THE DETERMINANTS OF PRIVATE FOREIGN INVESTMENT IN NIGERIAN MANUFACTURING INDUSTRIES*

INTRODUCTION

Since the attainment of independence in 1960, various policies of the Nigerian government have been geared essentially towards promoting the growth and development of the Nigerian economy by influencing the trend behaviour of the gross fixed domestic investment through direct government investment or indirectly through policies aimed at stimulating the flow of private foreign investment into various sectors of the economy. The reasons for government's interest as indicated can be rationalized against the facts of economic theory and experience that investment expenditure influences aggregate demand and is, therefore, an important instrument for promoting growth, stabilization or counter-cyclical objectives. Consequently, it is of interest to ascertain the determinants of investment behaviour and then see how policy may be used to influence same.

Business fixed investment is indeed influenced by several factors. The expectation that existing markets will widen with population growth, or that new markets may be discovered sooner or later often lead businessmen to expand their existing level of plant, equipment and structures. Tied to this, of course, are other considerations such as profit expectation, which also depends on the market demand for the goods to be produced and their probable cost of production. Once it is decided to finance new capital equipment the rate of interest enters the investment decision either as a cost of capital or as the opportunity cost of using internal funds. Furthermore, various quantifiable and non-quantifiable factors enter into play including the stability of the political climate, changes in government tax structure and general fiscal policies, the rate of inflation and other factors which may affect the expected level of investment.

An examination of the relevant statistics[1] does show that within the last two decades or so, the Nigerian industrial sector has recorded significant growths which have not been well articulated in much of the research work on that sector. In particular, the determinants of investment behaviour from industry to industry which have been given rather scanty attention so far is an undesirable trend which should be arrested in view of the importance of investment in the economy as discussed above. Accordingly, we examine critically in this paper the determinants of private foreign investment in selected Nigerian manufacturing industries based on five theories of investment that have undergone rigorous testing on data for the developed countries and partially so for the developing countries. The theories include the Accelerator, Liquidity, Expected Profit, Neoclassical I, and Neoclassical II, while the industries are Footwear, Textile, Products of Petroleum, Furniture and Fixtures, Rubber Products, Beverages, Leather, Basic Metal, Food, Paper, Metal and Tobacco. The period covered by the study is 1966-76 and the source of data for this investigation is the Foreign Investment Survey conducted annually by the Research Department of the Central Bank of Nigeria.

The paper is organised into five sections. In Section I. we present a brief review of the theories of investment as found in the literature, while Section II discusses the econometrics of investment behaviour. Section III is devoted to a treatment of the nature and sources of data utilized while the empirical implementation of the econometric models is undertaken in Section IV. A summary and conclusion section then wraps up the study.

*This paper is based on some earlier drafts of chapters II, III and IV of my Ph. D. thesis which was submitted to the Department of Economics, University of Lagos, in 1981.

[1]See for example, the Industrial Production Index published in the *Annual Report*, Central Bank of Nigeria, Lagos (various issues).

I
THEORIES OF INVESTMENT BEHAVIOUR

While the development of a theory underlining business investment behaviour has provoked sharp disagreements among various theorists, the empirical implementation of the theories derived has produced no less conflicting results. A cursory survey[1] of empirical tests and findings indicates that these disagreements have their root causes in four main issues:

(i) the determinants of the desired level of capital;
(ii) the relationship between changes in the demand for capital services and investment expenditures;
(iii) the nature of replacement investment; and,
(iv) the time structure of the investment process.

Taking these issues one after the other, one finds, for instance, that alternative econometric models of investment behaviour differ in the determinants of the desired level of capital. In the rigid accelerator model of Clark[2] and the flexible accelerator model of Chenery and Koyck, desired capital is proportional to output. In alternative models of investment behaviour, desired capital depends on capacity utilization, internal funds, the cost of external finance and other variables.

[1]For example, a review up to 1953 was given by J. Meyer and E. Kuh, *The Investment Decision*, Cambridge, Mass., Harvard Univ. Press 1957. Another review up to 1960 was presented by R. Eisner and R.H. Strotz, 'Determinants of Business Investment,' in Commission on Money and Credit, *Impacts of Monetary Policy*, Prentice Hall: Englewood Cliffs, N.J., 1963. A fairly more recent survey is that of D.W. Jorgenson, 'Econometric Studies of Investment Behaviour: A Survey', *Journal of Economic Literature*, 9, 4, 1111-1147, 1971. See also, J.F. Helliwell (ed) *Aggregate Investment*, Richard Clay (The Chaucer Press) Ltd., Bungay, Suffolk, 1976, for more recent controversies in the literature.

[2]J.M. Clark, 'Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles,' *Journal of Political Economy*, March 1917, 25(1). pp. 217-35.

The latter variables have been associated with the theories of finance of Duesenberry[1], Meyer and Kuh[2], and of Modigliani and Miller[3]. These determinants of the desired stock of capital are common to the empirical studies of Eisner[4], Grunfeld[5], Jorgenson and Siebert[6], and Kuh[7] undertaken both at the level of individual firms and for industry groups and employing annual observations.

On the other hand, the relationship between changes in the demand for capital services and investment expenditures has been examined with reference to the flexible accelerator model of investment originated by H.B. Chenery[8], and L.M. Koyck[9]. Thus, if K represents actual level of capital and K^* its desired level, capital is then adjusted towards its desired level by a constant proportion of the difference between desired and actual capital.

$$K_t - K_{t-1} = (1 - \lambda)[K^*_t - K_{t-1}] \quad (1)$$

Under the assumption commonly employed in empirical work that replacement investment follows a geometric mortality distribution, the change in capital stock may be written:

$$K_t - K_{t-1} = I_t - \delta K_{t-1} \quad (2)$$

where I is gross investment, δ is the rate of replacement, a fixed constant, and K is the actual capital stock. Combining equation (2) with the flexible accelerator model of net investment in equation (1) we obtain a model of investment expenditures following Jorgenson,[10]

$$I_t = (1 - \lambda)[K^*_t - K_{t-1}] + \delta K_{t-1} \quad (3)$$

where K^* is desired capital stock and $(1-\lambda)$ is the co-efficient of adjustment.

Again, alternative econometric models of investment behaviour differ in the characterisation of the time structure of the investment process with the basic premise that desired capital is determined by long-run considerations. In the flexible accelerator model of Chenery and Koyck, the time structure of the investment process is characterised by a geometric distributed lag function. Thus, from (1) we have,

$$K_t = (1 - \lambda)\sum_{\tau=0}^{\infty} \lambda^\tau K^*_{t-\tau} \quad 0 < \lambda < 1 \quad (4)$$

Hence, actual capital is a distributed lag function of desired capital with geometrically declining weights[11].

In the studies by Jorgenson and Siebert[12] the version of the flexible accelerator employed treats net investment as a distributed lag function of changes in desired capital wherein the weights associated with changes in desired capital are approximated by the weights in a rational distributed lag function. Estimates of average lags obtained from rational distributed lag functions[13] have been shown to be consistent with survey evidence on the lag structure while average lags resulting from studies based on the geometric distributed lag function have been reported to be biased upward.

Most studies that include replacement investment explicitly employ the geometric mortality distribution for investment goods with the exception of Evan's[14] study of investment by industry groups. The geometric mortality distribution both implies that replacement is proportional to capital stock and that capital stock is a weighted sum of past gross investments with geometrically declining weights. Eisner,[15] Grunfeld,[16] and Jorgenson and Siebert,[17] employed this distribution in the study of investment by individual firms while Bourneuf,[18] Eisner,[19] and Jorgenson and Stephenson,[20] used it in the study of investment by industry groups.

A formal characterization of replacement investment has been presented in one of the studies by Jorgenson and Stephenson[21] wherein they argued that replacement investment denoted IR tends to depend on the level of capital stock and also on its age structure. More concretely, replacement investment is a weighted average of past gross investments, so that,

$$IR_t = \delta I_{t-1} + \delta(1 - \delta)I_{t-2} + \dots\dots\dots$$

[1]J.S. Duesenberry, *Business Cycles and Economic Growth*, McGraw Hill, New York, 1958.

[2]J. Meyer and E. Kuh, op. cit.

[3]F. Modigliani and M.H. Miller, 'The Cost of Capital, Corporation Finance and the Theory of Investment', *Amer. Econ. Rev.*, June 1958, 48(3) pp. 261-97.

[4]R. Eisner, 'Realization of Investment Anticipations' in J. Duesenberry, G. Fromm, L.R. Klein and E. Kuh (eds) *The Brookings Quarterly Model of the United States*. Amsterdam: North Holland, 1965.

[5]Y. Grunfeld, 'The Determinants of Corporate Investment' in A.C. Herberger (ed) *The Demand for Durable Goods*, Univ. of Chicago Press, Chicago, 1960.

[6]D.W. Jorgenson and C.D. Siebert, 'A Comparison of Alternative Theories of Corporate Investment Behaviour', *Amer. Econ. Review*, Sept. 1958, 58(4) pp. 681-712; and 'Optimal Capital Accumulation and Corporate Investment Behaviour', *J. Polit. Econ.*, Nov-Dec. 1968, 76(6), pp. 1123-51.

[7]E. Kuh, *Capital Stock Growth: A Micro Econometric Approach*. Amsterdam.

[8]H.B. Chenery, 'Over-capacity and the Acceleration Principle', *Econometrica*, Jan. 1952, 20(1) pp. 1-28.

[9]L.M. Koyck, *Distributed Lags and Investment Analysis*, North-Holland, Amsterdam, 1954.

[10]D.W. Jorgenson, 'Econometric Studies ....' op. cit.

[11]It should be noted that the average lag of adjustment in this model is $\lambda(1-\lambda)$ indicating the average time required for a change in desired capital which continues indefinitely to be translated into a change in actual capital. The adjustment mechanism underlying the flexible accelerator may in fact be interpreted as a result of gestation lags. Alternatively, one may view it as resulting from an expectation formation process or both results may be operative.

[12]Jorgenson and Siebert, op. cit.

