Productivity Convergence among OECD Countries: The Postwar Experience

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1. Introduction

The "catch-up hypothesis" rests on the view that the historical course of technological progress operates through a mechanism which 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. 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.

However, being backward does not itself guarantee that a nation will catch up. Other factors must be present, such as strong investment, an educated and well trained work force, research and development activity, developed trading relations with advanced countries, a receptive political structure, low population growth, and the like. Indeed, Abramovitz (1986 and 1994) has summarized this group of characteristics under the rubric of *social capability*. This process has also been referred to as "conditional convergence" by Mankiw, Romer, and Weil (1992).

A. 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 inno-

vation 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. Moreover, if saving and investment play a primary role of their own, it becomes all the more important to explore the nature of that role, recognizing that because of unavoidable interactions 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).

B. Education

Another critical factor appears to be education. 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 productivity in that society is growing rapidly enough to narrow the gap with productivity 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.

C. Science and Technology

The role of science and technology, which are in the catch-up process, should also be considered. There is a vast literature which 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, for a review of the literature).

D. 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.

2. Comparative Statistics among OECD Countries

I begin with measures of real GDP (1985 dollar equivalents) per worker (RGDPW). Computations for 1950 to 1990 are based on the variable RGDPW from Penn World Table (PWT) Mark 5.6 (see Summers and Heston, 1991, for a description of the database). Computations for 1996 are based on the variables GDPD (Gross Value Added in US Dollars) and ET (Total Employment) from the OECD ISDB (International Intersectoral) Database for 14 OECD countries. The PWT figures for 1990 are used as benchmarks, and the figures are updated to 1996 on the basis of the growth rate of labor productivity for 1990-1996 computed from the ISDB data.

The now familiar convergence story is evident. The coefficient of variation (the ratio of standard deviation to mean) among the 24 OECD countries listed in Table 1 declines by more than half between 1950 and 1990. Results are also shown for a sample of Industrial Market Economies (IMEs), as classified by the World Bank, which consists of all OECD countries except Greece, Portugal, and Turkey. Convergence is even stronger among this group, with the coefficient of variation falling by almost two-thirds. The 14 ISDB countries are by and large the biggest OECD economies, excluding countries such as Austria, Greece, Iceland, Ireland, New Zealand, Portugal, and Turkey. As a result, the convergence results for the ISDB countries are very similar to those for the 21 IMEs. However, after 1980, the rate of convergence in RGDPW slows markedly in all three samples. Indeed, among the 14 ISDB countries, there is virtually no convergence in labor productivity levels during the 1990s.

Catch-up is also evident, as indicated by the correlation coefficient between the 1950 RGDPW level and the rate of growth of RGDPW after 1950. The correlation coefficient is -0.93 among all OECD countries, -0.92 among the IMEs, and -0.93 among the ISDB sample. The results indicate that the countries with the lowest productivity levels in 1950 experienced the fastest increase in labor productivity.

Table 2 shows the results of a regression analysis, where other pertinent factors beside the catch-up effect are included to explain country-level productivity growth. The convergence hypothesis predicts that the coefficient of initial productivity will be negative (that is, countries further behind near the beginning of the period will show more rapid increases in GDP per worker). The coefficients of the investment rate, R&D intensity, and education should be positive. Results are shown in Table 2 for all OECD countries over the 1950-1990 period and for a variety of educational measures.

The initial RGDPW level of the country relative to the U.S. level is by far the most powerful explanatory variable in accounting for differences in labor productivity growth among OECD countries. By itself, the catch-up variable explains 74 percent of the variation in RGDPW growth over the 1950-1990 period. The coefficient of the investment rate (INVRATE) is positive and significant at the 5 percent level or greater. The average investment rate, together with the catch-up variable, explains 80 percent of the variation in RGDPW growth. R&D intensity (RDGNP) is significant at the 10 percent in all cases and, together with the other two variables, explains 83 percent of the variation in labor productivity growth. The secondary school enrollment rate (SCND-ENRL) has a positive coefficient that is significant at the ten percent level. Together with the other three variables, it explains 86 percent of the variation in productivity growth among the OECD countries. The international trade variables are not statistically significant.

Table 1 Real GDP per Worker (RGDPW) in OECD Countries, 1950-1996
(Figures are in 1,000s, 1985 Dollar Equivalents)

