TEXTO PARA DISCUSSÃO Nº 42

INVESTMENT CYCLES IN BRAZIL, 1947-1985

Ednaldo Araquém da Silva

Fevereiro de 1988

338.1
S586i Silva, Ednaldo Araquém.
1988 Investment cycles in Brazil, 1947-1985. - Belo Horizonte, CEDEPLAR/UFMG, 1988.
15p. - (Texto para Discussão, 42).

1. Ciclo Econômico - Brasil. 2. Teoria do Investimento - Brasil. 3. Kalecki.
CDU 338.1

CENTRO DE DESENVOLVIMENTO E PLANEJAMENTO REGIONAL DA UFMG

C E D E P L A R

INVESTMENT CYCLES IN BRAZIL, 1947-1985

Ednaldo Araquém da Silva*

* Professor Assistente na New School for Social Research (New York), e Professor Visitante no CEDEPLAR/UFMG.

Fevereiro de 1988

SUMARIO

INVESTMENT CYCLES IN BRAZIL, 1947-1985

Ednaldo Araquém da Silva

1. INTRODUCTION

This paper attempts to analyze the determinants of investment cycles in the postwar Brazilian economy, utilizing Kalecki's (1971) approach. We are primarily interested in learning whether Kalecki's model can generate endogenous investment cycles resembling those found in the postwar Brazilian economy. The analysis of economic cycles in Brazil has been little explored, partly due to the paucity of relevant time series. In this respect, this paper also makes a contribution in generating a time series for the Brazilian net capital stock. Kalecki (1971) developed parcimonious macroeconomic models, with few parameters to be estimated, but possessing comparatively strong explanatory power.

2. KALECKI'S INVESTMENT MODEL

A basic feature of Kalecki's investment model is the distinction of investment orders from the actual production and delivery of investment goods. Investment orders and deliveries are separated by a time-lag lasting in the average less than a year. As formulated in his "Outline of a Theory of the Business Cycle" (1971), Kalecki's investment model can be translated into three equations and three endogenous variables: P_t profits, C_{kt} capitalist consumption, and I_{t+1} planned investment (t denotes calendar years). Current investment, I_t, and K_t the capital stock are exogenous; u_t denotes random errors:

(1) $P_t = C_t + I_t$ (profit identity)

(2) $C_{kt} = a + b\,P_t + u_{1t}$ (capitalist consumption)

(3) $I_{t+1} = m\,P_t - n\,K_t + u_{2t}$ (investment)

All variables are measured in constant prices. The first equation is an accounting identity. The second is the capitalist consumption function. Workers are assumed to have no savings. The third equation is the investment function relating the rate of capital accumulation to the profit rate. The coefficients m and n are positive parameters each assumed to be less than unity.

Substituting Equation (2) into Equation (1), it can be observed that the level of current profits depends on the level of current investment:

(4) $P_t = a' + b'\,I_t + u'_t$ $(0 < b < 1)$,

where $a' = a/(1 - b)$, $b' = 1/(1 - b)$ is the profit multiplier, and $u' = u_1/(1 - b)$.

Patinkin (1982, p. 67) argues that Kalecki's "analysis does not prove the existence of investment cycles, but instead assumes it by virtue of the crucial assumption of a positive n." But Kalecki (1971, p. 5-6) shows that n is positive because m and K_t are both positive.

According to Equation (3), the value of investment orders is an increasing function of current investment and a decreasing function of the capital stock (Kalecki, 1971, p. 8). Substituting Equation (4) into Equation (3), we obtain the reduced-form investment equation:

$$(5) \qquad I_{t+1} = c + d\,I_t - n\,K_t + u_t,$$

where c = ma/(1 - b), d = m/(1 - b), and u_t is the random error.

Equation (5) represents the operation of three factors in the capitalist economy: the internally generated forces through the lagged effect of investment, the exogenous factors associated with the lagged capital stock, and the random disturbance. Investment has a contradictory effect on the capitalist economy: it stimulates the economy, but the increase in the capital stock (productive capacity) brings with it the prospect of economic crisis.

