An Evolutionary Theory of Economic Change

Richard R. Nelson and Sidney G. Winter

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To

KATHERINE

MARGO

LAURA

GEORGIE

JEFF

KIT

Preface

WE BEGAN THIS BOOK over a decade ago. Our discussions of the promise and problems of evolutionary modeling of economic change date back years before that. For both of us, this book represents the culmination of work that began with our dissertations.

Our initial orientations were different. For Nelson, the starting point was a concern with the processes of long-run economic development. Early on, that concern became focused on technological change as the key driving force and on the role of policy as an influence on the strength and direction of that force. For Winter, the early focus was on the strengths and limitations of the evolutionary arguments that had been put forward as support for standard views of firm behavior. This soon broadened to include the general methodological issues of "theory and realism" in economics, the contributions of other disciplines to the understanding of firm behavior, and reconsideration of the evolutionary viewpoint as a possible framework for a more realistic economic theory of firm and industry behavior. From the earliest days of our acquaintance, the existence of significant overlaps and interrelations between these areas of research interest was apparent. Nelson's studies of the detailed processes of technological change led him to appreciate the uncertain, groping, disorderly, and error-ridden character of those processes—and the difficulty of doing justice to that reality within the orthodox theoretical scheme. In Winter's case, a study of the determinants of firm spending on research and development formed the empirical arena in which it first became apparent that much of firm behavior

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could be more readily understood as a reflection of general habits and strategic orientations coming from the firm's past than as the result of a detailed survey of the remote twigs of the decision tree extending into the future.

It was not, however, until the collaboration that led to this book was well underway that we realized that its purpose and promise were well defined by two relationships between our areas of interest. First, among the many obstacles to understanding the role of technological change in economic life, an important subset arise from the intellectual constraints associated with the treatment of firm and industry behavior that is now standard in economic theory. Second, among the many benefits that may derive from a theoretical approach that reconciles economic analysis with the realities of firm decision making, the most important relate to improved understanding of technological change and the dynamics of the competitive process.

Our cooperative intellectual endeavor commenced when we were both at the RAND Corporation in Santa Monica in the 1960s. Many people at that remarkably stimulating and intellectually diversified place influenced our thinking. Burton Klein deserves special mention. He conveyed to us a body of truth that has been recognized many times in the history of ideas, but that somehow always stands in need of rediscovery, reinterpretation, and persuasive illustration. Creative intelligence, in the realm of technology as elsewhere, is autonomous and erratic, compulsive and whimsical. It does not lie placidly within the prescriptive and descriptive constraints imposed by outsiders to the creative process, be they theorists, planners, teachers, or critics. To progress with the task of understanding where creative thought is likely to lead the world, it is therefore helpful to recognize first of all that the task can never be completed. Our evolutionary theory of economic change is in this spirit; it is not an interpretation of economic reality as a reflection of supposedly constant "given data," but a scheme that may help an observer who is sufficiently knowledgeable regarding the facts of the present to see a little further through the mist that obscures the future.

We committed ourselves to writing this book after Nelson had moved on to Yale and Winter to Michigan. For a few years the problems of long-distance coauthorship imposed significant costs in terms of the rate of progress of the collaborative effort, but there were also some benefits in the form of opportunities to test ideas in forums provided by two different universities. (Of course, the airlines and the telephone company derived substantial benefits from the arrangement, too.) With Winter's move to Yale in 1976, the communication costs fell and we began to take more seriously the idea of pulling the work together in the form of a book. Major efforts in that direction were made in 1978 and 1979. As our families, colleagues, and editors are well aware, the "almost done" phase of the project lasted almost three years.

In this protracted process of research and writing, we received support and assistance in a variety of forms and from a variety of sources. We will attempt here to acknowledge the main elements of our indebtedness under several major headings, but are uncomfortably aware that some of the lists are far from complete.

Our greatest intellectual debts are to Joseph Schumpeter and Herbert Simon. Schumpeter pointed out the right problem—how to understand economic change—and his vision encompassed many of the important elements of the answer. Simon provided a number of specific insights into human and organizational behavior that are reflected in our theoretical models; but, most important, his work encouraged us in the view that there is much more to be said on the problem of rational behavior in the world of reality than can be adequately stated in the language of orthodox economic theory.

