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An Empirical Evaluation of the Two-Gap Model of Development

by

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AN EMPIRICAL EVALUATION OF THE TWO-GAP MODEL OF DEVELOPMENT

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I. Introduction

The two-gap model of development, popularized especially by Chenery and associates, has been used widely in analyses of foreign aid requirements of less developed countries (LDC's). Despite several criticisms of both the theoretical structure and statistical implementation of the model [Bruton (1969), Conlisk and Huddle (1969), Findlay (1971), Joshi (1970), and Fei and Ranis (1968)], no widespread test of its adequacy has been undertaken. This paper attempts to provide such a test, from both a theoretical and practical point of view.

It is of interest, on theoretical grounds, to determine how well the two-gap model conforms to actual data for a number of LDC's. Inferences about the model can then be drawn from standard criteria such as goodness of fit, theoretical plausibility of parameter estimates, and the Chow test for structural change. This will be our task in Section II of the paper.

As a practical matter, the two-gap model is used to predict the capital inflow needed by various LDC's in order to maintain a specified rate of growth. Two-gap models posit a relationship involving gross income (GNP or GDP), the level of exports, and the level of capital inflow for any given year. Any two of the foregoing factors determine the other. In the aid-requirement projections, the first two quantities are fixed (income at a target level, exports as determined by world demand and local supply conditions), and the necessary aid is derived. As pointed out by Leamer and Stern (1970), these predictions cannot be directly verified in most cases, because we observe neither the income level nor the export level assumed in the projections. We thus cannot tell what inflow level would have been appropriate to achieve the target growth. However, using the structure of the model as published by those making projections, we can turn it around and look at the output level implied by the actual exports and capital inflow for any year, and compare this to the observed output level. Since the ultimate interest of policymakers who control foreign aid disbursements is ordinarily thought to be the income levels of the countries involved, this test should provide an indication of the usefulness of the two-gap models to them. It will be undertaken in Section III.

It is important to distinguish between these two performance dimensions of the model. Although of course related, predictive capability and statistical acceptability are not identical, and we will find that our attempts to obtain a satisfactory theoretical explanation of past growth are considerably less successful than previous forecasts of future growth have been. This seemingly paradoxical result will be elaborated in the conclusion.

II. Econometric Implementation of the Two-Gap Model

Before turning to our first empirical task, we need to say a few words about the data base. We took national accounts data from various issues of the IMF, International Financial Statistics and the UN, Yearbook of National Accounts Statistics, getting as many annual observations over the period 1950-69 as was possible. Table 1 shows the countries selected and the data period for each. Multiple regression analysis was used to guage the satisfactoriness of the model in explaining the existing data, and to provide some explanation for the prediction results which are shown in Section III. In the course of this exercise, certain fundamental statistical difficulties involved in estimating the model are brought to light.

The first step here is construction of a representative two-gap model which can encompass the various versions existing in the literature as subcases. Our model deals with the following endogenous variables:

- Y_t - gross output (GNP or GDP)
- I_t - gross investment
- S_t - gross saving
- M_t - consumption of importables
- VM_t - import-substituting production
- I_t^* - investment in import-substituting activities
- YS_t - maximum attainable Y_t based on previous capital accumulation

Table 1

Countries Selected for Study

Argentina	1950-69	Korea	1955-69
Bolivia	1958-69	Malaysia	1954-68
Brazil	1950-68	Malta	1955-68
Burma	1950-64	Mauritius	1958-66
Ceylon	1955-69	Mexico	1950-68
Chile	1955-69	Morocco	1958-69
Colombia	1950-69	Nicaragua	1953-69
Costa Rica	1950-69	Nigeria	1953-66
Cyprus	1955-68	Pakistan	1959-67
Dominican Republic	1954-68	Panama	1955-69
Ecuador	1950-69	Paraguay	1955-69
Egypt	1961-69	Peru	1950-69
El Salvador	1958-69	Philippines	1955-69
Ghana	1955-69	Sudan	1956-68
Guatemala	1950-69	Taiwan	1955-69
Honduras	1950-69	Thailand	1955-69
Indonesia	1960-68	Trinidad-Tobago	1951-68
Iran	1959-69	Tunisia	1960-68
Iraq	1955-69	Uruguay	1955-68
Israel	1950-69	Venezuela	1955-68
Jamaica	1955-69		

YT_t - maximum possible Y_t based on current importables consumption.

