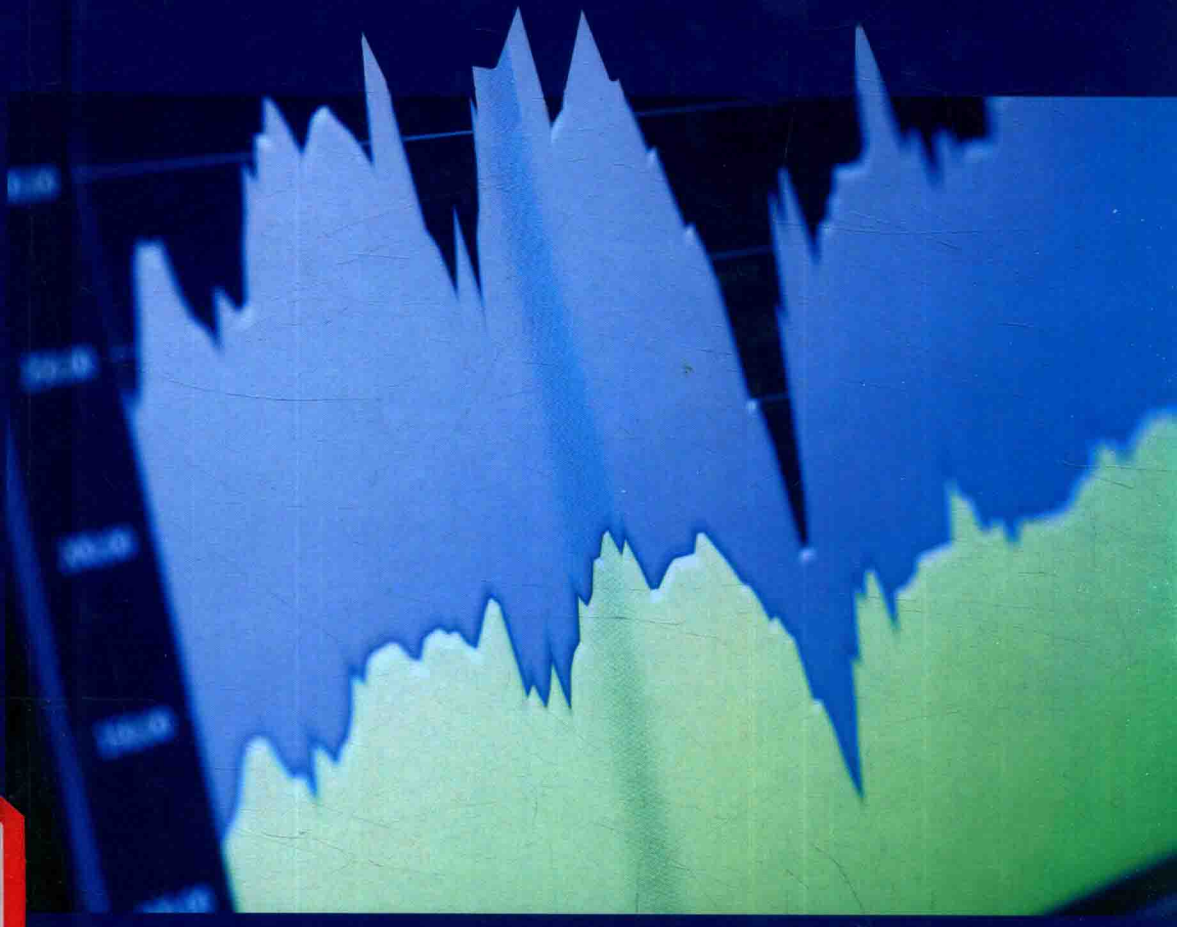
PRODUCTIVITY CONVERGENCE

THEORY AND EVIDENCE



EDWARD N. WOLFF

CAMBRIDGE

Productivity Convergence

Theory and Evidence

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PRODUCTIVITY CONVERGENCE

A vast new literature on the sources of economic growth has now accumulated. This book critically reviews the most significant works in this field and summarizes what is known today about the sources of economic growth. The first part discusses the most important theoretical models that have been used in modern growth theory as well as methodological issues in productivity measurement. The second part examines the long-term record on productivity among Organisation for Economic Co-operation and Development (OECD) countries, considers the sources of growth among them with particular attention to the role of education, investigates convergence at the industry level among them, and examines the productivity slowdown of the 1970s. The third part looks at the sources of growth among non-OECD countries. Each chapter emphasizes the factors that appear to be most important in explaining growth performance.