3. ESTIMATION OF KALECKI'S MODEL

Equation (5) has been estimated using Brazilian data for the period between 1947 and 1985. After several experiments, the adjustment lag was set at w = 0.25, involving a one-quarter lag. The relevant data are reproduced in the Appendix. All variables are expressed in billions of 1970 cruzeiros.

The regression results are presented as follows (with t ratios in parentheses):

$$I_t = \underset{(77.514)}{1.0422\,I_{t-0.25}} - \underset{(-3.549)}{0.0032\,K_{t-0.25}} + \underset{(2.404)}{0.7844}$$

$$\text{Adj } R^2 = 99.8 \qquad DW = 1.509 \qquad SE = 1.1594$$

Lagged investment $I_{t-0.25}$ was obtained approximately by adding 3/4 of investment in a given year to 1/4 of investment in the previous year. The variables I_t and K_t together explain 98 percent of the variation in $I_{t+0.25}$. The partial regression coefficients are statistically significant at the 5 percent level, and carry the expected signs. The Durbin H = 1.520 statistic[1] does not show evidence of autocorrelation among the residuals. The regression equation implies that an increase in current investment of one billion constant cruzeiros would increase planned investment by Cr$1 billion, while a similar increase in the capital stock would decrease planned investment by Cr$3.2 million. This means that ann increase in the capital stock has only a mild effect on the level of investment activity.

By making use of time lags in Equation (5), Kalecki (1971, p. 8-11) developed the "mechanism" underlying investment cycles in the capitalist economy. An increase in investment orders causes an increase in the capital stock. This will exert a depressing effect on investment activity, via n K_t. The résulting decrease in investment orders will unleash a downswing which is reversed only after investment orders fall below the replacement level of the depreciated capital stock. In time, the decline in the capital stock will again increase investment orders, via n K_t, and so the investment cycle is completed.

4. STABILITY ANALYSIS

The stability condition of Kalecki's investment model is ver important from the standpoint of economic policy. The reason is tha fluctuations in investment will be accompanied by fluctuations i employment and income. Kalecki's fundamental dynamic equation (5) will serve as the basis for the analysis of the investment cycle (see Pindyck and Rubinfeld, 1981, p. 384-88).

Net investment and the capital stock are related by the following identity:

(6) $$I_t = K_t - K_{t-1}.$$

Substituting Equation (6) into Equation (5), and transposing, we obtain:

(7) $$K_{t+1} - K_t - d\,(K_t - K_{t-1}) + n\,K_t = c,$$

or, equivalently:

(8) $$K_{t+1} + v\,K_t + d\,K_{t-1} = \text{constant},$$

where $v = (n - d - 1)$.

The difference Equation (8) has the following characteristic[1] equation:

(9) $$h^2 + v\,h + d = 0,$$

$$\text{or } h^2 - 2.0454\,h + 1.0422 = 0,$$

which can be solved for the two characteristic roots $h_1 = 1.0837$ and $h_2 = 0.9617$.

The cyclical oscillations in investment generated by Equation (5) may be stable, damped, or explosive, depending on the value of the coefficients d, n, and the time lag w. Since, according to the OLS estimates, the dominant root of the characteristic equation is positive, the time path of investment is nonoscillatory. But since the dominant root is slightly greater than unity, the nonoscillation is unstable, and will thus diverge from the equilibrium level. Therefore, the Brazilian economy appears to have been mildly unstable in the period from 1947 to 1985. This means that the postwar time path of the Brazilian capital stock, investment, employment, and income has been explosive but nonoscillatory.

The investment time path generated by the regression equation is shown in Figure 1. From econometric estimations of the coefficients d and n, Lange (1970, p.361) found that Kalecki's investment cycle, lasting about nine years, had a decreasing amplitude. But, as Lange (1970, p. 361) observed: "This cycle, however, does not come to an end because - according to Kalecki - certain accidental disturbances take place which set the fading cycle in motion again, and continue to keep it alive."