In addition, there are two exogenous variables:

$\overline{X}_t$ - exports

$\overline{F}_t$ - capital inflow.

All variables refer to time t, and all are in constant currency units (for convenience, everything has been converted to billions of 1962 U.S. dollars, based on 1962 exchange rates).

The model is composed of eight equations used to explain the eight unknowns:

$$I_t = S_t + \overline{F}_t \quad (1)$$

$$M_t = \overline{X}_t + \overline{F}_t + VM_t \quad (2)$$

$$YS_t = A + \frac{1}{k} \sum_{i=0}^{t-1} [I_i - \frac{(k^*-k)}{k^*} I_i^* - zY_i] \quad (3)$$

$$YT_t = B + \frac{1}{m} M_t \quad (4)$$

$$VM_t = C + \frac{1}{k^*} \sum_{i=0}^{t-1} (I_i^*) \quad (5)$$

$$S_t = D + sY_t + u\overline{X}_t \quad (6)$$

$$I_t^* = j[S_t - (kr+z)Y_t] \quad \text{if } YT_t < YS_t$$
$$= 0 \quad \text{if } YS_t \leq YT_t \quad (7)$$

$$Y_t = \min(YS_t, YT_t) \quad (8)$$

The first two equations are simple accounting identities. In the third equation, k represents the capital-output ratio, k^* the capital-output ratio which prevails

in the import-substituting sector ($k^* \geq k$), and z the proportion of income which must be devoted to social overhead investment. Thus, equation (3) represents savings-limited output as a function of cumulative directly productive investment, with a one-year lag. In this equation, A can be interpreted as base-year capacity output, and k and k^* are understood to include a depreciation factor. The fifth equation is a similar capital-output relation for import-substituting production. Equation (4) expresses trade-limited output as a function of current consumption of importables, and m is interpreted as the marginal-necessary-import requirement of output. Savings, in equation (6), are expressed as an ordinary Keynesian function of income, with exports contributing positively to savings behavior, due to an assumed higher propensity to save in the export sector. Exchange-saving investment, assumed only to occur under conditions of trade-constrained growth, is expressed as a positive fraction of the difference between savings and required investment. Part of required investment here is the term krY_t, where r is an expected rate of output growth. That is, in periods of trade-constrained growth, investors determine how much capital formation is needed to support next year's expected level of income (rY_t) and to provide necessary social overhead investments. They then devote a certain fraction of the difference between forthcoming savings and this amount of investment to the buildup of import-substituting production facilities.
Under conditions of a one-year lag in the capital-output relation, this concept is necessary in order to make exchange-saving investment behavior determinate, although the notion of a constant parameter r (i.e., one which does not vary with changing growth experience) is one of the more tenuous postulates of the model. Under ordinary applications of the model, where Y is exogenous and $\overline{F}$ is endogenous, being set at that level needed

to achieve the given income level, this device is not needed. But in order to explain growth as a function of capital inflow and exports under trade-dominated conditions (implying excess capacity in the economy), some ideas about expected future growth must be included. Finally, equation (8) closes the system, showing the distinctive feature of this model, namely, that there are two separate constraints to income growth.

Immediate statistical implementation of the model is of course impossible, since there are no current econometric techniques for estimating an equation of the sort $Y = \min(YS_t, YT_t)$. Simple equation-by-equation fitting of the other relations would of course be fallacious, so additional assumptions must be invoked. (This consideration, which is ordinarily not squarely faced by two-gap practitioners, is emphasized by Fei and Ranis (1968).) Here we adopt the assumption that either the trade gap or the savings gap was dominant throughout the entire sample period. In either case, a simple reduced-form equation for GNP can be derived. (In the formulations that follow, the symbol S will stand for $\sum_{i=0}^{t-1}$.) Savings-constrained growth can be represented as:

$$Y_t = A + \frac{1}{k} D(S1) + \frac{s-z}{k}(SY) + \frac{1}{k}(SF) + \frac{u}{k}(SX) \quad , \qquad (9)$$

while trade-constrained growth is:

$$Y_t = (B+\frac{1}{m}C) + \frac{1}{m}(\overline{X}_t+\overline{F}_t) + \frac{j}{mk^*}[D(S1) + (s-z-kr)(SY) + (SF) + u(SX)] \quad . \qquad (10)$$

This shows that the only difference between the two cases is that the term $(\overline{X}_t + \overline{F}_t)$ is included in trade-constrained growth, but not in savings-constrained growth. Of course, if expcrts do not contribute to savings behavior ($u = 0$), SX will be eliminated from both equations. And if exchange-saving investment does not take place ($j = 0$), equation (10) contains only a constant and $(\overline{X}_t + \overline{F}_t)$. Finally, if a country has experienced both cases of growth over the sample period, the estimated parameters will reflect neither experience faithfully and will be observed to shift over different subperiods.

