Do Poor Countries Catch Up to Rich Countries? Review Article on *Productivity Convergence: Theory and Evidence* by Edward Wolff

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ABSTRACT

This article provides a detailed review of Edward Wolff's Productivity Convergence: Theory and Evidence. Wolff examines the long run productivity growth and convergence experience of a variety of countries from across the world. Wolff's main contribution is the definition of two general classes of forces of convergence. He delineates "strong" forces of productivity convergence, such as the catch-up effect, capital formation, and education, from "weak" forces contributing to convergence like international trade, economic geography, and regulation. While some of the individual forces of convergence may switch categories as new research emerges, the categorization remains highly relevant. The focus on convergence suggests that non-frontier countries may not yet be in dire straits as a result of the purported recent productivity slowdown, as productivity growth may well still come from forces of convergence for years to come.

THE BOOK *Productivity Convergence: Theory and Evidence*, published in 2014 by Cambridge University Press and authored by Edward Wolff from New York University, provides a wide-ranging examination of a big subject: productivity growth and convergence. The volume joins a tide of new books on productivity growth, which perhaps goes to show that although we are not sure whether productivity growth is pro-cyclical, we have growing evidence that books on productivity growth are counter-cyclical.

Although the main subject is productivity convergence, the author of necessity takes the reader through issues related to productivity levels, productivity growth, and their measurement. He does this at some length in Chapter 3, which focuses on measurement, and also in Chapter 8, which focuses on the U.S. post-1973 productivity slowdown. The rest of the chapters are much more about comparative productivity performance and convergence (or the lack of it) between countries. Work is discussed using very long data (Maddison data back to 1 AD for example), using data in rich countries and data in poor countries. Much of this work has appeared already but there is some new work, for example the analysis in Chapter 4 on long run productiv-

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Table 1: Levels of Per Capita GDP, 1000, 1500, 1820, 1990, and 2008, 1990 International Dollars

	1000	1500	1820	1990	2008
World	453	566	666	5,150	7,614
Rich	425	702	1,102	18,750	25,285
Western Europe	427	771	1,194	15,908	21,672
United States	400	400	1,257	23,201	31,178
OtherWestern Offshoots	400	400	761	17,906	24,807
Japan	425	500	669	18,789	22,816
Rest	458	538	578	2,711	4,900
China	466	600	600	1,871	6,725
India	450	550	533	1,309	2,975
Other Asia	520	565	579	3,075	5,146
Latin America	400	416	691	5,065	6,973
Eastern Europe	400	498	686	6,458	8,102
Africa	425	414	420	1,425	1,780
Rich/Rest	0.93	1.30	1.91	6.92	5.16
Coefficients of Variation					
Rich	0.04	0.34	0.31	0.16	0.17
Rest	0.10	0.15	0.17	0.66	0.47
All	0.09	0.23	0.37	0.89	0.81

Source: Maddison (2008)

ity growth among the "Maddison 16" countries (Australia, European countries, Japan, the United States, and Canada) from Year 1 to 2006.

