AN ECONOMETRIC STUDY OF FIXED CAPITAL AND INVESTMENT BEHAVIOUR IN NIGERIAN MANUFACTURING INDUSTRIES

BY

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D E D I C A T I O N

This work is dedicated to my Father

MICHAEL AKINWANDE AKINNIFESI

and

to the memory of my late Mother

OMOYIWOLA OLADUNRUN AKINNIFESI

Acknowledgements

Capital accumulation involves lags but very much so is the accumulation of human capital. Much time has elapsed since the initial generation of my interest in the twin subjects of industrialization and investment behaviour. Employed as a Research Assistant in 1966 by the Nigerian Institute of Social and Economic Research (NISER), I had the opportunity of working with Professor O. Aboyade, on his several studies of Nigerian manufacturing industries and thus started my interest in these subjects.

Short as my stay at NISER was, I had developed the necessary interest in industrial matters which I could build upon at my next place of work, namely, the Research Department of the Central Bank of Nigeria (CBN). At various times beginning April 1967 I worked in Divisions of the Department (such as Industrial Studies, Economic Policy and Statistics and Econometrics) where I developed much greater acquaintance with the statistics on Industries and Private Foreign investment, and had the opportunity also to keep up with the literature in these areas.

I owe a good deal of my intellectual development to the undergraduate education received at the University of Ife, Nigeria (1963-1966) leading to the award of a B.Sc. (Econ) Degree, the post-graduate education received at Yale University, U.S.A (1974-1976) leading also to the award of an M.A (Econ) degree, and the further training at the University of Lagos (UNILAG), Nigeria (1976-1980) which culminated into this piece of research. In this connection, then, I am specially indebted to all the members of my thesis committee - Prof. S.O. Adamu, (Ph. D London), Dr. J.U. Umo (Ph.D Indiana), and Dr. J.O. Odufalu (Ph. D Berkeley), Chairman of Graduate Committee of the Dept of Economics, Unilag. Coupled with the encouragement and inspiration given at very critical times during the course of this study, these gentlemen also provided the much needed guidance, suggestions and constructive criticisms which helped to shape this research and for which I am, indeed very grateful.

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Abstract

The primary aim of this study is to analyse empirically the determinants of investment behaviour in Nigerian manufacturing industries based on five alternative theories of investment and private foreign investment data for a sample of eight manufacturing industries over the period 1966 to 1976. The industries include: Food Beverages, Textiles, Footwear, Furniture, Paper, Leather and Rubber while the theories are the Accelerator, Liquidity, Expected Profit, Neoclassical I and Neoclassical II. Using a "generalized accelerator mechanism", the theories are unified while the rational distributed lags also provide the basis for the lag generating mechanism of the investment functions.

A two-stage maximum likelihood (ML) method of estimation is adopted for the functions in the distributed lag form in which stage one yields a total of two hundred and eighty single equation results while stage two yields forty regression results. Following the derived regression estimates the relative performance of the investment theories is then compared using well established "performance criteria" such as minimum residual variance, analysis of the fitted coefficients of changes in desired capital, and the goodness-of-fit statistics. On the basis of the ranking procedures adopted we

conclude that the Liquidity theory is superior to the others in the explanation of investment behaviour by Nigerian manufacturing industries.

Further analysis of the regression results leads to the following findings: (i) the "truncation remainder" is a real number different from zero; (ii) the average lag between changes in desired capital and net investment expenditures ranges between six months and one year; (iii) lag distributions from industry to industry are non-symmetric; (iv) the response of the demand for capital services is largest for the rate of interest and low for the liberalization of depreciation allowances; (v) the short term responses of investment are much larger than the long term responses and, (vi) the responses of investment to market conditions are much larger than the responses to tax policy.

These results suggest, among others, that policy makers should (i) take into account replacement investment when formulating an investment policy for countercyclical ends; (ii) that fiscal incentives for investment promotion should be regarded as supplementary to market conditions when appraising policies for growth or stabilization purposes; and, finally, that policy makers should assess both the size and the timing of their policy measures so as to satisfy the desired objectives effectively.

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INTRODUCTION

This study conducts an econometric investigation into the investment activity of manufacturing industries in Nigeria based on a comparison of alternative theories of investment behaviour which have already undergone substantial testing on data for the developed countries and to some extent for the developing countries with regard to their ability to explain the investment activity of individual firms and industries.

Existing theories of investment behaviour differ in their degree of emphasis and general approach to four main issues, namely:

(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.

These differences are indeed common to the Accelerator, the liquidity, the Expected Profits and the Neoclassical theories of investment behaviour which have evolved in the last six decades or so. The situation is not even made any better if one turns to the econometric models and estimation of the investment theories where considerable disagreement rages as well. In order to compare different investment theories as is done in this study it is indeed necessary to provide a uniform structure within which each investment theory may be fitted.

Consequently, using the Accelerator theory as a point of departure, a 'generalized accelerator mechanism' is developed in which gross investment is a function of changes in the desired level of capital and the rate of replacement of existing capital. The appropriate distributed lag function is the rational lag mechanism for translating changes in desired capital into actual investment expenditures. This class of distributed lag functions, of course, contains the geometric and Pascal lag distributions as special cases. Viewed this way, the four theories of investment behaviour that are reviewed and tested only differ in terms of their characterization of the desired level of capital which may be summarized as follows: In the Accelerator theory, desired capital is proportional to output; in the liquidity theory it is proportional to liquidity while in the Expected Profits theory it is proportional to current profit. Finally, in the Neoclassical theory, desired capital is proportional to output, the price of output and the price of capital services.

The objectives of studying investment in the manner described so far, are somewhat clear. There is agreement in the literature that the relationship between investment and its underlying determinants can be critically important when policies are being considered for economic stabilization or growth. Decisions to undertake investment expenditures are naturally affected by such policy instruments as the tax structure and instruments that affect the cost of capital. In fact, investment expenditures are directly affected by the tax structure and the empirical results obtained in this study can facilitate a proper assessment of the effects of changes in tax rate and the tax treatment of depreciation allowances for investment expenditures.

Furthermore, a proper characterization of the time structure of the relationship between investment expenditure and its underlying determinants is of crucial importance in assessing the effects of changes in market conditions and tax policy on investment expenditures. It is important to know the average time elapsed between changes in the determinants of investment behaviour and actual investment expenditures while the form of the lag must be characterized as well. This will provide policy makers with some idea as to how precisely they must aim in the timing of their policies. If changes in tax policy produce effects that are distributed over long periods of time, the control over the timing of policy measures need not be very precise. If, on the other hand, the effects are of a short duration the control over the timing of policy measures has to be precise in order to stimulate the required investment expenditures.

This study covers six chapters. Chapter I which is basically introductory reviews some of the general problems of economic development and appraises the extent to which capital formation and industrialization may alleviate some of these problems. It then highlights some of the fiscal incentives which the Nigerian government has been providing for industrialization within the economy. In Chapter II, alternative theories of investment behaviour are reviewed with greater focus on the Accelerator, Liquidity, Expected Profit and Neoclassical theories. Chapter III takes up the formulation of distributed lag models, their estimation problems and the casting of the investment theories into their respective econometric forms for testing purposes. Chapter IV undertakes the emprical testing and discussion of the regression results whereby alternative theories of investment behaviour are ranked for superiority. In Chapter V, computations of average lags, distributed lag coefficients and comparative static analysis of investment behaviour are undertaken while the policy implications deriving from them are also discussed. Finally, Chapter VI summarizes the study as well as its broad conclusions and recommendations.

CHAPTER I

THE ROLE OF CAPITAL FORMATION IN ECONOMIC DEVELOPMENT

Features of Underdevelopment

For a majority of the developing countries of which Nigeria is a part, the desire to break loose from the 'vicious circle of poverty' can easily be seen as a motive for encouraging industrialization which in itself requires that capital formation should proceed at a rate somewhat in excess of the population growth rate otherwise additional population cannot be provided with adequate capital equipment to further the exploitation of natural resources. Various definitions of underdevelopment have been offered by several authors. While Samuelson[1] focussed on relative per capita income differentials between the developed countries as a group and other countries with far much less per capita income, Ragnar Nurkse, on the other hand, concentrated on capital and general resource endowment and suggested that,

> Underdeveloped countries are those which when compared with advanced countries are underequipped with capital in relation to population, and natural resources.[2]

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[1]P. Samuelson, Economics, 10th ed. McGraw Hill, New York and London, 1976, p. 737.

[2]R. Nurkse, Problems of Capital Formation in Underdeveloped Countries, Oxford University Press, 1953, p.1.

From this perspective, therefore, the paucity of capital turns out to be a major feature of an underdeveloped economy. In a more general sense Griffin and Enos have characterized underdevelopment as:

> .... an all embracing condition of society-its social institution, its political organization, and its economic characteristics..... (which) include such phenomena as the coexistence of market and predominantly self-subsistence economies..., the underutilization of resources..., the paucity of research and the multiplicity of barriers to innovations, the adoption of techniques unsuited to the resource mix of the country and the general failure to synchronize interdependent activities. 1

Based on the foregoing definitions, the main features of underdeveloped economies can be summarised as: low per capita income, low level of living, low level of productivity, excessive dependence on agriculture, low rate of capital formation, primitive techniques of production, sharp income inequalities unemployment and underemployment, underutilization of natural resources, dualistic structures, etc.[2] This view of economic backwardness is often rationalized against the background of the 'vicious circle of poverty' which is expressible in two forms namely, the supply side and the demand side. According to Nurkse, "on the supply side, there is a small capacity to save resulting from the low level of real income. The low real income is a reflection of low productivity, which in turn, is due largely to the lack of capital. The lack of capital

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[1] K.B. Griffin and J.L. Enos, Planning Development, Addison-Wesley Publishing Co., London, 1970. p.4.