Financial support for our work came from several sources. A major grant from the National Science Foundation, through its Division of Social Sciences, provided important momentum at an early stage. Some of the most recent research that is reported in this book was also supported by the NSF, under a grant from the Division of Policy Research and Analysis. The Sloan Foundation, through a grant to the Applied Microeconomics Workshop at Yale, was a major source of support for our research during the interval between the NSF grants. In addition, we received financial and other support from the Institute of Public Policy Studies at Michigan and the Institution for Social and Policy Studies at Yale. The directors of these organizations during the period in question—J. Patrick Crecine and Jack Walker at IPPS, Charles E. Lindblom at ISPS—deserve special thanks for their encouragement and for their skill at the tricky business of promoting intellectual contact among the social science disciplines.

In our efforts to develop computer simulation models as one type of formal evolutionary theory, we have depended heavily on the contributions of a series of skilled programmers and research assistants. We had the good fortune to attract to this role individuals who became intellectually engaged in the substance of our undertaking, and who contributed, along with their technical expertise, suggestions and criticisms regarding the underlying economics. The first of these was Herbert Schuette; his contributions to much of the work reported in Chapter 9 led to his inclusion as a coauthor of the principal previous publication of that work. We would like to acknowledge those contributions again here. Stephen Horner and Richard Parsons did most of the original programming for our simulation model of

Schumpeterian competition, and contributed a number of helpful suggestions to its formulation. Larry Spancake helped us transfer that model to the Yale computer. Abraham Goldstein and Peter Reiss followed in his footsteps as keepers of the beast at Yale, feeding it and training it in response to our requests and assisting in much of the analysis that helped us understand its behavior.

Many scholars have listened to our presentations, read our drafts and articles, and provided advice, encouragement, and criticisms. In Yale seminars and conversations, we have learned particularly from Susan Rose Ackerman, Donald Brown, Robert Evenson, Lee Friedman, Eric Hanushek, John Kimberly, Richard Levin, Richard Murnane, Guy Orcutt, Sharon Oster, Joe Peck, John Quigley, and Martin Shubik. During Winter's years at Michigan, he received similar benefits from interactions with Robert Axelrod, Michael Cohen, Paul Courant, J. Patrick Crecine, John Cross, Everett Rogers, Daniel Rubinfeld, Peter Steiner, Jack Walker, and Kenneth Warner. A great many friends and colleagues elsewhere have also given us the benefit of their reactions and suggestions on one occasion or another. We wish to thank particularly Richard Day, Peter Diamond, Avinash Dixit, Christopher Freeman, Michael Hannan, Jack Hirshleifer, James March, Keith Pavitt, Almarin Phillips, Michael Porter, Roy Radner, Nathan Rosenberg, Steve Salop, A. Michael Spence, David Teece, and Oliver Williamson.

As our research progressed, we reported on it in articles published in *The Economic Journal, The Quarterly Journal of Economics, Economic Inquiry, Research Policy, The Bell Journal of Economics*, and *The American Economic Review*. We thank the editorial boards of these journals for permission to use parts of our earlier articles in chapters of this book; specific citations are provided in the chapters involved. We are similarly indebted to North-Holland Publishing Co. for permission to use previously published material in Chapter 12.

Three individuals—Richard Levin, Richard Lipsey, and B. Curtis Eaton—did us the great favor of reading large portions of our draft manuscript and making detailed comments. We are greatly indebted to them, and wish to take especial care to exonerate them from responsibility for the final result. Many other people provided useful comments on portions of the manuscript; we particularly want to thank Katherine Nelson and Georgie Winter.

The preparation of the last typed version of the manuscript was a process haunted by the ghost of deadlines passed. Under those trying circumstances, we were fortunate to have the benefit of the outstanding typing skills of Margie Cooke.

In its final phase, our project benefited substantially from our decision to commit the book to Harvard University Press. General edi-

tor Michael Aronson provided suggestions and encouragement. Our copy editor, Maria Kawecki, did what she could to improve our prose. She did so with great tact, and with remarkable insight into what it was that we had been trying to say. Whatever errors and infelicities of expression remain constitute a minute fraction of those originally present, and that fraction may well be largely attributable to the stubbornness of the authors rather than to any lack of diligence on the part of the copy editor.