[13]See, for example, W.H.L. Anderson, *Corporate Finance, and Fixed Investment: An Econometric Study*, Div. of Research, Grad. School of Bus. Admin., Harvard Univ., 1964, B. Hickman, *Investment Demand and U.S. Economic Growth*, The Brookings Institution, Washington, D.C., 1965, Jorgenson and Siebert, op. cit., and Jorgenson and Stephenson, op. cit.

[14]M.K. Evans, 'A Study of Industry Investment Decisions,' *Rev. Econ. Statist.*, May 1967, 49(2), pp. 151-64.

[15]R. Eisner, 'A Permanent Income Theory for Investment,' *Amer. Econ. Rev.*, June 1976, 57(3), pp. 363-90.

[16]Grunfeld, op. cit.

[17]Jorgenson and Siebert, op. cit.

[18]A Bourneuf, 'Manufacturing Investment Excess Capacity and the Rate of Growth of Output,' *Amer. Econ. Rev.*, Sept. 1964, 54(5), pp. 607-25.

[19]R. Eisner, 'Realization of Investment Anticipations' in J. Duesenberry et. al. (eds), op. cit.

[20]Jorgenson and Stephenson, op. cit.

[21]D.W. Jorgenson and J.A. Stephenson, 'Investment Behaviour in U.S. Manufacturing 1947-1960', *Econometrica*, vol. 35, 169-220. See also R.F. Wynn & K. Holden, *An Introduction to Applied Econometric Analysis*, John Wiley & Sons, N.Y. 1974, pp. 23-24.

Using the lag operator, L such that $Lx_t = x_{t-1}$, $L^2x_t = x_{t-2}$ etc., we have,

$$IR_t = \delta LI_t + \delta(1-\delta)L^2I_t + \ldots\ldots$$

$$= \frac{\delta L}{1-(1-\delta)L}I_t$$

or,

$$I_t = \frac{(1-(1-\delta)L)}{\delta L} IR_t \qquad (5)$$

Since capital stock at the end of a period is the sum of all past net investments,

$$K_t = IN_t + IN_{t-1} + IN_{t-2} + \ldots\ldots$$

$$= (I_t - IR_t) + (I_{t-1} - IR_{t-1}) + (I_{t-2} - IR_{t-2}) + \ldots\ldots$$

$$= (1 + L + L^2 + \ldots\ldots\ldots\ldots)(I_t - IR_t)$$

$$= \frac{I_t - IR_t}{1-L}$$

Alternatively,

$$K_t = \frac{1}{1-L}\left[\frac{1-(1-\delta)L}{\delta L} - 1\right] IR_t$$

$$= \frac{IR_t}{\delta L}$$

Hence,

$$IR_t = \delta LK_t = \delta K_{t-1} \qquad (6)$$

Following the review presented so far, one may classify the theories of investment behaviour into four for the purpose of closer scrutiny: (i) The Accelerator Theory, (ii) the Liquidity Theory, (iii) the Expected Profits Theory and (iv) the Neoclassical Theory of Optimal Capital Accummulation.

The Accelerator Theory

The most important issues in the accelerator theory of investment behaviour[1] have already been touched upon, namely the proportionality between desired capital and output, and the proportionality between net investment and changes in desired capital as a description of the time structure of the investment process. Owing to dissatisfaction with this 'crude' form of the accelerator theory, modifications to it have been proposed to take account of some of its limitations[2] and hence provide the background to some alternative theories of investment expenditures which may be grouped under Liquidity, Expected Profit and the Neoclassical Theories.

The Liquidity Theory

Liquidity is here measured as the flow of internal funds available to the firm for investment. The basic premise underlying this theory of investment behaviour is a theory of the cost of capital which specifies that 'the supply of funds schedule is horizontal up to the point at which internal funds are exhausted and vertical at that point.'[3] Lund,[4] for example, lists five possible sources of funds for a firm as (i) depreciation allowances, (ii) net profits (that is, gross profits less taxes, and depreciation allowances), (iii) fixed interest borrowing, (iv) preference shares, and (v) equity shares. The first two sources are internal to the firm while the rest are external. Funds generated within the firm can, of course, be declared and paid out as dividends or used for investment purposes. Since both of these decisions are governed by different factors it may be safe to assume that the desired level of capital stock depends on the differential between internal funds and dividends. This has been referred to as the liquidity theory of investment behaviour where liquidity is measured as gross profits after tax plus depreciation less dividends.

The Expected Profits Theory

Many studies have specified the desired level of capital stock using current or realized profit as a measure of the expected profitability of investment. Grunfeld[5], on the other hand, has suggested discounted future earnings less the costs of future additions to capital as a better measure of expected profits. In other words, the stock market valuation of the company is the appropriate proxy variable for expected profit since stock market participants presumably possess as much information about the future as the managers of the firms and moreover they are economically motivated to analyse information relevant for assessing the future prospects of the firm. Thus, in the expected profits model, desired capital stock is made to depend on a measure of the stock market valuation of the company. This relationship was however based on Grunfeld's examination of individual corporation data and consequently may not necessarily hold true in an aggregate sense because the number of quoted companies changes rather frequently. Wynn and Holden[6] therefore suggested an alternative measure, namely, an index of the level of share prices which may correlate strongly with the stock market valuation of the companies included in the index. In this study, however, the most recent profit experience will be used as a measure of profit expectation. This could easily be regarded as rational behaviour on the part of businessmen operating in an underdeveloped economic environment.

The Neoclassical Theory

The neoclassical theory is yet again another theory which has been presented to compete with the theories of investment so far reviewed in this study. By applying the tool of comparative dynamics to the ordinary neoclassical theory of the firm Jorgenson derived a theory of investment which is based on an optimal time path for capital accumulation[7]. The procedure is as follows:

[1]This theory is also sometimes referred to as the capacity utilization theory since high levels of investment expenditure tend to be associated with high ratios of output to capital and vice versa.

[2]For a detailed list of these limitations see R.S. Eckaus, 'The Acceleration Principle Reconsidered,' *Quarterly Journal of Economics*, vol. 67, 1953, 209-30; D. Smyth, 'Empirical Evidence on the Acceleration Principle', *Review of Economic Studies*, vol. 31, 1964, 195-202 and, R.F. Wynn and K. Holden, op. cit. p. 25.

[3]Jorgenson & Siebert, 'An Empirical Evaluation of Corporate Investment', op. cit., p. 160.

[4]J. Lund, see also, Wynn and Holden, op. cit. p. 26.

[5]Y. Grunfeld, op. cit.

[6]Wynn and Holden, op. cit. p. 27.

[7]A rigorous reformulation of the theory of investment behaviour is given by D.W. Jorgenson, 'The Theory of Investment Behaviour', in R. Ferber (ed), *Determinants of Investment Behaviour*, (New York: National Bureau of Economic Research, 1967), pp. 129-155.

We start with a definition of the flow of net receipts:

$$R(t) = p(t)Q(t) - w(t)L(t) - q(t)I(t) \tag{7}$$

where,

R = flow of net receipts
P = the price of output
Q = the quantity of output
W = the price of labour input
L = the quantity of labour input
q = the price of capital goods
I = investment in durable goods.
t = time

If we define present value as the integral of discounted net receipts, net worth (W) is then given by the expression:

$$W = \int_0^{\infty} \exp[-\int_0^t r(s)\, ds]R(t)\, dt \tag{8}$$

where,

$r(S)$ = the rate of time discount at time s

If the rate of time discount $r(S)$ is taken to be a constant, the present value of the firm then reduces to the simple form:

$$W = \int_0^{\infty} e^{-rt}R(t)\, dt$$

Consistent with the objective of the firm, present value is maximized subject to two constraints:

(i) the rate of change of the flow of capital services is proportional to the flow of net investment[1] which is equal to total investment less replacement. If replacement is proportional to capital stock the first constraint then takes the form:

$$\dot{K}(t) = I(t) - \delta K(t) \tag{9}$$

where $K(t)$ is the time rate of change of capital services at time t;

(ii) the second constraint defines the production function for levels of output, labour and capital services in the form:

$$F(Q,L,K) = O \tag{10}$$

The maximization of present value (8) subject to the constraints (9) and (10) is achieved by maximising the Lagrangian expression:[2]

$$I_t = \int_0^{\infty}[e^{-rt}R(t) + \lambda_{0(t)}F(Q,L,K) + \lambda_{1(t)}(\dot{K} - I + \delta K)]\, dt \tag{11}$$
$$= \int_0^{\infty} f(t)\, dt$$

where,

$$f(t) = e^{-rt}R(t) + \lambda_{0(t)}F(Q,L,K) + \lambda_{1(t)}(\dot{K} - I + \delta K)$$

and, the time subscripts on K, I, and so on, have been dropped for notational convenience. Applying the calculus of variations technique[3] the Euler necessary conditions for a maximum of (11) are easily derived from which the marginal productivity condition for labour services may be derived as,

$$\frac{\partial Q}{\partial L} = \frac{W}{P} \tag{12}$$

and the marginal productivity condition for capital as,

$$\frac{\partial Q}{\partial K} = \frac{q(r + \delta) - \dot{q}}{p} = \frac{c}{p} \tag{13}$$

where

$$c = q(r + \delta) - \dot{q} \tag{14}$$

[1]The constant of proportionality may be interpreted as the time rate of utilization of capital stock or the number of units of capital service per unit of capital stock. Under the assumption that capital stock is fully utilized this constant may be taken to be unity. See Jorgenson, op. cit. p. 141.

[2]In general, the neoclassical model of optimal capital accumulation may be derived by maximizing present value of the firm, by maximizing the integral of discounted profits of the firm, or simply by maximizing profit at each point of time.

[3]See M.D. Intrilligator, *Mathematical Optimization and Economic Theory*, Englewood Cliffs, N.J., Prentice Hall, 1971.

This last expression defines the implicit rental value of capital services supplied by the firm to itself so that C is a shadow prices which the firm may use in computing an optimal path for capital accumulation. It should be noted that the conditions which determine the value of the variables that the firm must chose — output, labour input, and investment in capital goods — depend only on three things namely the rate of interest, prices, and the rate of change of the price of capital goods for the current period.

