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IS FIXED INVESTMENT THE KEY TO
ECONOMIC GROWTH?*

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I. INTRODUCTION

The strong relationship between fixed capital formation shares of GDP and growth rates since World War II has led many writers, such as De Long and Summers [1991, 1992], to conclude that the rate of capital formation or of capital formation in the form of equipment, determines the rate of a country's economic growth.[1] Yet, the strong association between fixed investment or equipment investment and growth, particularly over spans of fifteen to twenty years, does not prove causality. The effects may very well run from growth to capital formation, so that rapid growth leads to high rates of capital formation. An earlier study by Lipsey and Kravis [1987] found that for five-year periods within the longer spans, the rate of growth was more closely related to capital formation rates in succeeding periods than to contemporary or preceding rates. That result suggested that the observed long-term relationships were due more to the effect of growth on capital formation than to the effect of capital formation on growth.

In this paper we address that issue by again examining changes in capital formation and growth over successive five-year periods, but with more formal methods of studying the direction of causation. Our aim is to determine directions of influence and their timing between capital formation ratios and rates of growth.

TABLE I
REGRESSIONS OF GROWTH IN REAL GDP PER CAPITA ON FIXED CAPITAL FORMATION
RATIOS WITHOUT AND WITH COUNTRY DUMMIES

	Fixed capital formation/GDP		
	Preceding period	Current period	Following period
Country dummies excluded			
Coefficient	0.30	0.60	0.80
t-statistic	(3.42)	(5.71)	(8.94)
$\bar{R}^2$	0.03	0.07	0.16
No. of obs.	404	404	404
Country dummies included			
Coefficient	-1.00	-0.01	1.65
t-statistic	(3.95)	(0.04)	(6.78)
$\bar{R}^2$	0.16	0.12	0.23
No. of obs.	404	404	404

Real GDP per capita growth, 1965–1970, 1970–1975, 1975–1980, and 1980–1985 (ratio of end year over initial year).
Ratio of fixed capital formation to GDP, measured in current purchasing power parities, averaged over five-years periods (1960–1965, 1965–1970, 1970–1975, 1975–1980, 1980–1985, and 1983–1988).
Source. Summers and Heston [1991].

II. THE CAUSALITY BETWEEN FIXED CAPITAL FORMATION AND GROWTH

A first test of the timing issue is provided in the first part of Table I, which shows simple regressions of five-year growth rates in per capita GDP on preceding, current, and succeeding period fixed capital formation rates (ratios of fixed capital formation to GDP).[2] The coefficients, t-statistics, and $\bar{R}^2$'s increase as one moves from the preceding period to the current one and then from there to the succeeding period. From this timing relationship we are led to suspect that the case for effects running from growth rates to subsequent capital formation is stronger than that for the effects running from capital formation to subsequent growth.

One risk in using pooled time series and cross-section data, is that the cross-sectional differences among countries reflect per-

2. We chose five-year periods, partly to dilute cyclical influences, partly to maximize the number of countries included and to use most of the years of the ICP benchmark surveys (the basis for the Summers and Heston estimates), for which the data should be most reliable. However, there is no theoretical basis for this interval, and it might be worthwhile to experiment with others also. Much shorter intervals might, however, give results reflecting business cycle developments rather than the longer term influences that are important for development.
A list of the 101 countries included in the study is provided in Blomström, Lipsey, and Zejan [1994].

manent characteristics of the countries that encourage or dis-
courage both fixed investment and economic growth. Examples of
such characteristics might be the efficiency of government, the
degree of corruption, the level of violence, or the attitude of gov-
ernments and populations toward individual achievement or en-
terprise. Any such relationship could give a false impression that
high fixed capital formation resulted in high growth, or vice
versa. To eliminate any such bias, we include country dummies.
The effect is to remove cross-sectional differences among coun-
tries, leaving only time-series variations to be explained. The
main result persists when intercountry differences are elimi-
nated: growth seems to precede capital formation (see the second
part of Table I).

A more formal way of examining the direction of causality is
to apply tests in the Granger-Sims causality framework [Granger
1969; Sims 1972]. We first estimate the following equations:

(i) $RGDPC_t = f(RGDPC_{t-1}, RGDPC_{t-2})$

(ii) $RGDPC_t = f(RGDPC_{t-1}, RGDPC_{t-2}, INV_{t-1})$,

where $RGDPC$ is growth in real income per capita, INV is the
ratio of fixed capital formation to GDP, and t is the period (see
Table I). We interpret investment to be Granger-causing growth
when a prediction of growth on the basis of its past history can
be improved by further taking into account the previous period's
investment.

