale in state higher education systems and are indicative of discussions throughout this book.

TABLE P.1
Sample Higher Education Scale Relationships

Relationship	*Visual*	*Description*
Funding: Public UG Completion		Funding grows at a faster rate than completions (degree conferrals).
Population: no. For-Profits		The no. of for-profit institutions grows at a faster rate than population.

The first column shows the two exploratory higher education policy variables. The visuals in the second column show the nature of the relationship between the two variables, if we could theoretically view the original data for all 50 states on one graph. These visuals are increasingly familiar to the public, courtesy of numerous displays in the daily coronavirus briefings by health officials in the spring of 2020.

The table shows that funding grows at a faster rate than completion. In general, larger states spend more per completion. The explanations for this can vary. From a public investment perspective, it may be that completions are subject to diminishing public benefit returns (public returns are very different from private returns for the individual student). Or perhaps the relationship indicates that institutions in larger states are less cost-efficient seeing students through to completion than in smaller states. Yet another explanation may be that large states invest more to broaden completion efforts beyond those who are already likely to complete college, and it is expensive to do so.

The table also shows the relationship between state population and the number of for-profit (FP) institutions in a state. The visual in the table shows an exponential relationship. The number of FP institutions in a state grows

at a faster rate than state population. One explanation for this relationship is that investors seeking profit opportunities fuel the growth of FP institutions and concentrate their efforts in larger states with higher population densities. A competing and more benevolent explanation is that FPs flourish in larger states because there is a high demand for their services.

The sample relationships in Table P.1 are only two among many described throughout this book. The chapters build on what we know about scale behavior in the biological sciences and research on cities. Geoffrey West (2017) and his colleagues at the Santa Fe Institute (SFI) study cities as complex adaptive systems and the scale patterns associated with them. The forerunner to the SFI research was the scale relationships found in living systems, such as the two-variable weight:metabolism relationship across species (a cat is 100× heavier than the mouse but only consumes 32× the daily kilocalories).

West (2017) calls the prominence of scale features across cities *the science of cities.* Power laws explain the relationship between city population and infrastructure needs or city population and socioeconomic features such as income, innovation, crime, and the spread of disease. Remarkably, power laws explain various two-variable relationships, such as how much more infrastructure New York City needs compared to Los Angeles relative to city population, despite differences in geography, political culture, lifestyles, or climate.

The complex adaptive systems framework that applies to cities also applies to state higher education systems or state higher education ecosystems. At the center of these state higher education ecosystems is a government–market dynamic, fueled by complex interactions among policymakers; institutional leaders; students; and other actors at the local, state, federal, and national levels. These actor interactions occur within the context of each state's demographic, geographic, economic, and technological landscape, all continuously and simultaneously influencing state higher education policy and actor perceptions.

It is the complexity of the interactions, known as *network effects*, that eventually organizes into patterns accurately modeled by power laws. Once again, COVID-19 makes it clear that scale concepts such as network effects are at work in our world. The social distancing practices during the coronavirus pandemic aim to decrease the exponential virus spread associated with normal network effects. Reducing network effects reduces exponential scale (or what researchers also refer to as *superlinear scale*).

The science of higher education—a phrase I not-so-creatively revised from West's famous work—like the science of cities, represents a new paradigm for understanding state higher education ecosystems, a category of

complex adaptive systems called *social systems*. Given the parallels between cities and states as public social systems, it is perhaps unsurprising that many of the results in the science of higher education parallel findings in the science of cities (Appendices B–J show all data and results used throughout this book). Higher education is, after all, a form of public infrastructure, or as Klinenberg (2018) described it, social infrastructure.

State population and student demographics are the key macrovariables that describe various higher education scale relationships. The focus on demography in no way diminishes the influence that different states may assign to other forces that shape policy, such as geography, the composition of a state's economy, or even the mix of students attending different types of institutions. Furthermore, the scale metrics throughout this book provide information but alone do not claim to dictate policy. Enrollment and completion ROI, for example, contain information and clues that inform policy debate, but they are no substitute for also understanding the rich context that situates each state.

Three parts comprise this book to allow readers to focus on preferred topics and chapters. Part One provides the conceptual foundation. Chapter 1 bridges the philosophical underpinnings for complex adaptive systems and scale to state higher education systems. The state higher education ecosystem framework in chapter 2 is the conceptual foundation of this book. It is a contextual framework that views states as complex adaptive systems, surrounded by various macroforces and filled with internal microinteractions. Macroforces, from demography to geography and the economy, situate the system. The government–market dynamic encompasses actor interactions that create the push and pull tension between supply and demand. Chapter 3 categorizes actor interactions using a historic political science framework (Lindblom, 1977) that aligns with Epstein's (2019) idea that we can push forward by looking back; we can excavate old knowledge (in this case, Lindblom's framework) but wield it in new ways.

Practitioners with little interest in the philosophical foundations of the science of higher education may wish to skip to Part Two. Chapter 4 reviews scale concepts (and accompanying terminology) in biology and cities before applying them to the state population and higher education funding relationship in chapters 5 and 6. Chapter 7 concludes Part Two with an exploration of state populations and the number and types of institutions across the states, a new and innovative way to look at state higher education supply.

Part Three focuses on enrollment and completion. Chapter 8 looks at state population relative to both enrollment and completion, but it is chapter 9 that addresses the contemporary ROI approach by examining state funding relative to enrollment and completion. In scale analysis, it is possible

to compare a state's predicted enrollment or completion (state benefit) to a baseline prediction, all relative to funding (investment). The difference between actual and predicted (expected) values is what I define as an *ROI metric* to address the question of what enrollment or completion benefit a state gets for its higher education investment.

