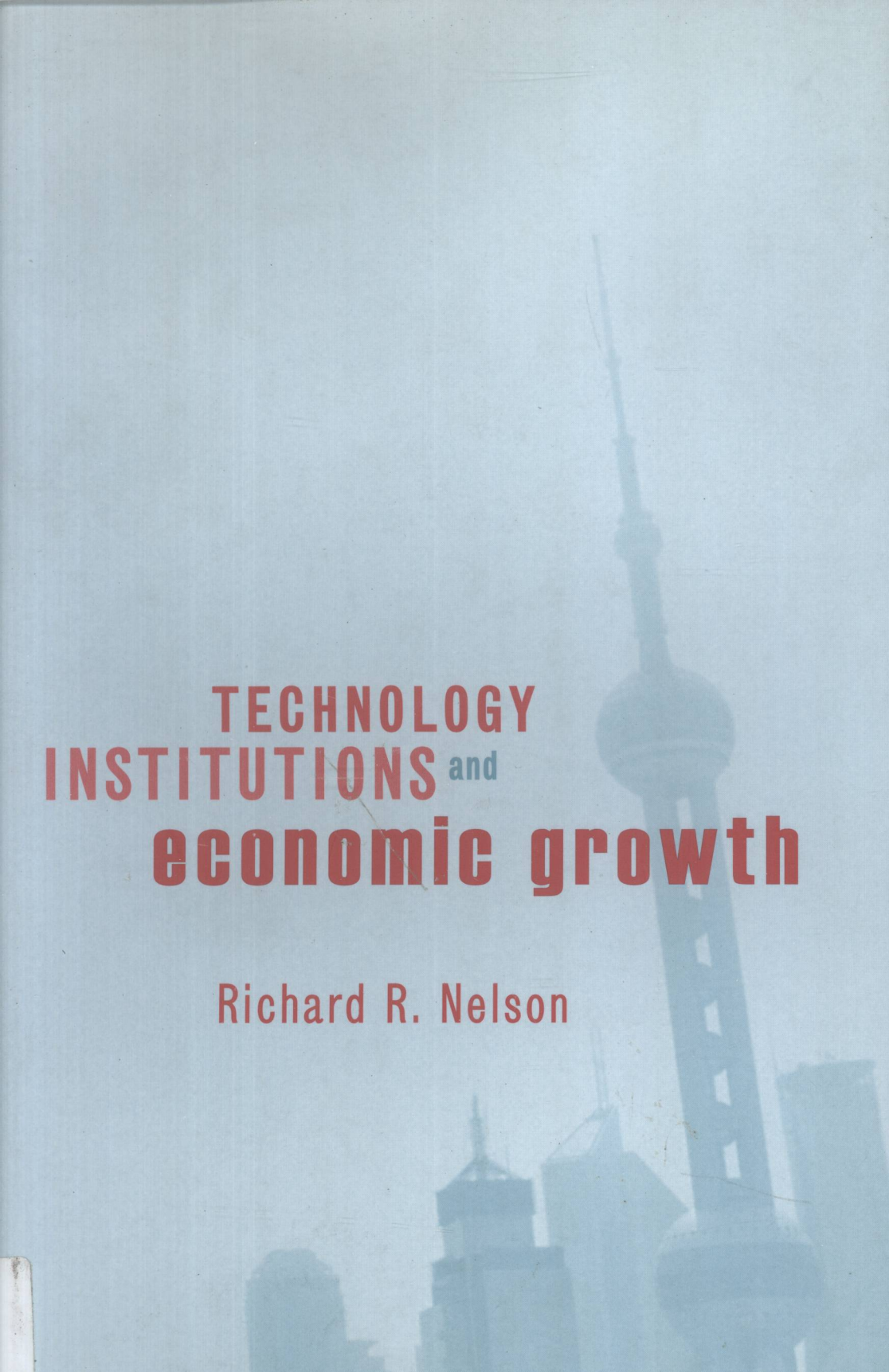
TECHNOLOGY INSTITUTIONS and economic growth