[2] A detailed analysis of these features can be found in B.K. Bhargava and S.N. Mookerjee, Capital Formation in Underdeveloped Countries: Problems and Prospects, Avtar Singh Datta, Prop., Datta Book Centre, Delhi, 1974, pp3.ff.

is the result of small capacity to save and so the circle is complete[1].

Nurkse went on further to suggest that "on the demand side, the inducement to invest may be low because of the small buying power of the people which is due to their low real income which again is due to low productivity. The low productivity, however, is a result of the small amount of capital used in production, which in its turn may be caused at least partially by the small inducement to invest."[2]

From the foregoing analysis, therefore, it can be inferred that the most important single effect of the vicious circle, is to constrict the formation and accumulation of capital in the developing countries. To this end, labour-intensive as opposed to capital intensive occupations tend to hold sway in those countries giving rise to low productivity, low incomes and hence limited purchasing power. Unfortunately, the low rate of savings due to low incomes also fails to generate capital accumulation at the required rate. But one could also argue in favour of the developing countries, that domestic saving can contribute just a small portion of the investment capital needed for rapid growth, additional capital being expected to come from the ploughing back of profits of existing manufacturing and other undertakings. Indeed, in several industrialized countries, firms' expansion depends critically upon the reinvestment of undistributed profits even though the source of the initial investment might have been external to the

[1] R. Nurkse, op. cit. p.5.

[2] Ibid. For a refutation of this thesis of vicious circle see, P.T. Bauer, Dissent on Development, Weidenfeld and Nicholson, London, 1971, p. 33 ff.

economy. The role of foreign trade in the capital formation process has also been quite significant. The exportation of primary products in the past has been quite influential in helping to finance the importation of machinery and equipment for use in nascent industries. The examples normally quoted in this regard include those of United States' and Canadian grains, Australian wool, Swedish timber and Venezuelan oil. Furthermore, foreign investment and in particular, direct investment has actively played a role in establishing basic utilities such as the railways, electricity, etc., which provided the necessary springboards for industrial take off.

The preceding analysis has actually given a broad characterization of the underdeveloped world which infact represents a very diverse collection of countries. There are, for instance, quite noticeable differences in the rate of growth of total real income and of income per head on which bases one could infer that some underdeveloped countries have indeed progressed much more rapidly than others in the last three decades or so.

There are important demographic differences too. These include differences in the growth rate of population as well as population density. The phenomenal population increase in India since the beginning of the 19th century seems to have tappered off in recent decades while in some parts of Latin America, the rates of increase have been rather high. Also while some Latin American and African countries are sparcely populated, China and India have recorded very sharp population densities.

Variations also occur among underdeveloped countries in their suitability for economic development or the rates of return which doses of capital investment are likely to enjoy in those countries. These differences can, of course, reflect differences in institutional arrangements or in national resources or both.

The next two sections of this chapter are given to a further examination of the issue of the vicious circle in terms of the role which industrialization and capital formation can play in breaking the 'shackles' of the circle in a development context.

Economic Development and Industrialization

The arguments in favour of industrialization as a means of economic growth and development have been aptly summarised into four by Kindleberger[1]. First, developed countries have industries and, therefore, underdeveloped countries can hope to develop by industrializing; second, the marginal value product of labour is higher in industry than in agriculture so that national output will rise if workers are transferred from agriculture to industry. This is, in fact the 'surplus labour' argument advanced by Arthur Lewis[2] and later extended by John Fei and Gustav Ranis.[3] Third, industrialization generates external economies, whereas agriculture does not. Aspects of these economies will include

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[1] C.P. Kindleberger, Economic Development, McGraw Hill Kogakusha, Ltd., 2nd ed, 1965, p. 213.

[2] W.A. Lewis, "Development with unlimited supplies of labour," The Manchester School, May 1954.

[3] J.C. Fei and G. RAnis, "A Theory of Economic Development," American Economic Review, 51 (Sept. 1961).

training facilities, demonstration effects in production and consumption, and a rapid rate of urbanization. Fourth, agricultural transformation on a commercial scale tends to depend upon industrial outputs like fertilizers, farm implements, tractors and so on.

Of course, one can easily regard these as a naive view of the requirements of economic development. In fact, proponents of the balanced-growth thesis have argued repeatedly that the development process must entail the development of agriculture side by side with that of industry. The argument has been pivoted largely upon the consideration that the movement of farm labour to the cities will increase urban population and its food requirements which, in the absence of disguised unemployment on the farm, will entail acute food shortage for city workers especially if one further assumes the non-interference of a 'deus-ex-machina' on the farms.

However, this fear of a conflict should not arise. Indeed there is no reason why rural labour should form the basis for pragmmatic programmes of urban industrialization. The cost of transferring workers from rural to urban areas is quite high both in terms of current exp enses on transport, and capital expenditure on housing and infrastructures. Hence, there need not be any sharp dichotomy for economic planners between developing agriculture and developing industry. As a matter of fact, the industrialization of agriculture itself may serve as the nerve-centre of an organic programme of industrialization based on food processing industries. This will be the case owing to the advantages often attributed to such industries.

In particular, food transformation industries are very often small enterprises requiring modest-size capital, and generating little or no economies of scale so that the optimum-sized plant can easily by established. These further imply that a rapid dispersal of such industries, (with its attendant benefits), over-large geographical areas can easily be undertaken through enterpreneural initiative or through public policy. Furthermore, these industries very easily provide a good source of seasonal employment particularly for the inhabitants of rural areas during the dead season thus ensuring all-year-round employment for this group of workers. Consequently, one can expect that a national industrialization programme can derive its success from an agrarian reform as a point of departure, and the attendant redistribution of income that such a reform nececessarily entails. In this sense, too, industrial investment can easily complement rather than be an alternative to agriculture.

Opportunities also abound for developing industries whose output can serve as inputs to the agricultural sector. Examples of such establishments include those that can manufacture and repair simple agricultural tools and implements. As technology advances, more intricate machinery and metal using industries are then required to produce other things like irrigation pumps, and tractors. The production of fertilizers,fuels and other petroleum products for the agricultural sector can then be taken up eventually. From the foregoing, therefore, it seems clear that the conflict one should expect is really not between investing in agriculture or industry but rather over the decision as to the desired composition of output such as producing consumption goods for home markets, producing investment goods and, or, export goods.

A number of studies have been conducted by Jorgenson,[1] Kuznets,[2] Chenery[3] and others to demonstrate the relationship between industrialization and economic development. Specifically, Jorgenson argued that, "the process of economic development may be studied as an increase in income per head or as an increase in the role of industrial activity to that in agriculture".[4] Some of the problems with this view, however, include the fact that only one objective of economic development, that is, increasing income per head, is mentioned, plus the fact that it discusses growth in terms of the dichotomy between agricultural and industrial development, the weaknesses of which have already been noted above; finally, the additional problem of causation of whether economic development precedes industrialization and vice versa. In order to tackle this problem and to ascertain particularly the extent to which industrialization has in practice aided development one can turn, for example, to the empirical findings of Hollis Chenery.[5] The study

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[1]D.W. Jorgenson, "Surplus Agricultural Labour and the Development of a Dual Economy", Oxford Economic Papers, Nov. 1967.

[2]S. Kuznets, "Quantitative Aspects of the Economic Growth of Nations II. Industrial Distribution of National Product and Labour Force," Economic Development and Cultural Change, July 1957 supplement.

[3]H.B. Chenery, "Patterns of Industrial Growth," American Economic Review, Sept., 1960.

[4]Jorgenson, op. cit, p. 288.

[5]H.B. Chenery, op. cit. cited by Griffith and Enos, op. cit. p. 142 ff.

which aimed at discovering the changes in the composition of national output that can likely occur in the growth process of the economy, given constant trading conditions and technology, utilized the tool of multiple regression on cross section data for more than fifty countries. The findings are in two categories, namely, those highlighting trends in the pattern of output and those that discuss the changes taking place within the manufacturing sector as per capital income increases. Chenery found that the share of industrial output in national income, i.e. manufacturing plus construction rose from 17 per cent at a per capita income level of $100 (N64)[1] to 38 percent at a level of $1,000 (N640). When considered alone the share of manufacturing rose from 12 to 33 percent while that of primary production (i.e. agriculture plus mining), declined from 45 per cent to 15 percent over the same income range.

Turning to the additional effect of industrialization on the changing composition of manufacturing output, Chenery found that, assuming a population of 10 million and a per capita income of $100 (N64), 68 per cent of manufacturing output will consist of consumer goods, 20 per cent intermediate goods (petroleum products, chemicals, etc.) and 12 per cent investment goods (transport equipment, machinery, etc.). A sixthfold increase in per capita income to $600 (N384) changes the composition of manufacturing output in the following direction: 43 per cent consumption goods, 23 per cent intermediate goods and 35 percent investment goods. This analysis implies that increasing per capital income over the range indicated will

[1]This conversion is undertaken at the current rate of exchange of N1 = U.S. S1.56

raise the share of investment and related goods by 192 per cent, and decrease the share of consumer goods by more than 35 per cent. One can really observe the operation of Engels' law in this analysis, namely, that as income increases above a certain minimum the consumption of food decreases as a percentage of income which necessitates altering the production structure in favour of increasing the quantities of industrial goods vis-a-vis consumption goods. Engels law actually operates through the low income elasticities of the demand for food.