5 - SIMULATION PERFORMANCE

Figure 12 compares actual net investment with their predicted values generated from the regression equation. Predicted investment tracks actual investment very closely. A model designed for forecasting purposes should have as small a standard error of forecast as possible. A useful test of performance of <u>ex post</u> forecasts is Theil's inequality coefficient (see Theil, 1966, p. 28, 59; Pindyck and Rubinfeld, 1981, p. 364-365):

$$\text{Theil's U} = \text{SQR}\ \{\text{SUM}\ (P_t - A_t)^2 \ /\ \text{SUM}\ A_t^2\} = 0.0241.$$

This means that the root-mean-square error (RMS) of the regression equation is 2.4 per cent of the RMS error that would have been observed if we had been confined to a naive no-change forecasting.[3] Although the regression diagnostics show that Kalecki's model provides a powerfull explanation of postwar investment behavior in Brazil, it is important to recognize that the estimates are based on simplifying assumptions. Lacking suitable data, we assumed that both the state and foreign sectors were balanced in the period considered. A more suitable estimation of the capital stock (such as by the perpetual inventory method) would also be desirable. The model also failed to generate endogenous investment cycles.

6 - CONCLUDING REMARKS

This paper has shown that investment in postwar Brazil has behaved mildly unstable. However, Kalecki's model has been unable to generate endogenous cyclical behavior in Brazilian investment. This suggests that actual oscillations may have been generated by external impulses. All models tested in comparative analyses of the U.S. economy generated noncyclical behavior in the absence of shocks (see Zarnowitz, Boschan, and Moore, 1972). But this result is inconsistent with the expectation of investment behavior in the capitalist economy. The question arises whether Kalecki's model is a poor representation of the actual Brazilian economy in the postwar period.

NOTES

1 - The Durbin-Watson test is insuitable in the case of lagged endogenous variables. As an alternative, we use Durbin's statistic H = r SQR {(T/ [1 - T var(d)] }, where T is the number of observations, d is the coefficient of the lagged endogenous variable, and r = 1 - DW/2 is the coefficient of autocorrelation among the residuals. If H>1.645, the null hypothesis of zero autocorrelation is rejected at the 5 percent level (see Pindyck and Rubinfeld, 1981, p. 194-95).

2 - The transient solution of Equation (8) is found by setting the right-hand side of the fundamental dynamic equation equal to zero (after shifting the subscripts foward by one-period):

$$(8a) \qquad K_{t+2} + v\,K_{t+1} + d\,K_t = 0,$$

and then assuming that the solution of this equation is:

$$(8b) \qquad K_t = A\,h^t .$$

Substituting Equation (8b) into Equation (8a), we obtain:

$$(8c) \qquad A\,h^{t+2} + v\,A^{t+1} + d\,A\,h^t = 0$$

After dividing the above expression by $A\,h^t$, we obtain the quadratic Equation (9).

3 - The pair (P_t, A_t) stands for the pair of predicted and actual values. U = 0 if all the forecasts are perfect ($P_t = A_t$, for all t); also, U = 1 when the regression equation produces the same RMS error as naive no-change extrapolation (see Theil, 1966, p. 28).

REFERENCES

KALECKI, M. Selected essays on the dynamics of the capitalist economy. Cambridge: Cambridge University Press, 1971.

LANGE, O. "Michal Kalecki's model of the business cycle". Papers in Economics and Sociology. Oxford: Pergamon Press, 1970.

PATINKIN, D. Anticipations of the General Theory? Chicago: University of Chicago Press, 1982.

PINDYCK, R. and RUBINFELD, D. Econometric models & economic forecasting. New York: McGraw-Hill, 1981.

THEIL, H. Applied economic forecasting. Amsterdam: North-Holland, 1966.

ZARNOWITZ, V., BOSCHAN, C., and MOORE, G. "Business cycle analysis of econometric model simulations." In HICKMAN, B. (ed.), Econometric models of cyclical behavior. New York: Columbia University Press, 1972.

APPENDIX: DATA SOURCES AND METHODS

The Brazilian Gross Domestic Product (GDP), Gross Investment (GI), and Depreciation (D) are estimated by the Getulio Vargas Foundation (FGV - Rio de Janeiro) and usually reported in Conjuntura Economica. I_t used in the regression represents real private net investment. All the data are in 1970 cruzeiros. After several revisions, the FGV has not yet offered a consistent postwar series of the Brazilian National Accounts. We use the series concatenated by Masashi Namekawa, "Uma Nota sobre a Serie de Longo Prazo das Contas Nacionais: 1947-82" (no further information). The series have been updated to 1985 with information from Conjuntura Economica, March 1985 and January 1986.