Ongoing refinements to the science of higher education likely will incorporate derivative metrics for enrollment, completion and even funding and broaden insight into the ROI metrics specifically and the scale analysis generally. The State Higher Education Executive Officers (SHEEO, 2019) annual finance reports now account for enrollment mix by sector, for example, though this refinement took place over time.

Chapter 10 compares the enrollment ROI to the traditional funding per student metric, considers the policy implications when viewing enrollment ROI and completion ROI simultaneously, and illustrates through a sample state profile (California) how qualitative descriptions and quantitative scale metrics work better together than either individually. Chapter 10, Part Three, and the book conclude with a summary of all the chapters and implications for the future.

The spirit of the science of higher education is the exploration of new ideas in a mature field. Soames (2019) underscored how important it is to create new ideas and raise questions about existing paradigms, even though inevitably new ideas mature, evolve, or may even turn out wrong. Soames noted that great philosophers created theories primitive by today's standards, but "they succeeded in identifying problems and framing questions that were later dealt with more satisfactorily using descendants of the concepts they helped articulate" (p. 70).

The science of higher education looks at higher education policy through a new lens while also raising questions and surfacing assumptions about existing conventions. Although scale analysis is a 21st-century tool that can benefit the field of higher education, the ideas in this book are in a primitive stage so will certainly require revision, correction, and necessary critique.

Oversights, errors, or faulty assumptions reside with me, but hopefully this book lays an initial foundation that contributes to more effectively identifying, framing, and solving higher education policy challenges, or as social scientists have long called them, the "wicked problems" we face. If critics find no reason to further examine scale in higher education phenomena but their consideration of it sharpens the defense and analysis of traditional funding per student metrics, then I will have met my goal for writing this book.

ACKNOWLEDGMENTS

Change experts advise that we should double or even triple our time estimates for the completion of a project. This is conservative advice for optimists. I should have quadrupled my estimate for the completion of this manuscript, but only because of the valuable critique and feedback that I received from colleagues throughout the construction of the book.

I would like to thank the two national reviewers who read the manuscript when I thought it was finished in the fall of 2019. They graciously but assertively asked me to eliminate sections and redundancies and redo calculations. Most importantly, they voiced disagreement with different analyses and conclusions throughout the book. Though some differences of opinion remain, the chapters have been strengthened with this critical input.

In late 2018, I presented the concepts and analysis in the book to a group of six higher education professionals who work tirelessly to promote access and student success around the nation. Their feedback was an important step in chapter development, particularly for chapters that discuss funding.

Stephen (Steve) Porter, from North Carolina State University, provided feedback as the chapters were just taking shape. He provided counsel on big ideas that fit together and those that didn't belong in the book. His direct approach (e.g., "I couldn't figure out why this entire section was there, you should eliminate it!") early on saved me from traveling down endless paths and helped me find some sort of convergence to map out the book.

My three sons, Matthew, Isaac, and Luke, read different chapters and provided reaction and input. Isaac did a lot of the early state-level analysis that helped me think about ideas related to population and funding across the states. My partner and spouse, Sara de Martinez, is in all rights a cocreator of this work. She did all the data management and extraction of the state and institutional-level data sets and all the Excel analysis upon which the chapters rest. Her technical expertise and intellectual curiosity also proved an important source for discussion of countless ideas, some of which made it into the book and some of which did not.

Two people discussed logarithms and exponents with me. The first is high school advanced placement calculus teacher Jody Turner. Jody works at Chisholm Trail High School in Fort Worth, Texas. She helped me work out

the algebra associated with solving log and exponential equations and converting the results from log-log analysis back to original units. Sara was heavily involved in these lively discussions as well. Christopher Kribs reviewed my data and graphs and offered guidance on logarithms. Christopher is a mathematician and professor at the University of Texas at Arlington

Finally, John von Knorring, my publisher, is always so positive and encouraging. He presses me to "get to the point" but also appreciates that a new paradigm must lay some conceptual foundations. John allowed me to try to balance discussions of theory and policy practice throughout the book, even though my preference is for the former.

PART ONE

FOUNDATIONS FOR A SCIENCE OF HIGHER EDUCATION

I

COMPLEX SYSTEMS AND STATE HIGHER EDUCATION

- *Power laws explain features of complex adaptive systems, including biological systems, cities, and state higher education systems.*
- *New explanations of higher education systems give rise to new ways of thinking about higher education policy.*

Organizations—from cities to corporations and universities—are complex adaptive systems; they are living and breathing, connected by dynamic interactions between and among people and groups. Dynamic interactions produce *network effects* (see Appendix A for a glossary of terms), many of which organize into predictable patterns between system features.

Scientists at the Santa Fe Institute (SFI) study complex systems, searching for order and patterns in natural systems as well as humanly constructed ones. Their work on cities opens new possibilities for how we think about human interaction, resource allocation, and public policy. The Massachusetts Institute of Technology's Human Dynamics Laboratory studies patterns of information exchange in social networks that help explain the coordination of social groups (Pentland, 2014), an essential building block of any organization.

The mathematical function known as the *power law* explains various features of complex adaptive systems across a range of fields. The general power law that explains the relationship between mass and metabolism across species also explains the relationship between city population and various features of cities.

West (2017) and his colleagues at SFI showed that the power law explains differences between cities in terms of infrastructure needs, wages, spread of diseases, and even innovation, all relative to population. One city is a scaled

version of another. New York City is a scaled-up version of Los Angeles for various infrastructure and socioeconomic features of the city. The power law accurately models scale behavior across cities for these features despite drastic city differences in social dynamics, geography, economic activity, and even government policies.

The central finding of this book is that power laws that apply to what West (2017) called a "science of cities" also apply to many features of state higher education systems (p. 7). We therefore have the foundation to examine how certain features of state higher education systems scale across states and influence policy.

Power laws accurately model state higher education funding, enrollment, completion, and supply (the number and type of institutions in a state), all relative to state population. Power laws also explain state differences between funding and public undergraduate enrollments and public undergraduate completions.