This latter consideration reflects a fundamental difficulty with the two-gap model. That is, if it were completely inapplicable to the data, this could not be statistically distinguished from a simple shift in the type of constraint which is operative. A second statistical difficulty, not endemic to the model, is the limited number of observations (twenty at a maximum) and high collinearity among the independent variables. With these warnings in mind, we proceed to our necessarily hindered statistical analysis.

A stepwise procedure was followed. Equation (10) was first estimated using ordinary least squares, and the hypothesis $j = 0$ (i.e., the coefficients on S1, SY, SF and SX all equalled zero) was tested. (All statistical tests were conducted at the 95% level of significance.) If this could not be rejected, which is to say that these variables contributed no significant explanatory power beyond that attributable to imports, we assumed trade-constrained growth was occurring with no exchange-saving investment, and only the constant and $(\overline{X}_t + \overline{F}_t)$ were used in the final estimation. If j was found different from zero, the hypothesis $\frac{1}{m} = 0$ was tested. When this could be rejected, we assumed that exchange-constrained growth accompanied by import-substituting investment was taking place. When $\frac{1}{m} = 0$ could not be rejected, we assumed savings-constrained growth was occurring. In each case, a further test, namely u = 0, was made to see if exports were contributing to savings behavior. At the end of the procedure, a reduced-form equation for Y resulted. If any of the coefficients were of the theoretically incorrect sign (i.e., a negative sign on $(\overline{X}_t + \overline{F}_t)$, SY, SF or SX), the analysis was ended, since interpretation of the equation would have been nonsensical in terms of the two-gap model. When all slopes showed the proper sign, a Chow test was conducted to determine whether structural change could be observed over the sample period.[1] For each Chow test, the sample was divided in half, with the odd observation, if any, assigned to the second part. (Due to the high collinearity of the variables and the small number of observations, the Chow test was sometimes numerically impossible.)

Actually, four equations were derived for each country. We tried to explain both GNP and GDP, and we deflated foreign trade variables $(\overline{X}_t$, $\overline{F}_t$, SX, and SF) by both home prices and U.S. export prices. Results for the four possibilities were quite similar and are available from the author on request. The discussion here is confined to the outcome for the GNP-U.S. export-price variant, which seemed to give marginally better results according to goodness of fit and Chow tests.

Table 2 breaks down the country results into three groups: those whose final reduced form indicated trade-constrained growth, with all coefficients having the correct sign; those which similarly indicated savings-constrained growth; and those which displayed at least one faulty sign. Table 2 also indicates which equations showed no evidence of structural change according to the Chow test, presumably a sign of a stable one-gap structure under the hypotheses of the model.

The results are disappointing, since only 13 out of the 41 countries showed acceptable coefficients along with no evidence of structural change. (With 5 more of the acceptable equations, it proved impossible to carry out the Chow test, so they cannot really be said to have shown change.) Furthermore, 6 out of the 17 cases which showed some theoretically incorrect negative coefficients had them significantly different from zero, showing that they were probably not merely sampling errors. Finally, all but 2 of the 13 acceptable equations indicated that trade-constrained growth was occurring. This is in contrast to the projections based on previously published studies, to be investigated in Section III, that showed the savings gap to more commonly predominate.

Turning to the numerical results, as displayed in Table 3, we can investigate the plausibility of the estimated coefficients. In the 8 cases of savings-gap conditions, all displayed acceptable marginal savings rates (ranging from .05

Table 2

Summary of Regression Results

	Trade-Constrained Growth		Savings-Constrained Growth		Theoretically Incorrect Sign
	Burma	NC	Bolivia		Argentina
OK	Cyprus	OK	Brazil	s	Chile
OK	El Salvador	NC	Ceylon		Colombia
OK	Ghana		Ecuador	s	Costa Rica
NC	Guatemala		Jamaica		Dom. Rep.
	Indonesia	OK	Korea	s	Egypt
	Iran	NC	Morocco		Honduras
OK	Malaysia	NC	Uruguay		Iraq
OK	Malta			s	Israel
OK	Mauritius				Mexico
OK	Nicaragua			s	Panama
OK	Nigeria				Paraguay
OK	Pakistan				Peru
	Sudan				Philippines
OK	Taiwan				Thailand
OK	Tunisia			s	Trin.-Tobago
					Venezuela

OK - Chow test showed no evidence of structural change.