Since Brazil does not have a benchmark estimate of the capital stock, the net capital stock (K) used in the regression equation was generated by a three step procedure: first, the capital-output ratio and the initial value of the net capital stock were estimated from Harrod-Domar's accelerator equation:

$$(A\text{-}1) \qquad K_t = v\,(GDP - D)_t$$

where K_t is the only unknown.

Taking the first-difference across Equation (A-1), we obtain:

$$(A\text{-}2) \qquad d\,K_t = v\,d\,(GDP - D)_t$$

$$(A\text{-}3) \qquad (GI - D)_t = v\,d\,(GDP - D)_t\,.$$

The capital-output ratio was estimated as the mean of

$$I_t / (Y_t - Y_{t-1}) = 2.828, \text{ std} = 1.398,$$

where I = (GI - D) denotes net investment and Y = (GDP - D) denotes Net Domestic Product. The capital-output coefficient was estimated for the trendless period 1947-1980.

Second, we estimated the initial value of the net capital stock with the computed capital-output ratio and the estimation of Potential Net Domestic Product. Examining the residuals of the log of the Brazilian Net Domestic Product regressed against time, we observe that its first major postwar peak, when actual output came closest to potential output, was attained in 1961. Hence, the initial net capital stock was estimated from the actual Net Domestic Product in 1961.

$$\text{(A-4)} \qquad K_{1961} = 2.828\ Y_{1961} .$$

Third, the net capital stock and net investment series are related by the following equation:

$$\text{(A-5)} \qquad K_t = I_t + K_{t-1} .$$

The Brazilian net capital stock generate with this procedure is reproduced in the Appendix.

GROSS DOMESTIC PRODUCT, GROSS INVESTMENT, DEPRECIATION,

AND NET CAPITAL STOCK IN BRAZIL

(In Billions of 1970 Cruzeiros)

YEAR	GDP	GI	D	K
1947	42.3	7.0	2.4	186.3
1948	45.7	7.4	2.9	190.7
1949	48.7	8.1	3.3	195.6
1950	51.6	9.1	3.7	201.0
1951	54.7	11.4	3.7	208.7
1952	59.9	12.6	4.4	216.9
1953	62.0	10.9	4.1	223.7
1954	68.1	12.2	4.1	231.9
1955	73.6	11.8	4.8	238.9
1956	76.6	13.0	5.0	246.9
1957	83.2	15.1	5.7	256.4
1958	90.0	16.4	5.3	267.5
1959	96.0	18.9	5.3	281.2
1960	105.6	20.7	6.0	295.8
1961	116.7	22.8	6.3	312.3
1962	123.1	24.5	6.3	330.5
1963	125.5	24.8	6.3	349.1
1964	130.3	26.5	6.9	368.7
1965	135.3	26.8	7.5	388.1
1966	140.7	31.1	8.1	410.9
1967	147.6	31.8	8.4	434.3
1968	164.1	38.4	9.3	463.4