In a later article, Chenery and Taylor[1] followed up the above analysis of patterns of industrialization by examining a sample of 54 developed and underdeveloped countries under three broad groupings: (i) large countries whose population exceed 15 million- (ii) small countries that primarily export manufactured goods- and (iii) small countries that concentrate on the export of primary (Agricultural or mineral) commodities. The study found that both the countries in groups (i) and (ii) exhibited similar behaviour while those in group (iii) that are primary oriented behaved somewhat differently. In particular, for the large countries, the share of industry increased rapidly from 16 per cent of GNP at a per capita income of $100 (N64) to 32 per cent at $400 (N256). After this a much slower increase was observed until a peak share of 37 per cent was reached at $1,200 (N768).

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[1]H.B Chenery and L. Taylor, "Development Patterns Among Countries and Over Time," Review of Economics and Statistics, November, 1968.

As for the third group the share of primary production fell from about 50 per cent at a per capita income of $100 (₦64) to 30 per cent at $500 (₦320) while the share of industry rose marginally from 17 per cent to 19 per cent over the same income range. For this third group primary production experienced a slower rate of decline in GNP so that agriculture and mining remained more important than industry as income ranged to about $800 (₦512).

A further examination of the sample data showed that 39 of the 57 countries were underdeveloped with per capita income below $600 (₦384). Fourteen of the thirty nine countries were small primary producers for whom primary acitivities might continue to be more important than industrialization. Conversely, one would expect the remaining 25 underdeveloped countries to be able to benefit from industrialization by capturing the effects of large economies of scale attributable to their rather extensive domestic markets or through specialization and trade based on their comparative cost advantage.

In practice, several patterns of industrialization have been witnessed. Writing a few years later than Chenery and Taylor, Cukor observed first of all the main tendencies of changes in the internal structure of industry to be as follows: "heavy industry usually grows quicker than light and food industries. In the course of growth, first metallurgy and engineering were the dynamic branches--metallurgy later increasing, though slowly--and the chemical industry has finally become the most dynamic branch."[1] He then went on to discuss the deviations from this general scheme on an intercountry basis.

[1] G. Cukor. Strategies for Industrialization in Developing Countries, C. Hurst & Co., London, 1974, p. 180 ff.

When industrialization begins, the 'leading sector' naturally differs from country to country. In the case of England, the textile industry was initially the leading sector yielding ground to machines building and transport which became the most important branch of exports later. In Germany, textile did not take off owing to stiff competition from British textile industry but engineering to serve railway construction experienced such rapid development to become significant export branch.

In the socialist countries, the process of industrialization led initially to a fast development of heavy industry notably metallurgy and engineering. In Hungary, the share of heavy industry was 70.5 per cent in 1964 of which engineering was 32.1 per cent. For some of the other developed countries, the share of engineering in the same year was 15.5 per cent in Ireland, 14.3 in Greece, 21.0 in Austria, 34.5 in West Germany, and 36.0 in the U.K. By 1976[1], the share of engineering remained the same for Hungary, rose marginally for Austria, and fell marginally for others.

Investment and Economic Growth

The literature on economic development[2] explicitly recognises the role of investment as a key factor determining the growth rates

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[1]See, World Bank, World Development Report, 1980, Washington, D.C. August 1980, p.121.

[2]See for example, A.K. Cairncross, "Reflections on the growth of capital and Income," Scottish Journal of Political Economy, June 1959; "The Contribution of Foreign and Indigenous Capital to Economic Development", International Journal of Agrarian Affairs, April 1961; W.A. Lewis, The Theory of Economic Growth, Homewood 1955; S.P. Schatz, "The Role of Capital Accumulation in Economic Development," Journal of Development Studies, October 1968.

of various sectors of the economy and of the national economy as a whole. Thus in the process of economic planning, after estimating the current rate of savings the next question of interest is the amount of net national output which may be expected from the investment that is to be made on the basis of the estimated savings. Several studies have been conducted on the amount of capital required to raise output by one unit per annum in each sector of the economy and for the entire economy. This variable often called "capital-output ratio" or "capital coefficient" features prominently in the basic Harrod-Domar model[1] as shown in the relation, $g = s/k^*$ where g is the percentage growth rate of the economy, s is the percentage of the national income which is saved and devoted to investment and k^* is the incremental capital-out-put ratio (ICOR). Thus, the growth rate can be increased by increasing the rate of investment or by decreasing the ICOR.

In an industrial country an investment of N100 may lead to an increase in national income of N33 a year yielding a capital output ratio of 3:1. This implies that an annual investment of 12 per cent of national income should result in an annual increase of about 4 per cent in the national income. While this estimate of the ICOR accords well with observed behaviour in advanced countries estimates computed for developing countries

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[1] See Evsey Domar, "The problem of Capital Formation" American Economic Review, December 1948. pp. 777-94; "Economic Growth: An Econometric Ap proach," American Economic Review, Papers and Proceedings, May 1952. pp. 479-95; R.F. Harrod, "An Essay in Dynamic Theory," Economic Journal, March 1939. For some criticisms of the capital output ratio, See G.M. Meier, Leading Issues in Economic Development 3rd ed. Oxford University Press, Hong Kong. pp. 169-179.

are generally much higher and of the order of 4:1. Thus, the capital-output ratio of 3:1 on which India's first Five Year Plan was based turned out to be an underestimate. Hence underdeveloped countries that characteristically saved as low as 5 to 6 per cent of their net national incomes annually, obviously needed to drastically raise this proportion towards 12 to 15 per cent (as recorded for developed countries) consistent with their population growth rates in order to really launch themselves into the "take off" stage. When capital formation in under-developed countries was so low and had failed somewhat to keep pace with population growth then, with a capital-output ratio of 4:1, the investment rate of 5 per cent out of net national income was only sufficient to sustain a population growth rate of about 1.25 per cent at the current level of income. This implied that a higher rate of population increase and higher standards of well-being could only occur if the rate of investment was pushed higher.

A bird's eye view of the gap between the rates of investment in some developed and developing countries is provided in Tables 1 and 2 below:[1]

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[1]For further details, see, World Bank, opcit, pp. 118-119.

TABLE 1

Rates of Investment in Developed Countries

Countries	%Investment	
	1960	1978
Australia	29	23
Canada	23	23
West Germany	24	22
Japan	34	31
U.S.A.	18	19
U.K.	19	19

TABLE 2

Rates of Investment in Underdeveloped Countries

Countries	% Investment	
	1960	1978
Rwanda	6	10
Bangladesh	7	12
Uganda	11	4
Egypt	13	28
Nigeria	13	30
Venezuela	21	40

In 1960, the p roportion invested out of GDP by the developed countries ranged from 18 to 34 per cent compared with 6 to 11 and 13 to 21 for the low income and middle income countries respectively. By 1978, the proportion had declined marginally to a range of 19 to

31 per cent for the developed countries, 4 to 10 per cent for the low-income countries, and improved significantly to between 28 and 40 per cent for the middle-income countries. Consequently, while rates of investment over the 1960-1970 decades have remained depressed for some developing countries vis-a-vis the developed countries, other developing countries recorded rates of investment that either equalled or greatly surpassed those of the developed countries.

Some statistical evidence about the influence of capital formation on economic growth is provided by P.J. Lund.[1] Specifically, Lund observed that, after steadily increasing to over 30 per cent the ratio of her gross domestic fixed investment to the GNP during 1950-1966 Japan achieved an annual rate of growth of GNP of 9.3 per cent. The United Kingdom and United States of America which, on the other hand, invested much less than 20 per cent of their GNP consequently chieved lower growth rates of 3 and 4 per cent respectively. This analysis is even carried a stage further by Denison and Poullier[2] who tried to measure the relative contributions of twenty three different factors (including, the capital input from 'residential structures and equipment') to the recorded growth of nine Western countries. It was observed that this [illegible]

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[1] See P.J. Lund, Investment The Study of an Economic Aggregate, Oliver and Boyd, Edinburgh, 1971, p.17.

[2] E.F. Denison and J.P. Poullier, Why Growth Rates Differ, Postwar, Experiences in Nine Western Countries, The Brookings Institution Washington, DC, 1967, cited by P.J. Lund, ibid.

capital input factor contributed between 9 and 20 per cent to the growth rates of those countries. The significance of this factor even appears to be further enhanced by the fact that out of the twenty three sources of growth in the countries examined, the influence of capital was most dominant in Norway, followed by Germany, Denmark, Netherlands. France, Belgium and the United States in that order. It may alao be mentioned that one other important source of growth after the capital input factor was 'advances of knowledge' and this finding also gains considerable emphasis in the study by Thomas[1] where he showed that a labour surplus economy such as Nigeria could very well improve the effectiveness of capital investment through "learning" thereby lowering its ICOR and raising productivity gains.

Much as capital input has been shown to be an important source of economic growth the choice of technique nevertheless poses an important problem for developing countries whether in terms of the choice between labour-using and capital-using techniques or between small-scale, light and heavy industries. In general, labour intensive production is often identified with small or medium-sized plant operations capable of producing 'light' consumer goods while capital intensive production orients toward large scale industrial output of heavy machinery or capital goods. Thus, iron and steel works, power plants and oil refineries require large capital investments though offering little

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[1]See D.B. Thomas, Capital Accumulation and Technology Transfer: A Comparative Analysis of Nigerian Manufacturing Industries, Praeger Publishers, N.Y., U.S.A. 1975.

employment but often times guaranteeing high output per worker. On the other hand, activities such as rice milling, manufacture of footwear, galvanising etc., are often organised on a comparatively small-scale basis and thus requiring lower capital investment while guaranteeing increased employment. The choice between these policies in a particular country may sometimes reflect the relative factor endowments of the country concerned and at other times, its foreign trade position which may, for example, permit a 'labour surplus' economy to exchange its foreign surplus for capital imports.