Richard R. Nelson



Technology, Institutions, and Economic Growth

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Introduction

The 1950s saw a renaissance of interest among economists in economic growth. There were several reasons for this. One was the availability of the new GNP statistics, which gave economists an aggregate measure of a country's economic size, and hence the ability, through analysis of time series, to measure economic growth rates. A second was the development of neoclassical growth theory, which suggested or justified a particular way of analyzing such time series. As a result of research since that time, we now possess a wealth of empirical understanding about economic growth.

Ironically, what we have learned suggests strongly that the neoclassical theory of economic growth, which clearly was an important source of interest in the subject among economists, and which provided considerable focus to their research, is hopelessly inadequate as a growth theory. On the one hand, the theory is blind to many of the important variables and processes involved. On the other hand, certain fundamental assumptions of the theory would seem to be just wrong. Also, what we have learned suggests that using an aggregate measure, like increase in GNP of GNP per capita, as a measure of economic growth tends to take attention away from what is going on beneath the aggregate, where differing rates of advance in different sectors, and the birth and death of industries, seem to be an essential part of the economic growth story. The essays in this volume are motivated by these issues.

I have been among a group of scholars who, for some years, have

been trying to call attention to the problem with neoclassical theory, and to build a more satisfactory theory of economic growth. For the most part the reaction of my colleagues in economics has been to cover their ears.

There clearly are important things that neoclassical growth theory has got right. One is that technological advance is the central driver of growth, as we have experienced it. That part of standard growth theory is strongly supported by the empirical evidence. However, the theory treats economic growth in terms of a moving equilibrium of the economic system. And it is very clear that technological advance, and economic growth driven by technological advance, involve disequilibrium, indeed continuing disequilibrium, in a fundamental way. Economic growth needs to be understood as an evolutionary process.

The standard growth theory in economics focuses on the roles of business firms, and the incentives and the constraints provided by competition in a market setting. Firms operating, interacting, and competing in a market context surely are an important part of the institutional structures that have spurred and oriented the economic growth experience. However, the standard theory is blind to a wide range of other institutions that have played key roles, like universities and public laboratories, scientific and other professional associations, and government agencies and programs.

Some of my colleagues in economics recognize the difficulties with prevailing dominant economic growth theory but then argue two things. First, that it is in the nature of a theory to simplify the reality greatly, to strip the picture down to its essence. Second, that in any case, there is no real alternative to a neoclassical formulation of economic activity, including the activities that generate economic growth.

But my argument to the first claim above is that prevailing growth theory does not just "simplify" the growth experience, it oversimplifies it, distorts it, and leaves out essential elements. My response to the second remark is that there indeed is an alternative. There long has existed in economics a tradition of evolutionary theorizing about economic change that is comfortable with contexts that are out of equilibrium, and a rich institutional economics strand that has recognized the complexity of modern capitalist systems. These traditions were strong in economics from the beginnings of the modern discipline up until World War II, after which they were pushed to the boundaries

and almost disappeared. Over the past quarter century, however, both evolutionary and institutional economics have shown new life, and they are beginning to join together again, as they were joined earlier in the history of economic thought. My own work has been very much part of this intellectual renaissance.

In my 1996 book, *The Sources of Economic Growth,* I collected a set of my earlier writings that sought to advance the agenda of evolutionary and institutional economics. This book includes essays mostly written since that time.

Part I contains two chapters that flesh out my argument that neoclassical growth theory is not simply an oversimplified, and hence inadequate, characterization of economic growth as we have come to understand it empirically. An even more serious problem is that it provides a very misleading view of the key processes at work. The chapters in Part II develop an evolutionary theory of economic growth within which prevailing institutions both strongly affect the rate and direction of change, and themselves evolve. Here I provide a broad view of the different strands of evolutionary and institutional theorizing that have been developing over the past quarter century, and attempt to pull those strands together.