							Annual Growth Rate (percent)	
	1950	1960	1970	1980	1990	1996	1950-90	1950-96
Australia	16.1	19.3	25.2	27.3	30.3	32.7	1.59	1.58
Austria	5.9	10.7	18.0	23.5	26.7		3.79	
Belgium	10.9	14.3	22.2	27.7	31.7	34.6	2.66	2.56
Canada	16.1	19.5	24.9	28.7	34.4	36.1	1.89	1.79
Denmark	10.8	14.8	20.0	21.5	25.0	27.5	2.09	2.07
Finland	7.0	11.6	17.0	21.8	27.4	32.4	3.41	3.41
France	8.8	13.5	21.6	26.8	30.4	32.1	3.10	2.88
Germany, West	7.3	13.9	21.3	27.3	29.5	31.9	3.48	3.27
Greece	3.4	5.2	10.9	15.5	17.7		4.09	
Iceland	8.7	12.6	15.6	22.5	25.0		2.64	
Ireland	6.3	8.4	13.2	18.4	24.1		3.34	
Italy	6.3	11.1	19.4	26.8	30.8	34.5	3.97	3.78
Japan	2.6	5.0	11.5	16.3	22.6	23.4	5.41	4.89
Luxembourg	14.2	18.8	25.4	28.5	37.9		2.46	
Netherlands	11.4	17.1	25.4	29.2	31.2	33.1	2.52	2.37
New Zealand	17.4	21.3	24.1	24.6	25.4		0.95	
Norway	10.2	14.3	19.4	25.3	29.2	34.4	2.64	2.71
Portugal	2.9	4.9	8.4	11.3	16.6		4.34	
Spain	5.0	8.2	16.6	21.4	26.4		4.16	
Sweden	13.2	17.4	23.2	24.9	28.4	32.8	1.91	2.02
Switzerland	15.0	20.1	27.2	29.5	32.8		1.96	
Turkey	1.9	3.2	4.8	6.7	8.6		3.85	
United Kingdom	11.7	14.8	18.6	21.2	26.8	28.8	2.08	2.01
United States	20.5	24.4	30.5	31.7	36.8	38.8	1.46	1.42
Summary Statistics: All 24 OECD Countries								
Mean	9.7	13.5	19.3	23.3	27.3			
Std. Deviation	5.0	5.6	6.2	6.0	6.3			
Coeff. of Var.	0.51	0.41	0.32	0.26	0.23			
Correlation with 1950 RGDPW							-0.93	
Summary Statistics: 21 Industrial Market Economies (All countries except Greece, Portugal, and Turkey)								
Mean	10.7	14.8	21.0	25.0	29.2			
Std. Deviation	4.5	4.7	4.6	3.9	4.0			
Coeff. of Var.	0.42	0.32	0.22	0.15	0.14			
Correlation with 1950 RGDPW							-0.92	
Summary Statistics: ISDB-14 Countries								
Mean	10.9	15.1	21.4	25.5	29.6	32.4		
Std. Deviation	4.4	4.4	4.3	3.9	3.5	3.7		
Coeff. of Var.	0.41	0.29	0.20	0.15	0.12	0.11		
Correlation with 1950 RGDPW								-0.93

Sources: own computations from the Penn World Table Mark 5.6 and the OECD ISDB (International Intersectoral) Database. See the text for details.

Table 2 Regressions of the Annual Growth in Real GDP per Worker (RGDPW) On Initial RGDPW, the Investment Rate, R&D Intensity, and the Secondary School Enrollment Rate, All OECD Countries, 1950-1990

Relative $RGDPW_0$	INVRATE	RDGNP	SCND-$ENRL_{65}$	R^2	Adjusted R^2	Standard Error	Sample Size
-0.017**				0.74	0.73	0.0056	24
-7.99							
-0.016**	0.063*			0.80	0.78	0.0051	24
-8.35	-2.38						
-0.018**	0.064*	0.314#		0.83	0.80	0.0050	24
-8.20	-2.51	-1.80					
-0.018**	0.070**	0.336#	0.018#	0.86	0.82	0.0047	23
-8.77	-2.88	-2.04	-1.90				

Note:

The sample consists of the 24 OECD countries shown in Table 1. The absolute value of t-ratios are shown in parentheses below the coefficient estimate.

Key:

- Dependent variable: ln(RGDPW90/RGDPW50)/40.
- $RGDPW_t$: GDP per worker in year t, measured in 1985 international prices (in units of $10,000). Source: Penn World Table Mark 5.6.
- Relative $RGDPW_0$: RGDPW level of the country relative to the RGDPW level of the U.S. in 1950. Source: Penn World Table Mark 5.6.
- INVRATE: Ratio of investment to GDP (both in 1985 dollar equivalents) averaged over the regression period. Source: Penn World Table Mark 5.6.
- RDGNP: the ratio of R&D expenditures to GNP averaged over the regression period. Source: UNESCO Statistical Yearbooks, various years.
- SCND-$ENRL_{65}$: Total enrollment of students of all ages in secondary school in 1965 as a proportion of the total population of the pertinent age group. Sources: World Bank, World Development Report 1988.

\# significant at the 10 percent level, 2-tail test.

* significant at the 5 percent level, 2-tail test.

** significant at the 1 percent level, 2-tail test.

3. Conclusion

This brief article has documented the gradual catch-up and convergence in productivity levels that has characterized the OECD countries over the postwar period. It has, moreover, shown that investment, education, and R&D investment have also played a role in this process. However, what is most surprising — if not disturbing — is that this process of convergence appears to have ended in the 1990s. Since that time, at least as far as the evidence shows, there has been almost no additional convergence in productivity levels. This is partly a result of the sluggish growth performance of both the European countries and Japan in the 1990s. Moreover, this lack of convergence has occurred even before the recent acceleration of productivity growth in the United States over the last three or four years.

Another reason for the slow convergence in the 1990s is that as countries catch up, the forces of convergence themselves diminish. This is particularly true for the catch-up term, which accounted for most of the productivity convergence among OECD countries. It is also germane for underlying factors such as investment, education, and R&D, which have converged over time among OECD countries as differences in their productivity levels have narrowed.

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