NC - Chow test numerically impossible.

s - Theoretically incorrect coefficient statistically significant at 95% level.

Table 3

Summary of Numerical Results

Country	Variables in Final Regression	Point Estimates of Parameters
Bolivia	CO, S1, SY, SF	k=1.32 s=.13
Brazil	CO, S1, SY, SF	k=1.32 s=.16
Burma	CO, M	m= .24
Ceylon	CO, S1, SY, SF	k=2.50 s=.18
Cyprus	CO, M	m= .40
Ecuador	CO, S1, SY, SF	k=2.94 s=.09
El Salvador	CO, M	m= .38
Ghana	CO, M	m= .67
Guatemala	CO, S1, SY, SF, M	m= .85 j/k*=.26 (s-z-kr)=.10
Indonesia	CO, M	m=1.72
Iran	CO, M	m= .20
Jamaica	CO, S1, SY, SF	k=5 s=.10
Korea	CO, S1, SY, SF	k=2.44 s=.12
Malaysia	CO, M	m= .45
Malta	CO, M	m= .78
Mauritius	CO, M	m= .66
Morocco	CO, S1, SY, SF	k= .85 s=.09
Nicaragua	CO, M	m= .44
Nigeria	CO, M	m= .41
Pakistan	CO, M	m= .17
Sudan	CO, M	m= .81
Taiwan	CO, M	m= .36
Tunisia	CO, M	m= .77
Uruguay	CO, S1, SY, SF	k=5.00 s=.05

CO - constant term

S1 - lagged summed constant

SY - lagged summed income

SF - lagged summed capital inflow

M - $\bar{X}_t + \bar{F}_t$

SX - lagged summed exports

Table 3 notes continued

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k - capital-output ratio

s - marginal savings rate

m - necessary import coefficient on income

j - proportion of excess savings devoted to exchange-saving investment under trade-constrained growth

k* - capital-output ratio in exchange-saving sector

z - proportion of output devoted to social overhead investment

r - expected rate of growth

to .18), although 3 had capital-output ratios below 1.33 and 1 (Morocco) was less than unity. In only the case of Guatemala was there evidence of trade-gap growth accompanied by exchange-saving investment. Here the estimated coefficients are reasonable, but it was unfortunately impossible to carry out the Chow test. All the other trade-gap countries gave results indicating that $j = 0$ could not be rejected, and although in 11 of the 15 no evidence of parameter change was found, in 2 of these 11 (Ghana and Tunisia), the estimate of m was so unreasonably high that it cannot be viewed as a permanent characteristic of the economy.

Taking all these results together, it must be concluded that the two-gap model does not give a satisfactory explanation of LDC economic history over the last few years according to currently accepted standards of empirical economics. It may be that LDC data are so faulty that no model can be expected to do well in the statistical sense, particularly one which is not strictly amenable to regression techniques. But this does not give us a reason to accept the two-gap model regardless of the negative evidence presented here.

III. Prediction Performance of Selected Two-Gap Models

We now come to the main task of this paper, namely, an evaluation of the accuracy of various models in the literature that purport to explain growth performance of LDC's.

Four specific works have been chosen for evaluation here, those of Chenery and Strout (1966), Maizels (1968), Chenery and Eckstein (1970), and UNCTAD (1968). Each of these estimates the economic structure of various individual countries and each was designed to predict foreign aid requirements, given a target level of income. Thus, as mentioned earlier, it was necessary for purposes of evaluation to reverse the causal structure of the models, letting income be determined by capital inflow and exports, rather than aid determined by income, exports, and autonomous capital inflow. However, the formal structure of each model remains the same, and we are merely changing variables between the endogenous and exogenous classification. In this section, only a sketchy review of each model is given. Full particulars can be found in the references given above.

We first describe the detailed results for each of the four projection series, then compare them with each other and with our own regression predictions, which were based on the model presented in Section II, but which used only the data available at the time the former projections were prepared. Since some of the projections we evaluate tried to project GNP, and some GDP, the results are not strictly comparable, although Section II noted that there is not much difference in forecasting the two series.