Part III is concerned with the fact that, while the economic growth we have experienced has dramatically lifted the living standards of peoples fortunate enough to live in areas where growth has been significant, once one looks beneath the aggregate, the evolution of human capabilities has been extraordinarily uneven. The advance of productivity, broadly defined, has varied greatly from sector to sector. This has been reflected in the continuing rise in the relative cost of certain basic services, like education, which has been the source of a variety of economic and political problems.

Another manifestation of our uneven ability to advance various economic activities and mechanisms is that institutional change is both much more sluggish and more difficult to evaluate than technological advance. An important reason for this is that the body of understanding bearing on institutions and how they work is much weaker than the body of understanding underlying modern technologies. As a result, institutional change is strongly tied up with ideologies. In recent years a major component of prevailing ideologies has been that market organization almost always is the most effective way to govern eco-

nomic activity. The two chapters in Part IV are concerned with this fact, and with some of the consequences.

The view of economic growth that I present recognizes, highlights, that an economy consists of many different sectors, providing a vast variety of goods and services, and focuses on variables like the strength of scientific knowledge and the character of prevailing institutions as key factors affecting how progress is made in different fields. This view has two implications that are strongly reflected in the way I have written the various chapters, that I want to put up front and in clear view.

First, it is misguided to look for a simple formal model, or a few simple empirical laws, that will capture the essence of what we know about economic growth. It may be useful to build and explore simple models for the purpose of learning to think through the implications of various processes we have reason to believe are at work. I myself have, in other places, done a considerable amount of formal modeling, particularly formal evolutionary modeling. However, it is a mistake to think that one can achieve a broad theory of economic growth that has a simple mathematical form. As in biology (which long ago Marshall argued was the future form of economic analysis), our basic understandings, our broad theory, must mostly be expressed verbally.

Second, it certainly is useful if portions of what we know about growth—the phenomenon itself, the causal factors—can be described quantitatively. However, many of the most important variables defy simple quantitative characterization (the state of scientific knowledge, for one; the nature of prevailing institutions, for another). Various quantitative indicators can be devised to provide measures of aspects of these kinds of variables, just as a GNP measure was devised to provide an indicator of the overall size of an economy. But scalar measures almost always are inadequate. As I indicated above, the tendency of many economists to see economic growth strictly in terms of what has been happening to GNP or GNP per person has blinded analysis to the fact of dramatic intersectoral differences. And in many cases, even multiple indicators provide only a partial summary of what we know about an important variable. Thus we know much more about the nature of research in the fields of medicine, and in education, than we can describe in numbers. Numbers help greatly in description and comparison, but they are only a part of what we know empirically. Just as much of theorizing in economics needs to be verbal, with formal

analysis playing a supporting but not dominant role, much of our empirical knowledge can be described only qualitatively, with quantitative measures in a supporting but not exhaustive role.

I know well that these two positions fly in the face of current orthodox thinking on these matters. But I propose that they need to be considered seriously.

PART I

Neoclassical economic growth theory is a cramped and awkward way of abstracting what economists know about the processes of economic growth. This is not simply because much of consequence is omitted, although this is important. It also is because the interpretation of prevailing configurations of outputs and inputs, and the specification of the processes through which they change over time, are basically inconsistent with what we know empirically. As a result, the theory provides at best an inadequate, and in some cases a downright misleading, explanation for the economic growth we observe.

Economists working with and developing neoclassical growth theory are not totally unaware of this. The first chapter in Part I is concerned with efforts over the past fifteen years to develop a "new" neoclassical growth theory. These new growth models bring into the formal theoretical structure certain important aspects of technological advance that long have been known to empirical scholars but that were absent, even implicitly denied, in older neoclassical growth theory. For example, a number of the new neoclassical growth models break from the assumption of perfect competition that was a standard feature of the old models, to recognize that in capitalist economic systems, the process of innovation involves the creation of at least temporary positions of market power. Some of the authors of the new theory even claim their models to be "Schumpeterian."