In summary then, the complete neoclassical model of optimal capital accumulation as presented thus far consists of (i) the production function (10), (ii) two marginal productivity conditions (12) and (13), and (iii) the two side conditions (9) and (14) which are differential equations. So we have,

$$F(Q,K,L) = O, \frac{\partial Q}{\partial L} = \frac{W}{P}, \frac{\partial Q}{\partial K} = \frac{c}{P}$$
$$\dot{K} = I - \delta K$$
$$c = q(r + \delta) - \dot{q}$$

In order to derive the determinants of the desired capital stock necessary for an empirical implementation of Jorgenson's theory of investment, a production function of the Cobb-Douglas type may be assumed:

$$Q = AK^{a}L^{1-a} \tag{15}$$

where a is the elasticity of output with respect to capital input. The marginal productivity condition (13) for capital input is then[4],

$$\frac{\partial Q}{\partial K} = aAK^{a-1}L^{1-a} = \frac{C}{P}$$

so that,

$$a(Q/K^*) = \frac{C}{P}$$

and,

$$K^* = a\,\frac{PQ}{c} \tag{16}$$

where K^* is the desired level of capital [5] and is then proportional to output and the relative prices of output and capital services.

Jorgenson, however distinguished two versions of his neoclassical theory depending on the treatment of the cost of capital. While he still accepts the Modigliani-Miller[5] hypothesis that the cost of capital is a weighted average of the return to equity and the return to debt, the return to equity may be measured in at least two ways:

(i) if capital gains on assets held by the firm are regarded as transitory then return to equity and the price of capital services may be measured excluding capital gains;

(ii) if such capital gains are regarded as part of the return to investment then the return to equity and the price of capital services should be measured inclusive of capital gains.

Consequently, the theory of investment behaviour incorporating capital gains is referred to as Neoclassical I and the theory excluding capital gains as Neoclassical II.

Our review of the theories of investment so far may be summarized as follows: First it is necessary to group the theories

[4]See Hall and Jorgenson 'Theory of Optimal Capital Accumulation', op. cit. p. 22.

[5]Modigliani and Miller, op. cit.

according to their specification of the desired level of capital. Second, the accelerator mechanism should be generalized both in its lag structure, as well as incorporating a model of replacement investment. In this way the various theories are unified so that differences in empirical results may be due to differences in alternative specifications of desired capital and, hence, alternative theories of investment behaviour.

Thus, desired capital in the theories of investment behaviour is alternatively specified as follows:

1. Accelerator: $K^*_t = aQ_t$

where a is the desired capital output ratio.

2. Liquidity: $K^*_t = aL_t$

where a is the desired ratio of capital to the flow of internal funds available for investment.

3. Expected Profits: $K^*_t = aV_t$

where a is the desired ratio of capital to the market value of the firm (or realized profit as used in the present study).

4. Neoclassical I: $K^*_t = a\frac{P_tQ_t}{c_t}$

$$c_t = \frac{q_t}{1 - u_t}\left[(1-u_tn_t)\delta + r_t - \frac{q_t - q_{t-1}}{q_t}\right]$$

where a is the elasticity of output with respect to capital input, c_t is the price of capital services, q_t the investment goods price index, δ the rate of replacement, r_t the cost of capital, u_t the rate of taxation of corporate income, and n_t the proportion of depreciation at replacement cost deductible from income for tax purposes.

5. Neoclassical II: $K^*_t = a\frac{P_tQ_t}{c_t}$

$$c_t = \frac{q_t}{1 - u_t}\left[(1 - u_tn_t)\delta + r_t\right]$$

where, a is once more the elasticity of output with respect to capital and capital gains have been set equal to zero. The procedure for generalising the accelerator mechanism now follows.

The assumption of geometrically declining weights in the flexible accelerator model (4) has been generalized by Jorgenson and Siebert[1] by adopting new weight series, u_τ, which are nonnegative and sum to unity:

$$u_\tau = 0, \sum_{\tau=0}^{\infty} u_\tau = 1 \ (\tau = 0, 1, \ldots\ldots\ldots)$$

Hence the distributed lag function (4) takes the form,

$$K_t = \sum_{\tau=0}^{\infty} u_\tau K^*_{t-\tau} \tag{17}$$

The flexible accelerator mechanism (1) is then generalised by first differencing both sides of the distributed lag function (17)

$$K_t = K_{t-1} = \sum_{\tau=0}^{\infty} u_\tau[K^*_{t-\tau} - K^*_{t-\tau-1}],$$

and adding the model of replacement (2)

$$I_t - \delta K_{t-1} = K_t - K_{t-1}$$

so that,

$$I_t = \sum_{\tau=0}^{\infty} u_\tau(K^*_{t-\tau} - K^*_{t-\tau-1}) + \delta K_{t-1} \tag{18}$$

Alternatively,

$$I_t = \mu(S)\,(K^*_t - K^*_{t-1}) + \delta K_{t-1}$$

where $\mu(S)$ is a power series in the lag operator S.

This completes our review of the available theories of investment behaviour which are later tested in this study on data for industry groups. However, before undertaking the testing exercise it is necessary to place the problem in its proper econometric setting. Thus it is important to fully characterize the form of the μ_τ weights appearing in equation (18). It is equally essential to discuss the estimation of these weights from an econometric standpoint and introduce the necessary assumptions concerning the distribution of the random errors in the estimating equations. These are some of the issues to which attention is turned in the next section.

[1]D.W. Jorgenson and C.D. Siebert, 'An Empirical Evaluation of Alternative Theories of Corporate Investment', in K. Brunner (ed) *Problems and Issues in Current Econometric Practice*, Ohio State University, Columbus, Ohio, 1972, pp. 155-217.

II
ECONOMETRICS OF INVESTMENT BEHAVIOUR

Distributed Lags

There exists already an extensive literature on distributed lags and their applicability in describing the investment process[1]. Various arguments have been presented in some of this literature to support the claim that firms adjust to changes in their desired stocks of capital over a given period and rarely instantaneously. The factors accounting for the delays in adjustment often include uncertainty, the lag involved in arranging for the financing of expenditures, and the lag between appropriations and actual expenditures[2].

In previous studies, three schemes of distributed lags have been proposed including the geometric distributed lag of Koyck[3], the Pascal distribution of Solow[1] and the generalization of these two in the rational distributed lag function of Jorgenson[2]. To see the nature of a distributed lag response of one variable upon another, consider the function,

$$Y_t = B(w_0X_t + w_1X_{t-1} + w_2X_{t-2} + \ldots\ldots\ldots\ldots)$$

with the usual restrictions

$$w_i > 0, \sum_{i=0}^{\infty} w_i = 1$$

The weights w_i can be regarded as probabilities and use can be made of the probability generating function $w(L)$ so that,

$$w(L) = w_0 + w_1L + w_2L^2 + w_3L^3 + \ldots\ldots\ldots\ldots$$

which is the distributed lag function. Koyck introduced the geometric lag distribution where $w_i = (1 - \lambda)\lambda^i$ or

$$w(L) = (1 - \lambda)\,(1 + \lambda L + \lambda^2L^2 + \ldots\ldots\ldots) = \frac{1-\lambda}{1-\lambda L}$$

Applying this to the relationship between X and Y, we have,

$$Y_t = Bw(L)X_t$$

[1]See for example P.J. Dhrymes, *Distributed Lags: Problems of Estimation and Formulation*, Holden Day, San Francisco; Z. Griliches, 'Distributed Lags: A Survey', *Econometrica*, 35, 1, 16-49, 1967; M. Nerlove, 'Distributed Lags and Unobserved Components in Economic Time Series', in W. Fellner et al. (eds), *Ten Economic Studies in the Tradition of Irving Fisher*, Wiley, New York, 1967, and 'Lags in Economic Behaviour', *Econometrica*, 40, 2, 221-51, 1972; and D.W. Jorgenson, 'Rational Distributed Lag Functions', *Econometrica*, 32, 1, 135-148, 1966.

[2]S. Almon, 'The Distributed Lag Between Capital Appropriations and Expenditures', *Econometrica*, vol. 33, (January 1965), pp. 178-196.

[3]L.M. Koyck, *Distributed Lags*, op. cit.

Thus, for the geometric lag

$$Y_t = B\frac{1-\lambda}{1-\lambda L}X_t$$

or,

$$(1-\lambda L)Y_t = B(1-\lambda)X_t$$

so that,

$$Y_t = B(1-\lambda)X_t + \lambda Y_{t-1}$$

The Koyck lag schemes therefore involves estimating only one parameter, λ. However, its main shortcoming relates to the suggestion that the major impact comes immediately while subsequent impacts have lesser strength. This assumption may not be completely true if, for instance a variable has to go through a two-stage process each of which takes time. In such a case, the lag distribution of the entire process will be a function of the two lag distributions of each stage and the entire process distribution will be a convolution of the stage processes. Also the probability generating function of the entire process will be the product of those of the two stages. So, assuming the same lag for the two stages the distribution of the process lag will be

$$\begin{aligned} w(L) &= w(L)_1 w(L)_2 \\ &= (w(L)_1)^2 \\ &= \frac{(1-\lambda)^2}{(1-\lambda L)^2} \end{aligned}$$

This is a Pascal distribution for two stages which can be expanded to yield the final form:

$$Y_t = B(1-\lambda)^2X_t + 2\lambda Y_{t-1} - \lambda^2 Y_{t-2}$$

As it is less restrictive than the Koyck scheme Solow[1] proposed the Pascal Lag distribution form. The final form of the distribution when r stages are allowed for can be derived from the distribution

$$W(L) = \frac{(1-\lambda)^r}{(1-\lambda L)^r}$$

as,

$$Y_t - \binom{r}{1}\lambda Y_{t-1} + \binom{r}{2}\lambda^2 Y_{t-2} \quad .. + (-1)^r\lambda^r Y_{t-r} = B(1-\lambda)^r X_t$$

Unfortunatley the Pascal lag distribution of Solow suffers from the estimation problem of non-linearity in parameters which Jorgenson[2] attempted to overcome by generalizing the form in such a way that the roots of the polynominal no longer need to be equal. Thus, with r = 2

$$(1-\lambda L)(1-\lambda_2 L)Y_t = B(1-\lambda_1)(1-\lambda_2)X_t$$

which reduces to

$$Y_t = B(1-\lambda_1)(1-\lambda_2)X_t + (\lambda_1+\lambda_2)Y_{t-1} - \lambda_1\lambda_2 Y_{t-2}$$

Jorgenson even went further to prove that any arbitrary lag function can be approximated by the rational lag form

$$w(L) = \frac{u(L)}{v(L)}$$

where u (L) and v (L) are polynominals in the lag operator. This includes the Koyck and Solow schemes as special cases.