The statistic by which projections will be evaluated is the percentage-root-mean-square error (PRMSE). Letting

$P_1, \ldots, P_n$ stand for n annual projections, and $A_1, \ldots, A_n$ for the actual figures, the formula for this statistic is:

$$\text{PRMSE} = \frac{\sqrt{\sum_{i=1}^{n} (A_i - P_i)^2 / n}}{\sum_{i=1}^{n} A_i / n}$$

It is important to note that any exercise in evaluating projections without knowledge of the user's loss function is somewhat arbitrary. We have chosen the basic idea of the mean-square-error criterion because it heavily penalizes extreme deviations, which presumably matter a great deal when income projections are at issue. This criterion has been used widely in other studies and is therefore relatively familiar to many readers. Taking the square root of the mean-square error as a percentage of the mean will allow us to compare projections dealing with series of figures of differing orders of magnitude (e.g., the GNP of Brazil and Costa Rica) on an equal basis.

Before proceeding, it should be pointed out that several two-gap studies of the less developed world as a whole have been published, notably, Balassa (1964), GATT (1962), and UN (1964). These have not been evaluated here, mainly because the aggregate data needed to confirm them are not available in published sources. However, their extremely wide range, over at least a hundred countries, seems to indicate that they are not meant to be terribly precise in any case, and their authors always express reservations about using them to infer anything but orders of magnitude. It should be noted that the authors of the studies to be considered here also include disclamers about extreme accuracy. But these works at least operate on a national level, which is usually considered reasonable in economic inquiry, and it thus seems fair to evaluate the results.

Complete detailed results of all projections, including an accuracy analysis of each relation in each projection, can be obtained from the author upon request. Here we have only summarized their performance, and Table 4 indicates the main results.

Chenery and Strout

The Chenery and Strout (C-S) work contained projections for a wide range of countries, of which 36 are evaluated here. Their data base ended in 1962, so there were potentially 7 observations of projected and actual GNP available at the time of writing. Taking exports as given, their model contained four relations: (a) necessary imports as a function of GNP (no specific import-substituting sector was included in the numerical results, although the high performance estimates were supposed to include this effect); (b) savings as a function of GNP; (c) GNP as a function of lagged cumulative gross investment; and (d) a rate-of-growth constraint on investment increases from year to year. In the original article, several sets of parameters were given for each country, corresponding to different performance levels. Since the

Table 4

Comparative PRMSE's of Income Predictions[a]

	1962 Base Year			1964 Base Year		
Country	Chenery-Strout	Maizels	Regression Prediction	Chenery-Eckstein	UNCTAD	Regression Prediction
Argentina	.08(*)		.08(+)	.11(+)	.14(+)	.08(+)
Bolivia	.07(-)		.16(-)	.03(+)		.09(-)
Brazil	.14(+)		.54(-)	.20(+)	.11(+)	.50(-)
Burma	.05(-)	.04(*)	.04(*)			
Ceylon	.14(-)	.04(*)	.07(-)		.13(-)	.09(-)
Chile	.16(-)		.14(-)	.10(-)	.23(-)	.17(*)
Colombia	.04(*)		.09(+)		.14(-)	.07(-)
Costa Rica	.04(-)		.08(-)	.05(-)		.10(*)
Cyprus	.13(-)		.15(-)			.19(-)
Ecuador	.05(-)		.06(-)			
Egypt	.04(*)				.14(-)	
El Salvador	.21(-)		.10(-)	.19(-)		.26(+)
Ghana	.07(*)	.07(*)	.21(-)		.16(-)	.09(-)
Guatemala	.16(-)		.03(-)	.05(-)		.02(*)
Honduras	.02(+)		.03(-)	.02(-)		.04(-)
Indonesia	.40(-)				.04(*)	.03(*)
Iran	.28(-)				.17(-)	.26(-)
Israel	.05(*)		.18(+)		.10(*)	.12(-)
Jamaica	.02(-)	.02(+)	.21(+)			.19(*)
Korea	.29(-)		.31(-)			.72(+)
Malaysia					.10(-)	.11(-)
Mauritius	.06(*)		.46(+)			
Mexico	.10(-)		.18(-)	.04(-)	.04(-)	.05(+)
Morocco	.11(-)		.09(-)			.05(*)
Nicaragua	.14(-)		.20(-)	.05(*)		.10(*)
Nigeria	.04(*)	.05(*)	.12(-)		.03(+)	.04(-)
Panama	.09(-)		.19(-)	.12(-)		.03(*)
Pakistan	.03(-)	.04(-)			.14(-)	.02(*)