Additional mathematical regularities that describe various phenomena outside of higher education also apply to higher education. The 80/20 rule, made famous at the dawn of the Industrial Revolution by Italian thinker Vilfredo Pareto, describes a range of phenomena, from income distributions in different countries to the size variations of U.S. public companies.[1] In chapter 7, I refer to "Pareto-like imbalances" that describe diverse features of higher education, from enrollment variations across different sectors of higher education to the disproportionate representation of authors from just a few institutions in top academic journals.

Mathematical descriptions of patterns in complex adaptive systems generate fresh insights that can help solve system problems. Urban planners may compare existing infrastructure capacity against anticipated population changes and use the power law to forecast future infrastructure costs. In higher education, patterns of state higher education funding and outcomes can help policymakers decide whether to emphasize enrollment or completion policies, or perhaps both.

The application of complex adaptive systems to human organizations has its roots in the life sciences. Researchers took insights about living systems, laid by thinkers such as Galileo, and discovered that the scale principles applicable to mass and metabolism across species also explain the relationship between city population and various socioeconomic features and infrastructure needs. In turn, these insights apply to state higher education systems which, like cities, are complex adaptive systems.

The next section describes the enabling power of using the complex adaptive system concept as a framework for the study of state higher education systems. This sets the stage for an overview of the philosophical

underpinnings of complex adaptive systems and links it to state higher education systems, policies, outcomes, and interactions between and among people and groups. Those who wish to begin with the domain-specific framework for higher education and skip the discussion of the philosophical basis for this book may wish to turn to chapter 2.

The Value of a Framework

- *The complex adaptive systems framework describes state higher education systems and policy challenges from a new perspective.*

Practitioners often lack the time (and patience) to review theories or conceptual frameworks. They want the application, the how. Researchers in a variety of fields, including in higher education, however, have long used frameworks to understand their subjects of interest and provide guidance to practitioners.

Luckett and Casey (2016) emphasized that frameworks help organize complex phenomena, which then translates into meaningful action. Luckett and Casey used a biological framework that outlines seven essential characteristics of life to describe the nature of social media. They initially relied on the framework and then suggested actionable policies and practices to turn social media into a constructive democratic platform.

Poverty researchers Daminger et al. (2015) stated that frameworks help us understand why something works, noting that "when practitioners understand why a particular strategy works, they will be in a better position to find new ways to apply it, as well as to effectively advocate for the resources they need" (p. 16). Daminger et al. utilized a behavioral science framework to explain that environment influences behavior, and they subsequently suggested nudge strategies to address chronic scarcity, based on their framework.

Frameworks increase understanding of why something works, not just how it works. Importantly, insights derived from frameworks in one field often find application in others. Findings from research on cities, specifically scale relationships between infrastructure and socioeconomic features, apply to state higher education higher systems. Cities and state higher education systems have much in common. Just as city officials provide funding for cities, state policymakers provide funding for higher education. Just as investment in cities produces public and private benefits, so too does investment in higher education.

Klinenberg (2018) described specific city and higher education investments that produce public benefits as *social infrastructure*. In cities, public

libraries create a social space for a diverse range of people. Libraries facilitate the acquisition of social and human capital (technical skills) by spreading literacy and the development of social networks (human connections and network ties) through various community programs. Klinenberg identified universities as vehicles that facilitate the acquisition of social and human capital in a similar manner. Institutions of higher education are a form of social infrastructure.

The burgeoning work on cities offers frameworks useful from which to view persistent policy challenges in higher education, or what Churchman (1967) and social planners referred to as *wicked problems*. Wicked problems have no single, agreed-upon solution. Incomplete and changing dynamics influence how different people view the problem and frame ideas, all of which result in different solutions to the problem.

Many policy problems are wicked problems. Tandberg and Fowles (2018) charted the historical progression and application of various frameworks and theories to higher education policy, starting with wicked problems. According to the authors, there is no shortage of opinions on how to resolve difficult policy matters in higher education. Wicked problems arise because it is difficult to prioritize competing interests in an arena where there is no true-or-false or right-and-wrong dichotomy.

Wicked problems in higher education generate opposing policy solutions to perennial issues: Can we achieve both access and quality? How do we determine whether states underfund or adequately fund higher education? What does higher education achieve for the state funding it receives?

Tandberg and Fowles (2018) described how researchers have framed higher education policy to address wicked problems over the last 40 years. They started with Cohen et al. (1972), who referred to colleges and universities as organized anarchies where problem and solution choices are akin to garbage cans. Organizational garbage cans are a collection of choices looking for problems, solutions looking for answers, and decision-makers looking for work. Competing stakeholder preferences, changing technologies, dynamic group interactions, and fluid organizational participation characterize organized anarchies. The problems that organized anarchies attempt to solve are invariably complex and ambiguous, often wicked.

Wicked problems arise in what Hogarth (2001) called *wicked learning environments*, which are distinct from *kind learning environments*. A kind learning environment is an arena where accurate feedback connects decisions to outcomes. Wicked learning environments feature more ambiguity and complexity. The link between decisions and outcomes is murky, ambiguous, or even nonexistent. Wicked learning environments describe the complex environment in which so many higher education policy problems arise and why leaders have difficulty advancing definitive solutions.

Kingdon's (1995) multiple streams theory builds on the garbage can metaphor and wicked environments and addresses how different stakeholders advance a policy solution and look for windows of opportunity to do so during the policy process. Higher education researchers have applied Kingdon's theory to different aspects of state higher education policy, such as the policy process for addressing governance reform (McLendon, 2003).

Tandberg and Fowles (2018) also showed how theories ranging from principal agent theory to boundary spanning inform higher education policy, and they encouraged further consideration of different perspectives. The common theme throughout these studies describes state higher education systems as complex organizations working on difficult problems in unpredictable and nonlinear policy worlds.

