Measurement of Productivity and Efficiency

Methods and perspectives to model and measure productivity and efficiency have made a number of important advances in the last decade. Using the standard and innovative formulations of the theory and practice of efficiency and productivity measurement, Robin C. Sickles and Valentin Zelenyuk provide a comprehensive approach to productivity and efficiency analysis, covering its theoretical underpinnings and its empirical implementation, paying particular attention to the implications of neoclassical economic theory. A distinct feature of the book is that it presents a wide array of theoretical and empirical methods utilized by researchers and practitioners who study productivity issues. An accompanying website includes methods, programming codes that can be used with widely available software like Matlab and R, and test data for many of the productivity and efficiency estimators discussed in the book. It will be valuable to upper-level undergraduates, graduate students, and professionals.

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Measurement of Productivity and Efficiency

Theory and Practice

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To my family: Janet, Danielle, and David

—Robin Sickles

To my family: Natalya, Angelina, Kristina, Mary; my parents: Hryystyna Myhaylivna and Petro Ivanovych; my brother Oleksiy and sister Elena

—Valentin Zelenyuk
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Preface

Cambridge University Press has published a number of successful books that focus on topics related to ours: Chambers (1988), Färe et al. (1994b), Chambers and Quiggin (2000), Kumbhakar and Lovell (2000), Ray (2004), Balk (2008), and Grifell-Tatjé and Lovell (2015). These books – and an increasing number of articles related to production analysis, published in top international journals in economics, econometrics, and operations research – suggest a growing interest in the academic and business audience on the subject.¹

Our book is meant to complement and expand selected topics covered in the above-mentioned books, as well as the volume edited by Fried et al. (2008) and the edited volume by Grifell-Tatjé et al. (2018), and addresses issues germane to productivity analysis that would be of interest to a broad audience. Our book provides something genuinely unique to the literature: a comprehensive textbook on the measurement of productivity and efficiency, with deep coverage of both its theoretical underpinnings as well as its empirical implementation and a coverage of recent developments in the area. A distinctive feature of our book is that it presents a wide array of theoretical and empirical methods utilized by researchers and practitioners who study productivity issues. Our book is intended to be a relatively self-contained textbook that can be used in any graduate course devoted to econometrics and production analysis, of use also to upper-level undergraduate students in economics and in production analysis, and to analysts in government and in private business whose research or business decisions require reasoned analytical foundations and reliable and feasible empirical approaches to assessing the productivity and efficiency of their organizations and enterprises. We provide an integrated and synthesized treatment of the topics we cover. We have covered some topics in greater depth, some at a broader scope, but at all times with the same theme of motivating the material with an applied orientation.

¹ For a remarkable treatment of the history of the US economic growth experience and the sustainability of innovation-induced productivity growth see Gordon (2016).
xxii  Preface

Our book is structured in such a way that it can be used as a textbook for (instructed or self-oriented) academics and business consultants in the area of quantitative analysis of productivity of economic systems (firms, industries, regions, countries, etc.). In addition, some parts of this book can be used for short, intensive courses or supplements to longer courses on productivity and other topics, such as empirical industrial organization. Another example of the book’s application would be to use the first section on production theory as a supplement in a course on advanced microeconomics. We have tried to structure the textbook in such a way as to broaden the audience for the topics we cover, and – just as important – help readers to have a self-contained source for gaining knowledge on the topics we cover with key references for further details.

It is important to note that the many methods we detail in our textbook are meant to be viewed as relative measures to some benchmark. We provide several different benchmarks in our early chapters, based on technical considerations as well as on excess costs, diminished revenues, and lower profits than could be generated were the firm or decision-making unit optimizing with respect to standard neoclassical assumptions. However, we are purposeful in our silence about the type of market mechanism that is adopted by firms or industries that are being analyzed. Reality shows that any country, or industry within any country, or firm within any industry – whether centrally planned or market oriented, or a hybrid of the two – can have inefficiency and low levels of productivity and therefore can be analyzed using the methods we detail in our book. As Thaler and Sunstein (2009, p. 6) have pointed out:

> Individuals make pretty bad decisions in many cases because they do not pay full attention in their decision-making (they make intuitive choices based on heuristics), they don’t have self-control, they are lacking in full information, and they suffer from limited cognitive abilities.

Our book speaks to firms or agencies that are privately or state-owned, capitalist or centrally planned economies, developed, developing, or transitional countries – anywhere where the goal is to measure productivity and identify and explain possible inefficiencies. An aim of our textbook is to help a productive entity improve and move to higher levels of efficiency and productivity and a more efficient utilization of valuable and costly resources.