Various development plans in the past have clearly indicated broad areas for investment emphasis. In the case of the United Arabic Republic (U.A.R.) for example, the development plan provided for a faster growth in industry than in Agriculture and, within industry itself, a faster growth in heavy than light industry. Similarly, the Philippine government in its five year plan 1962-67 allocated roughly one-third of total planned investment to industry of which 57 per cent was for the production of ferrous and non-ferrous metals and for the engineering and chemical industries. On the other hand the plan of the Ivory Coast placed primary emphasis on Agriculture followed by energy production and mining while manufacturing development was only to play a complementary role to agricultural development. Although India emphasized basic heavy industries, the cottage and small-scale industries were in no way neglected owing to their labour-using and so capital-saving advantages vis-a-vis large industries coupled with the ease of dispersal for small-scale ventures[1].

After all is said and done, it should be mentioned that capital alone will perhaps not do the trick of development or of rapid industrial growth. Professor Kindleberger even posed the same problem by asking the question: "Is capital formation the key to economic development?"[2] In providing an affirmative answer to this question, he argued that capital can substitute for resources including labour, and, also with a given capital--output ratio more output tend to derive from capital formation. However, as he further argued, capital formation is necessary but cannot solely explain economic development for three reasons. First, the "take off" of a country from being a 5 per cent to a 12 per cent saver is often but not always abrupt thus requiring one to find other explanations beside models of geometric growth whereby capital induces growth in income which generates new additions to capital. Second, the growth process itself tends to proceed at rates which far exceed those that can be explained by capital formation process alone- and third, as economic growth gathers momentum, the rate of capital formation tends to level off and one needs to explain this by some other theory different from the one that ascribes a prime position to capital. Indeed, capital is but one of a number of economic factors that combine with social, political, and cultural forces to bring about the changes inherent in economic growth and development.

[1]For details about these and other thirty countries on this issue, see G.Cukor, op. cit. pp. 134 ff; I. Orchard, 'Industrialization in Japan, China mainland and India,' Annals, Assoc. American Geographers, (1960) pp. 193-125; and J.N. Bhagwati and P. Desai, India Planning for Industrialization and Developing Countries, Autchinson & Co. Ltd., London, 1975, pp. 163 and 190.

[2]P. Kindleberger, op. cit. p. 101

With the preceding analysis of the conditions of under-development, the role of industrialization in the growth process and the further role of capital formation in the process of industrial and general economic growth, it becomes pertinent to discuss fairly briefly trends in Nigerian capital formation over the last two decades and also review some of the fiscal incentives which government has provided for the encouragement of industrial growth in the economy.

Trends in Capital Formation in Nigeria

When measured against the rates of investment reported in Table 1 & 2 for developed and less-developed countries falling in the ranges 15 - 25 and 8 - 12 per cent annually one may be led to infer that capital formation in Nigeria grew rather impressively during the period 1958/59 to 1976/77. On an annual average basis over the period 1958/59 to 1960/61 gross fixed investment (GFI) constituted 11 per cent of gross national product (GNP) in current prices.[1] By the period 1973/74 to 1976/77 which coincided with the expiration life of the Second National Plan and the beginning life of the Third Plan, the GFI showed a remarkable growth to an annual average of 23 per cent of GNP.

As one shifts attention to the distribution of the GFI, the picture becomes equally as impressive as the growth which has just been discussed. The major divisions of gross fixed capital formation are between buildings, other construction except land improvement, and machinery and equipment.

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[1] The data on capital formation used in this section have been obtained from the following sources IBRD (1974), Nigeria Options for longterm Development, John Hopkins Univ. Press, Baltimore; FMED, Second National Plan (1970 - 1974), Lagos, 1975, and Third National Plan (1975 - 80), Lagos.

The share of aggregate investment in residential and non residential housing construction has assumed a declining trend since the fiscal year 1958/59. In specific terms, this sector accounted for a preponderant 34 per cent of gross capital formation during 1958/59 to 1962/63 which it successfully maintained into the period of the first development Plan but, however, lost control of owing to the political disturbances beginning in 1966. Hence, the share of this sector in total investment averaged 27.5 per cent annually from 1966/67 to 1970/71 and fell to 25.4 per cent in the later period 1970/71 to 1973/74.

By contrast, the behaviour of investment in other types of constuction activity has been quite impressive averaging about 20 per cent of the total during the five year period 1958/59 to 1962/63. Although this proportion declined marginally to an average of 19.4 percent from 1962/63 to 1966/77, investment in the sector picked up rapidly to an average level of 27.8 per cent during the war period and then to a significant 35.1 per cent in the post war period of the Plan for National Reconstruction and Development, namely, 1970/71 to 1973/74.

Investment in land improvement has also pursued a course similar to that of housing investment. More specifically, capital formation in land improvement declined with significant jumps from an annual average ratio of 13 per cent during the period 1958/59 to 1966/67, to 8.1 per cent during the war period and, to a trough of 3.0 per cent in the period of National Reconstruction.

The proportion of investment in transport equipment in aggregate capital formation has been on the upward trend. Thus, at a level of 7.4 per cent in the initial phase of analysis, capital formation in this sector progressed to 9.2, 12.8 and 14.6 per cent of the total in the respective subperiods of our analysis. Along with non-residential construction, the pace of investment in this sector has been quite noticeable.

The share of total investment taken by machinery and equipment has been steady, more or less, during the entire observation period which is probably explained by the relatively short-dated existence of most manufacturing industries in Nigeria and hence a much reduced rate of actual capital depreciation and replacement, and also the uncertainties for capital investment dictated partly by political events such as war, or the fluctuations in public policy. Hence, the rate of investment in machinery and equipment stood at an annual average level of 24 per cent of the total over the observed period immediately preceding the war, dropping marginally to 23.8 per cent later to reflect was conditions, and plummeting finally to 21.9 per cent in the period 1970/71 to 1973/74 to reflect the business sector's reaction to the implementation of the indigenization policy of the government.

Fiscal Incentives For Industrial Development in Nigeria

Since about 1957 when the Nigerian government seems to have taken active interest in a programmed growth of industries in Nigeria, this interest has been reflected through various legislative policies and other physical actions of the government. The most relevant of these for our purpose is the set of fiscal incentives that have been provided which have their origin in the four Acts of parliament passed in 1957, 1958 and 1959 namely, the Industrial Development (Import Duty Relief) Act 1957; theIndustrial Development (Income Tax Relief) Act 1958; the Customs Duties (Dumped and Subsidized Goods) Act, 1958; and the Customs (Drawback) Regulations, 1959. Under the income tax relief act, a company which has been granted a pioneer certificate could be exempted from tax for a period ranging from two to five years depending on the amount of capital invested but not less than ₦10,000. It has been estimated that between 1958 and 1967, a total of 60 industries had been declared pioneer while about 140 companies received pioneer certificates[1].

On the other hand, the Import Duty Relief Act permitted a firm to claim relief up to 100 per cent on duties paid for its raw material imports and indeed, under the Approved Users Scheme,[2] a firm that is approved in that behalf only needs to pay its concessionary duty on raw material imports without having to tie down its working capital unnecessarily.

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[1]The literature on the Nigerian fiscal incentives is fairly rich but see, for example, P.C. Asiodu, "Industrial Policy and Incentives in Nigeria", The Nigerian Journal of Economic and Social Studies, vol.9, No.2 July, 1967, pp 161 - 174 and A.O. Phillips, "Nigeria's Tax Incentives Policy: Recent Developments and Future Perspectives" in O. Teriba & M.O. Kayode (eds) Industrial Development in Nigeria, Ibadan Univ. Press, 1977, pp 348-363.

1. See P.C. Asiodu, ibid. July 1967
2. This scheme was however abolished in the 1972/73 budget

The Customs Duty (Dumped and Subsidized Goods) Act permitted the government to charge additional duties on specified imported goods if such goods were being dumped or subsidized by the government of the exporting country. The corrollary to this legislation which aimed at encouraging export industries was the Customs (Drawback) regulation whereby a local manufacturer could claim duty drawbacks or refunds of duty paid on imported materials used in the manufacture of export goods.

Further fiscal incentives for industrial development were provided in the Company Tax Law. Both initial and annual capital (depreciation) allowances were provided to enable firms quickly write off their capital investment within a short time. It was indeed possible, prior to the revision in October 1966, for a firm to write off as much as 70 per cent of a commercial vehicle during the first year. While the revision in 1966 was undertaken in favour of mining expenditure vis-a-vis plant expenditure so as to allow the depressed state of the tin mining industry to be revamped, the revisions undertaken in 1970 were meant to favour plantation expenditure as part of a package deal to rescue agriculture from its worsening position, and to assist in the reconstruction of damaged productive assets in the war affected areas. From this brief review of the changes in initial and annual capital allowances one can easily see the way by which these allowances were being used as a tool of industrial and general development policy.

In order to assess the role of tax incentives for investment and the promotion of industries in Nigeria a number of studies have been carried out notably by May, Hakam, and Phillips. After observing from his study that 6 out of the 26 British companies operating in Nigeria believed that the tax incentives were important, May concluded that "The generous tax incentives ...... appear to have had only a marginal effect."[1] In his own survey, Hakam found that only 16 per cent of his respondents selected fiscal incentives in their choice of Nigeria over other countries and thus concluded that "the incentives were not as significant as they would appear to be ..... (and that) tax incentives have been less of an attraction and more of a condition to be fulfilled before an investment is made."[2] Indeed one can easily see a dichotomy here between tax incentives being less of an attraction and their being a condition for investment to be undertaken.