Edward N. Wolff is a professor of economics at New York University. He is also a research associate at the National Bureau of Economic Research. He served as managing editor of the *Review of Income and Wealth* from 1987 to 2004 and was a council member of the International Association for Research in Income and Wealth from 1987 to 2012. He is the author (or coauthor) of numerous books, including *Growth, Accumulation, and Unproductive Activity* (Cambridge University Press, 1987); *The Transformation of the American Pension System: Was It Beneficial for Workers?* (2011); and *Productivity Growth: Industries, Spillovers and Economic Performance* (with Thijs ten Raa, 2012). He received his Ph.D. from Yale University.

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Introduction

1.1 Scope of the Book

Over the past three decades there has accumulated a vast new literature on the sources of economic growth. Indeed, these studies have now formed the basis of what is referred to as the "new growth theory." The purpose of this book is to review critically the most significant works in this field and to summarize what is today known about the sources of economic growth. Where appropriate, I will add my own empirical analyses as well as update some of my previous work on the subject.

The book will first discuss methodological issues as well as the most important theoretical models that have been used in modern growth theory (Chapter 2). Chapter 3 summarizes some of the most important papers on methodological issues in the measurement of productivity. The next four parts will survey the empirical literature on the subject. This literature can be most conveniently divided into six groups. The first of these examines the long-term historical record of productivity growth among OECD countries (that is, the advanced industrial countries) (Chapter 4). The second considers the sources of growth among OECD countries over the postwar (that is, post–World War II) period (Chapter 5). The third of these focuses more closely on the role of education in the growth process among OECD countries (Chapter 6). The fourth looks at the pattern of growth and convergence at the industry level among OECD countries (Chapter 7). The next takes a slight digression to look into the source of the productivity slowdown of the 1970s in the United States (Chapter 8). The next part conducts an analysis similar to that of Chapter 5 of the sources of growth among newly industrialized countries (NICs), middle-income countries, and less developed countries or LDCs (Chapter 9). In each chapter, the emphasis will be to isolate those factors that appear to be most important in explaining

their performance. The last chapter of the book, Chapter 10, will recap the findings of the previous chapters.

I generally take a "history of thought" approach, focusing on the earliest works on different topics. I also try to highlight the most important works on each topic. However, because of the now-voluminous literature on the subject of growth, I have inevitably left out other important articles and papers on this subject.

1.2 Factors Affecting Economic Growth

Before presenting a detailed summary of the book, it might be useful to list the factors that appear most germane in accounting for the pattern of economic growth on the basis of the recent literature on the subject. It should be noted at the outset that the explanatory variables considered here by no means represent an exhaustive list of relevant factors.

I divide these factors into two groups. The first of these is what I call "strong forces." These are variables that almost consistently show up with a positive and significant coefficient in growth regressions. Moreover, as a group, they explain the vast majority (often of the order of 80 to 90 percent) of the variation in economic or productivity growth in the sample of countries used. This group includes (1) the "catch-up" effect; (2) investment, including embodied technological change (or the "vintage" effect); (3) the level of educational attainment of the population or workforce (the "threshold" effect); (4) science and technology and, in particular, investment in research and development (R&D); and (5) the establishment of certain basic social institutions such as a stable state and the rule of law (what are also called "social capabilities").

The second group constitutes the "weak forces." These are variables that give mixed or statistically insignificant results in growth regressions or are ones in which the direction of causation is not clear. Individually and collectively, they explain only a small fraction of the variation in economic or productivity growth in the sample of countries used. In this group are, among others, (1) trade openness and foreign direct investment (FDI); (2) structural change (population growth); (3) and various sociopolitical variables such as the degree of democracy in a country, its level of income inequality, and the extent of government spending.

1.2.1 The Catch-Up Process

The first of the strong forces is the so-called catch-up effect. The catch-up hypothesis rests on the view that the historical course of technological

progress operates through a mechanism that enables countries whose standard of productivity performance is reasonably close to that of the leader(s) to catch up. Through the constant transfer of new technology, leader countries and those most closely in their van learn the latest productive techniques from one another, but virtually by definition the follower countries have more to learn from the leaders than the leaders have to learn from them (the so-called advantages of backwardness). This mechanism has two implications: First, it means that those countries that lag somewhat behind the leaders can be expected systematically to move toward the level of achievement of the leaders. Second, the mechanism undermines itself automatically as follower countries gradually eliminate the difference between their own performance and that of the countries that were ahead of them – that is, the very fact of convergence means that the differential learning opportunities that are the source of these advantages of (slight) backwardness will exhaust themselves. On an analytical level, this hypothesis would imply faster productivity growth for the (initially) more backward economies relative to the more advanced ones, but the gap in productivity performance would gradually diminish over time as convergence was achieved.

