THE RISE AND FALL OF BUSINESS FIRMS

At the intersection between statistical physics and rigorous econometric analysis, this powerful new framework sheds light on how innovation and competition shape the growth and decline of companies and industries.

Analyzing various sources of data including a unique micro-level database which collects historical data on the sales of approximately 5,000 firms and 130,000 products in 21 countries, the authors introduce and test a model of innovation and proportional growth, which relies on minimal assumptions and accounts for the empirically observed regularities. Through a combination of extensive stochastic simulations and statistical tests, the authors investigate to which extent their simple assumptions are falsified by empirically observable facts.

Physicists looking for application of their mathematical and modeling skills to relevant economic problems as well as economists interested in the explorative analysis of extensive data sets and in a physics-oriented way of thinking will find this book a key reference.

S. V. BULDYREV is Professor of Physics at Yeshiva University. His research interests span theoretical and computational statistical physics and its applications to various complex systems, physical chemistry, material science, and biological physics.

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H. E. STANLEY is William Fairfield Warren Distinguished Professor and Director of the Center for Polymer Studies at Boston University. He is one of the founding fathers of econophysics, a pioneer of interdisciplinary science, and has made seminal contributions to the field of statistical physics. He is a member of the US National Academy of Sciences and a recipient of numerous awards throughout his career.

"This is a superb and fascinating book. The distribution of firms' growth rates exhibits a large number of regularities, including some that are very hard to explain. The authors are pioneers in that enterprise, combining empirical and theoretical work. This team of economists and physicists provides a model for a future way to do economics."

Xavier Gabaix,
Pershing Square Professor of Economics and Finance, Harvard University

"*The Rise and Fall of Business Firms* offers a lucid reconstruction and extension of the exciting developments that fundamentally reshaped our understanding of how firms grow and evolve, brought to you by the scientists responsible for the key discoveries. A must for anyone interested in the deep laws that govern economic processes."

Albert-László Barabási,
Robert Gray Dodge Professor of Network Science at Northeastern University

"There is a long tradition of physicists being interested in and contributing to economics. That tradition continues here in *The Rise and Fall of Business Firms.* The book is based on generalized proportional growth models for the dynamics and stochastics of the growth and decline of business firms. For further studies, the book points out where more detailed specific inter-related complexities (such as among products, markets, and technologies) can be incorporated. The theoretical analysis paired with empirical data provides valuable insight for firms to understand their past trajectory and future choices."

Michael F. Schlesinger,
Office of Naval Research

THE RISE AND FALL OF BUSINESS FIRMS

A Stochastic Framework on Innovation, Creative Destruction, and Growth

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To our families

If the very same regularity appears among diverse phenomena having no obvious common mechanism, then chance operating through the laws of probability becomes a plausible candidate for explaining that regularity.

Ijiri and Simon (1977, p. 3)

At the core of the discussion is a concern as to how we can distinguish between apparent regularities that just happen to crop up in same single data set from those regularities whose happening reflects some underlying law.

Sutton (2000, pp. 16–17)

Less is more.

Ludwig Mies Van der Rohe

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Preface

It all began in Lausanne, when John Sutton invited us for a session on the growth of firms at the European Conference of the Econometric Society. That meeting was the beginning of a deep friendship and intense collaboration. At that time, John Sutton's work on innovation, firm growth, and industry structure, together with that of Herbert A. Simon, the founding father of the stochastic tradition in the analysis of the growth of business firms, was already a fundamental source of inspiration.

For more than 15 years, the four of us traveled between Boston, Lucca, and Milan, combining hard work with vibrant discussions on the most disparate themes. Gene's enthusiasm and generosity have sustained us to "get the work done," to overcome every difficulty, and to focus our gaze on "The Book," as if gazing on a polar star. We remember our ideas drafted on the blackboards at the Center of Polymer Studies at Boston University, the long conversations and collaborations with Kazuko Yamasaki, Kaushik Matia, Dongfeng Fu, Linda Ponta, and with the great students and scholars that animated Gene's Laboratory. These are all memories of our $\Phi\iota\lambda\acute{\iota}\alpha$, to look back on with a smile and a content heart. Soon, Sergey fell in love with the ancient town of Lucca, where he spent many months working on the book, secluded in the ancient monasteries of San Francesco and San Micheletto, and whose walls he encircled by jogging, thinking, and discussing with Fabio on the puzzles of preferential growth.

Sole and Stefano deserve a special mention for their hospitality at Il Mecenate, first under The Fig Tree in Gattaiola and then in Piazza San Francesco, where heated discussions took place.

Gene and Sergey want to thank their colleague and coauthor Michael A. Salinger without whose guidance it would have been impossible for them to enter the field of economics. Gene and Sergey are also grateful to Shlomo Havlin, their most frequent coauthor, whose interest in applying concepts of statistical physics to complex systems has stimulated their research for four decades. Last, but not least, we are in debt to those who participated in the creation of the new field of Econophysics

in the late 1990s: Luis A. Nunes Amaral, Rosario N. Mantegna, Heiko Leschhorn, Philipp Maass, and especially Gene's son, Michael Stanley, who was a high school student at the time, and whose fascination with Zipf's law ignited the interest of his father.

Over the years, we have had the privilege to learn from exceptional colleagues who have influenced us with their writings, comments, caveats, critiques, and suggestions. We would like to mention here Xavier Gabaix, Didier Sornette, Laszlo Barabasi, and Angelo Maria Petroni.

Several colleagues have contributed to our research in the field, while others have read and commented on the content of this book. Special mention goes to Nicola Nottoli, who has designed the cover of our first PNAS article and has inspired us in the selection of the cover for the book, as well as to Gianni de Fabritiis, Jakub Growiec, Alex Petersen, Orion Penner, Greg Morrison, Armando Rungi, Marco Bee, Stefano Schiavo, and, for the most recent comments, Andrea Flori, Alessandro Spelta, Salvatore di Novo, and Stefano Martinazzi. We would also like to thank Mark Buchanan, Giorgio Gnecco, Simone Scotti, Andrea Vindigni, Stefano Gattei, Aymeric Stamm, and Daniele Regoli for their critical reading and valuable comments to earlier versions of the manuscript.

Andrea Morescalchi and Valentina Tortolini are our young, distinguished, coauthors of Chapter 4. Valentina has followed the entire preparation of the manuscript, always combining research endurance with admirable patience.

The Merck Foundation supported, with a multiyear unrestricted grant, Fabio's and Gene's research on innovation and industrial dynamics in pharmaceuticals. We say a big thank you to Lou Galambos, Jeff Sturchio, Brian Healy, Goffredo Freddi, Zoe Bell, and Leslie Hardy. A special thought goes to William Looney for his friendship and wisdom. Sarah Morrison, Wessen Maruwge, and Marina Eskin made an excellent contribution to the editing of the manuscript.

The data that we have had access to thanks to IMS International (now IQVIA) have been a key enabling condition for our research on the nuts and bolts of firm growth.

The research presented in this book was also funded by the National Science Foundation, the Italian Ministry of Education, University and Research (Crisis Lab Project), and the CERM Foundation.

This book is dedicated to our families.