Because the rational lag function is completely general the criterion adopted by Jorgenson and Siebert[3] to determine the most satisfactory specification of w(L) is to choose the lag structure which minimises the residual variance subject to the condition that the signs of the estimated parameters satisfy their a priori expectations. This approach is of course equivalent to maximizing the value of $\bar{R}^2$. It may be noted that further constraints on the weights w_i are $w_i \geqslant 0$ and $w_i = 1$. An expansion of the equation $w(L) = \frac{u(L)}{v(L)}$ for the quadratic case yields

$$w_o + w_1L + w_2L^2 = \frac{u_o + u_1L + u_2L^2}{v_o + v_1L + v_2L^2}$$

where $v_0 = 1$ by the normalization rule.

To illustrate how the rational lag form enters the investment function consider the case where u(L) and v(L) are both linear in L so that

$$u(L) = u_o + u_1L$$
$$v(L) = v_0 + v_1L$$

From earlier results,

$$I_t = w(L)(K^*_t - K^*_{t-1}) + \delta K_{t-1} + z_t$$

where w(L) now represents the original $\mu(S)$ in equation (19). Rearranging and applying the rational lag distribution gives

$$v(L)(I_t - \delta K_{t-1}) = u(L)(K^*_t - K^*_{t-1}) + v(L)z_t$$

which is a mixed moving average and autoregressive scheme in changes in the desired level of capital and net investment.

Hence,

$$(v_0 + v_1L)(I_t - \delta K_{t-1}) = (u_0 + u_1L)(K^*_t - K^*_{t-1}) + v(L)z_t$$

Simplifying yields,

$$v_0(I_t - \delta K_{t-1}) = u_0(K^*_t - K^*_{t-1}) + u_1(K^*_{t-1} - K^*_{t-2}) - v_1(I_{t-1} - \delta K_{t-2}) + v(L)z_t$$

By normalising v_0 so that $v_0 = 1$, we have the equation to be estimated as

$$I_t = u_0(K^*_t - K^*_{t-1}) + u_1(K^*_{t-1} - K^*_{t-2}) - v_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1} + \epsilon_t \qquad (20)$$

where, $E_t = z_t + vz_{t-1}$

Suitable substitutions for the desired capital stock K^*_t from the theories of investment behaviour presented in section 1 will lead to our final estimating equations as follows:

1. Accelerator Investment Function:

Since desired capital is proportional to output under the Accelerator theory, we may write the complete Accelerator theory of investment behaviour as

$$I_t = \alpha u_0(Q_t - Q_{t-1}) + \alpha u_1(Q_{t-1} - Q_{t-2}) - v_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1} + \epsilon_t$$

2. Liquidity Investment Function:

Under the liquid theory of investment behaviour, desired capital is proportional to liquidity whereby we may write the complete theory as

$$I_t = \alpha u_0(L_t - L_{t-1}) + \alpha u_1(L_{t-1} - L_{t-2}) - v_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1} + \epsilon_t$$

3. Expected Profits Investment Function:

Similarly, desired capital is proportional to realized profit of the firm in the Expected Profits theory of investment behaviour and hence its complete specification may be written:

$$I_t = \alpha u_0(V_t - V_{t-1}) + \alpha u_1(V_{t-1} - V_{t-2}) - v_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1} + \epsilon_t$$

4. Neoclassical Investment Function:

In the neoclassical theory of investment behaviour desired

[1] R.M. Solow, 'On a Family of Lag Distributions', *Econometrica*, vol. 28, 393-406, (1960).

[2] D.W. Jorgenson, 'Rational Distributed Lag Functions', op. cit.

[3] Jorgenson and Siebert, op. cit.

capital is proportional to the value of output divided by the price of capital services whereby we can write the complete theory as:

$$I_t = \alpha u_0\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \alpha u_1\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) + v_1(I_{t-1} - \delta K_{t-2}) + \delta K_{t-1} + \epsilon_t$$

This general form holds for both Neoclassical I and Neoclassical II functions the difference for estimation purposes being due only to the assumptions about capital gains in the computation of c_t — the price of capital services — and its lagged values.

Estimation of Parameters

In order to estimate the parameters of our theory of investment behaviour based on the generalized accelerator mechanism and the five alternative speficiations of the desired level of capital, we note that in the final form of the rational distributed lag function, gross investment is a function of changes in desired capital, lagged values of net investment and the lagged value of capital. Hence, we can write, as before, the complete Accelerator theory of investment behaviour as,

$$I_t = \alpha u_0\left[\left(\frac{PQ}{c}\right)_t - \left(\frac{PQ}{c}\right)_{t-1}\right] + \alpha u_1\left[\left(\frac{PQ}{c}\right)_{t-1} - \left(\frac{PQ}{c}\right)_{t-2}\right] - v_1(1_{t-1}\delta K_{t-2}) + \delta K_{t-1} + \epsilon_t$$

We estimate the parameters — α, u_0, u_1,$v_1\delta$ — from data on output, capital stock, and investment expenditures. Owing to the fact that the weights in the distributed lag function must sum up to unity, we require the coefficients of this function to satisfy,

$$u_0 + u_1 - v_1 = 1$$

or,

$$u_0 + u_1 = 1 + v_1$$

This constraint then allows us to estimate the parameters — , u_0, u_1, v_1, — from estimates of αu_0, αu_1, and v_1.

The rate of replacement, δ, which occurs in our final estimating equation above may be estimated directly during the process of estimating capital stock. One then evaluates a series of net investments, $I_t - \delta K_{t-1}$, and substitutes same into the final estimating equation. The equation is estimated and the resulting co-efficient of K_{t-1} is compared with the value of δ from the data. If the two differ, the co-efficient of K_{t-1} is used as the new value of δ and the new process is repeated until the two values are close together. In order to obtain the initial value of δ from the data, we note that,

$$I_t - IR_t = K_t - K_{t-1}$$

or

$$IR_t = \delta K_{t-1} = I_t - (K_t - K_{t-1}) \tag{21}$$

Summing for t = 1 to t = N yields,

$$\delta \Sigma K_{t-1} = \Sigma I_t - (K_N - K_0)$$

so that,

$$\delta = \frac{\Sigma I_t - (K_N - K_0)}{\Sigma K_{t-1}} \tag{22}$$

Distribution of Errors

To estimate the parameters of the distributed lag function for each theory of investment behaviour so far specified, we assume that the error term z_t is distributed independently on successive observations with zero mean and constant variance. However, the final error term ϵ_t has the potential of being autocorrelated. Accordingly, we estimate the model and test for serial correlation. This approach has previously been employed by Chenery,[1] Grunfeld,[2] Jorgenson and Stephenson,[3] and Kuh[4] in studies based on the flexible accelerator mechanism and its generalization and has been justified on the following grounds:[5]

(i) all the variables used were deflated which should eliminate the effects of common price trends;

(ii) the investment series appear largely in first difference form which should remove much of the trend in the capital stock data and,

(iii) any further trend in the investment data should be traced to an increasing rate of replacement investment induced by the capital stock variable.

However, the Durbin Watson (D.W.) 'd' Statistic[6] normally used in testing for serial correlation in regression disturbances has a number of shortcomings. One of these is the fact that the test is inapplicable when observations are fewer than fifteen. Another problem is the inconclusive region over which the test is powerless in diagnosing serial correlation. Furthermore, in our situation of distributed lags, transformation of a 'd' to an 'h' statistic as recommended by Durbin[7] for testing purposes is rendered infeasible by the fact that the number of observations has to exceed thirty.

Consequently, in this study, we resort to a non-parametric test for serial correlation as developed by Geary.[8] The test is based on observing the pattern of residuals from a regression run. More specifically, assume that we have a set of residuals from a regression run. We then examine these residuals and note the number of sign changes τ'. Given the number of observations T for the regression under consideration, we compare τ' with tabulated minimum and maximum values of τ at specified probability levels. If the inequality τ min $\leq \tau' \leq \tau$ max holds from our comparison where τ min and τ max represent minimum and maximum values of τ respectively, we then accept the hypothesis that the errors are randomly distributed. If the inequality fails, we accept the alternative hypothesis of positive serial correlation. This is the approach adopted in Section IV in testing for serial correlation among the estimated functions.

[1]H.B. Chenery, 'Over-capacity and the Acceleration Principle', op. cit.

[2]Y. Grunfeld, op. cit.

[3]D.W. Jorgenson & J.A. Stephenson, 'Investment Behaviour ....', op. cit.

[4]E. Kuh, op. cit.

[5]See D.W. Jorgenson, op. cit.

[6]J. Durbin and G.J. Watson, 'Testing for Serial Correlation in Least Squares Regression, I & II', *Biometrika*, 37 (1950), 409 and 38 (1951), 145.

[7]J. Durbin, 'Testing for Serial Correlation in Least Squares Regression when some of the Regressors are Lagged Dependent Variables', *Econometria*, vol. 38, pp. 410-421, 1970.

[8]R.C. Geary, 'Relative Efficiency of Count of Sign Changes for Assessing Residual Autoregression in Least Squares Regression', *Biometrika*, 57 (1970), 123.

METHODS OF MEASUREMENT AND SOURCES OF DATA

Methods of Measurement

Investment

Ordinarily, investment is the monetary value of gross expenditures on equipment and plant which may be obtained in real terms through deflating by the investment goods deflator. In this study, investment is measured as annual cumulative private foreign investment (CPFI) in each of the twelve industry groups while the choice of a deflator is obtained from the ratio of nominal gross fixed investment (GFI) to that of GFI at constant 1962 prices.