Estimating (i) and (ii) gives the following results (t-values
are in parentheses):

$$RGDPC_t = \quad 0.661 + 0.227\, RGDPC_{t-1} + 0.142\, RGDPC_{t-2}$$
$$\quad (7.0) \quad\;\; (3.7) \qquad\qquad (2.1)$$
$$\bar{R}^2 = 0.06$$
$$n = 303$$

$$RGDPC_t = \quad 0.660 + 0.228\, RGDPC_{t-1} + 0.142\, RGDPC_{t-2}$$
$$\quad (6.7) \quad\;\; (3.5) \qquad\qquad (1.9)$$
$$- \; 0.002\, INV_{t-1}$$
$$(0.02)$$
$$\bar{R}^2 = 0.06$$
$$n = 303$$

Thus, we cannot reject the null hypothesis that capital formation
in the preceding period has no explanatory power with respect to
growth in the current period, given the past history of growth in
that country. The past history of growth is a poor predictor of

current growth, but lagged investment does not improve the prediction.

We can then reverse the question to ask whether past growth has an effect on current capital formation rates, given the history of capital formation rates. The results are as follows (*t*-values are in parentheses):

$$INV_t = \underset{(4.6)}{2.48} + \underset{(15.3)}{0.948\,INV_{t-1}} - \underset{(1.27)}{0.075\,INV_{t-2}}$$

$$\bar{R}^2 = 0.79$$
$$n = 303$$

$$INV_t = \underset{(4.9)}{-7.35} + \underset{(13.7)}{0.828\,INV_{t-1}} - \underset{(0.21)}{0.012\,INV_{t-2}}$$
$$+ \underset{(6.9)}{(9.49\,RGDPC_{t-1}}$$

$$\bar{R}^2 = 0.82$$
$$n = 303.$$

The significant *t*-statistic on $RGDPC_{t-1}$ suggests that past growth has a significant effect on current capital formation even after past capital formation is taken into account. Even though the past history of capital formation rates predicts current rates well, past growth rates improve the prediction.

We have also included preceding, current, and following period fixed capital formation ratios in the growth regression concurrently. This regression tests a form of Sims [1972] definition of causality. As suggested by Geweke (see Harvey [1990, p. 307]), we also included lagged values of the dependent variable to eliminate serial correlation. The results are as follows (*t*-values are in parentheses):

$$RGDPC_t = \underset{(14.6)}{0.853} - \underset{(2.8)}{0.005\,INV_{t-1}} - \underset{(1.66)}{0.005\,INV_t} + \underset{(8.0)}{0.016\,INV_{t+1}}$$
$$+ \underset{(2.4)}{0.132\,RGDPC_{t-1}}$$

$$\bar{R}^2 = 0.23$$
$$n = 404.$$

This test again suggests that growth Granger-causes investment.[3] The finding that INV_{t-1} and INV_t carry negative coeffi-

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3. De Long and Summers emphasize machinery and equipment investment rather than investment in fixed capital. Using their equipment investment variable in place of the fixed capital formation variable does not change our results.

cients is probably related to the fact that all three investment variables are highly correlated (0.89, 0.89, and 0.79).

In sum, informal and formal tests using only fixed investment ratios as independent variables give evidence that economic growth precedes capital formation, but no evidence that capital formation precedes growth. Thus, the causality seems to run in only one direction, from economic growth to capital formation.

III. MULTIPLE REGRESSIONS

In an earlier paper, studying growth over the whole post-World War II period, we found, in addition to fixed capital formation ratios, several other determinants of real GDP per capita growth [Blomström, Lipsey, and Zejan 1994]. Among the significant variables were the initial (1960) real per capita income level (i.e., a convergence or catch-up variable), the proportion of the population in the relevant age group enrolled in secondary education (a proxy for the level of secondary education in the population), income changes that were due to changes in the world price structure (we used this variable as a more general alternative to excluding oil-producing countries), changes in the labor force participation rate (intended to catch the effects of demographic changes, particularly in birth rates, on the ratio of dependent population to working population), and inflows of foreign direct investment relative to GDP (a measure of the inflow of disembodied technology from abroad). Here we include these variables in our equations and rerun the multiple regression, using pooled five-year period data instead of data for the full 1960–1988 period.

If we pool cross-section and time-series observations, using current period values for all variables other than fixed capital formation[4] and not eliminating the cross-section variation (first part of Table II), we find, as in the single-variable equations mentioned above, that the results improve when capital formation rates are dated later relative to output growth. The explanatory power of the model, the coefficients, and the *t*-values for capital

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4. We addressed the issue of timing and direction of causation also for these additional variables and found for all of them, a causality pattern similar to what we found for the investment variable: However, the effect of growth on the other variables was much smaller than the effect of growth on capital formation, and the impact of moving from preceding- to current- or to following-period values for these variables in the growth equations was small: nothing like that of the same process for fixed capital formation.