1.2.2 Investment

The second of the strong forces is investment. It seems generally agreed that there are two prime ingredients in the growth of labor productivity: technological innovation and the accumulation of capital through saving (and the subsequent investment of those savings). Innovation and the international transfer of its products play a prime role in the converging productivity levels of a number of relatively successful industrialized economies. But even if technological innovation is the more important factor in the scenario (which is by no means certain), substantial capital accumulation very likely would have been required to put the inventions into practice and to effect their widespread employment. If, moreover, saving and investment play a primary role of their own, it becomes all the more important to explore the nature of that role. However, recognizing that unavoidable interactions may exist between the rates of innovation and investment, any attempt to separate the two may prove to be artificial, if not ultimately unworkable (see Abramovitz and David, 1973, for an extremely illuminating analysis of the data and the theoretical issues, as well as some references to other discussions by economic historians).

1.2.2.1 Vintage Effect

There are several ways in which capital formation and total factor productivity growth may have positive interactions or complementarities. First, it is likely that substantial capital accumulation is necessary to put new inventions into practice and to effect their widespread employment. This association is often referred to as the "embodiment effect," since it implies that at least some technological innovation is embodied in capital (see, for example, Kuznets, 1973; Abramovitz and David, 1973; or Solow, 1988). It is also consistent with the "vintage effect," which states that new capital is more productive than old capital per (constant) dollar of expenditure (see, for example, Nelson, 1964, or Hulten, 1992). If the capital stock data do not correct for vintage effects, then a positive correlation should be observed between the rate of technological gain and the change in the growth rate of capital.

A second avenue is that the introduction of new capital may lead to better organization, management, and the like. This may be true even if no new technology is incorporated in the capital equipment. A third is through learning by doing, which would also imply a positive relation between technological advance and the accumulation of capital stock (see Arrow, 1962). A fourth is that potential technological advance may stimulate capital formation, because the opportunity to modernize equipment promises a high rate of return to investment. Wolff (1991a, 1996a), for example, finds that the vintage effect is of particular importance in the early postwar period among OECD countries.

1.2.2.2 Public Infrastructure

One form of capital that has been singled out for being particularly productive is social infrastructure. This may take the form of networks of roads and other transportation systems, power generation, communications systems, and the like. Most of this type of infrastructure may be government financed or government owned. Work by Aschauer (1989a, 1989b) has shown that the rate of return to public infrastructure may be far in excess of that to private investment, though these estimates have been criticized by other economists.

1.2.2.3 Computers and Information Technology

Another form of capital that has also been singled out for special consideration is computers and the associated information technology. Particular

interest is focused on the post-1980 period, which has seen a tremendous growth in the use of computers in production and which Freeman (1987) and others have termed a new "technoeconomic paradigm," based on computer-driven information technology. Fantastic increases in productivity have been found for both computers and software. Berndt and Griliches (1993) estimated a real price decline of microcomputers of 28 percent per year between 1982 and 1988. Gandal (1994) estimated a real price reduction in computer spreadsheets of 15 percent per year over the 1986–91 period. Many economists have felt that the growing use of IT throughout the sectors of the economy resulted in an acceleration of TFP growth during the 1990s and early 2000s.

1.2.3 Education

Another critical factor in economic growth is education, the third of the strong forces considered in the book. It will be seen that the statistical evidence is consistent with the hypothesis that the quantity of education provided by an economy to its inhabitants is one of the major influences determining whether per capita income in that society is growing rapidly enough to narrow the gap with per capita income in the more prosperous economies. This is important for policy because it suggests that a country can do a great deal to improve its performance in the convergence arena by increasing the resources it devotes to education. It is at the secondary school level, and to an even greater degree in higher education, that large differences persist. The book will consider the statistical evidence on the magnitude of the role that education plays in determining the growth rate of an economy.

One apparent paradox that will receive some attention is that while education levels are found to be highly significant in growth equations, the growth of education attainment is generally not found to be significant. This is a disturbing result for two reasons. First, it opens the question of causality – perhaps, rising educational levels are an outcome of the growth in per capita income rather than the reverse. Second, it raises profound policy issues about the one seemingly important mechanism for promoting economic growth.

1.2.4 Science and Technology

The role of science and technology is the fourth strong force considered in these works. There is a vast literature that supports the view that research

and development (R&D) is positively associated with productivity growth. This has been demonstrated on the aggregate (national) level, the industry level, and the firm level (see, for example, Griliches, 1979; Mohnen, 1992; and Nadiri, 1993, for reviews of the literature). This work considers the role of two variables in particular – R&D expenditures as a percentage of GDP and scientists and engineers employed in R&D per capita – on productivity performance.

A related issue is whether there has been a slowdown in the process of invention and innovation. In a way, most of the major products that form the contemporary lifestyle were invented in the latter part of the nineteenth century or the first half of the twentieth century – electrification, the light bulb, the telephone, radios, televisions, phonographs, motion pictures, airplanes, automobiles, plastics, and so on. Since World War II, a comparable list might include computers, the jet engine, satellites, and bioengineering – an impressive list but, perhaps, not as significant as the earlier list. Some assessment will be made of this issue.