Capital Stock and Depreciation

Benchmark figures were obtained for capital stock by taking net fixed assets for 1966 and 1976 and deflating them by the GFI deflators. With the CPFI expressed in constant prices and the two benchmark figures of capital stock, we computed the remaining capital stock figures and replacement figures using the following model for replacement:

$$K_t = (1-\delta)K_{t-1} + I_t$$

where I_t is gross investment, K_t is capital stock and δ is the rate of depreciation. The solution to this difference equation in capital stock is:

$$K_t = (1-\delta)^t K_0 + (1-\delta)^{t-1} I_1 + (1-\delta)^{t-2} I_2 + \ldots\ldots + (1-\delta) I_{t-1} + I_t$$

Where K_0 and K_t are initial and terminal values of capital stock. An estimate for δ was obtained from the replacement model as,

$$\delta = \frac{\sum I_t - (K_t - K_0)}{\sum K_{t-1}}$$

This value of δ was then used in the difference equation to compute capital stock for the other periods and to compute replacement for all periods. It was not possible to compute capital stock by the perpetual inventory method because the data series were not long enough to calculate the required depreciation rate based on the average length of life of the fixed assets.

Output

For the output variable, we employed the current value of sales, P_tQ_t which is the variable usually employed as the numerator of the Neoclassical and Accelerator models. More appropriately, one should compute output as sales plus the change in finished goods inventory but this was not feasible in our case because most companies either did not report on inventory at all or when they did they failed to break this down into finished goods, goods-in-process and raw materials. The output variable in the Accelerator model was deflated by the GFI deflator in the absence of a wholesale price index for each industry.

Liquidity

The liquidity variable employed was measured by profits after taxes plus depreciation less dividends paid. The deflator for the liquidity variable was the GFI deflator.

Expected Profit

In the Expected Profits model current profits were used as a measure of expected profit and deflated by the GFI deflator.

User Cost and the Cost of Capital

For the Neoclassical model I which includes capital gains, the price of capital services which is the denominator of the desired capital stock is defined as

$$c_t = \frac{q_t}{1-u_t} \left[(1 - u_t n_t)\delta + r_t - \frac{\dot{q}_t}{q_t}\right]$$

The GFI deflator was used to measure the price of investment goods, q. The rate of depreciation, δ, was obtained as shown above, while the rate of change of the GFI deflator was taken as the measure of the rate of capital loss, $\frac{\dot{q}}{q}$. The income tax rate, u, was measured by taking the ratio of profits before taxes less profits after taxes to profits before taxes. The proportion of depreciation deductible for tax purposes, n, was taken as the ratio in current prices of depreciation deducted in the firm's accounts aggregated for all firms (as per cent of fixed assets) and the depreciation figure which was computed in the process of computing capital stock.

In the second Neoclassical model, the term involving capital gains is set equal to zero. Hence the expression for the price of capital services becomes.

$$c_t = \frac{q_t}{1-u_t} (1 - u_t n_t)\delta + r_t)]$$

where all variables are measured as before except for, r, the cost of capital. In the original Jorgenson model the measurement of the cost of capital, r, in both Neoclassical models I and II contained variables such as the market value of all of the firm's securities, various types of assets such as depreciable, depletable and inventory assets together with their corresponding price deflators. Since data do not exist for these variables yet in our economy we merely used the minimum bank lending rate of interest as a measure of the cost of capital.

Sources of data

The most important single source of data for this study is the annual foreign investment survey undertaken since 1961 by the Research Department of the Central Bank of Nigeria (CBN). The survey covers approximately 600 foreign owned businesses in Nigeria and represents the most authoritative source for such statistics in Nigeria. Since 1961 also, the results of the survey have generally been published in the Bank's Economic and Financial Review on an annual basis with a lag of about three years.

While data have been reported on a sectoral basis over the years a further breakdown of the manufacturing sector on an industry basis began to feature consistently since about 1966. Accordingly, this study is restricted to the sample period 1966-1976 and for twelve industry groups under the manufacturing sector. The Industrial Survey of the Federal Office of Statistics (F.O.S.) which otherwise could have competed with the CBN survey is subject to considerable lags and gaps in data reporting.

Other sources have been used to supplement the CBN data where necessary. By and large, the data resulting from these other sources are deflators except for the cost of capital variable — the minimum bank lending rate of interest — which was obtained from various issues of the International Financial Statistics published by the International Monetary Fund, USA. A complete list of the variables used is as follows:

List of Variables

Investment, I_t = Cumulative private Capital inflow into manufacturing industries.

Deflator, q_t = Ratio of nominal gross fixed investment to gross fixed investment at constant 1962 prices.

Capital Stock, K_t = *Net fixed assets* with benchmark figures for 1966 and 1976 and q_t as deflator.

Output, Q_t = Current sales deflated by C_t

Liquidity, L_t = Profits after tax plus depreciation minus dividends paid divided by investment goods deflator.

Expected Profit, V_t = Current profit divided by investment goods deflator.

Price of Investment goods, q_t = Investment goods deflator.

Price of Capital Services, c_t = Includes capital gains for Neoclassical I model but excludes it for Neoclassical II model.

Rate of depreciation, δ = Rate of replacement as obtained from capital stock formula.

Cost of capital, r_t = Minimum bank lending rate of interest.

Rate of corporate income tax, u_t = Profits before tax minus profit after tax divided by profit before tax.

Proportion of depreciation deductible for = Depreciation deducted in firm's account tax purposes, n_t (summed over firms in the industry) divided by δ.

Rate of capital loss, $-\frac{\dot{q}}{q}$ = Rate of change of investment goods deflator.

IV
EMPIRICAL RESULTS

The distributed lag functions specified in section II have been fitted to annual data from twelve manufacturing industries in Nigeria for the sample period 1966 to 1976 representing the period for which comparable and consistent data were found available. The choice of industries while reflecting data availability, turned out to be equally representative of a broad categorization of the Nigerian manufacturing sector into durable and non-durable goods industries. Thus the industries selected include: Food, Beverages, Textile, Footwear, Furniture and Fixtures, Metal Products, Petroleum Products, Paper and Paper Products, Rubber, Leather, Tobacco, and Basic Metal. In this section, empirical results are reported on the determinants of investment behaviour in these industries based on the tool of multiple regression analysis.

Estimates of the Distributed Lags

In order to provide a meaningful basis for the comparison of alternative theories of investment behaviour a linear rational distributed lag function was selected from among the wide range of general Pascal distributed lag functions. Such a rational lag distribution of a reasonably low order also allows one to more efficiently estimate structural parameters in a situation of fairly limited time series data similar to ours. A linear rational lag distribution for our investment functions should then contain, as explanatory variables, one current and one lagged change in desired capital, one lagged value of net investment and current level of replacement. These specifications, coupled with the fact that the competing theories of investment behaviour have been standardized through the generalized accelerator mechanism, enable one to compare these theories in terms of how well they are able to explain the determination of investment by the selected group of Nigerian industries.

As revealed in Tables 1-12, we have determined the best distributed lag functions for each of our competing theories and for each of the twelve sampled industries based on available data for the period 1966 to 1976. The derived coefficients for each function are reported in the Tables with the t-ratio appearing in parenthesis below each regression coefficient. The usual rule of thumb may be applied in several cases to determine that a particular regression coefficient is significant at the 5 per cent level whenever the computed t-ratio indicates a value of two or more. On the basis of the t-ratio, the coefficient of multiple determination, and other criteria such as the number of significant coefficients of changes in desired capital, judgment can be made as to the overall best distributed lag function for each industry on which forecasts and policy decisions may then be based.

To provide a brief explanation about the interpretation of Tables 1-12, we take, as an example the Textile industry in Table 1. In the Liquidity theory of investment, desired capital is proportional to Liquidity, L_t. For the Textile industry, the distributed lag function under the Liquidity model contains the following explanatory variables — current and lagged changes in desired capital, lagged net investment and current replacement. Hence, the distributed lag function may be written in the final form as,

$$I_t = B + au_o(L_t - L_{t-1}) + au_1(L_{t-1} - L_{t-2}) - v_1(I_{t-1} - K_{t-2}) + \delta K_{t-t}$$

In Table 1, numerical values have been determined for each of the unknown parameters — B, au_o, au_1, v_1, δ — of this function. In particular,

$B = 7.1219, au_o = 0.0017, au_1 = 0.0008, v_1, = -1.2193, \delta = 0.4290.$

Further individual estimates of a, u_o, u_1, may be obtained by applying the restriction stated previously in section II. By

TABLE 1

ESTIMATES OF THE DISTRIBUTED LAGS
TEXTILE INDUSTRY

ACCELERATOR MODEL

$$\begin{array}{lllll} I_t = 15.6023 & -\ 0.2190\,(Q_t - Q_{t-1}) & +\ 0.0314\,(Q_{t-1} - Q_{t-2}) & +\ 0.6215\,(I_{t-1} - \delta K_{t-2}) & +\ 0.4315\,K_{t-1} \\ & (-5.5613) & (0.4223) & (1.9961) & (7.0544) \end{array}$$

$R^2 = 0.9879 \qquad d = 2.69$

LIQUIDITY MODEL

$$\begin{array}{lllll} I_t = 7.1219 & +\ 0.0017\,(L_t - L_{t-1}) & +\ 0.0008\,(L_{t-1} - L_{t-2}) & +\ 1.2193\,(I_{t-1} - \delta K_{t-2}) & +\ 0.4290\,K_{t-1} \\ & (2.3930) & (1.1390) & (2.9819) & (3.7610) \end{array}$$

$R^2 = 0.9469 \qquad d = 1.78$

EXPECTED PROFIT MODEL

$$\begin{array}{lllll} I_t = 30.8187 & -\ 0.0031\,(V_t - V_{t-1}) & -\ 0.0008\,(V_{t-1} - V_{t-2}) & -\ 1.0081\,(I_{t-1} - \delta K_{t-2}) & +\ 0.4772\,K_{t-1} \\ & (-1.8106) & (-0.6030) & (-0.9282) & (2.6530) \end{array}$$