The complex adaptive system framework and power law methodologies applied to state higher education systems reveal relationships between population and funding, population and supply (the number and different types of institutions), and funding and enrollment and completion. These relationships offer a new way to compare states across common system features. Policymakers can also assess their individual states. For example, the power law relationship between funding and enrollment produces predicted enrollments for each state, which can be compared against actual enrollments.

Complex Adaptive Systems and Intersubjective Worlds

- *State higher education systems are social systems, a specific type of complex adaptive system.*
- *Dynamic and complex human interactions lie at the heart of social systems.*

The study of complex adaptive systems is varied and multidisciplinary. Complex adaptive systems as livable and changeable systems have been used to describe biological systems, traffic flows, and governments. Multiple interacting subjects and forces comprise any complex adaptive system, producing dynamic effects that escape simple cause-and-effect characterization.

Smil (2019) offered what is perhaps the most comprehensive description of growth and scale in complex adaptive systems to date. His volume covers historical and contemporary findings for topics ranging from the growth of microscopic organisms to scale in human populations, megacities, and entire civilizations. Complex adaptive systems commonly exhibit scale in the form of exponential or finite growth patterns.

The Science of Higher Education describes state higher education systems as complex adaptive systems that conform to growth patterns like

those Smil (2019) documented. State higher education systems are also what Smil called a *social system*, a specific type of complex adaptive system (I use *social systems* and *complex adaptive systems* interchangeably to describe higher education). Though biological and social systems are both complex adaptive systems that exhibit scale relationships among various features that characterize them, physical laws drive biological systems, whereas network effects that emanate from dynamic human interactions drive social systems.

Social Systems and Intersubjectivity

Social systems live and breathe through this network of dynamic human interactions, including state higher education systems. Interactions may be between two people or among many; formal or informal; planned or unplanned; direct (linear) or indirect (nonlinear); personal, social, or professional; and virtual or face-to-face (and everything in between). Time (temporal) and space (spatial) influence human interaction as well, such as when, where, and in what format leaders choose to share information.

For Taleb (2018), complex systems do not have obvious one-dimensional cause-and-effect mechanisms. Patterns exist among the messiness and complexity, though those patterns are not easily reducible to singular explanations as might be the case in physical or biological systems.

Social systems as complex adaptive systems align with Wilber's (2001) description of intersubjective worlds. Collectively, subjective individuals and groups populate intersubjective worlds. According to Wilber, different realities, perceptions, feelings, and judgments collide in intersubjective worlds. Cause and effect do not exist in these worlds, as a complex web of past, present, and anticipated actions and interactions confounds singular and reductionist explanations for any given outcome.

State higher education systems as social systems are intersubjective. Dynamic and complex human interaction lies underneath any resultant funding, enrollments, or completions in a state. Individuals and groups, including institutional administrators and policymakers, compete to frame wicked problems and influence colleges and universities that receive funding, enroll students, and produce degrees.

Individuals and groups not only frame problems differently but also view the entire social system through different lenses. Harari (2014, 2016) believed that groups create collective fictions to make sense of messy and complex intersubjective worlds. Even an organization is something people create, a fiction that facilitates the coordination of human activity. The very purpose and function of organizations can change over time as well, driven by social system dynamics and competing fictions.

Even though intersubjective worlds defy singular cause-and-effect explanations because of the many actors and the fictions they create, researchers find that power laws accurately describe many features of these worlds. Competing groups and organizations—component parts of the whole—create the network effects that shape and define these features. The next section describes, in more detail, the parts and whole of higher education systems.

Higher Education as a Complex Adaptive System

- *Complex adaptive systems consist of smaller complex adaptive systems, alongside other systems, and nested within larger systems.*
- *Actors—individuals, groups, organizations—create different realities and seek to advance their realities over others.*

The complex adaptive systems framework and power law function describe patterns between and among cities. Cities are complex adaptive systems, comprising and surrounded by other complex adaptive systems (companies, community colleges, universities, churches, businesses, and other organizations). Cities also are part of larger complex adaptive systems (states and the nation). Despite system-level complexities and idiosyncratic differences among individual cities, scale patterns still describe features across cities (Bettencourt, 2013; West, 2017).

The complex adaptive systems framework and power law functions apply to state higher education systems as well. Consider public universities. Each public institution is a complex adaptive system, itself nested within a larger complex adaptive system, known as a *state system of higher education*. The state higher education system consists of individual institutions and a centrally managed office (the chancellor or president's office). This state system of higher education is part of state government, another complex adaptive system, which formulates idiosyncratic higher education policies and laws that account for local, state, and national conditions.

Public universities also exist alongside other complex adaptive systems, including community colleges, private institutions, for-profit (FP) institutions, businesses, local government agencies, and K–12 schools. Despite all the differences between and among state systems of higher education, scale patterns still describe features across systems and states, such as funding and completion.

The idea of a public institution as a complex adaptive system, itself consisting of smaller complex adaptive systems and simultaneously surrounded by and part of other complex adaptive systems, means each system is always part of a larger whole. The whole limits the parts by placing boundaries on individual autonomy while also conferring collective benefits to the parts.

State systems place boundaries on institutional autonomy, but each unit also benefits by belonging to the system. Similarly, university administrators place boundaries on colleges, and colleges place boundaries on academic departments. Colleges benefit by belonging to the university, and departments benefit by belonging to the college. At every level, the larger whole constrains its constituent parts, but the parts also receive the benefits of belonging to the larger system—*e pluribus unum*.