The evidence from Phillips' survey suggests that out of the 41 responding companies, as many as 35 ranked the incentives to be of second or third importance in their investment decision process while no respondent ranked this factor least. This result tends to illuminate on the results earlier presented by May and Hakam and consequently led Phillips to conclude, even though with less vigour than his data would

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[1]R.May, "Direct Overseas Investment in Nigeria: 1953-63," Scottish Journal of Political Economy, vo,. 12, Nov. 1965, p. 253.

[2]A.N. Hakam, "The Motivation to Invest and the Locational Pattern of Foreign Private Investment in Nigeria," Nigerian Journal of Economic and Social Studies, March 1966, p.55.

seem to have indicated, that "while the incentives may not be crucial, they are nevertheless of some importance.[1]

These pieces of evidence, though not conclusive, certainly suggest that the fiscal incentives have had a role to play in the investment decision of the companies operating in Nigerian manufacturing industries. Since an integral aim of this study is to throw light on the role of tax incentives on investment spending, we examine this problem empirically in Chapter V of this study by assessing the effects of changes in tax rate and the tax treatment of depreciation allowances on investment expenditures. Meanwhile, however, we present in the next chapter a review of the theories of investment which are later tested on data for selected industries.

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[1] A. O. Phillips, "The significance of Nigeria's Income Tax Relief Incentive," Nigerian Journal of Economic and Social Studies, vol.II, No. 2, July 1969.

CHAPTER II

THEORIES OF INVESTMENT

The preceding chapter has examined the role of industrialization during the process of economic development and the further role of capital formation in the process of industrial and general economic growth. Furthermore, trends in Nigerian capital formation were briefly reviewed followed by a discussion of the tax incentives provided for business investment in Nigeria and, an assessment of available survey evidence on the role of such incentives in stimulating investment spending. The present chapter now examines more critically the determinants of business fixed investment expenditures in a theoretical setting thus providing the background for the subsequent formulation and implementation of specified models on the Nigerian data at the level of individual manufacturing industries.

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 nonquantifiable 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.

Survey of Issues

In this chapter, attention is focussed on one of the most controversial areas in the economics literature so far which may be described as capital theory. 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 review of some surveys[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 time structure of the investment process; and

(iv) the nature of replacement investment.

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

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.

Clark[1] 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. The latter variables have been associated with the theories of finance of Duesenberry[2] and Meyer and Kuh[3] and of Modigliani and Miller[4]. These determinants of the desired stock of capital are common to the empirical studies of Eisner[5], Grunfeld[6], Jorgenson and Siebert[7], and Kuh[8] undertaken both at the level of individual firms and for industry groups and employing annual observations.

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1. 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.

2. J.S. Duesenberry, Business Cycles and Economic Growth, McGraw Hill, New York, 1958.

3. J. Meyer and E. Kuh, op. cit.

4. 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.

5. 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.

6. Y. Grunfeld, "The Determinants of Corporate Investment" in A.C. Herberger (ed) The Demand for Durable Goods, Univ. of Chicago Press, Chicago, 1960.

7. 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.

8. E. Kuh, Capital Stock Growth: A Micro Econometric Approach. Amsterdam: North Holland, 1963.

To be more specific, we could consider four major theories that have gained popularity so far which include the Accelerator, the Liquidity, Expected Profit and the Neoclassical theories. If K^* is taken to represent the level of desired capital, we then find that in the Accelerator theory of investment desired capital is specified as,

$$K_t^* = \alpha Q_t \qquad (1)$$

where Q_t is current output and α is the desired capital output ratio. In the case of the Liquidity theory, desired capital, K_t^*, is specified as,

$$K_t^* = \alpha L_t \qquad (2)$$

where L_t measures the flow of internal funds available for investment, and α is the desired ratio of capital to the flow of internal funds. The Expected Profit theory of investment relates desired capital to the market value of the firm as a measure of profit expectation in the following way:

$$K_t^* = \alpha V_t \qquad (3)$$

where V_t measures the market value of the firm and α is the desired ratio of capital to the market value of the firm. Finally, in the Neoclassical theory of investment, the specification for desired capital is,

$$K_t^* = \alpha \frac{p_t Q_t}{c_t} \qquad (4)$$

where α is the elasticity of output with respect to capital input, p_t is the price of output, Q_t is output and c_t is the price of capital services.

It should be remarked however that the preceding summary of alternative specifications of desired capital is simply given as a preview for ease of exposition and comprehension. The rationale for each specification is, therefore, delayed and treated later in this chapter under each appropriate theory of investment. Meanwhile we consider the other controversial issues in the studies of investment behaviour.

The second issue, 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[1], and L.M. Koyck[2]. Although the model has been gradually modified and extended under the impact of new empirical findings, its basic outlines have found substantial empirical support. Thus, if K represents actual level of capital and K* its desired level, capital is then adjusted toward its desired level by a constant proportion of the difference between desired and actual capital,

$$K_t - K_{t-1} = (1 - \lambda) \quad (K_t^* - K_{t-1}) \tag{5}$$

Now, using accounting definition, the change in capital from period to period is equal to gross investment less replacement investment. While the flexible accelerator provides an explanation of change in capital it is totally silent on the issue of gross investment. Hence one may transform the flexible accelerator mechanism into a complete theory of investment behaviour by adding a specification of the desired level of capital and a model of replacement.

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

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1. H.B. Chenery, "Overcapacity and the Acceleration Principle," Econometrica, Jan. 1952, 20(1) pp. 1-28.

2. L.M. Koyck, Distributed Lags and Investment Analysis, North-Holland, Amsterdam, 1954.

$$K_t - K_{t-1} = I_t - \delta K_{t-1} \quad (6)$$

where I is gross investment, δ is the rate of replacement, a fixed constant and K is the actual capital stock. Combining this identity (6) with the flexible accelerator model of net investment (5), we obtain a model of investment expenditures following Jorgenson,[1]

$$I_t = (1 - \lambda)\ (K^*_t - K_{t-1}) + \delta K_{t-1} \qquad 0<\lambda<1 \quad (7)$$

where K* is desired capital stock and $(1 - \lambda)$ is the coefficient 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 longrun 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 (5) we have,

$$K_t = (1 - \lambda) \sum_{\tau=0}^{\infty} \lambda^{\tau} K^*_{t-\tau} \quad 0<\lambda<1 \quad (8)$$

Hence, actual capital is a distributed lag function of desired capital with geometrically declining weights.[2]

1. D. W. Jorgenson, "Econometric Studies ...." op. cit.

2. 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 stock. 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.

The characterisation given in equation (8) has been modified first by Chenery so that desired capital is proportional to lagged output. Koyck also modified the geometric distributed lag function so that the first weight may be determined as a separate parameter with successive weights declining geometrically,

$$K_t = \alpha K^*_t + (1-\alpha)(1-\lambda)\sum_{\tau=0}^{\infty} \lambda^{\tau} K^*_{t-\tau-1} \qquad (9)$$

Further modifications of the geometric distributed lag function are also possible, if additional weights are allowed to be determined as separate parameters or if desired capital is made a function of the lagged values of its determinants.

In the studies by Jorgenson and Siebert[1] the version of the flexible accelerator employed treats net investment as a distributed lag function of changes in desired capital, that is,

$$I_t - \delta K_{t-1} = \mu(\theta)(K^*_t - K^*_{t-1}) \qquad (10)$$

where (θ) is a power series in the lag operator θ such that

$$\mu(\theta) = \mu_o + \mu_1\theta + \mu_2\theta^2 + \mu_3\theta^3 + \ldots\ldots\ldots\ldots$$

and $\theta x_t = x_{t-1}$ for any sequence $\{x_t\}$

The weights associated with changes in desired capital are approximated by the weights in a rational distributed lag function. This class of distributed lag functions includes the geometric distributed lag function and generalizations of it proposed by Koyck as special cases. Empirical evidence from studies based on the geometric distributed lag function of Chenery and Koyck has suggested in Jorgenson's survey article that the resulting estimates of average lags are biased upward

1. Jorgenson and Siebert, op.cit.

quite substantially. However, rational distributed lag functions employed by Anderson[1], Hickman[2], Jorgenson and Siebert[3], and Jorgenson and Stephenson[4] have been shown in the same survey article to produce estimates of the average lags that are consistent with survey evidence on the lag structure.

The fourth issue which we examine is replacement. Most studies that include replacement investment explicitly employ the geometric mortality distribution for investment goods with the exception of Evan's[5] study of investment by industry groups. The geometric mortality distribution both implies that replacement is proportional to capital stock and that capital is a weighted sum of past gross investments with geometrically declining weights. Eisner[6], Grunfeld[7], Jorgenson

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1. W.H.L. Anderson, Corporate Finance, and Fixed Investment: An Econometric Study, Div. of Research, Grad. School of Bus. Admin., Harvard Univ., 1964.