$R^2 = 0.9228 \qquad d = 3.10$

NEOCLASSICAL MODEL I

$$\begin{array}{lllll} I_t = 16.8808 & -\ 0.1784\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) & -\ 0.0126\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) & +\ 0.6161\,(I_{t-1} - \delta K_{t-2}) & +\ 0.3966\,K_{t-1} \\ & (-4.0223) & (-0.1510) & (1.5475) & (4.7349) \end{array}$$

$R^2 = 0.9774 \qquad d = 3.32$

NEOCLASSICAL MODEL II

$$\begin{array}{lllll} I_t = 17.2519 & -\ 0.2084\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) & -\ 0.0073\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) & +\ 0.5687\,(I_{t-1} - \delta K_{t-2}) & +\ 0.3958\,K_{t-1} \\ & (-4.6491) & (-0.0809) & (1.5575) & (5.0612) \end{array}$$

$R^2 = 0.9825 \qquad d = 3.09$

TABLE 2

ESTIMATES OF THE DISTRIBUTED LAGS
FOOTWEAR INDUSTRY

ACCELERATOR MODEL

$$\begin{array}{lllll} I_t = -2.4174 & +\ 0.1317\,(Q_t - Q_{t-1}) & -\ 0.1584\,(Q_{t-1} - Q_{t-2}) & -\ 0.3694\,(I_{t-1} - \delta K_{t-2}) & +\ 1.5329\,K_{t-1} \\ & (2.0805) & (-3.1690) & (-0.7096) & (6.3949) \end{array}$$

$R^2 = 0.9907 \qquad d = 2.57$

LIQUIDITY MODEL

$$\begin{array}{lllll} I_t = -2.3094 & +\ 0.0016\,(L_t - L_{t-1}) & +\ 0.0068\,(L_{t-1} - L_{t-2}) & +\ 3.2451\,(I_{t-1} - \delta K_{t-2}) & +\ 0.7003\,K_{t-1} \\ & (4.6533) & (10.7232) & (9.0390) & (6.8404) \end{array}$$

$R^2 = 0.9989 \qquad d = 2.34$

EXPECTED PROFIT MODEL

$$\begin{array}{lllll} I_t = -2.0420 & +\ 0.0012\,(V_t - V_{t-1}) & +\ 0.0050\,(V_{t-1} - V_{t-2}) & +\ 2.9923\,(I_{t-1} - \delta K_{t-2}) & +\ 0.7084\,K_{t-1} \\ & (2.6664) & (6.1512) & (5.1488) & (4.0476) \end{array}$$

$R^2 = 0.9968 \qquad d = 2.37$

NEOCLASSICAL MODEL I

$$\begin{array}{lllll} I_t = -1.9633 & +\ 0.1921\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) & +\ 0.0848\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) & -\ 1.5507\,(I_{t-1} - \delta K_{t-2}) & +\ 1.8337\,K_{t-1} \\ & (1.7221) & (0.6390) & (-0.9916) & (3.1831) \end{array}$$

$R^2 = 0.9703 \qquad d = 2.62$

NEOCLASSICAL MODEL II

$$\begin{array}{lllll} I_t = -3.1071 & +\ 0.1330\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) & +\ 0.0873\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) & +\ 0.1269\,(I_{t-1} - \delta K_{t-2}) & +\ 1.4471\,K_{t-1} \\ & (0.8070) & (0.5710) & (0.1270) & (2.8647) \end{array}$$

$R^2 = 0.9433 \qquad d = 2.32$

TABLE 3

ESTIMATES OF THE DISTRIBUTED LAGS
PRODUCTS OF PETROLEUM INDUSTRY

ACCELERATOR MODEL

$$I_t = 11.0561 + \underset{(5.7045)}{1.4460}\,(Q_t - Q_{t-1}) + \underset{(3.3377)}{0.9866}\,(Q_{t-1} - Q_{t-2}) - \underset{(-5.2688)}{1.0159}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-2.2964)}{0.7305}\,K_{t-1}$$

$R^2 = 0.9856$ $d = 2.78$

LIQUIDITY MODEL

$$I_t = 5.9247 - \underset{(-0.9261)}{0.0007}\,(L_t - L_{t-1}) - \underset{(-0.7287)}{0.0009}\,(L_{t-1} - L_{t-2}) - \underset{(-1.0568)}{0.3899}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.8871)}{0.4748}\,K_{t-1}$$

$R^2 = 0.8031$ $d = 1.96$

EXPECTED PROFIT MODEL

$$I_t = 7.6585 - \underset{(-1.0901)}{0.0007}\,(V_t - V_{t-1}) - \underset{(-0.9373)}{0.0001}\,(V_{t-1} - V_{t-2}) - \underset{(-1.0993)}{0.3605}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.7993)}{0.4085}\,K_{t-1}$$

$R^2 = 0.8270$ $d = 2.18$

NEOCLASSICAL MODEL I

$$I_t = 15.1305 + \underset{(1.6337)}{1.9754}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \underset{(1.3136)}{2.9866}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-1.6866)}{0.6637}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.6645)}{0.5949}\,K_{t-1}$$

$R^2 = 0.8848$ $d = 3.31$

NEOCLASSICAL MODEL II

$$I_t = 17.5209 + \underset{(1.2932)}{2.5379}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \underset{(0.8609)}{2.3887}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-1.3738)}{0.7854}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.6636)}{1.0633}\,K_{t-1}$$

$R^2 = 0.8587$ $d = 3.52$

TABLE 4

ESTIMATES OF THE DISTRIBUTED LAGS
FURNITURE AND FIXTURES INDUSTRY

ACCELERATOR MODEL

$$I_t = 2.5793 - \underset{(-1.4701)}{0.1151}\,(Q_t - Q_{t-1}) - \underset{(-2.3421)}{0.1851}\,(Q_{t-1} - Q_{t-2}) + \underset{(4.0136)}{1.0508}\,(I_{t-1} - \delta K_{t-2}) + \underset{(2.8733)}{0.3280}\,K_{t-1}$$

$R^2 = 0.9606$ $d = 2.39$

LIQUIDITY MODEL

$$I_t = 4.4329 - \underset{(-0.8584)}{0.0049}\,(L_t - L_{t-1}) - \underset{(-0.6545)}{0.0038}\,(L_{t-1} - L_{t-2}) + \underset{(0.8408)}{0.6210}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.3858)}{0.2996}\,K_{t-1}$$

$R^2 = 0.8785$ $d = 1.14$

EXPECTED PROFIT MODEL

$$I_t = 3.7965 - \underset{(-1.7654)}{0.0037}\,(V_t - V_{t-1}) - \underset{(-1.4289)}{0.0033}\,(V_{t-1} - V_{t-2}) + \underset{(0.6125)}{0.3400}\,(I_{t-1} - \delta K_{t-2}) + \underset{(2.7656)}{0.4590}\,K_{t-1}$$

$R^2 = 0.9352$ $d = 1.28$

NEOCLASSICAL MODEL I

$$I_t = 2.4224 - \underset{(-1.3910)}{0.1385}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) - \underset{(-2.3689)}{0.2408}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) + \underset{(3.9113)}{1.0248}\,(I_{t-1} - \delta K_{t-2}) + \underset{(2.7581)}{0.3144}\,K_{t-1}$$

$R^2 = 0.9609$ $d = 2.35$

NEOCLASSICAL MODEL II

$$I_t = 2.7658 - \underset{(-0.7738)}{0.1529}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) - \underset{(-1.3450)}{0.2651}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) + \underset{(2.9019)}{1.1219}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.9153)}{0.3249}\,K_{t-1}$$

$R^2 = 0.9130$ $d = 2.26$

TABLE 5

ESTIMATES OF THE DISTRIBUTED LAGS
RUBBER PRODUCTS INDUSTRY

ACCELERATOR MODEL

$$I_t = 2.7330 - \underset{(-0.6176)}{0.1763}\,(Q_t - Q_{t-1}) - \underset{(-1.5669)}{0.3157}\,(Q_{t-1} - Q_{t-2}) - \underset{(-0.6296)}{0.4278}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.7728)}{0.6786}\,K_{t-1}$$

$R^2 = 0.6027$ $\quad d = 1.41$

LIQUIDITY MODEL

$$I_t = 12.5872 - \underset{(-1.1186)}{0.0049}\,(L_t - L_{t-1}) - \underset{(-0.5260)}{0.0024}\,(L_{t-1} - L_{t-2}) + \underset{(0.2801)}{0.1548}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.4078)}{0.3556}\,K_{t-1}$$

$R^2 = 0.4429$ $\quad d = 2.54$

EXPECTED PROFIT MODEL

$$I_t = 17.4924 - \underset{(-1.1390)}{0.0040}\,(V_t - V_{t-1}) - \underset{(-0.8285)}{0.0034}\,(V_{t-1} - V_{t-2}) + \underset{(0.5052)}{0.2965}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.6780)}{0.7087}\,K_{t-1}$$

$R^2 = 0.4617$ $\quad d = 2.64$

NEOCLASSICAL MODEL I

$$I_t = 3.4584 - \underset{(-0.3236)}{0.1443}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) - \underset{(-1.3075)}{0.4165}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-0.2959)}{0.2295}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.5669)}{0.5632}\,K_{t-1}$$

$R^2 = 0.5115$ $\quad d = 1.43$

NEOCLASSICAL MODEL II

$$I_t = 3.4584 - \underset{(-1.3081)}{0.1443}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) - \underset{(-0.6715)}{0.2875}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-0.5463)}{0.3042}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.4027)}{0.2824}\,K_{t-1}$$

$R^2 = 0.5646$ $\quad d = 1.74$

TABLE 6

ESTIMATES OF THE DISTRIBUTED LAGS
BEVERAGES INDUSTRY

ACCELERATOR MODEL

$$I_t = 38.1849 + \underset{(0.9961)}{0.3420}\,(Q_t - Q_{t-1}) + \underset{(0.8508)}{0.6067}\,(Q_{t-1} - Q_{t-2}) - \underset{(-1.0015)}{2.3510}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.7762)}{2.1896}\,K_{t-1}$$