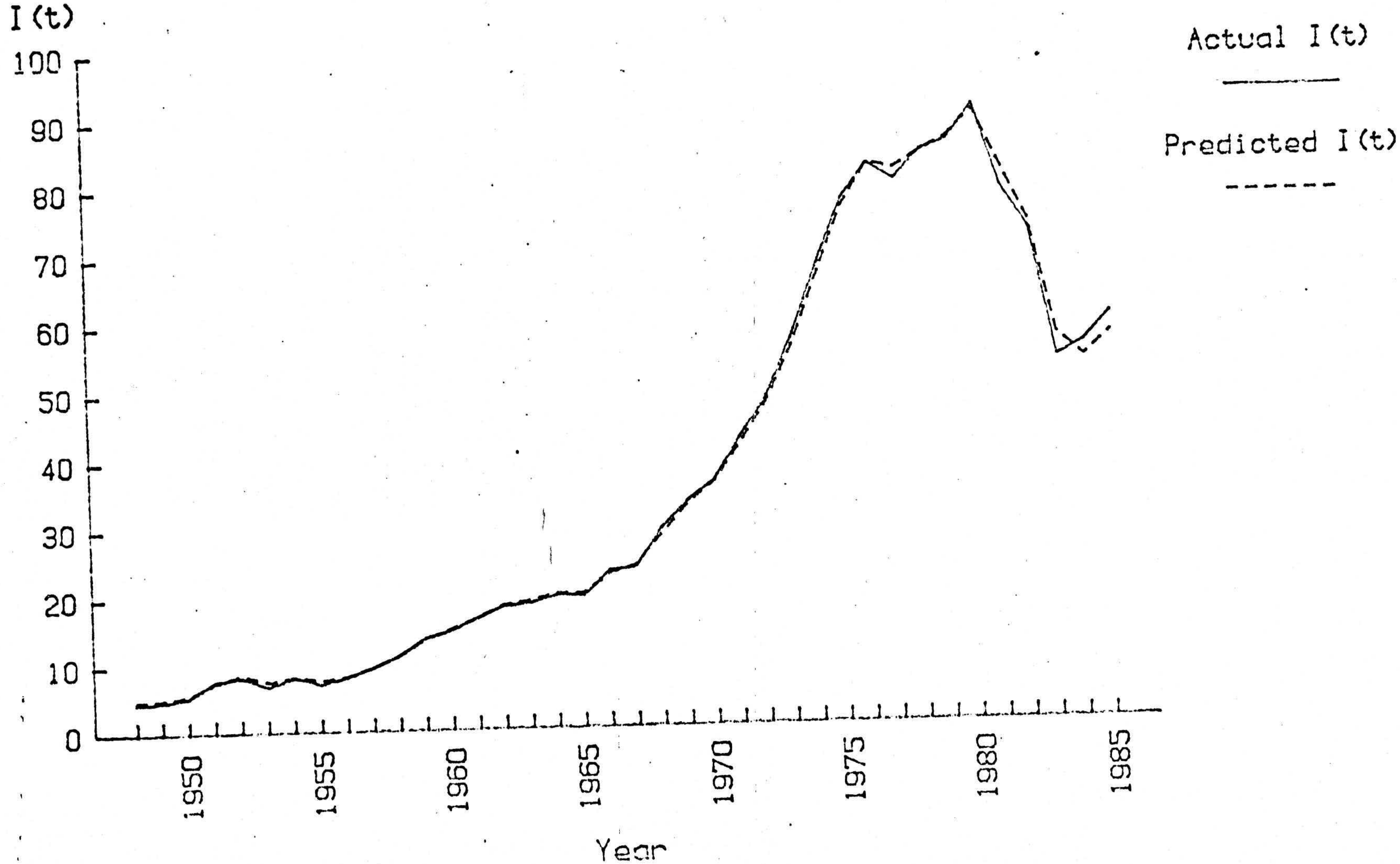
GROSS DOMESTIC PRODUCT, GROSS INVESTMENT, DEPRECIATION,

AND NET CAPITAL STOCK IN BRAZIL

(In Billions of 1970 Cruzeiros)

YEAR	GDP	GI	D	K
1969	180.3	43.0	10.0	496.4
1970	196.1	46.7	10.8	532.3
1971	219.7	54.3	12.1	574.6
1972	244.1	60.9	13.2	622.2
1973	277.2	71.6	15.0	678.8
1974	304.2	83.1	16.0	745.9
1975	320.6	93.7	16.8	822.8
1976	351.8	102.1	20.1	904.8
1977	372.0	100.2	20.6	984.4
1978	390.6	105.6	21.7	1,068.3
1979	415.6	109.8	24.5	1,153.6
1980	445.5	117.3	26.9	1,244.0
1981	438.6	103.2	25.0	1,322.3
1982	442.7	98.9	26.7	1,394.4
1983	428.7	81.6	28.4	1,447.6
1984	448.0	80.8	25.5	1,502.9
1985	485.1	87.1	27.6	1,562.4

BRAZIL, 1947 - 1985
ACTUAL AND PREDICTED NET INVESTMENT
(In billions of 1970 Cr$)



BRAZIL, 1947 - 1985
NET INVESTMENT CYCLES
(In billions of 1970 Cr$)