2. B. Hickman, Investment Demand and U.S. Economic Growth, The Brookings Institution, Washington, D.C., 1965.

3. Jorgenson and Siebert, op. cit.

4. Jorgenson and Stephenson, op. cit.

5. M.K. Evans, "A Study of Industry Investment Decisions," Rev. Econ. Statist., May 1967, 49(2), pp. 151 - 54.

6. R. Eisner, "A Permanent Income Theory for Investment," Amer Econ. Rev., June 1976, 57(3), pp. 363-90.

7. Y. Grunfeld, op.cit.

and Siebert,[1] and Kuh[2] employ this distribution in the study of investment by individual firms. Bourneuf[3], Eisner,[4] Hickman,[5] Jorgenson and Stephenson,[6] and Resek[7] employ this distribution 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[8] wherein they argued that replacement investment denoted IR depends 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,

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1. Jorgenson and Siebert, op.cit

2. E. Kuh, op.cit.

3. A. Bourneuf, "Manufacturing Investment, excess Capacity and the Rate of Growth of Output," Amer. Econ. Rev., Sept. 1964, 54(5) pp. 607-25.

4. R. Eisner, "Realization of Investment Anticipations" in J. Duesenberry et. al. (eds), op.cit.

5. B. Hickman, op. cit.

6. Jorgenson and Stephenson, op. cit.

7. R.W. Resek, "Investment by Manufacturing Firms: A Quarterly Time Series Analysis of Industry Data," Rev. Econ. Statist., August 1966, 48(3), pp. 322-33.

8. D.W. Jorgenson and J.A. Stephenson, "Investment Behaviour in U.S. Manufacturing 1947-60", 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.

$$IR_t = \delta I_{t-1} + \delta(1-\delta)I_{t-2} + \delta(1-\delta)^2 I_{t-3} + \ldots \ldots$$

Using the lag operator, θ such that $\theta x_t = x_{t-1}$, $\theta^2 x_t = x_{t-2}$ etc.,

we have,

$$IR_t = \delta\theta I_t + \delta(1-\delta)\theta^2 I_t + \delta(1-\delta)^2\theta^3 I_t + \ldots\ldots$$

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

or,

$$I_t = \frac{(1-(1-\delta)\theta)}{\delta\theta} IR_t \qquad (11)$$

Since capital stock at the end of a period is the sum of all past net investments (IN)

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

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

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

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

Substituting for I_t from equation (11) we have,

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

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

Hence,

$$IR_t = \delta\theta K_t = \delta K_{t-1} \qquad (12)$$

We have now reviewed the issues involved in previous empirical studies of investment behaviour. It is clear that the accelerator theory of investment provided a point of departure for the development of alternative theories of investment. To summarize briefly, the approach of the Accelerator Theory to the issues examined is as follows:

1. output is a major determinant of desired capital, and so, desired capital is proportional to output (equation 1);
2. changes in demand for capital services are proportional to the difference between desired and actual capital as shown in equation 5;
3. the geometric distributed lag function is the mechanism for translating changes in desired capital into actual investment expenditures as portrayed by equation 8;
4. the geometric mortality distribution of investment goods serves as the basis for deriving replacement investment so that replacement is proportional to net capital stock as shown in equation 12.

In alternative theories of investment such as the Liquidity, Expected Profit, and Neoclassical theories, the desired level of capital is made to depend on the following variables respectively; liquidity of the firm, market value of the firm and, the relative price of output to the price of capital services multiplied by output. On the relationship between changes in the demand for capital and investment expenditures the basic premise is that of the flexible accelerator model as shown in equation 5 which explains net investment expenditure. Jorgenson then generalized this into a relationship in gross investment expenditures as contained in equation 7. On the description of the time structure of the investment process the basic premise has been the idea that desired capital is determined by long run considerations while the geometric distributed lag as shown in equation 8 has provided the basis for the lag generating mechanism. Once again, Jorgenson generalized this lag structure by employing rational distributed lags as embodied in the weights $u(\Theta)$ contained in equation 10. Finally, alternative theories agree that replacement investment is proportional to net capital stock as shown in equation 12.

Having discussed the preceding controversies and highlighted the approaches to their resolution by appealing to four popular theories of investment i.e. the Accelerator, Liquidity, Expected Profit and Neoclassical theories, we now present some reasons for the dissatisfaction with the Accelerator theory as well as the rationale for the specifications given under each theory of investment. For completeness, the Tobin's Q theory is also briefly discussed although its empirical evaluation will not be undertaken in this study for lack of the necessary data.

The Accelerator Theory

Although the rigid Accelerator Theory gave way to the flexible accelerator as a description of the nature of the investment process, even the refinements introduced by the latter theory were considered to be unsatisfactory and so paved the way for the development of other theories of investment behaviour. The most important limitations[1] of the Accelerator theory seem to have included:

[1]A detailed list of these limitations is provided by, 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, 19-4, 195-202 and, R.F. Wynn and K. Holden, op.cit. p.25.

(i) the symmetry of the accelerator mechanism implying, for example, that a 20 per cent increase (decrease) in output will lead to the same amount of capital stock being bought (scrapped);

(ii) the complete neglect of financial variables despite the fact that shortage or lack of finance may hinder the attainment of the desired level of capital stock;

(iii) absence of the role of prices when it is recognised that a change in the relative prices of labour and capital may lead firms to alter their investment plans;

(iv) assumption of a constant value for the desired capital output ratio which does not necessarily hold particularly if returns to scale are non-constant and,

(v) the implication that only output matters thus ignoring the influence of variables like profit, expectations, interest rates and liquidity on the investment decision of the firm.

Attempts to overcome these limitations have therefore produced alternative theories of investment behaviour which may be grouped under liquidity, Expected Profit, Tobin's Q, and the Neoclassical Theories.

The Liquidity Theory

Liquidity is here measured as the flow of internal fund 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"[1]

Lund,[2] 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. This approach has been severely criticized by Grunfeld[3] who found that the partial correlation between profits and

1. Jorgenson & Siebert, "An Empirical Evaluation of Corporate Investment" op. cit., p. 160.
2. P. J. Lund, op. cit See also, Wynn and Holden, op.cit. p. 26.
3. Grunfeld, op. cit.

investment, given capital stock, was insignificant and therefore, 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[1] 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.

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1. Wynn and Holden, op. cit. p. 27.

THE SECURITIES VALUATION OR TOBIN'S "Q THEORY"

Although Grunfeld simply proposed and used the stock market valuation of a company as a proxy variable for expected profit, a number of theories have focussed specifically on the market value of the firm as a determinant of its investment. Tobin, for instance, has argued that managers, when seeking to miximize the market value of their corporations, will add to their fixed capital stock whenever such a marginal addition to the firms' market value, measured by the marginal increase in the stock, exceeds the actual cost or replacement value of the addition[1] In other words, "the market valuation of equities relative to the replacement cost of the physical assets they represent is the major determinant of new investment. Investment is stimulated when capital is valued more highly in the market than it costs to produce it, and discouraged when its valuation is less than its replacement cost".[2] The ratio of the market value of equities to their replacement cost has been referred to by Tobin as "q". If q exceeds one there is an incentive to invest, and vice versa.

While Tobin's "q" theory has been held as a major competitor to Jorgenson's theoretical framework for investment behaviour, so far very limited attempts

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[1]This theory has been summarized in W.C. Brainard and J. Tobin, "Pitfalls in Financial Model Building," American Economic Association, Papers and Proceedings (American Economic Review, Vol.58, May 1968), pp 99-122. See also, J. Tobin, "An Essay on the Principles of Debt Management," in Essays in Economics, Vol.1 Macroeconomics. New York North Holland Publishing Co., 1971.

[2]W. C. Brainard and J. Tobin, op. cit pp 103-104.

have been made to reconcile both theories in the literature. In one of such attempts Robert Hall derived a relationship between changes in desired capital stock and Tobin's q and refers to it as "an implication of Jorgenson's model under static expectations and a geometric distribution of delivery times".[1]

Among some of the criticisms which have been levelled against the q theory, the following may be mentioned[2]: (i) the measurement of q is not so clear because in the literature, various means have been used to approximate both the market value of firms and the replacement cost of incomplete sets of assets, and (ii) it is difficult to sort out the market valuation of physical capital from that of the rest of a firm's asset. In general, therefore, fairly crude empirical approximations have been made to this theory which may be found in the studies by Bischoff, Von Furstenberg, and Ciccolo.[3] However, given the problems noted with the q theory and, more seriously, the lack of the required Nigerian data, its empirical investigation will not be undertaken subsequently in this study.

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[1]R.E. Hall, "Investment, Interest Rates, and the Effects of Stabilization Policies", Brookings Papers on Economic Activity 1: 1977, p.88

[2]For details of these criticisms, see C. Bischoff, "Business Investment in the 1970's; A comparison of Models, "Brookings Papers on Economic Activity 1: 1971, p.20, and G.M. Von Furstenberg, "Corporate Investment Does Market Valuation Matter in the Aggregate?" Broookings Papers on Economic Activity 2: 1977, p. 350.

[3]C. Bischoff, op. cit., G.M. Von Furstenberg, op cit., and J.H. Ciccolo, Jr. "Four Essays on Monetary Policy" (Ph. D. Dissertation Yale University 1975).

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 the Neoclassical theory of optimal capital accumulation[1] and having the flexible accelerator theory as a special case.

The essential ingredients of a theory of optimal capital accumulation may be summarised as follows:[2]

(i) The firm maximizes the utility of a consumption stream subject to a production function;

(ii) the firm supplies capital services to itself by acquiring investment goods;[3]

(iii) the rate of change in the flow of capital services is proportional to the rate at which investment goods are being acquired less the rate of replacement of previously acquired investment goods;

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

2. Jorgenson, ibid. p.136.

3. The chain of causation may be seen thus: the demand for investment is derived from the demand for capital assets which in turn is derived from the demand for capital services. Within this chain the firm may acquire capital assets (or may rent them from another firm that has previously acquired them) See Jorgenson, ibid. p.162.