In addition to complex internal dynamics of parts and wholes, every system resides in an environmental landscape of interacting macro forces. Macro forces include each state's demographic, economic, and geographic features that situate system and actor interactions. Random forces and environmental context create unique complexity within each state.[2] I address the environmental landscape of state higher education systems in chapter 2, as have previous scholars such as Peterson (1997), but I only acknowledge randomness as a real and influential force in passing. Randomness in higher education includes unpredictable leadership decisions and unanticipated political, technological, or economic events.

The view of state higher education systems as complex adaptive systems, or social systems, draws attention to the many interacting organizations, subsystems, and forces that influence higher education policy. Different actors populate these organizations and subsystems and drive the interactions that define them.

The Centrality of Actors Advancing Their Realities

Social systems are social because they are made up of interacting actors. Actors can be individuals, groups, or organizations. Actors attempt to make sense of the system and its parts. Macro forces and randomness also shape actors' perceptions and thus the realities they construct about their intersubjective worlds. Attempts to make sense of such realities are attempts at sensemaking (Weick, 1995). Sensemaking occurs through self-contemplation, dialogue, storytelling, and actor exposure to sensory input.

The sensemaking process is subjective because social systems are intersubjective and messy. Different actors construct different realities, different fictions, in messy worlds, or what Epstein (2019) called "wicked worlds" (p. 189). Actors behave according to their realities. This dynamic is like Kingdon's (1995) multiple streams theory, discussed earlier in the chapter, where different stakeholders advance different ideas and policy solutions to wicked problems. In policy environments, a dominant paradigm emerges when one reality gains momentum over others.

Higher education actors include students, faculty, administrators, legislators, policy analysts, industry executives, community leaders, K–12 administrators and teachers, associations, foundations, and many others. Higher education actors have different agendas and different solutions for important challenges and issues. What administrators and faculty see as an ailing and underfunded higher education system, certain politicians or business groups may see as a spending problem within institutions. Higher education publications regularly document declining funding per student as evidence of lack of state commitment, whereas business writers use the same metric to identify states with high spending per student—different realities.[4]

Actors work to convince others of their reality through a variety of means. For example, universities hire consultants to write reports about their economic contributions to their states, foundations fund activities to increase certificate and degree conferrals, associations publish analyses of state funding to encourage investment in higher education, and FP lobbyists work to reduce federal oversight of their institutions.

State higher education systems are complex adaptive systems precisely because of the many and conflicting perspectives actors seek to advance. Existing conventions and paradigms in any field develop over time and represent actor success in gaining acceptance of their realities. New realities represent a challenge to existing conventions and paradigms.

In the best case, research and evidence inform new realities. *The Science of Higher Education* presents a view of state higher education systems as social systems whose many features conform to evidence-based scale patterns described by power laws. That features such as funding and enrollment conform to a scale relationship challenges the view that funding and enrollment change at the same rate, an assumption underlying much higher education policy work today. This seemingly small difference carries large policy implications that challenge existing interpretations of state funding, enrollment, and completion. New frameworks create competing interpretations, a necessary but not always welcome development.

Toward a New Framework

- *All frameworks include some perspectives and exclude others.*

The study of higher education is multidisciplinary and benefits from frameworks and theories from other fields. Innovation research emphasizes the value of applying ideas from one field to another (Hargadon & Douglas,

2001; Rogers, 2003; Verganti, 2009), a concept also long known as *lateral thinking*. In this respect, research and findings from the science of cities (Bettencourt, 2013; West, 2017) provide valuable direction for establishing a new paradigm for higher education.

In addition to discoveries from city research, theories from political science, education, and economics contribute to the new science of higher education paradigm. Public administration, political science, and economics have long informed research on student aid, governance, and higher education policy. Markets and governments are central to higher education policy frameworks. Lindblom (1977) described the complex dynamic between governments and markets as a politico-economic system, which also is the core of all state public higher education systems.

Finally, current events and trends influence state higher education systems. The topic of disruptive innovation in higher education, for example, still generates as much excitement today as it did when massive open online courses (MOOCs) came on the scene, with all the accompanying hype that began in 2012. MOOCs never fulfilled the utopian ideals that evangelists promised, but the search for the next great innovation continues to influence actor realities and expectations about higher education funding, enrollments, and completions.

Though no one has matched the substantive contributions of the late innovation researcher Everett Rogers (2003), Clayton Christensen elevated disruptive innovation as the premier trend at higher education conferences and board meetings across the country (Christensen, 2016; Christensen & Eyring, 2011). Birnbaum (2000) warned of the pitfalls and dangers of falling victim to trendy thinking, but that does not reduce the influence it has.

Given the vagaries and unknowns associated with higher education trends, *The Science of Higher Education* primarily draws on literatures from political science, higher education, and economics. No paradigm is completely comprehensive, though, so some perspectives do not explicitly appear in this book. I do not make direct interpretations from the very important social justice lens, for example, though I do point out issues related to equity and access when the interpretation of the results seems to lean in that direction. Experts in social justice may legitimately frame the analysis or interpret results differently than I do.

Notes

1. Population patterns are often associated with Zipf's law. Harvard linguist George Kingsley Zipf actually applied this law in 1935 not to cities but to word usage in the English language (www. https://en.wikipedia.org/wiki/Zipf's_law). The law states that the frequency of any word is inversely

proportional to its rank in frequency. It was later applied to city size (West, 2017). Zipf's law is actually an application of the Pareto principle.

2. Nassim Nicholas Taleb (2007, 2012), in both *The Black Swan* and *Antifragile*, articulated the power of randomness and its influence on systems and societies.
3. The *Chronicle of Higher Education* and *Inside Higher Ed* regularly feature articles documenting declining state funding per student for different years and time periods. Baumol and Bowen's (1966) theory of the "cost disease" provides an alternative perspective on higher education funding, by focusing on institutions. Cooper (2018) is an example of a contemporary writer who sees institutional spending as the problem rather than declining funding per student.

References

Akers, B. , & Chingos, M. M. (2016). Game of loans: The rhetoric and reality of student debt. Princeton University Press.