The argument I present in Chapter 1 is that these accommodations simply are not sufficient to enable a theory of economic growth that

encompasses what we know empirically. A viable economic growth theory must recognize the evolutionary nature of the processes of technological advance, and of the ways in which the structure of inputs, outputs, and institutions is molded by and molds the advance of technology. And it must recognize the institutional complexity of modern capitalist economies. Both of these themes are developed further in subsequent chapters of this book.

Chapter 2, drawn from an article written with Howard Pack, is concerned with the misleading interpretation of experienced economic growth that neoclassical growth theory can give. The context is the extraordinary economic growth achieved over the past forty years by Korea, Taiwan, and the other Asian Tigers. In the 1990s several empirical investigations, based on neoclassical growth theory, attacked the standard view that innovation and technological learning had played the central role in lifting productivity and incomes in those countries, and proposed that, rather, their growth was simply the result of high investment rates. Pack and I propose that a good way of thinking about the alternative interpretations of growth is to contrast an "accumulation" theory, which is what the authors we criticize propose, with an "assimilation" theory, in which innovation and learning are central, which we argue in fact captures the key driving forces. The case for the latter is overwhelming, once one takes off the blinders afforded by neoclassical growth theory.

CHAPTER 1

The Agenda for Growth Theory: A Different Point of View

1. Introduction

From the time they were first developed in the mid-1950s (Solow 1956, Swan 1956), almost all formal neoclassical models of economic growth have recognized technical advance as the key driving force, and thus have been consistent with a central conclusion of the empirical research on the sources of growth. However, most of the earlier formal models were mute or incoherent regarding the sources of technical advance. A new generation of neoclassical growth models began to emerge in the late 1980s and early 1990s, in which technical advance was endogenous, being the product of the profit-seeking investments of business firms (among the important early models see Aghion and Howitt 1990, Grossman and Helpman 1989, Romer 1990). These models captured in stylized form several of the understandings about technical advance that for many years have been well documented by empirical scholars. (For a good survey of these understandings, see Freeman 1982.)

To build in features that make R & D profitable for firms, these models departed from the earlier ones in one or both of the following ways. First, firms are able to keep proprietary at least a portion of the value of the increased productivity or better product performance won through their R & D. Second, to square with the recognition that

* Based on Richard R. Nelson, "The Agenda for Growth Theory: A Different Point of View," *Cambridge Journal of Economics* 22, July 1998.

technology is in some degree proprietary, and also that support of R & D is feasible only if price exceeds production cost by some margin, markets are assumed to be imperfectly, not perfectly, competitive. (For a good statement of this, see Grossman 1994.)

The endogenizing of technical advance in this way was complemented by the building in or deduction of other phenomena. Thus some of the models treat technical advance as a process of "creative destruction," in which new technologies make obsolete older ones (see Grossman and Helpman 1989). In many of the models there are "externalities" from investments in R & D (as in Romer 1990) or from other activities, for example, education (see Lucas 1988). Up-front R & D investments and, in some models, other factors such as differentiation of intermediate products, which enables varied production needs to be better met as an economy gets larger, generate economies of scale. In some of these models the rate of investment in new plant and equipment affects the steady-state growth rate, because of scale economies or externalities or both, whereas in the older generation of models the steady-state growth rate was independent of the investment rate.

The characterization above does not do justice to the elegance of some of the new neoclassical growth models, nor does it lay out their variety. (For more extended and systematic reviews, see Romer 1991 and 1994, and Verspagen 1992.) And it does not treat neoclassical growth models of a more recent vintage (largely because these have stayed pretty much in the mold described above). However, the account suffices to bring out several points.