The subject is important. Indeed, productivity convergence has taken on a new significance in the light of the current heart-searching about the possible productivity slowdown and associated secular stagnation. In countries not on the productivity frontier, such as the one of your reviewer, commentators tend to be much more sanguine about productivity prospects since they often assert that productivity can grow simply by catching up to the US level. Thus the broad scope of this book to cover non-frontier countries is welcome.
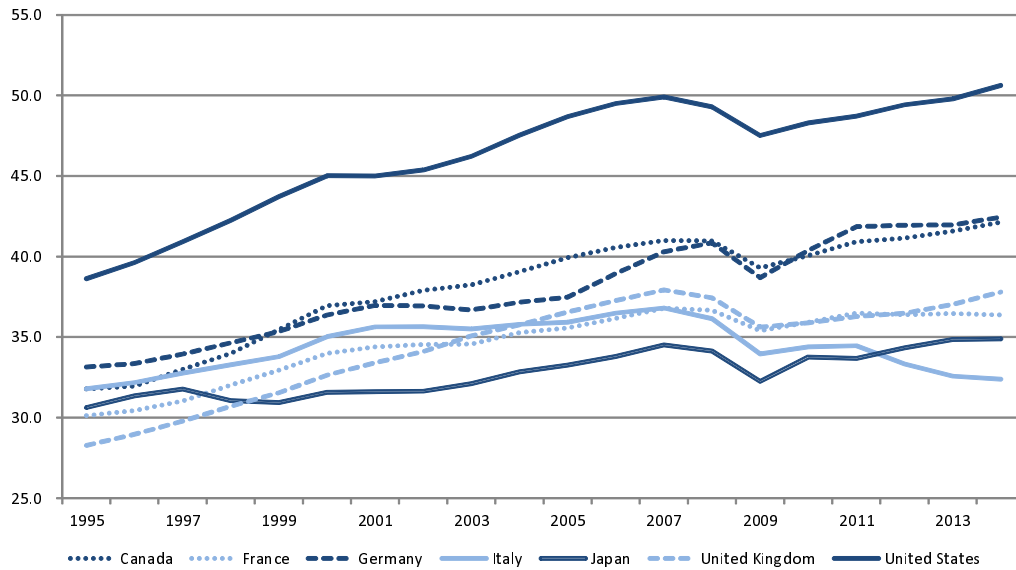
As Wolff knows well, the whole question of convergence actually raises an incredibly important question: which country is the frontier country? Students, at least in my classes, are often staggered to hear this question even articulated, since only one nation designs their phones, provides their search engine and is the portal for their online social life. The realization that the United States was not always the productivity leader is, I think, often their initial step into thinking more broadly about the world and beginning to see the power of economic data and theory in asking the big questions. This book will help them on that journey.

With this historical perspective in mind, a natural starting point is Chapter 4 of the book, called "Long-term Record among the Advanced Industrial Countries." This chapter sets the stage for Chapters 5, 6, and 7, which are on post-war performance for advanced countries (chapter 8 is, as the author says, a slight digression in spirit being just on the United States), whereas Chapter 9 is about post-war performance in the world. Many of these chapters use the famous Maddison database, a small part of which I reproduce below, using the data in Maddison (2008), also drawn upon in Wolff's' Chapter 4, for Figure 4.7 updated to 2008.

The table lists in the top panel the "Rich" countries and in the middle panel the "Rest," with the rest consisting of Asia, Latin America and Africa. Let us start with some levels of GDP per head. Starting in 1000 AD, we learn that the rich countries were not always rich; indeed they were somewhat poorer than the Rest in that period. By 1500, however, the rich countries had pulled away and continued to do so by 1820. Indeed on these data, only Eastern Europe and Latin America made any appreciable progress among the Rest. By 1990, the Rich countries were dominant and the poor countries were catching up to Latin America and Eastern Europe. By 2008, the Rich countries remained dominant, but gap between the Rich and the Rest had fallen by nearly a quarter. The Rest's convergence was driven by China and India, who respectively more than trebled and more than doubled their GDP per capita between 1990 and 2008. By 2008, China had largely

Chart 1: GDP Per Capita in G7 Countries, $US, 2011 PPP, 1995-2014

Source: OECD database.

caught up to Latin America and Eastern Europe in terms of GDP per capita.

What does this tell us about convergence? The lower panel sets out the coefficient of variation among the rich, the rest and all. Looking at the rich row, we have divergence from 1000 to 1500, but, since 1500, convergence. That should give some comfort to non-frontier countries. But the "Rest" row shows a stable coefficient of variation but then a sharp rise from 1820 to 1990 and tapering from 1990 to 2008, a less comforting picture. Turning to the "All" row, the picture is of a large divergence until 2008, with large divergence up to 1990 but then some convergence since.

Thus very long history tells us that convergence is, if anything, a modern phenomenon, confined to rich nations and the poor nations only recently. What about short history? Chart 1 shows data for GDP per capita for G-7 countries, from 1995 to 2014.

Since the financial crisis in 2007-8, the United States has continued to grow relative to others G-7 countries. The sample coefficient of varia-

tion has risen from 0.10 in 1995 to 0.15 in 2014. That looks like divergence.