$R^2 = 0.5030$ $\quad d = 1.19$

LIQUIDITY MODEL

$$I_t = 10.1932 - \underset{(-0.1080)}{0.0002}\,(L_t - L_{t-1}) + \underset{(0.1879)}{0.0003}\,(L_{t-1} - L_{t-2}) - \underset{(-0.7890)}{0.8925}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.6837)}{0.4104}\,K_{t-1}$$

$R^2 = 0.2658$ $\quad d = 1.24$

EXPECTED PROFIT MODEL

$$I_t = 6.4810 + \underset{(0.7624)}{0.0005}\,(V_t - V_{t-1}) - \underset{(-0.7108)}{0.0006}\,(V_{t-1} - V_{t-2}) - \underset{(-0.7954)}{0.6190}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.2591)}{0.5753}\,K_{t-1}$$

$R^2 = 0.5910$ $\quad d = 1.18$

NEOCLASSICAL MODEL I

$$I_t = 9.8817 + \underset{(1.4871)}{0.0842}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \underset{(2.3357)}{0.1375}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-1.6392)}{0.8418}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.9399)}{0.2736}\,K_{t-1}$$

$R^2 = 0.8221$ $\quad d = 2.08$

NEOCLASSICAL MODEL II

$$I_t = 12.8847 + \underset{(3.1978)}{0.1545}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \underset{(4.7371)}{0.2647}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-3.3909)}{0.8418}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.4924)}{0.0877}\,K_{t-1}$$

$R^2 = 0.9387$ $\quad d = 1.98$

TABLE 7

ESTIMATES OF THE DISTRIBUTED LAGS
LEATHER INDUSTRY

ACCELERATOR MODEL

$$I_t = \underset{(-0.9274)}{1.2145 - 0.2918}\,(Q_t - Q_{t-1}) + \underset{(-0.5650)}{0.1117}\,(Q_{t-1} - Q_{t-2}) - \underset{(-1.4286)}{1.2621}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.4131)}{0.3558}\,K_{t-1}$$

$R^2 = 0.7495 \quad d = 1.38$

LIQUIDITY MODEL

$$I_t = \underset{(-1.0795)}{0.8990 - 0.0042}\,(L_t - L_{t-1}) - \underset{(-2.3001)}{0.0097}\,(L_{t-1} - L_{t-2}) - \underset{(-0.3823)}{0.1197}\,(I_{t-1} - \delta K_{t-2}) + \underset{(3.0198)}{0.4970}\,K_{t-1}$$

$R^2 = 0.9058 \quad d = 1.71$

EXPECTED PROFIT MODEL

$$I_t = \underset{(-0.5360)}{0.6096 - 0.0015}\,(V_t - V_{t-1}) - \underset{(-1.7244)}{0.0067}\,(V_{t-1} - V_{t-2}) - \underset{(-0.2714)}{0.1049}\,(I_{t-1} - \delta K_{t-2}) + \underset{(3.1837)}{0.7099}\,K_{t-1}$$

$R^2 = 0.8729 \quad d = 1.72$

NEOCLASSICAL MODEL I

$$I_t = \underset{(10.1892)}{0.0264 + 0.3479}\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) + \underset{(11.6614)}{0.4907}\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - \underset{(-11.9601)}{0.6764}\,(I_{t-1} - \delta K_{t-2}) + \underset{(19.0476)}{0.5353}\,K_{t-1}$$

$R^2 = 0.9967 \quad d = 2.17$

NEOCLASSICAL MODEL II

$$I_t = \underset{(-0.6601)}{1.2087 - 0.4288}\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - \underset{(-0.4324)}{0.1659}\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - \underset{(-1.0959)}{1.1921}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.3239)}{0.3671}\,K_{t-1}$$

$R^2 = 0.7049 \quad d = 1.25$

TABLE 8

ESTIMATES OF THE DISTRIBUTED LAGS
BASIC METAL INDUSTRY

ACCELERATOR MODEL

$$I_t = \underset{(-0.0740)}{8.6136 - 0.0913}\,(Q_t - Q_{t-1}) - \underset{(-1.0777)}{1.4681}\,(Q_{t-1} - Q_{t-2}) - \underset{(-1.6546)}{0.5353}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.5696)}{0.8529}\,K_{t-1}$$

$R^2 = 0.6608 \quad d = 1.94$

LIQUIDITY MODEL

$$I_t = \underset{(-0.0217)}{8.0651 - 0.0004}\,(L_t - L_{t-1}) - \underset{(-0.6453)}{0.0082}\,(L_{t-1} - L_{t-2}) - \underset{(-0.9600)}{0.4671}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.8819)}{0.6311}\,K_{t-1}$$

$R^2 = 0.5895 \quad d = 2.27$

EXPECTED PROFIT MODEL

$$I_t = \underset{(0.4310)}{6.5459 + 0.0054}\,(V_t - V_{t-1}) - \underset{(-0.0447)}{0.0005}\,(V_{t-1} - V_{t-2}) - \underset{(-1.3462)}{0.5158}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.1276)}{0.7396}\,K_{t-1}$$

$R^2 = 0.5201 \quad d = 2.05$

NEOCLASSICAL MODEL I

$$I_t = \underset{(0.4309)}{9.8283 + 4.0854}\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - \underset{(-1.9223)}{17.2752}\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - \underset{(-2.2583)}{0.6298}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.3565)}{0.7327}\,K_{t-1}$$

$R^2 = 0.8093 \quad d = 2.21$

NEOCLASSICAL MODEL II

$$I_t = \underset{(-0.6080)}{9.6402 - 3.4109}\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - \underset{(-1.2783)}{6.5586}\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - \underset{(-1.5434)}{0.4929}\,(I_{t-1} - \delta K_{t-2}) + \underset{(1.4328)}{0.7363}\,K_{t-1}$$

$R^2 = 0.6999 \quad d = 2.02$

TABLE 9

ESTIMATES OF THE DISTRIBUTED LAGS
FOOD INDUSTRY

ACCELERATOR MODEL

$$I_t = 39.1231 - 0.8999\,(Q_t - Q_{t-1}) - 0.4602\,(Q_{t-1} - Q_{t-2}) + 0.0610\,(I_{t-1} - \delta K_{t-2}) + 0.2970\,K_{t-1}$$

(−0.939) (−0.5016) (0.0624) (0.4664)

$R^2 = 0.3970$ $d = 2.26$

LIQUIDITY MODEL

$$I_t = 6.8993 + 0.0012\,(L_t - L_{t-1}) - 0.0001\,(L_{t-1} - L_{t-2}) - 1.6955\,(I_{t-1} - \delta K_{t-2}) + 0.8397\,K_{t-1}$$

(3.5069) (−0.1756) (−2.5941) (2.3332)

$R^2 = 0.8709$ $d = 2.34$

EXPECTED PROFIT MODEL

$$I_t = 7.8948 + 0.0008\,(V_t - V_{t-1}) - 0.00002\,(V_{t-1} - V_{t-2}) - 1.4784\,(I_{t-1} - \delta K_{t-2}) + 0.8397\,K_{t-1}$$

(2.4996) (−0.0810) (−1.7787) (1.5508)

$R^2 = 0.7775$ $d = 2.27$

NEOCLASSICAL MODEL I

$$I_t = 20.3091 + 0.1504\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - 0.6492\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - 0.3029\,(I_{t-1} - \delta K_{t-2}) + 0.3759\,K_{t-1}$$

(0.1439) (−0.6403) (−0.2165) (0.4805)

$R^2 = 0.2362$ $d = 2.17$

NEOCLASSICAL MODEL II

$$I_t = 27.9101 - 0.4841\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - 0.2284\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) + 0.3711\,(I_{t-1} - \delta K_{t-2}) + 0.1234\,K_{t-1}$$

(−0.4708) (−0.2497) (0.2914) (0.1670)

$R^2 = 0.2055$ $d = 2.48$

TABLE 10

ESTIMATES OF THE DISTRIBUTED LAGS
PAPER INDUSTRY

ACCELERATOR MODEL

$$I_t = 13.2476 - 0.7558\,(Q_t - Q_{t-1}) - 0.6208\,(Q_{t-1} - Q_{t-2}) - 0.4600\,(I_{t-1} - \delta K_{t-2}) - 0.2744\,K_{t-1}$$

(−1.8534) (−1.4026) (−0.7481) (−0.5120)

$R^2 = 0.6790$ $d = 1.78$

LIQUIDITY MODEL

$$I_t = 7.3566 - 0.0052\,(L_t - L_{t-1}) - 0.0052\,(L_{t-1} - L_{t-2}) - 0.1234\,(I_{t-1} - \delta K_{t-2}) + 0.3491\,K_{t-1}$$

(−0.8021) (−0.1765) (−0.1120) (0.4045)

$R^2 = 0.4646$ $d = 1.99$

EXPECTED PROFIT MODEL

$$I_t = 4.2389 - 0.0053\,(V_t - V_{t-1}) + 0.0045\,(V_{t-1} - V_{t-2}) - 0.4082\,(I_{t-1} - \delta K_{t-2}) + 0.5883\,K_{t-1}$$

(−1.6026) (0.4744) (−0.5716) (0.9889)

$R^2 = 0.5863$ $d = 2.81$

NEOCLASSICAL MODEL I

$$I_t = 3.1731 - 0.2356\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - 1.1135\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - 0.1916\,(I_{t-1} - \delta K_{t-2}) + 0.3388\,K_{t-1}$$

(−0.6389) (−2.9793) (−0.4437) (0.9940)

$R^2 = 0.8310$ $d = 2.74$

NEOCLASSICAL MODEL II

$$I_t = 13.2866 - 0.9779\left(\frac{P_tQ_t}{C_t} - \frac{P_{t-1}Q_{t-1}}{C_{t-1}}\right) - 0.9766\left(\frac{P_{t-1}Q_{t-1}}{C_{t-1}} - \frac{P_{t-2}Q_{t-2}}{C_{t-2}}\right) - 0.3852\,(I_{t-1} - \delta K_{t-2}) - 0.3344\,K_{t-1}$$

(−2.4429) (−2.1374) (−0.8166) (−0.8019)