Our textbook also can be viewed as a comprehensive and integrated treatment of both neoclassical production theory and of the broader contextual theoretical and empirical treatment that renders it a special case. Such a treatment of production theory and productivity that explicitly allows and accounts for inefficiency has the advantage of providing researchers with the tools to pursue the production side of theories developed by Robert Thaler, the winner of the 49th Sveriges Riksbank prize in economic sciences (2017 Nobel Memorial Prize in Economic Science). According to the Nobel committee, Thaler provided a “more realistic analysis of how people think and behave.
when making economic decisions.” We feel that allowing for similar realistic possibilities that producers, just like consumers, make decisions that may not reflect optimizing behaviors is warranted on both empirical and theoretical grounds.

Another important distinctive feature of our book is the availability of software. Much of the applied work in productivity and efficiency analysis that we discuss can be implemented using the packages of code for the MATLAB software that can be accessed at https://sites.google.com/site/productivityefficiency/ and is maintained by Dr. Wonho Song of the School of Economics, Chung-Ang University, Seoul, South Korea. The different packages for the MATLAB software were programmed by various scholars – Pavlos Almanidis, Robin Sickles, Léopold Simar, Wonho Song, Valentin Zelenyuk – and then checked, integrated and synthesized by Dr. Song to go along with this book. This MATLAB code is free and can also be integrated into R, Julia, and C++ programming environments. Details on how to access and implement the various estimators we discuss in our book, as well as data sources available to productivity researchers, are in Chapter 17. We anticipate that the availability of such freeware will allow a broad audience of interested scholars and practitioners to implement the methods outlined in our book as well as promote empirical research on the subject of efficiency and productivity modeling. The website has data sets for efficiency analysis, an inventory of the public use data available to researchers worldwide, and various instructional aids for teachers as well as students, including answer keys for selected exercises from the book. Software to estimate several of the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) models that we have considered using cross-section, time series, and panel data can also be found in LIMDEP, R, STATA, and SAS, to mention a few.
Acknowledgments

For both of us, this book is a culmination of professional careers in economics dating back over several decades. It would make sense that there are numerous people we wish to thank for making this book possible. They are our families, our mentors, our collaborators, our students, and our many colleagues who contributed by providing substantive comments and contributions to the book’s narrative and technical details. Below we give individual and more specific acknowledgments.

From Robin Sickles I was quite fortunate to have remarkable mentors in my life. My brother Rick, who has given me advice throughout my entire life; my first economics teacher, Carl Biven, whose course in the History of Economic Thought at Georgia Tech inspired my transition from a major and co-op job in aerospace engineering to economics; and Mike Benoit, whose friendship and support was instrumental in my making the career choice to pursue graduate studies. In some cases, an individual or individuals may take on the role of both a mentor and a collaborator. C. A. Knox Lovell and Peter Schmidt are two such people. It is remarkably fortunate that I would be in graduate school at the University of North Carolina at Chapel Hill in the early 1970s at a time when these remarkable scholars’ careers were defined by their collaborative efforts that led to the iconic Aigner, Lovell, and Schmidt stochastic frontier paper and many other seminal works, often with each other, with other colleagues at UNC, or with other students at UNC. I have expressed my appreciation and gratitude and have acknowledged my debt to Knox and Peter in many venues – edited special journal issues, volumes, and special awards that I have been honored to present. It is rare indeed for a collaborative enterprise to have lasted such a long time, but we continue to work together on many projects and to attend many of the same professional conferences. Not only have the collaborative efforts among us been long lasting as a professional enterprise, but so has our friendship. That is a rare gift, and I will always know how lucky I have been to have had such mentors, collaborators, and friends.

My career in productivity and efficiency would not have had the longevity it has had were I also not in the right place at the right time in 1976 when
I began my appointment as an assistant professor at the George Washington University. John Kendrick (who received his PhD at UNC) asked me to assist him in developing methods to attribute specific factor productivity growth to particular factors of production in the US airline industry. That work with the Air Transport Association was my first formal endeavor in the field of productivity, and I thank my late colleague and mentor John Kendrick for giving me that opportunity. Lovell and Sickles (2010) have a brief memorial article on John and his seminal contributions to productivity. Later, after I had moved to the University of Pennsylvania, I was lucky enough to have an appointment as a Faculty Research Fellow at the National Bureau of Economic Research. I am indebted to Ernst Berndt and to Zvi Griliches for making that possible, and to Ned Nadiri, Erwin Diewert, and my many other colleagues in the Productivity Program during my time in that position. While at Penn, Jere Behrman, Robert Pollak, Paul Taubman and I worked on a number of productivity-related issues, some of which are referenced in this book. I am indebted to them for their kind support and their most appreciated mentorship.

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to translate the MATLAB code for estimating the various productivity and efficiency estimators discussed in Chapter 17 into compatible R code.

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there on a fellowship). After giving me a great foundation in production theory and in the theory of DEA and its applications, and helping with developing and publishing several works that were exciting for me, Rolf and Shawna strongly recommended me (at my public PhD defense) to find ways to work with and learn from Léopold Simar. A few weeks later I attended NAPW-2002, where I first met and talked to Léopold and another research era started for me at that point, filled with many other exciting research projects.

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