Almanac of higher education 2018—19. (2018). https://www.chronicle.com/specialreport/The-Almanac-of-Higher/214

Almanac of higher education 2019—20. (2019). https://www.chronicle.com/specialreport/The-Almanac-of-Higher/214

American Museum of Natural History. (n.d.). Size and strength. https://www.amnh.org/exhibitions/the-world-s-largest-dinosaurs/size-and-scale/size-and-strength

Angulo, A. J. (2016). Diploma mill$: How for-profit colleges stiffed students, taxpayers, and the American dream. Johns Hopkins University Press.

Baum, S. (2016). Student debt: Rhetoric and realities of higher education financing. Springer.

Baum, S. , Ma, J. , Pender, M. , & Welch, M. (2017). Trends in student aid 2017. College Board. https://trends.collegeboard.org/sites/default/files/2017-trends-student-aid_0.pdf

Baumol, W. J. , & Bowen, W. G. (1966). Performing arts, the economic dilemma: A study of problems common to theater, opera, music, and dance. MIT Press.

Berdahl, R. M. (1971). Statewide coordination of higher education. American Council on Education.

Best, J. (2004). More damned lies and statistics: How numbers confuse public issues. University of California Press.

Best, J. (2012). Damned lies and statistics: Untangling numbers from the media, politicians, and activists (Updated). University of California Press.

Bettencourt, L. M. A. (2013). The origins of scaling in cities. Science, 340(6139), 1438-1441. https://doi.org/10.1126/science.1235823

Birnbaum, R. (2000). Management fads in higher education: Where they come from, what they do, and why they fail. John Wiley & Sons.

Bowen, H. R. (1979). Costs of higher education: How much do colleges and universities spend per student and how much should they spend? Jossey-Bass.

Bransberger, P. , & Michelau, D. K. (2016). Knocking at the college door: Projections of high school graduates. Western Interstate Commission for Higher Education.

Brown, S. (2019, July 25). Here’s why Alaska’s governor thinks his university system needs steep cuts—and why experts say he’s wrong. Chronicle of Higher Education. https://www.chronicle.com/article/Here-s-Why-AAlaska-s/246779?cid=wsinglestory_hp_1a

Brynjolfsson, E. , & McAfee, A. (2016). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. W. W. Norton.

Burke, J. C. (Ed.). (2004). Achieving accountability in higher education. Balancing public, academic and market demands. John Wiley & Sons.

Callan, P. M. , & Finney, J. E. (2005). State-by-state report cards: Public purposes and accountability for a new century. In Joseph C. Burke & Associates (Eds.), Achieving accountability in higher education: Balancing public, academic, and market demands (pp. 189—215). Jossey-Bass.

Carnevale, A. P. , Cheah, B. , & Van Der Werf, M. (2019). A first try at ROI: Ranking 4,500 colleges. Center on Education and the Workforce. Georgetown University.

Carnevale, A. P. , Jayasundera, T. , & Gulish, A. (2016). America’s divided recovery: College haves and have-nots. Center on Education and the Workforce. Georgetown University.

Center for the Study of Education Policy & State Higher Education Executive Officers. (n.d.). Welcome to Grapevine, fiscal year 2019—20. Illinois State University.

Christensen, C. M. (2016). The innovator’s dilemma: When new technologies cause great firms to fail. Harvard Business Review Press. (Reprint)

Christensen, C. M. , & Eyring, H. J. (2011). The innovative university: Changing the DNA of higher education from the inside out. Jossey-Bass.

Churchman, C. W. (1967). Wicked problems. Management Science, 14(4), B-141—B-146. https://doi.org/10.1287/mnsc.14.4.B141

Clark, B. R. (1983). The higher education system: Academic systems in cross national perspective. University of California Press.

Clark, B. S. (2016). Political economy: A comparative approach (3rd ed.). Praeger.