Wolff reviews a number of theories on the patterns of very long run growth and divergence. Many theories focus on technical progress and population growth, citing, for example, Fogel's work documenting early developments in agriculture (9000 BC), pottery (6000 BC) and the plow (4500 BC); readers familiar with Jared Diamond's *Guns, Germs and Steel* will recognise many of these points. The main sense is that if technical progress can somehow offset the scarcity of resources caused by population growth in pre-technology eras, then economies can grow past the Malthusian trap. Wolff suggests all this work puts the research ball firmly in the court of improving our understanding of technical progress, which brings us firmly up to date with the work of, for example, Gordon and Mokyr.

These very long trends are not, however, the central empirical themes of the book, which is more about post-war trends. To frame all this,

the book starts in Chapters 2 and 3 with theory and measurement.

In Chapter 2, Wolff starts with an overview of modern growth theory, beginning with the Cobb-Douglas production function $Y = cL^a K^{1-a}$, with notation for output Y, labour L, and capital K. He then sets out as well an approach that he credits to Mansfield (1965, 1980) and Griliches (1979) which he writes $Y = ce^{\eta t} L^a K^{1-a} R^\beta$, where R is the stock of R&D capital. A discussion then follows of various endogenous growth models.

This chapter discusses convergence. Given that this concept is the core of the book, this is a rather brief discussion. Wolff defines two notions of convergence. First, β-convergence is defined as "a narrowing of initial difference in income levels over some time horizon". Second, σ-convergence is defined as a reduction over time in the cross-country variance of productivity. β-convergence implies that initially low countries grow faster and so is often tested by the "growth-initial level" regression, a relation that β-convergence predicts to be negative. However, β-convergence does not necessarily imply a reduction in the cross-country dispersion of per capita income, i.e. σ-convergence.

Wolff also discusses unconditional and conditional convergence and a related concept called club or group convergence. He defines unconditional convergence as implying that the coefficient in a growth-initial level regression should be negative even if no other variable, such as education, is included. Conditional convergence however "requires appropriate variables be included on the right-hand side of the growth-initial level regression equation in order to control for the effects of other factors on growth (p.62)". Club or group convergence is where different groups of countries might converge to different levels.

This discussion leads directly to a discussion of why this method might produce fragile

results, and Wolff refers to important papers by Temple (1999) and Levine and Renelt (1992). Indeed, in his conclusion, Wolff states (p.431) that "...many of the results reported in the works cited in this book were not robust." The remarkably candid conclusion is due to factors such as measurement error, endogeneity and lack of robustness to sample choice.

Chapter 3 is a long discussion of measurement. This covers a remarkable amount of ground. Wolff starts with Diewert's index number approach, which shows how a series of well-known index numbers are in fact quite consistent with a set of economic assumptions regarding technology and optimising behaviour. To my mind, this is an amazing synthesis of economic theory and measurement. He then discusses econometric approaches to productivity. Tucked away on p. 80 is, in my view, the central measurement point that "...the objective of productivity measurement is fundamentally to identify output differences that cannot be explained by input differences." I think this is a point worth making right up front, since non-productivity researchers often cannot understand economists' obsession with TFP.

This chapter ranges over countries, industries and firm-level productivity measurement, as befits a subject where the range of datasets (and computing power) available to economists has multiplied remarkably over even the last twenty years. One reservation, to me, was the discussion of capital services.

Capital services are addressed in a subsection entitled "Measurement of Capital Services," as part of a section called "How do we Move from Data to Theory?" This is an arresting title since the question is typically framed the other way around. The section on capital services sets out, in some detail, Berndt and Fuss' justly well-known and important 1986 contribution to the question of how to measure capital services in conditions of what Wolff calls temporary equi-

librium. In this case, the elasticity of output with respect to inputs might not equal the measured factor share, since the shadow cost of capital, when it is say, being underutilized, will not be the Hall-Jorgenson implied-rental cost.

There are at least two points to be made here. First, in the single capital type case, with constant returns, the unobserved shadow cost can be recovered as a residual from value added less other costs, thus rendering the ex post approach to capital share measurement correct under these assumptions even if there is short-run disequilibrium.