1.2.5 Social Institutions

The last of the strong forces considered in this work are basic social institutions. There is a large literature on how institutions affect economic development, beginning, perhaps, with North and Thomas (1973), who defined institutions as the formal and informal rules that govern human, social, economic, and political interactions. They argued that progress in the Western world occurred because of the development of basic economic institutions that fostered economic growth through establishing the rule of law and granting and protecting property rights of individuals. The establishment of a strong, stable government was another necessary ingredient to sustained economic growth.

1.2.6 Foreign Trade

The first of the weak forces is foreign trade. Another factor that may be directly relevant to the international transfer of technology is the extent of international trade and the pattern of trade. It is generally argued that trade is a mechanism for the transmission of information concerning new technologies and products. For example, imports of computers may revolutionize the production technology of importing industries. Also, the exposure to new products may induce local competitors to imitate. The argument on the export side is weaker. Competition in export markets may lead to the

exposure to new foreign products; it may also lead to more rapid developments of new technology in industries competing in export markets. The evidence on this score generally supports a positive role played by international trade on economic growth, though it appears stronger on the import side than the export side.

1.2.6.1 Foreign Direct Investment

Related to trade is the role that foreign direct investment (FDI) may play in the process of economic growth, particularly that of LDCs. FDI constitutes the second of the weak forces considered in this work. Technology transfer through foreign direct investment can also result in indirect productivity gains for host developing countries through the realization of external economies. Generally these benefits are referred to as "spillovers," a characterization that indicates the importance of the way in which the influence is transmitted. There are several ways in which these spillovers may occur. Presumably the most important channel is via competition. Existing inefficient local firms may be forced by the competition of foreigners to make themselves more productive by investing in physical or human capital or importing new technology.

Another source of gain to the host economy is the training of labor and management provided by the multinationals, which may then become available to the economy in general. Since such resources are in short supply in developing countries, this type of spillover efficiency is expected to be more important there. A third potential source of spillover efficiency benefits is through the impact made by the foreign subsidiaries in the host economy on their local suppliers, by insisting that they meet standards of quality control, delivery dates, prices, and so forth.

1.2.7 Structural Change

Another major issue in understanding aggregate economic growth is to analyze how countries deal with differential productivity growth among the sectors of their economy and the inevitable dislocations it introduces – that is, sectoral shifts in employment. Do countries try to protect backward sectors, as Japan does for agriculture, or do they allow market forces to operate?

Structural change refers to shifts in the industrial composition of employment. This is another weak force in explaining economic growth. There are two principal mechanisms by which structural change may influence the

rate of aggregate productivity growth. First, employment may shift from low productivity spheres to high productivity ones. The prime example is the shift out of agriculture, a sector in which marginal productivity is usually quite low, to manufacturing, a sector with a higher marginal productivity. Such a shift in employment, will, ceteris paribus, cause average productivity to rise. This type of structural shift is usually referred to as a "levels effect," since it arises from the difference in productivity levels between industries.

Second, employment may shift from a high productivity growth sector to one in which the rate of productivity growth is lower. Since the rate of overall productivity growth is the weighted sum of the rates of productivity growth of the individual sectors, where the employment shares are the weights, such a shift will cause aggregate productivity growth to decline. The prime example of this type of shift is from manufacturing to services. This type of structural shift is usually referred to as a "growth effect," since it arises from the difference in productivity growth rates between sectors. Both types of shift effects will be examined in the ensuing chapters.

The analysis of structural change will lead to a related set of issues, concerning productivity growth on the industry level. We will be particularly interested in the pace of technological advance in services, a sector that has been singled out for its "stagnancy." As will become evident, there is a dualistic structure to the service sector. There are some service industries, such as telecommunications, that have enjoyed and continue to enjoy rapid rates of technological progress. There are others, like government, community, and personal services, that seem to be permanently stagnant.

A related issue is "outsourcing," which refers to the process of replacing in-house services, such as legal, advertising, accounting, and related business services with services purchased from outside the firm (see, for example, Postner, 1990, for a discussion of this issue from an accounting point of view). This process has two effects of interest for us. First, it may speed up the shift of employment out of goods industries to services. Second, by sloughing off the more stagnant service activities, manufacturing should experience more rapid TFP growth (see, for example, Carter, 1970; Barker and Forssell, 1992; Siegel and Griliches, 1991; and ten Raa and Wolff, 1996).

1.2.8 Population Growth

This factor is often included in analyses of economic growth in order to control for any country whose population growth is so rapid as to swamp any gains from the advantages of backwardness. In these cases, any gains