Each chapter of the book has its own history, and almost every one of those histories is complex. The informed reader may discern that a few chapters seem to be predominantly Nelson, while a few others are predominantly Winter. But in most chapters our individual contributions are thoroughly intermingled, and every chapter has been shaped by the hands of both authors. We share responsibility for the work as a whole. Together, we wish to absolve all of our friends and critics from responsibility for the product, while again expressing our gratitude for their interest. Such absolution is more than a ritual in the case of this book, for there certainly are some among those acknowledged above who consider our effort to be largely misguided.

Our collaboration has not been a separate, self-contained segment of our lives. Rather, it has been a way of life for ourselves and our families. Our children, young when we began, grew up with "the book." In the early days, the book provided the occasion for visits between New Haven and Ann Arbor. In recent years, the book has been a background theme of summer vacations on Cape Cod—or perhaps, on some occasions, it was the vacation that was in the background. We have established a virtual tradition of celebratory dinners marking the "completion" (to some stage) of the book. Our families have shared all this with us; we know that they share a sense of fulfillment, relief, and even amazement that it is done. To them we dedicate the book.

Contents

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I

Overview and Motivation

1

Introduction

IN THIS VOLUME we develop an evolutionary theory of the capabilities and behavior of business firms operating in a market environment, and construct and analyze a number of models consistent with that theory. We propose that the broad perspective provided by an evolutionary theory is useful in analyzing a wide range of phenomena associated with economic change stemming either from shifts in product demand or factor supply conditions, or from innovation on the part of firms. The specific models we build focus in turn on different aspects of economic change—the response of firms and the industry to changed market conditions, economic growth, and competition through innovation. We draw out the normative as well as the positive implications of an evolutionary theory.

The first premise of our undertaking should be noncontroversial: *it is simply that economic change is important and interesting.* Among the major intellectual tasks of the field of economic history, for example, certainly none is more worthy of attention than that of understanding the great complex of cumulative change in technology and economic organization that has transformed the human situation in the course of the past few centuries. Among policy issues regarding the world economy today, none present a more critical mix of promise and danger than those that reflect the wide disparities in present levels of economic development and the strains that afflict societies struggling to catch up. In the advanced economies, meanwhile, successful modernization has brought forth new concerns about the long-term ecological viability of advanced industrial society and renewed questions about the relation between material success and more fundamental human values. Among the focal concerns of theoretical economics in recent years have been the roles of information, the formation of expectations by economic actors, detailed analysis of markets functioning given the presence of various "imperfections," and new versions of old questions about the efficiency of market systems. Much of this work seeks to comprehend, in stylized theoretical settings, the unfolding of economic events over time. Thus, any significant advance in understanding of the processes of economic change would cast new light on a range of intellectually challenging questions that are of great social consequence.

We expect, however, that many of our economist colleagues will be reluctant to accept the second premise of our work—that a major reconstruction of the theoretical foundations of our discipline is a precondition for significant growth in our understanding of economic change. The broad theory that we develop in this book, and the specific models, incorporate basic assumptions that are at variance with those of the prevailing orthodox theory of firm and industry behavior. The firms in our evolutionary theory will be treated as motivated by profit and engaged in search for ways to improve their profits, but their actions will not be assumed to be profit maximizing over well-defined and exogenously given choice sets. Our theory emphasizes the tendency for the most profitable firms to drive the less profitable ones out of business; however, we do not focus our analysis on hypothetical states of "industry equilibrium," in which all the unprofitable firms no longer are in the industry and the profitable ones are at their desired size. Relatedly, the modeling approach that we employ does not use the familiar maximization calculus to derive equations characterizing the behavior of firms. Rather, our firms are modeled as simply having, at any given time, certain capabilities and decision rules. Over time these capabilities and rules are modified as a result of both deliberate problem-solving efforts and random events. And over time, the economic analogue of natural selection operates as the market determines which firms are profitable and which are unprofitable, and tends to winnow out the latter.