(iv) the results of the productive process are then transformed into a stream of consumption on the assumption of fixed prices for output, labour services, investment goods and consumption goods which imply, alternatively, that current and future prices are taken as fixed as well as the current and future values of the rate of interest.

Given these conditions, utility maximization can proceed in two stages:

(a) the firm chooses a production plan so as to maximize present value;

(b) consumption is allocated over time in order to maximize utility subject to the present value of the firm.

The firm's production plan includes the levels of output, its labour input, the input of capital services and all other inputs. In order to provide an optimal level of capital services the firm then accumulates or decreases its capital stock over time. In summary, therefore, a productive enterprise demands capital services so as to maximize its own net worth. For this purpose, the firm also takes into account the manner in which the tax structure, particularly, the provision of business income tax, affects its demand for capital services.

We now derive formally, the neoclassical theory of optimal capital accumulation which underlines Jorgenson's theory of investment[1]. We start with definitions for net receipts and the tax structure leading to the definition for present value. Thus the flow of net receipts

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1. For full details, see D.W. Jorgenson, "Anticipations and Investment Behaviour," in J.S. Duesenberry, G. Fromm, L.R. Klein, and E. Kuh (eds) The Brookings Quarterly Econometric Model of the United States, R. McNall & Co., Chicago, 1965.

which is the difference between revenue and outlay on both current and capital account in period t, say R, is of the form:

$$R(t) = p(t)\ Q(t) - s(t)L(t) - q(t)I(t) \quad (13)$$

where p is the price of output, Q is the quantity of output, s represents the price of labour input, L measures the quantity of labour input, q is the price of capital goods, I represents investment in capital stock and t is time. Next we derive an expression for the tax structure of the firm as a relationship between direct taxes, T, and the product of the tax rate, u, and income:

$$T(t) = u(t)\{ pQ - sL - q(n(t)\delta - w(t)r + x(t)\dot{q}/q)k\} \quad (14)$$

where,

T(t) = amount of direct tax assessed in period t;

K = stock of capital employed;

u(t) = rate of taxation of net income

d = rate of depreciation (replacement);

r = cost of capital;

$-\dot{q}/q$ = rate of capital loss, ($\dot{q}_t = q_t - q_{t-1}$)

n(t) = proportion of depreciation chargeable against net taxable income;

w(t) = proportion of cost of capital chargeable against net taxable income;

x(t) = proportion of capital loss on assets subject to taxation.

Present value or net worth of the firm, say V, is obtained by taking the integral of discounted net receipts minus discounted direct taxes as contained in equations 13 and 14 so that;

$$V = \int_0^\infty e^{-rt} \left[R(t)-T(t) \right] dt \tag{15}$$

where,

r is the rate of discount.

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 which is equal to total investment less replacement. If replacement is proportional to capital stock the first constraint then takes the form:

$$\dot{K}(t) = I(t) - \delta K(t) \tag{16}$$

where,

$\dot{K}(t)$ 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:

$$F(Q,L,K) = 0 \tag{17}$$

This production function is assumed to be well behaved[1] and strictly convex.

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1. From economic theory, this assumption implies that the production function is twice differentiable, with positive marginal rates of substitution between inputs and positive marginal productivities of both inputs. See for example, R.C.D. Allen, Macro-economic Theory: A Mathematical Treatment, London, Macmillan, 1967.

The maximization of present value (15) subject to the constraints (16) and (17) is achieved by maximizing the lagrangian expression[1]:

$$L = \int_0^\infty \{e^{-rt}(R-T)+\lambda_1 F(Q,L,K)+\lambda_2(\dot{K}-I+\delta k)\}dt,$$

$$= \int_0^\infty f(t)\, dt, \qquad (18)$$

where,

$$f(t) = e^{-rt}(R-T) + \lambda_1(t)F(Q,L,K) + \lambda_2(t)(\dot{K}-I+\delta K)$$

and the time subscripts on R,T, and so on, have been dropped for notational convenience. Applying the calculus of variations technique[2] the Euler necessary conditions for a maximum of (18) are:

$$\frac{\partial f}{\partial Q} = e^{-rt}(1-u)\, p + \lambda_1(t)\frac{\partial F}{\partial Q} = 0,$$

$$\frac{\partial f}{\partial L} = -e^{-rt}(1-u)s + \lambda_1(t)\frac{\partial F}{\partial L} = 0,$$

$$\frac{\partial f}{\partial I} = -e^{-rt}q - \lambda_2(t) = 0, \qquad (19)$$

$$\frac{\partial f}{\partial k} - \frac{d}{dt}\frac{\partial f}{\partial \dot{K}} = e^{-rt}u(t)q\,\{n(t)\,\delta + w(t)r - x(t)\dot{q}/q\} + \lambda_1(t)\frac{\partial F}{\partial K} + \lambda_2(t)\delta - \frac{d}{dt}\lambda_2(t) = 0$$

and also

$$\frac{\partial f}{\partial \lambda_1} = F(Q,L,K) = 0$$

$$\frac{\partial f}{\partial \lambda_2} = \dot{K} - I + \delta K = 0 \qquad (20)$$

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

2. See M.D. Intrilligator, Mathematical Optimization and Economic Theory, Englewood Cliffs, N.J., Prentice Hall, 1971 and A. Takayama, Mathematical Economics, The Dryden Press, Hinsdale Illinois, 1974. The latter author obtained much similar results by the use of optimal control technique.

The fourth expression in (19) i.e. the Euler equation, is the condition for the optimal growth path of K. In order to derive the marginal productivity condition for capital services we combine three of the expressions in (19) involving the partial derivatives with respect to output, investment, and the Euler equation. Thus, from the partial derivative with respect to investment we obtain,

$$\lambda_2(t) = -e^{-rt}q(t), \tag{20a}$$

and,
$$\frac{d}{dt}\lambda_2(t) = re^{-rt}q - e^{-rt}\dot{q} \tag{20b}$$

Substituting (20a) and (20b) into the Euler equation gives:

$$e^{-rt}uq\{n\delta + wr - x\dot{q}/q\} + \lambda_1(t)\frac{dF}{dk} - e^{-rt}q\delta$$
$$-re^{-rt}q + e^{-rt}\dot{q} = 0, \tag{21a}$$

or,
$$\lambda_1(t)\frac{dF}{dk} + e^{-rt}uq\{n\delta + wr - x\dot{q}/q\}$$
$$-e^{-rt}q\{\delta + r - \dot{q}/q\} = 0 \tag{21b}$$

Combining the first equation in (19) with (21b) we get the marginal productivity condition for capital services:

$$\lambda_1(t)\frac{\partial F}{\partial k} = -e^{-rt}uq\{n\delta + wr - x\dot{q}/q\} + e^{-rt}q\{\delta + r - \dot{q}/q\}$$

and,
$$\lambda_1(t)\frac{\partial F}{\partial Q} = -e^{-rt}(1-u)p$$

So,
$$\frac{\partial F/\partial k}{\partial F/\partial Q} = -\frac{\partial Q}{\partial k} = \frac{e^{-rt}q\{-un\delta + \delta - uwr + r + ux\dot{q}/q - \dot{q}/q\}}{-e^{-rt}(1-u)p} \tag{21}$$

$$= -\frac{q}{1-u}\,\frac{\{(1-un)\delta + (1-uw)r - (1-ux)\dot{q}/q\}}{p}$$

which simplifies to,

$$\frac{\partial Q}{\partial k} = \frac{c}{p} \qquad (22)$$

where, $c = \frac{q}{1-u}\{(1-un)\delta + (1-uw)r - (1-ux)\dot{q}/q\}$

Consequently, equation 22 expresses the fact that, the marginal productivity of the input of capital services is equal to the ratio of the price of capital services, c, to the price of output, p, and this condition determines the equilibrium capital stock of the firm. The variable c is alternatively referred to in the literature as the user cost of capital and so defines the implicit rental value of capital services supplied by the firm to itself.

The theory of optimal capital accumulation developed so far suggests that if investment projects were to be completed without any lags then the level of investment or actual capital stock could be determined from the constraint equation (16) that the rate of change of capital stock is equal to investment minus replacement, while desired capital stock may be determined from the marginal productivity condition for capital (21). Furthermore, the actual level of capital stock on hand will equal the desired or optimal level of capital stock in the absence of lags. These basic ideas of the existing neoclassical theory of optimal capital accummulation were then extended by Jorgenson on the premise that investment expenditures are characterized by lags so that the desired level of capital stock is in fact equal to actual capital stock plus the backlog of uncompleted investment projects for the expansion of capital stock. The full expression of Jorgenson's theory of investment behaviour was stated in equation (7) while we now review the details of the developments leading to that equation.

The basic ideas then are that gross investment expenditure, I_t, is the sum of two parts, that is, investment for the expansion of capacity, IE_t, and investment for the replacement of capital previously acquired, IR_t. However, the level of investment for expansion depends on the level of projects initiated in previous periods up to the present while replacement investment is proportional to net capital stock. These ideas are now developed more rigorously.