Table 4 (Continued)

Country	1962 Base Year Chenery-Strout	1962 Base Year Maizels	1962 Base Year Regression Prediction	1964 Base Year Chenery-Eckstein	1964 Base Year UNCTAD	1964 Base Year Regression Prediction
Paraguay	.07(-)		.01(*)	.06(-)		.01(*)
Peru	.04(*)		.13(+)	.05(*)	.04(+)	.12(+)
Philippines	.08(-)		.37(+)		.05(*)	.08(-)
Sudan	.12(*)		.09(*)			.07(*)
Taiwan	.24(-)		.17(-)		.21(*)	.23(-)
Thailand	.16(-)		.27(+)		.18(-)	.13(-)
Trin.-Tob.	.07(*)	.09(+)	.02(+)			.02(+)
Tunisia	.05(+)					.05(+)
Venezuela	.09(-)		.05(+)	.08(-)	.06(-)	.07(-)

[a]Intersection of row and column shows PRMSE of prediction of income of row country by column source and base year. Symbol in parentheses after PRMSE coded as:

+ - last 3 years of forecast overestimated income
- - last 3 years of forecast underestimated income
* - last 3 years of forecast had at least one over- and one underestimate.

"historical experience" variant gave the best predictive results, only these projections will be examined here.

Looking at the predictive performance, we find that in most cases (24 out of 36) the saving gap was forecast to be predominant, contrary to C-S expectations, while in only 7 did the trade gap predominate. ("Predominate" here means "was binding in at least the last 3 years." Actually, in the great majority of cases, one gap held throughout the entire projection period.) In most cases the C-S projections underestimate GNP as a function of exports and capital inflow. In saving-constrained growth, this was usually the result of underestimating saving as a function of GNP, while the capital-output relation was predicted much more accurately. In trade-constrained growth, of course, the underestimates resulted from a general overestimation of import requirements.

Maizels

The Maizels projections were actually based on a one-gap model which is derivative from the basic two-gap structure. He forecasted investment as a function of imports and then GDP through a standard capital-output relation. This makes for the possibility of straightforward regression analysis and prediction, not possible in ordinary two-gap models. Our base year is again 1962.

The results are remarkably good by the PRMSE criterion, especially when the orders of magnitude are compared to the

C-S results. There is no systematic bias upwards or downwards in any of the relations. The sample, however, is quite small, since Maizels only worked with Sterling currency countries, and it turns out that C-S did as well with these same countries.

Chenery and Eckstein

The Chenery and Eckstein (C-E) projections dealt only with Latin American countries and used 1964 as the last data year. Two projections were prepared in the study; the first did not allow for exchange-saving production, while the second did. The C-E model was much more sophisticated than the others; it included an influence of exports on savings and of exports and foreign exchange reserves on import requirements. This addition to the import equation was an attempt to estimate correctly the import equation under conditions of saving-constrained growth, which cannot be done by conventional techniques as pointed out in Section II.

An inspection of the results showed that the first variant turned out to be more accurate, confirming the impression gained in Section II that there is little evidence of import-substituting investment under conditions of trade-constrained growth. In the C-E results, we see that, in 10 of the 14 countries, savings-constrained growth predominated, much as in the C-S results. Again, there was a tendency toward underprediction, and again it seemed to be the result of too pessimistic saving functions along with less pessimistic capital-output relations.

UNCTAD

Using 1964 as the base year, UNCTAD predicted relations among GDP, exports, and capital inflow. Although some of the country studies were quite detailed for this evaluation, we have used only summary statistics reported in the UNCTAD study. As a consequence, we may be underestimating the accuracy of the entire UNCTAD study. Again, two performance variants were provided, but in this case the more optimistic set of parameters turned out to be more accurate. The structure of the basic UNCTAD model is quite similar to that of the C-S model, but does not contain a growth-of-investment constraint.

The results show no bias toward under- or overestimating GDP, but the PRMSE criterion shows these results to be somewhat worse than the others here considered. For example, PRMSE figures of .10 or above, a convenient cutoff point, are much more common here than in the other studies. This observation may be qualified by the fact that in those countries for which C-E and UNCTAD both tried to project, they do about the same. However, looking at C-S, whose projection period is two years longer, places UNCTAD in a worse light.