A second, much broader point, is that to my mind anyway, the measurement of capital services has been a major current of the productivity research effort in recent times, starting with Jorgenson and Griliches justly famous 1967 paper and continuing to become a standard output of many statistical agencies and the centrepiece of many contemporary descriptions of productivity growth. Witness the EU- and now World KLEMS programme developed by van Ark, O'Mahony, Timmer and partners (see Timmer et al., 2007, Timmer et al., 2011, and Jorgenson, 2012). The notion of capital services, rather than stocks, is an important intellectual breakthrough in its own right. The implementation of capital services, international harmonization, measurement of the ICT revolution, and accurate capital measurement in an era of rapidly changing investment composition, seem like subjects worthy of a longer discussion.

The remaining chapters in the book examine post-war trends in convergence. Wolff argues the data support convergence of GDP per capita among OECD countries but not others, many of whom seem to be stuck in the same low income rank as 50 years ago. Regarding convergence, Wolff's main contribution is to set out a set of

"strong" and "weak" forces that contribute to convergence.[2] Of course, convergence is by no means assured, but such convergence seems to have occurred at least among rich countries for most of the post-war period. Wolff then argues the data allow us to isolate "strong" and "weak" forces in such convergence

The first strong force is the catch-up effect, referring to the negative coefficient on the initial level in the "growth-initial level" regressions. This force is, however, weak for low income countries. The second strong force is capital formation, which likely embodies new technology. The third is education, which can raise productivity directly via productive human capital formation, or indirectly, via social capacity to absorb new technology or learn. The macro findings on education are spotty. This raises a puzzle: we have near gold-standard results from birth cohort and/or twin studies that education boosts productivity (earnings) at the micro level, so how can this not show up at the macro level? Wolff rightly cites an important paper by Krueger and Lindhadl (2001) showing that measurement error in the macro data was very large, likely obscuring the results in this context. Of course, this is but one example of the major measurement challenge that hangs over this large macro literature, one that Wolff rightly acknowledges.

Finally, Wolff suggests that R&D and social institutions are also strong forces. He runs though a series of studies on R&D that seem to provide evidence for strong effects of R&D in developed countries but not in developing countries. On institutions, he reviews a set of papers in the *Quarterly Journal of Economics* (Knack and Keefer, 1997, Temple and Johnson, 1998 and Hall and Jones, 1999), all of which support the

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2   Specifically, Wolff (2014) defines, "Strong forces are those that consistently show up with a positive and significant coeffict in growth regressions and [...] expalin the vast majority of the variation in economics of productivity growth in the sample of countries used. Weak forces are those consistently insignicant, or where causation is not clear, and which explain a small fraction of the variance."

idea that infrastructure, trust, and civic norms all contribute to growth.

There are many weak forces contributing to convergence: international trade and foreign direct investment (FDI), democracy and political institutions, inequality, financial development, economic geography and natural resources, the role of IT, regulation, structural change,, and foreign aid.

As Wolff notes, many studies cited are subject to lack of robustness, measurement error and other problems. I suspect that future research might move some of the weak forces into the strong forces group and vice versa. That is not a criticism of Wolff however, since the book is a reflection of how economists are using better data and statistics to navigate an ever-changing world.

Finally, Wolff offers some prospects for future growth in advanced and less-developed countries. Given the massive current interest in this topic, this section is remarkably prescient. Wolff predicts that for developed countries, labour productivity growth will "subside to its long run average of about 2% per year" (459). He makes the point also made by Gordon (20016), namely that there will be diminished growth in years of schooling, and adds to this lower potential for catch-up in many industrialized countries. Against that, he thinks there might be gains in the service sector from (a) deregulation of service industries, (b) greater use of ICT in services and (c) service outsourcing, but concludes they will be small, in that they might add only an additional 0.2 percentage points to TFP growth. As for middle and lower income countries, he suggests they cannot rely on catch-up and will only grow with appropriate institutions, capital investment and education.

Some of Wolff's conclusions on strong and weak forces contributing to convergence will be turned over by better data and changing historical circumstance. His forecast of a return to the average of 2 per cent growth in GDP per capita might be too optimistic, if, as per Gordon, that growth is historically unusual. But his encyclopaedic navigation and review of the literature on productivity convergence will remain.

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