$R^2 = 0.8027$ $d = 1.99$

TABLE 11

ESTIMATES OF THE DISTRIBUTED LAGS
METAL INDUSTRY

ACCELERATOR MODEL

$$I_t = 11.7595 - \underset{(-0.8699)}{0.7071}\,(Q_t - Q_{t-1}) - \underset{(-1.9341)}{1.6708}\,(Q_{t-1} - Q_{t-2}) + \underset{(0.2124)}{0.0107}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.1625)}{0.0253}\,K_{t-1}$$

$R^2 = 0.8140$ $\quad d = 1.79$

LIQUIDITY MODEL

$$I_t = 8.4141 + \underset{(0.2150)}{0.0003}\,(L_t - L_{t-1}) - \underset{(-0.5393)}{0.0008}\,(L_{t-1} - L_{t-2}) - \underset{(-0.3051)}{0.0374}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.3470)}{0.1035}\,K_{t-1}$$

$R^2 = 0.5007$ $\quad d = 1.67$

EXPECTED PROFIT MODEL

$$I_t = 10.7175 - \underset{(-0.5150)}{0.0012}\,(V_t - V_{t-1}) - \underset{(-0.6309)}{0.0027}\,(V_{t-1} - V_{t-2}) + \underset{(0.5084)}{0.0541}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.1052)}{0.2117}\,K_{t-1}$$

$R^2 = 0.4775$ $\quad d = 2.18$

NEOCLASSICAL MODEL I

$$I_t = 7.2165 + \underset{(0.6208)}{3.5187}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \underset{(0.0352)}{0.1507}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-0.5107)}{0.5518}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.4662)}{0.0972}\,K_{t-1}$$

$R^2 = 0.3501$ $\quad d = 1.61$

NEOCLASSICAL MODEL II

$$I_t = 7.0155 + \underset{(0.7830)}{4.9869}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + \underset{(0.0221)}{0.0921}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) - \underset{(-0.6378)}{0.0704}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.2578)}{0.5402}\,K_{t-1}$$

$R^2 = 0.3989$ $\quad d = 1.56$

TABLE 12

ESTIMATES OF THE DISTRIBUTED LAGS
TOBACCO INDUSTRY

ACCELERATOR MODEL

$$I_t = 27.4644 - \underset{(-0.4883)}{0.0971}\,(Q_t - Q_{t-1}) - \underset{(-0.2536)}{0.0482}\,(Q_{t-1} - Q_{t-2}) + \underset{(0.2616)}{0.1640}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.4043)}{0.3804}\,K_{t-1}$$

$R^2 = 0.1529$ $\quad d = 2.15$

LIQUIDITY MODEL

$$I_t = 25.7836 + \underset{(1.4071)}{0.0049}\,(L_t - L_{t-1}) + \underset{(0.5921)}{0.0028}\,(L_{t-1} - L_{t-2}) - \underset{(-0.2881)}{0.1413}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.5193)}{0.4103}\,K_{t-1}$$

$R^2 = 0.5193$ $\quad d = 2.02$

EXPECTED PROFIT MODEL

$$I_t = 20.5284 + \underset{(0.7957)}{0.0014}\,(V_t - V_{t-1}) - \underset{(-1.1996)}{0.0013}\,(V_{t-1} - V_{t-2}) - \underset{(-0.4219)}{0.2429}\,(I_{t-1} - \delta K_{t-2}) + \underset{(0.0882)}{0.0681}\,K_{t-1}$$

$R^2 = 0.4743$ $\quad d = 1.33$

NEOCLASSICAL MODEL I

$$I_t = 28.986 - \underset{(-0.4904)}{0.1995}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) - \underset{(-0.2221)}{0.0846}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) + \underset{(0.2771)}{0.1742}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.4458)}{0.4397}\,K_{t-1}$$

$R^2 = 0.1480$ $\quad d = 2.27$

NEOCLASSICAL MODEL II

$$I_t = 25.9992 - \underset{(-0.6207)}{0.2507}\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) - \underset{(-0.0242)}{0.0101}\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right) + \underset{(0.2799)}{0.1756}\,(I_{t-1} - \delta K_{t-2}) - \underset{(-0.3325)}{0.2937}\,K_{t-1}$$

$R^2 = 0.1954$ $\quad d = 2.36$

comparing the numerical values of the regression coefficients with their respective t-ratios, it can be seen that virtually all the coefficients under the Liquidity theory are significant at the 5 per cent level for the Textile industry with an R^2 value of 0.9469. Similar interpretations of the estimated regression coefficients may be done for the remaining theories under the Textile industry and for the other eleven industries as well. However, such a detailed analysis of coefficients and a comparison of the investment theories from the point of view of their performance are beyond the scope of the present paper and are pursued elsewhere.[1] For now it probably suffices to employ simple notions of comparison such as the size of the R^2, and the number of significant coefficients of changes in desired capital and also possessing the right signs.

When these criteria are applied we find that for the Textile industry, the liqudity model of investment actually performs best even though the results for all the five models are pretty close in terms of the R^2 criterion alone. The best results for the other eleven industries may be summarised as follows: Footwear industry (Liquidity model), Products of Petroleum industry (Accelerator model), Furniture and Fixtures industry (Neoclassical I model), Rubber products industry — poor results generally, Beverages industry (Neoclassical II model), Leather industry (Neoclassical I model), Basic Metal industry (Neoclassical I model), Food industry (Liquidity model), Paper industry (Neoclasical I), Metal Product industry (Accelerator model) and Tobacco industry (Liquidity model). We may, therefore, infer that out of twelve industries, the Neoclassical I model is best for four industries, the Neoclassical II model for one industry, the Liquidity model for four, the Accelerator for two and the Expected Profit model for none. Consequently, we find that both Neoclassical I and Liquidity models scored a tie in providing the best explanation of investment behaviour among the theories tested in this study.

Turning to replacement investment we find that δ ranges between the following values for the industries indicated: Textile (0.3958 to 0.4290), Furniture (0.2996 to 0.4590), Leather (0.3558 to 0.7099), Basic metal (0.6311 to 0.8529), Food (0.1234 to 0.8397), and Metal (0.0253 to 0.5402). For the remaining industries, the value of δ varies from equation to equation being larger than unity, smaller than unity or implausibly negative. Out of the sixty estimated equations, however, we find δ to be positive and smaller than unity in forty five cases, positive and greater than unity in three cases, and negative in twelve cases. The evidence thus appears to support the contention that δ is a positive fraction of capital stock.

The analysis of residuals which was conducted on the basis of the Geary test statistics indicates that at 5 per cent probability level the mull hypothesis of randomly distributed disturbances was supported for fifty cases out of sixty; seven cases showed the evidence at 1 per cent probability level while three cases showed evidence of positive serial correlation. We then conclude that the estimation of our distributed lag functions has generally been free of serial correlation problems.

These findings do provide some answers to some of the basic issues raised at the beginning of this study in relation to the controversial subject of capital theory as discussed in the literature. More specifically, results in this study indicate that the desired level of capital may be specified either as a function of Liquidity or, (following the Neoclassical model), as a function of four variables: δ, the elasticity of output with respect to capital input: C_t; the price of capital services; P_t, the price of output; and Q_t, the level output. In turn, the variable C_t which contains fiscal and monetary policy variables provides an avenue for the injection of policy into the investment equation for the purpose of influencing investment spending. The evidence also shows that net investment may be characterized as a distributed lag function of changes in desired capital wherein the weights associated with these changes are approximated by the weights in a rational distributed lag function. Finally, replacement investment is also shown to be positively related to capital stock. These results which derive from the Nigerian data, therefore, help to cast some light on the present stage of the controversies as indicated.

Important as our results are particularly for the purpose of predicting the likely magnitudes of investment expenditures in Nigerian manufacturing industries and hence estimating their probable impact on aggregate demand, it should be noted that one significant area of interest has not been closely examined in this study, namely, the time structure of the investment process in the selected industries. In other words, we need to determine whether the lags in investment expenditure are short, long or substantially distributed over time since such results have implications for the application of policy instruments, while an effective characterization of the form of the lag between changes in policy measures and the level of investment spending may yield fruitful information to policy makers about the appropriate timing of their policies. Since these issues are however beyond the scope of the present paper they are conveniently reserved for future research.[1]

[2] See E.O. Akinnifesi, 'The Time Structure of Manufacturing Investment Behaviour: Some Estimates and Policy Implications', C.B.N. Lagos (forthcoming).

V
SUMMARY AND CONCLUSIONS

Several controversies still loom large in the literature on capital theory. Of no less importance is the question of the factors that determine business investment. The interrelationship between investment and aggregate demand is a fact of economic necessity just as well as the time pattern of this relationship bears crucially on the timing of economic policies for effective results. Based on a distributed lag specification and tests of alternative investment models, this paper has helped to illuminate, somewhat, these basic controversies.

Starting with a review of some popular theories of investment such as the Accelerator, the Liquidity and the Expected Profit theories the paper went on to discuss the Neoclassical theory of Optimal Capital Accumulation which was presented by Jorgenson and his associates as a competing theory to the ones earlier popularised in the literature. Using a generalized accelerator mechanism these theories were then unified for testing purposes so that net investment was shown as a distributed lag function of changes in desired capital. The weights appropriate to the lag distribution were approximated by the weights in a rational distributed lag function.

Based on relevant data for twelve Nigerian manufacturing industries covering the period 1966 to 1976 the five models of investment behaviour were then implemented. The results of our investigation show that the Liquidity and Neoclassical I theories of investment are superior to the other three theories tested. Consequently, gross investment expenditures may be specified as a function of changes in desired capital, the lagged value of net investment and the current level of replacement. Also, desired capital is in turn dependent upon four variables namely, the elasticity of output with respect to capital input, the price of output, the volume of output and the price of capital services through which monetary and fiscal policies may be injected to affect the flow of investment spending. Alternatively, desired capital may be made to depend on liquidity particularly where the objective of the investment study is simply for the purpose of deriving future levels of gross investment with no policy implications in mind.

Finally, although the study did not quite get to the issue of the time response pattern of investment expenditures which necessarily falls outside the scope of the present study, much information appears available now on which reasonable forecasts of investment in the manufacturing sector can be based. Such forecasts are definitely useful for informed policy decisions.

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