A number of our fellow economists do share with us a sense of general malaise afflicting contemporary microeconomic theory.[1] It is

1. It is noteworthy that since 1970 several of the presidential addresses given annually before the American Economic Association have lamented the state of economic theory. Leontief's address (1971) is explicitly concerned with the inability of microeconomic theory to come to grips with empirical realities. Tobin's address (1972), and Solow's (1980), are focused on macroeconomics, but are substantially concerned also

widely sensed that the discipline has not yet located a path that will lead to a coherent and sustained advance beyond the intellectual territory claimed by modern general equilibrium theory. The discovery of such a path will, it is believed, require a theoretical accommodation with one or more of the major aspects of economic reality that are repressed in general equilibrium theory. Much of the most interesting theoretical work of the past two decades may be interpreted as exploratory probing guided by a variety of different guesses as to which of the possible accommodations are the most important ones to make. Considerable attention has been given to imperfections of information and of competition, to transaction costs, indivisibilities, and increasing returns, and to some of the relations among these. It has been recognized that general equilibrium theory's austere description of the institutions of capitalism becomes woefully inadequate as soon as any of these accommodations to reality are made—and, on the other hand, that the actual institutional devices employed in real market systems constitute a complex and challenging object for theoretical study. The fruits of these exploratory efforts include a good deal of work that is intellectually impressive when taken on its own terms, much that is directly useful in understanding certain portions of economic reality, and some that seems likely to be of lasting value regardless of the future course that economics may take. But the great majority of these exploratory probes have carried along (or at least intended to carry along) almost all of the basic conceptual structure that orthodoxy provides for the interpretation of economic behavior.

We regard that structure as excess baggage that will seriously encumber theoretical progress in the long run, however much its familiarity and advanced state of development may facilitate such progress in the short run. Here, obviously, our appraisal of the situation is more radical than anything that can be associated with the "general malaise" referred to above. What we offer in this book is,

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with the adequacy of the theoretical foundations that orthodox microeconomics provides for macroeconomics. Similar themes have been sounded in addresses to other professional organizations; see, for example, Hahn (1970), Phelps Brown (1972) and Worswick (1972). The sense of malaise is also reflected in a number of the review articles in the *Journal of Economic Literature*. Shubik (1970), Cyert and Hedrick (1972), Morgenstern (1972), Preston (1975), Leibenstein (1979), Marris and Mueller (1980), and Williamson (1982) all complain explicitly about the inability of the prevailing theory to come to grips with uncertainty, or bounded rationality, or the presence of large corporations, or institutional complexity, or the dynamics of actual adjustment processes. We do not aim in this footnote, or in the book as a whole, to identify all the souls that are kindred at least in their surface diagnosis of the problem, if not in their deeper diagnoses or prescriptions. We know that in this respect we are part of a crowd.

we believe, a plausible promise that fundamental reconstruction along the lines we advocate would set the stage for a major advance in understanding of economic change—and, at the same time, make it possible to consolidate and preserve most of the discipline's significant achievements to date. To make full delivery on such a promise is not a task for two authors, or for a single book.

1. THE TERMS OF THE DISCUSSION: "ORTHODOX" AND "EVOLUTIONARY"

We have above made the first of many references to something called "orthodox" economic theory. Throughout this book, we distinguish our own stance on various issues from the "orthodox" position. Some such usage is inevitable in any work that, like the present one, argues the need for a major shift of theoretical perspective on a wide range of issues. However, there may be some who would deny that any "orthodoxy" exists in economics, apart from a widely shared commitment to the norms and values of scientific inquiry in general. Others would agree that an orthodoxy exists in the descriptive sense that there are obvious commonalities of intellectual perspective and scientific approach that unite large numbers of economists. But they would strenuously deny there is an orthodox position providing a narrow set of criteria that are conventionally used as a cheap and simple test for whether an expressed point of view on certain economic questions is worthy of respect; or, if there is such an orthodoxy, that it is in any way enforced. Our own thought and experience leave us thoroughly persuaded that an orthodoxy exists in this last sense, and that it is quite widely enforced. We do concede that contemporary orthodoxy is flexible and ever-changing, and that its limits are not easily defined. It therefore seems important to attempt, if not an actual definition, at least a clarification of our use of the term.

We should note, first of all, that the orthodoxy referred to represents a modern formalization and interpretation of the broader tradition of Western economic thought whose line of intellectual descent can be traced from Smith and Ricardo through Mill, Marshall, and Walras. Further, it is a *theoretical* orthodoxy, concerned directly with the methods of economic analysis and only indirectly with any specific questions of substance. It is centered in microeconomics, although its influence is pervasive in the discipline.

To characterize the actual content of contemporary orthodoxy is a substantial undertaking, with which we will concern ourselves recurringly in this book. Here we address the question of how one

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