IS FIXED INVESTMENT THE KEY TO ECONOMIC GROWTH?*

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ROBERT E. LIPSEY
MARIO ZEJAN

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.

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

<table>
<thead>
<tr>
<th>Fixed capital formation/GDP</th>
<th>Preceding period</th>
<th>Current period</th>
<th>Following period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country dummies excluded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>0.30</td>
<td>0.60</td>
<td>0.80</td>
</tr>
<tr>
<td>t-statistic</td>
<td>(3.42)</td>
<td>(5.71)</td>
<td>(8.94)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.03</td>
<td>0.07</td>
<td>0.16</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>404</td>
<td>404</td>
<td>404</td>
</tr>
<tr>
<td>Country dummies included</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>-1.00</td>
<td>-0.01</td>
<td>1.65</td>
</tr>
<tr>
<td>t-statistic</td>
<td>(3.95)</td>
<td>(0.04)</td>
<td>(6.78)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.16</td>
<td>0.12</td>
<td>0.23</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>404</td>
<td>404</td>
<td>404</td>
</tr>
</tbody>
</table>

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). The coefficients, t-statistics, and $R^2$'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-
permanent characteristics of the countries that encourage or discourage 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 governments and populations toward individual achievement or enterprise. 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 countries, leaving only time-series variations to be explained. The main result persists when intercountry differences are eliminated: 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:

\[(i) \quad RGDPC_t = f(RGDPC_{t-1}, RGDPC_{t-2})\]
\[(ii) \quad RGDPC_t = f(RGDPC_{t-1}, RGDPC_{t-2}, INV_{t-1}),\]

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 = 0.661 + 0.227 RGDPC_{t-1} + 0.142 RGDPC_{t-2}
(7.0) \quad \(3.7) \quad (2.1)
\]

\[\bar{R}^2 = 0.06 \quad n = 303\]

\[
RGDPC_t = 0.660 + 0.228 RGDPC_{t-1} + 0.142 RGDPC_{t-2} - 0.002 INV_{t-1}
(6.7) \quad (3.5) \quad (1.9) \quad (0.02)
\]

\[\bar{R}^2 = 0.06 \quad n = 303\]

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):

\[
INV_t = 2.48 + 0.948 \text{INV}_{t-1} - 0.075 \text{INV}_{t-2}
\]

\[R^2 = 0.79\]

\[n = 303\]

\[
INV_t = -7.35 + 0.828 \text{INV}_{t-1} - 0.012 \text{INV}_{t-2} + (9.49 \text{RGDPC}_{t-1}
\]

\[R^2 = 0.82\]

\[n = 303.\]

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):

\[
\text{RGDPC}_t = 0.853 - 0.005 \text{INV}_{t-1} - 0.005 \text{INV}_t + 0.016 \text{INV}_{t+1}
\]

\[R^2 = 0.23\]

\[n = 404.\]

This test again suggests that growth Granger-causes investment.\(^3\) The finding that \(\text{INV}_{t-1}\) and \(\text{INV}_t\) 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.
IS FIXED INVESTMENT THE KEY TO GROWTH?

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 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 formation 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**

<table>
<thead>
<tr>
<th></th>
<th>Preceding period</th>
<th>Current period</th>
<th>Following period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country dummies excluded</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>0.25</td>
<td>0.62</td>
<td>1.04</td>
</tr>
<tr>
<td>t-statistic</td>
<td>(1.94)</td>
<td>(4.56)</td>
<td>(8.85)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.12</td>
<td>0.16</td>
<td>0.27</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>364</td>
<td>364</td>
<td>364</td>
</tr>
<tr>
<td><strong>Country dummies included</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>-0.63</td>
<td>0.31</td>
<td>1.27</td>
</tr>
<tr>
<td>t-statistic</td>
<td>(2.43)</td>
<td>(1.26)</td>
<td>(4.88)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.42</td>
<td>0.41</td>
<td>0.46</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>364</td>
<td>364</td>
<td>364</td>
</tr>
</tbody>
</table>

**Dependent variable:**

**Explanatory variables:**
- 1960 income per capita relative to that of the United States. Source: Summers and Heston [1991].
- Price deflator. Calculated as $PRICE_t = \frac{CGDPC}{RGDPC}$, 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].

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

<table>
<thead>
<tr>
<th>Fixed capital formation/GDP</th>
<th>Machinery and equipment/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preceding period</td>
<td>Current period</td>
</tr>
<tr>
<td>Coefficient</td>
<td>-0.49</td>
</tr>
<tr>
<td>t-statistic</td>
<td>(1.87)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.51</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>265</td>
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</table>
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.

REFERENCES


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