A Composite Evaluation

For the purposes of this paper, regression predictions of GNP and GDP were prepared, using both 1962 and 1964 as the last data year, for comparison with the predictions of the four studies just examined. The procedure was to regress GNP and GDP on: (a) a constant and imports deflated by home prices; (b) a constant and imports deflated by U.S. export prices; (c) a constant and S1 as defined in Section II; and (d) the final reduced form equation for the country as derived in Section II. The regression prediction was then based on that equation which had the highest r^2, subject to the constraint that all coefficients have the theoretically correct sign. The results of these equations are not presented here, but are available from the author upon request.

As was noted earlier, there is no straightforward way of estimating the two-gap model as it stands. Nonetheless, the works examined here made no formal allowance for the model's statistical difficulty, although all referred to some "adjustments" of the estimated coefficients to bring them more in line with a priori expectations. Thus, these models, and the consequent projections, were derived from a hybrid procedure of statistics and intuition. On the contrary, the regression predictions are perfectly statistically acceptable, but involve no post-regression tampering with coefficients. Comparative results are summarized in Table 5.

We see that in the 1962 base projections, Maizels and C-S, in those few countries for which they both project,

Table 5

Comparison of Projection Results[a]

	1962 Base Year		
	Chenery-Strout	Maizels	Regression Prediction
Chenery-Strout		3/5	19/30
Maizels			4/5
Regression Prediction			
Median PRMSE	.08	.04	.13
Maximum PRMSE	.40	.09	.54

	1964 Base Year		
	Chenery-Eckstein	UNCTAD	Regression Prediction
Chenery-Eckstein		2/5	8/14
UNCTAD			10/18
Regression Prediction			
Median PRMSE	.05	.11	.08
Maximum PRMSE	.20	.23	.72

[a] Intersection of row and column shows: (a) number of times the projection of the row was superior to that of the column; and (b) number of times both methods attempted to project income for the same country, with different results.

turn out about even, while both are superior to the regression results in about two-thirds of the cases. Median PRMSE scores show Maizels to dominate C-S, and C-S to dominate the regression forecasts. In the 1964 base forecasts, all three predictions are about even in frequency of best forecast, while in median PRMSE scores C-E beats regression, and regression dominates UNCTAD. The maximum-error criterion shows a serious deficiency in the regression predictions, for using both base periods they turned out a PRMSE greater than .50.

IV. Conclusion

This paper must end with somewhat mixed conclusions about the usefulness of two-gap models. The regression analysis of Section II was quite pessimistic about their ability to account for the existing data; few of the statistical inferences which could be drawn from strict scientific rules seemed to support the basic idea. However, given a lack of knowledge about the user's loss function, we cannot rule out the utility of the concept for projection purposes. Median PRMSE scores were not ridiculously high, and although the highest error was almost always greater than .10 (except in the Maizels case), it is not clear how a better technique might be found. The most interesting result was that over a short sample period (5 years), some simple regression predictions proved to be as good as detailed two-gap projections. This may lead the way to procedures which are both statistically sound and accurate in forecasting. Since none of the two-gap estimates, except that of Maizels, is statistically proper in the mathematical sense, it may be that the "feel" of the projectors added to the accuracy of the forecasts (each study referred to "adjustments" of estimated coefficients). Since the regression predictions were based on existing published data alone, they may in the long run provide more sure projections.

This use of intuitive adjustments of the estimated coefficients also explains how we can conclude that in the strict sense, the two-gap model is a failure in explaining past growth, while use of it by different analysts for predictive purposes may be satisfactory. The harsh test of past published data does not support the basic concept, at least as far as can be determined given the basic intractability of statistically implementing the model. However, some sophisticated forecasters, familiar with many extra-model considerations, have been able to pin down some relations which prove to have forecasting ability. To repeat and summarize, it appears that, at least over shorter periods, some regression predictions can equal those of the forecasters, but this again does not substitute for the statistical confirmation through historical data which was missed in Section II.

Footnotes

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[1]Chow (1960) describes the procedure for this test of structural change in the parameters. Basically, we divide the sample into two subperiods, fit a least-squares relation in each of the subperiods, and use estimated residual sums of squared errors to test whether the parameters are the same in each subperiod.

[2]These statistics are located on pp. 29, 36, and 37 of UNCTAD (1968).

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