TABLE II
COEFFICIENTS FOR FIXED CAPITAL FORMATION RATIOS IN MULTIPLE REGRESSIONS
EXPLAINING GROWTH IN REAL GDP PER CAPITA

	Fixed capital formation/GDP		
	Preceding period	Current period	Following period
Country dummies excluded			
Coefficient	0.25	0.62	1.04
t-statistic	(1.94)	(4.56)	(8.85)
$\overline{R}^2$	0.12	0.16	0.27
No. of obs.	364	364	364
Country dummies included			
Coefficient	−0.63	0.31	1.27
t-statistic	(2.43)	(1.26)	(4.88)
$\overline{R}^2$	0.42	0.41	0.46
No. of obs.	364	364	364

Dependent variable:
Real income per capita growth, 1965–1970, 1970–1975, 1975–1980, and 1980–1985 (ratio of end year over initial year). *Source:* Summers and Heston [1991].
Explanatory variables:
1960 income per capita relative to that of the United States. *Source:* Summers and Heston [1991].
  The average ratio of secondary education to the number in the "appropriate" age group, 1965–1970, 1970–1975, 1975–1980, and 1980–1985. *Source: UNESCO Yearbook,* various issues.
  Price deflator. Calculated as $PRICE_{\cdot}$ = CGDPC / RGDPC, ratio of end of year over initial year, where *CGDPC* is GDP per capita at current international prices and RGDPC is real GDP per capita at 1985 international prices. *Source:* Summers and Heston [1991].
  Ratio of fixed capital formation to GDP, measured in current purchasing power parities, averaged over five-years periods (1960–1965, 1965–1970, 1970–1975, 1975–1980, 1980–1985, and 1983–1988). *Source:* Summers and Heston [1991].
  The change in the labor force participation rate, the ratio of labor force to total population, 1965–1970, 1970–1975, 1975–1980, and 1980–1985. *Sources:* ILO, *Labor Statistics Yearbook*; Summers and Heston [1991].
  Ratio of inflow of foreign direct investment to GDP, measured in current dollars, averaged over five-years periods (1965–1970, 1970–1975, 1975–1980, and 1980–1985). *Sources:* IMF Balance of Payments tape; UNCTC, *Transnational Corporations in World Development* [1988].

formation increase when we use INV_t instead of INV_{t-1}, and increase further when we substitute INV_{t+1} for INV_t.

  If we eliminate the cross-sectional differences among countries by including country dummies, we arrive at the results shown in the second part of Table II. The pattern for the three fixed capital formation measures survives the elimination of intercountry differences. The only fixed capital formation coefficient that is positive and significantly different from zero is that for fixed capital formation in the following period.[5]

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  5. Substituting the De Long and Summers equipment investment variable for our fixed capital formation variable does not change the results significantly in any of the regressions or the causality tests. For instance, the multiple regres-

Finally, we also applied the Sims-causality test, discussed above, to this multiple regression framework. The result with regard to the investment variable was essentially the same.

What, then, determines the rate of growth of a country? The strongest contemporary cross-section and time series influences we find, in the sense of being contemporary with the growth, are increases in (1) prices relative to world prices, (2) the proportion of students in secondary education, (3) the ratio of the labor force to population, (4) the inflow of foreign direct investment relative to GDP, (5) the investment ratio, and (6) the initial distance behind the United States [Blomström, Lipsey, and Zejan 1993, Appendix Table 1]. Some of these variables are important mainly in cross-country comparisons, but do not seem to affect time series changes in growth rates for individual countries, perhaps because they vary little over time within countries. The variables that seem important over time are the initial distance behind the United States in each period and the change in relative prices during the period. Changes in the contemporary investment ratio are not significant.

IV. CONCLUSIONS

Relating the growth rate of real GDP per capita to the share of fixed investment or equipment investment in GDP, and to other variables over long periods, De Long and Summers [1991, 1992] and most other studies conclude that the investment ratio exerts a major influence on income growth. Dividing the post-World War II period into five-year subperiods, we find that per capita GDP growth in a period is more closely related to subsequent capital formation than to current or past capital formation. Moreover, the results of simple causality tests suggest that growth induces subsequent capital formation more than capital

sions with fixed effects, using a common sample size of 72 countries, give the following result:

	Fixed capital formation/GDP			Machinery and equipment/GDP		
	Preceding period	Current period	Following period	Preceding period	Current period	Following period
Coefficient	−0.49	0.66	1.76	−1.10	1.60	5.00
t-statistic	(1.87)	(2.58)	(6.12)	(1.03)	(1.49)	(4.00)
R^2	0.51	0.52	0.58	0.50	0.51	0.54
No. of obs.	265	265	265	265	265	265

formation induces subsequent growth. Thus, we find no evidence that fixed investment (or equipment investment) is the key to economic growth. This conclusion is in line with the last 25 years of research in development economics, which shows that the path to growth and development is much more than simply raising saving and investment rates from 5 to 15 percent, as Arthur Lewis, Walter Rostow, and others suggested in the 1950s. Institutions, economic and political climate, and economic policies that encourage education, inflows of direct investment, lower population growth, and the efficient use of investment seem to be the chief foundations for economic growth.

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