Clotfelter, C. T. (2017). Unequal colleges in the age of disparity. Harvard University Press.
Cohen, M. D. , March, J. G. , & Olsen, J. P. (1972). A garbage can model of organizational choice.AdministrativeScience Quarterly, 17(1), 1—25. https://doi.org/10.2307/2392088
Cooper, P. (2018, September 12). The crazy amount America spends on higher education in one chart. Forbes. https://www.forbes.com/sites/prestoncooper2/2018/09/12/the-crazy-amount-america-spends-on-higher-education-in-one-chart/#8e0e9e14482a
Credential Engine. (2019, September 25). Analysis of U.S. education and training landscape identifies over 738,000 unique credentials. https://credentialengine.org/wp-content/uploads/2019/09/Press-Release_Analysis-of-U.S.-Education-and-Training-Landscape-Identifies-Over-738000-Unique-Credentials_190925.pdf?cid=wc&source=ams&sourceId=4798860
Daminger, A. , Hayes, J. , Barrows, A. , & Wright, J. (2015). Poverty interrupted: Applying behavioral science to the context of chronic scarcity. Ideas, 42, 1—49. http://www.ideas42.org/wp-content/uploads/2015/05/I42_PovertyWhitePaper_Digital_FINAL-1.pdf
Delaney, J. A. , & Doyle, W. R. (2018). Patterns and volatility in state funding for higher education, 1951—2006. Teachers College Record, 120(6), 1—42. https://www.tcrecord.org
Desrochers, D. M. , & Wellman, J. V. (2011). Trends in college spending 1999-2009: Where does the money come from? Where does it go? What does it buy? The Delta Cost Project.
DiMaggio, P. , & Powell, W. W. (2010). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields (G. Yudin , Trans.). Journal of Economic Sociology, 11(1), 34—56. https://doi.org/10.17323/1726-3247-2010-1-34-56
Eagan, K. , Stolzenberg, E. B. , Zimmerman, H. , Aragon, M. C. , Sayson, H. W. , & Rios-Aguilar, C. (2017). The American freshman: National norms fall 2016. Higher Education Research Institute, UCLA.
Epstein, D. (2019). Range: Why generalists triumph in a specialized world. Riverhead Books.
Erixon, F. , & Weigel, B. (2016). The innovation illusion: How so little is created by so many working so hard. Yale University Press.
Fain, P. (2018, June 12). As California goes? InsideHigherEd. https://www.insidehighered.com/news/2018/06/12/calif-finalizes-performance-funding-formula-its-community-colleges
Fain, P. (2019, April 4). Doing more with data. InsideHigherEd. https://www.insidehighered.com/news/2019/04/04/experts-discuss-uses-labor-market-data-postsecondary-training
Fayer, S. , Lacey, A. , & Wilson, A. (2017). STEM occupations: Past, present, and future. Bureau of Labor and Statistics. https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf
Florida, R. (2014). The rise of the creative class—Revisited (Revised and expanded). Basic Books.
Florida, R. (2017). The new urban crisis: How our cities are increasing inequality, deepening segregation, and failing the middle class—And what we can do about it. Basic Books.
FRED. (n.d.). Economic research. https://fred.stlouisfed.org/
Frey, W. H. (2018). Diversity explosion: How new racial demographics are remaking America. Brookings Institution Press.
Goldenberg, J. , Mazursky, D. , & Solomon, S. (1999). The fundamental templates of quality ads. Marketing Science, 18, 333—351. https://doi.org/10.1287/mksc.18.3.333
Gordon, R. J. (2016). The rise and fall of American growth: The U.S. standard of living since the Civil War. Princeton University Press.
Grant, R. M. (2016). Contemporary strategy analysis: Text and cases edition (9th ed.). John Wiley & Sons.
Grawe, N. D. (2018). Demographics and the demand for higher education. Johns Hopkins University Press.
Harari, Y. N. (2014). Sapiens: A brief history of humankind. Random House.
Harari, Y. N. (2016). Homo deus: A brief history of tomorrow. Random House.
Hargadon, A. B. , & Douglas, Y. (2001). When innovations meet institutions: Edison and the design of the electric light. Administrative Science Quarterly, 46(3), 476-501. https://doi.org/10.2307/3094872

Hauptman, A. (2020, April 16). States must reform how they fund colleges. Inside-HigherEd. https://www.insidehighered.com/views/2020/04/16/covid-19-must-not-obscure-need-states-fund-colleges-more-wisely-over-long-term

Hauptman, A. , & Krop, C. (2001). Federal student aid and the growth in college costs and tuitions: Examining the relationship. In J. Yeager , G. Nelson , E. Potter , J. Uedman , & T. Zullio (Eds.), ASHE reader on finance in higher education (2nd ed., pp. 127-142). Pearson Education Limited.

Helland, E. , and Tabarrok, A. (2019). Why are the prices so damn high? Health, education and the Baumol effect. The Mercatus Center, George Mason University.

Hogarth, R. M. (2001). Educating intuition. University of Chicago Press.

Hovey, H. A. (1999). State spending for higher education in the next decade: The battle to sustain current support. National Center for Public Policy and Higher Education.

IPL. (2020). States ranked by size &population. www.ipl.org/div/stateknow/popchart.html

Ismail, S. (2014). Exponential organizations. Diversionbooks.

Jaschik, S. (2019, March 4). Will Clay Christensen put his money where his mouth is? InsideHigherEd. https://www.insidehighered.com/news/2019/03/04/ university-president-challenges-clay-christensen-1-million-bet-future-private

Kahneman, D. (2013). Thinking, fast and slow. Farrar, Straus and Giroux.

Kerr, C. , & Gade, M. (1989). The guardians: Boards of trustees of American colleges and universities, what they do and how well they do it. Association of Governing Boards.

Kingdon, J. W. (1995). Agendas, alternatives, and public policies (2nd ed.). Harper Collins.

Klinenberg, E. (2018). Palaces for the people: How social infrastructure can help fight inequality, polarization, and the decline of civic life. Crown.

Koch, R. (2011). The 80/20 Principle: The secret of achieving more with less (Updated 20th anniversary edition). Hachette UK.

Kuhns, T. (2012). The structure of scientific revolutions (4th edition). University of Chicago Press.

Lederman, D. (2019, December 17). The biggest movers online. InsideHigherEd. https://www.insidehighered.com/digital-learning/article/2019/12/17/colleges-and-universities-most-online-students-2018

Lietzke, M. H. (1956). Relation between weightlifting totals and bodyweight. Science, 124, 486. https://doi.org/10.1126/science.124.3220.486

Lindblom, C. E. (1977). Politics and markets: The world's political economic systems. Basic Books.

Luckett, O. , & Casey, M. (2016). The social organism: A radical understanding of social media to transform your business and life. Hachette UK.

Lumina Foundation for Higher Education. (2019). A stronger nation: Learning beyond high school builds American talent. Author.

Ma, J. , Baum, S. , Pender, M. , & Libassi, C. J. (2018). Trends in college pricing 2018. College Board. https://trends.collegeboard.org/sites/default/files/2018-trends-in-college-pricing.pdf

Marcy, M. B. (2020). The small college imperative: Models for sustainable futures. Stylus.

Martinez, M. (1999). South Dakota: Developing policy-driven change in higher education. The National Center for Public Policy and Higher Education.

Martinez, M. , & Nodine, T. (1997). California: Financing higher education amid policy drift. In P. M. Callan & J. E. Finney (Eds.), Public and private financing of higher education (pp. 81-106). ACE/Oryx Press.