First, these new-generation neoclassical growth models are different from most of the earlier generation in ways that appear to make them more "realistic," in the sense of capturing, in stylized form, at least some of the features of growth fueled by technical advance that many economists studying the topic empirically have long known to be important. Incorporation of these features almost certainly makes it somewhat easier for formal growth theorizing to engage effectively with the empirical work of economists trying to come to grips with the puzzling features of experienced economic growth.

Second, this brief review also suffices to highlight that the phenomena incorporated in the new formal models, and neglected in many of the old ones, scarcely represent novel new insights or ideas. The basic

notions that "technical change is largely endogenous," "technology is to at least some extent proprietary, and market structures supporting technical advance are not perfectly competitive," "new technology often makes obsolete old technology," "growth fueled by technical advance involves externalities and economies of scale," and "the investment rate may matter in the long run" scarcely smack of novelty. All have been part of the body of understanding of those studying economic growth and technical advance for a long time (Freeman 1982, already cited, is a good reference). Indeed, as I shall show in the next section, Abramovitz put forth most of these propositions in his review article on the economics of growth, written more than fifty years ago, in 1952.

The authors of the new models might respond that a causal argument is not well posed until it is articulated formally. Indeed, formalization of previously unformalized ideas about growth seems to be an important part of the agenda of the new growth theorists. However, it certainly is relevant to ask just what is gained by formalization of existing unformalized understandings.

It is also important to note that, while the new models have picked up pieces of the understanding about technical change and economic growth made by economists who have studied the subject empirically, the models neglect or misspecify what seem to be equally important parts of that understanding. Thus virtually all detailed empirical studies of major technological advances have highlighted the inability of the actors involved early in the game to foresee the path of development, even in broad outline, and the major surprises that often occurred along the path (see Rosenberg 1996). In contrast, the new models assume perfect foresight, or if they admit less than that, they assume that uncertainty about the future can be treated in terms of a well and correctly specified probability distribution of possible future events.

As another example, several recent writers have argued that differences across nations in the way firms are organized and managed has significantly influenced their economic growth performance. Thus Chandler (1990) and Lazonick (1990) ascribe a good portion of the reason why the United States surpassed Great Britain in economic performance in the last part of the nineteenth century and the first part of the twentieth to differences in management and organizational

structure between American and British firms. A number of authors (see, for example, Womack, Jones, and Roos 1990) view the organization of Japanese firms in the post–Second World War era as a major factor explaining Japan's extraordinary growth performance. The past two decades also have seen a resurgence of interest among economists in differences in national institutions—for example financial systems (Gilson and Roe 1993), universities (Nelson 1993, Rosenberg and Nelson 1994), or more generally (North 1990)—as important aspects of the explanation for differential national growth performance. The new neoclassical growth models, in contrast, treat firms in a highly stripped-down way, and have little in them about institutions, aside from "the competitive (or monopolistically competitive) market."

To the extent that formalization of important and previously unformalized understandings about technical change and economic growth defines an important part of the agenda for the new growth theorists, it seems useful to ask why certain ideas have been picked up and formalized and others not. The salience of the understanding certainly would seem to be one operative criterion. Thus the incompatibility of the assumption of perfect competition with the facts of endogenous technical advance called attention to an obviously serious limitation of earlier formal growth models. But uncertainty, in the sense of Knight (1921), would also seem highly salient to realistic modeling of economic growth fueled by technical advance. Why has imperfect competition been taken aboard but not Knightian uncertainty? And if imperfect competition for some reason has proved attractive or easy to build in, why has the understanding that firms differ significantly in their capabilities and their strategies proved unattractive or undigestible for the new growth theorists? Why the failure to treat national economic institutions, like financial institutions or the university research system?

The answer, I believe, is that another part of the agenda of the new growth theory, or a constraint on that agenda, is to hold the modeling as close as possible to the canons of general equilibrium theory. Romer (1990) states this explicitly, and the form of the models that have been developed by others suggests that they too hold this as an objective or constraint. However, it certainly seems relevant to think a little about what is gained and what is lost by operating under this constraint.