McLendon, M. K. (2003). Setting the governmental agenda for state decentralization of higher education. Journal of Higher Education, 74(5), 479—515. https://doi.org/10.1080/00221546.2003.11778887

Milanovic, B. (2019). Capitalism alone: The future of the system that rules the world. Belknap Press of Harvard University Press.

Moretti, E. (2012). The new geography of jobs. Houghton Mifflin Harcourt.

Morland, P. (2019). Human tide: How population shaped the modern world. Hachette Book Group.

Muller, J. Z. (2018). The tyranny of metrics. Princeton University Press.

Murphy, J. D. (2013). Mission forsaken: The University of Phoenix affair with Wall Street. Proving Ground Education.

National Center for Higher Education Management Systems. (n.d.). Welcome to the NCHEMS information center. NCHEMS Information Center for Higher Education Policymaking and Analysis.

http://www.higheredinfo.org/
National Student Clearinghouse. (2018). Term enrollment estimates: Spring 2018. Author.
Nau, R. (n.d.). Beer sales vs. price, part 3: Transformations of variables. Linear Regression Models. http://people.duke.edu/~rnau/regex3.htms
Pentland, A. (2014). Social physics: How good ideas spread—The lessons from a new science. Penguin.
Performance based funding for Texas community colleges. (n.d.). https://tacc.org/sites/default/files/documents/2018-08/performance_based_funding_for_community_colleges.pdf
Peterson, M. W. (1997). Planning and management for a changing environment: A handbook on redesigning postsecondary institutions. Jossey-Bass.
Piketty, T. (2014). Capital in the 21st century. Belknap Press of Harvard University Press.
Piketty, T. (2015). About capital in the twenty-first century. American Economic Review, 105(5), 48—53.
Piper, A. , & Wellmon, C. (2017, October 8). How the academic elite reproduces itself. The Chronicle of Higher Education, 64(7), B6—B9. https://www.chronicle.com/article/how-the-academic-elite-reproduces-itself/
Plecher, H. (2020, February 11). Distribution of the workforce across economic sectors in the United States 2019. Statista. https://www.statista.com/statistics/270072/distribution-of-the-workforce-across-economic-sectors-in-the-united-states/
Pumain, D. (2006). Hierarchy in natural and social sciences. Springer.
Reeves-Bracco, K. , & Martinez, M. (2005). A case study of Utah higher education. The National Center for Public Policy and Higher Education.
Reich, R. B. (2016). Saving capitalism: For the many, not the few. Vintage. (Reprint)
Richardson, R. C. , & Martinez, M. (2009). Policy and performance in American higher education: An examination ofcases across state systems. Johns Hopkins University Press.
Rifkin, J. (2015). The zero marginal cost society. Palgrave MacMillan.
Rogers, E. M. (2003). The diffusion of innovation. Free Press.
Rosinger, K. , Oragus, J. , Kelchen, R. , Cassell, A. , & Voorhees, N. (2020). The landscape of performance-based funding in 2020 (Policy Brief). Informed States Higher Education Policy Initiative.
Santa Fe Institute. (n.d.). About. https://www.santafe.edu/about
Seltzer, R. (2017a, November 21). Growing less equal. Inside Higher Ed. https://www.insidehighered.com/news/2017/11/21/qa-author-book-unequal-higher-ed-landscape
Seltzer, R. (2017b, December 12). Oberlin’s enrollment headache lingers. Inside Higher Ed. https://www.insidehighered.com/news/2017/12/12/oberlin-faces-budget-crunch-due-missed-enrollment-targets
Smil, V. (2019). Growth: From microorganisms to megacities. MIT Press.
Snyder, T. D. , de Brey, C. , & Dillow, S. A. (2018). Digest ofeducation statistics, 2016. National Center for Education Statistics.
Soames, S. (2019). The world philosophy made: From Plato to the digital age. Princeton University Press.
State Higher Education Executive Officers. (2018). State higher education finance: FY 2017. Author.
Taleb, N. N. (2007). The black swan: The impact of the highly improbable (Vol. 2). Random House.
Taleb, N. N. (2012). Antifragile: Things that gain from disorder (Vol. 3). Random House.
Taleb, N. N. (2018). Skin in the game: Hidden asymmetries in daily life. Random House.
Tandberg, D. A. , & Fowles, J. T. (2018). Theoretical perspectives on the SHEEO: How theory can inform and improve policy, practice and research. In D. A. Tandberg , B. A. Sponsler , R. W. Hanna , & J. P. Guilbeau (Eds.), The state higher education executive officer and the public good: Developing new leadership for improved policy, practice, and research (pp. 255—281). Teachers College Press.
Thaler, R. H. , & Sustein, C. R. (2009). Nudge: Improving decisions about health, wealth, and happiness. Penguin Books.
Thelin, J. R. (2017). American higher education: Issues and institutions. Routledge.
Trammel, K. (2019). California joins a handful of states that provide community college tuition free. CNN. https://www.cnn.com/2019/08/28/us/california-free-community-college-tuition-

trnd/index.html
Vedder, R. (2019). Restoring the promise: Higher education in America. Independent Institute.
Verganti, R. (2009). Design-driven innovation: Changing the rules of competition by radically innovating what things mean. Harvard Business Press.
Waters, T. , & Waters, D. (Eds.). (2015). Weber's rationalism and modern society: New translations on politics, bureaucracy, and social stratification. Palgrave Macmillan.
Weber, M. (1947). The theory of social and economic organization. Oxford University Press.
Weick, K. E. (1995). Sensemaking in organizations (Vol. 3). SAGE.
West, G. B. (2017). Scale: The universal laws of growth, innovation, sustainability, and the pace of life in organisms, cities, economies, and companies. Penguin.
Wilber, K. (2001). A brief history of everything. Shambhala Publications.
Young Invincibles. (2016, January). 2016state report cards. https://younginvincibles.org/wp-content/uploads/2017/04/YI-State-Report-Cards-2016.pdf