We begin with the relationship between investment for the expansion of capacity and projects newly initiated. If u_t is taken to represent the proportion of investment projects started at time t and completed at time $t + \tau$,

such completed proportions over time may be represented by the following sequence of non-negative numbers $u_o, u_1, u_2,$ (23)

which sum to unity, that is $\sum_{\tau=0}^{\infty} \mu_\tau = 1$ (24)

Now, let IE_t represent investment projects for the expansion of capacity and IN_t the level of projects initiated in period t. Hence,

$$IE_t = \mu_o IN_t + \mu_1 IN_{t-1} + \mu_2 IN_{t-2} \quad . . . (25)$$

or,

$$IE_t = \mu(\theta) IN_t$$

where u(θ) is a power series in the lag operator θ such that

$$\mu(\theta) = \mu_o + \mu_1 \theta + \mu_2\theta^2 + \mu_3\theta^3 + . . .$$

Equation (25) thus shows the distributed lag relationship between investment for capacity expansion and projects newly initiated and expresses the fact that the level of actual investment expenditure for expansion in each period is a weighted average of the level of projects initiated in all previous periods.

It has been assumed above that the desired level of capital is equal to the actual level plus the backlog of projects not yet completed. In order words, projects are continuously being initiated until the backlog of projects still to be completed is equal to the level of desired capital stock denoted K^*_t, less actual capital, K_t. This idea may be represented formally as

$$IN_t + (1-\mu_o) IN_{t-1} + (1-\mu_o - \mu_1) IN_{t-2} + . . . = K^*_t - K_{t-1} \quad (26)$$

where the weights, $(1-\mu_o - \mu_1)$ and so on, indicate the proportion of projects started during the preceding period but not completed at the beginning of the current period. The lag operator mechanism introduced previously may now be used to convert equation (26) into a manageable form as follows. Beginning with the left hand side and setting it finally equal to the right hand side we have:

$$IN_t + (1-\mu_o)\,\theta IN_t + (1-\mu_o-\mu_1)\theta^2 IN_t + (1-\mu_o-\mu_1-\mu_2)\theta^3 IN_t + \ldots$$

$$= (1 + (1-\mu_o)\theta + (1-\mu_o-\mu_1)\theta^2 + (1-\mu_o-\mu_1-\mu_2)\theta^3 + \ldots)) IN_t$$

$$= (1 + \theta+\theta^2+\theta^3+ \ldots) - (1+\theta+\theta^2+\theta^3 +)\theta\mu_o -$$

$$(1+\theta+\theta^2+\theta^3 + \ldots)\,\theta^2\mu_1 - (1+\theta+\theta^2+\theta^3+\ldots)\theta^3\mu_2 - \ldots))IN_t$$

$$= (1+\theta+\theta^2+\theta^3 + \ldots)(1-\theta\mu_o-\theta^2_{\mu 1} - \theta^3_{\mu_2} - \ldots)\; IN_t$$

$$= (\frac{1}{1-\theta}\,(1-\theta\mu_o-\theta^2_{\mu 1}-\theta^3\mu_2 - \ldots))\; IN_t$$

$$= \frac{1}{1-\theta}(1-\theta(\mu_o+\mu_1\theta+\mu_2\theta^2 + \ldots))\; IN_t$$

$$= \frac{1 - \theta\mu(\theta)}{1-\theta}\, IN_t$$

So that

$$K^*_t - K_{t-1} = \frac{1 - \theta\mu(\theta)}{1-\theta}\, IN_t \qquad (27)$$

In order to derive a relationship between investment for expansion and changes in desired capital we operate on equation (27) as follows:-

$$K^*_t = K_{t-1} + \frac{1 - \theta\mu(\theta)}{1-\theta}\, IN_t$$

Taking the first difference yields,

$$K^*_t - K^*_{t-1} = K_{t-1} - K_{t-2} + \left[\frac{1 - \theta\mu(\theta)}{1-\theta}\right]\left[IN_t - IN_{t-1}\right]$$

which simplifies to,

$$K^*_t - K^*_{t-1} = (1-\theta)\, K_{t-1} + \left[\frac{1-\theta\mu\,(\theta)}{1-\theta}\right](1-\theta)\; IN_t$$

or, $K^*_t - K^*_{t-1} = (1-\theta)\, K_{t-1} + IN_t - \theta\mu(\theta)\; IN_t.$

Using the fact that,

$$(1 - \theta)K_{t-1} = IE_{t-1} = \theta\mu(\theta)IN_t$$

we have finally,

$$IN_t = K^*_t - K^*_{t-1} \tag{28}$$

Equation (28) states that projects initiated in each period are equal to the change in desired capital from period to period. Combining (25) and (28) we obtain investment for expansion as a distributed lag function of changes in desired capital:

$$IE_t = u(\theta) \quad (K^*_t - K^*_{t-1}) \tag{29}$$

In order to complete Jorgenson's theory of investment behaviour we need to combine the theory of investment for expansion with the theory of replacement derived earlier on. This is done by first recognising that gross investment is the sum of two components:

$$I_t = IE_t + IR_t. \tag{30}$$

Substituting equations (12) and (29) into (30) we have the final expression for gross investment

$$I_t = u(\theta) \quad (K^*_t - K^*_{t-1}) + \delta K_{t-1} \tag{31}$$

Thus, gross investment is a distributed lag function of changes in desired capital plus replacement investment.

It can easily be shown that equation 31 is a generalization of the flexible accelerator mechanism (5) which assumed geometrically declining weights. This time, the weights u_τ embodied in $u(\theta)$ are simply assumed to be non-negative and sum to unity:[1]

$$\mu\tau > 0, \quad (\tau = 0, 1, \ldots),$$

$$\sum_{\tau=o}^{\infty} \theta_{\tau} = 1$$

Hence the distributed lag function (8) takes the form,

$$k_t = \sum_{\tau=o}^{\infty} \mu_{\tau} \; K^*_{t-\tau} \tag{32}$$

The flexible accelerator mechanism (5) is then generalized by first differencing both sides of the distributed lag function (32),

$$K_t - K_{t-1} = \sum_{\tau=o}^{\infty} \mu_{\tau} \; (K^*_{t-\tau} - K^*_{t-\tau-1}),$$

and using identity (6) to get,

$$I_t - \delta K_{t-1} = \sum_{\tau=o}^{\infty} \mu_{\tau}(K^*_{t-\tau} - K^*_{t-\tau-1}).$$

Rearranging gives,

$$I_t = \sum_{\tau=o}^{\infty} \mu\tau \; (K^*_{t-\tau} - K^*_{t-\tau-1}) + \delta K_{t-1} \tag{33}$$

Equation 33 is therefore equivalent to equation 31, i.e,

$$I_t = \mu(\theta) \; (K^*_t - K^*_{t-1}) + \delta k_{t-1} \tag{34}$$

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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 Univ. , Columbus, Ohio, 1972 pp. 155-217.

We could actually describe equation 31 as the basis of this study. In particular, we take the equation as the standard one for the explanation of investment behaviour, vary the definition for desired capital stock K^* in accordance with equations (1) to (4) so as to test differences in alternative investment theories, and then determine the nature of the lag structure $u(\theta)$ for the purpose of describing the time structure of the investment process from industry to industry.

Prior to these empirical testing exercises which are taken up in later chapters we need to determine the desired capital stock K^* by choosing a particular form of the production function (17) which we may assume to be Cobb-Douglas

$$Q = AK^{\alpha}L^{1-\alpha} \tag{35}$$

where α is the elasticity of output with respect to capital input. The marginal productivity condition (21) for capital input is now:[1]

$$\frac{\partial Q}{\partial k} = \alpha A^{\alpha-1}L^{1-\alpha} = \frac{c}{p}$$

which simplifies to,

$$\alpha(Q/K^*) = \frac{c}{p}$$

and could be solved for desired capital as

$$K^* = \alpha(p\frac{Q}{c}) \tag{36}$$

Equation 36 expresses the fact that the desired level of capital under the Neoclassicial theory is proportional to output and the relative

1. See R. E. Hall and D.W. Jorgenson "Application of the Theory of Optimal Capital Accumulation," in G. Fromm (ed)., Tax Incentives and Capital Spending, The Brookings Institution, Washington, D.C., 1971.

prices of output and capital services, and it shows the complete process of deriving desired capital stock under the Neoclassical theory as stated earlier in equation 4.

We may remark further that Jorgenson distinguished two versions of his neoclassical theory depending on the treatment of the cost of capital. While he still accepted the Modigliani-Miller 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.

By reflecting this distinction in equation 4 we now have two specifications for desired capital under the Neoclassical theory i.e.,

$$\text{Neoclassical I:} \quad K_t^* = \alpha \frac{p_t Q_t}{c_{1t}} \tag{37}$$

where,
$$c_1 = q \left\{ \left(\frac{1-un}{1-u}\right)\delta + \left(\frac{1-uw}{1-u}\right) r - \left(\frac{1-ux}{1-u}\right)\frac{\dot{q}}{q} \right\}$$

and,

Neoclassical II: $$K_t^* = \frac{\alpha p_t Q_t}{c_{2t}} \tag{38}$$

where, $$c_2 = q\left\{\left(\frac{1-un}{1-u}\right)\delta + \left(\frac{1-uw}{1-u}\right)r\right\}$$

This completes our review of the available theories of investment which are now summarized.

Summary

Previous studies of investment behaviour have examined four main controversial issues with limited agreement. The issues include the determinants of desired capital, the relationship between changes in the demand for capital and investment expenditures, the time structure of the investment process and, the nature of replacement investment. Attempts to resolve these issues led to the development of four major theories of investment behaviour. The Accelerator theory which served as the point of departure for other theories specified the level of desired capital as proportional to output and then concerned itself with explanations for net investment expenditure. The geometric distributed lag function was also employed as the mechanism for translating changes in desired capital into actual investment expenditure. Alternative theories such as the Liquidity, Expected Profit and Neoclassical theories specified the desired level of capital as a function of the following variables respectively:

liquidity of the firm, market value of the firm and, the relative price of output to the price of capital services multiplied by output.

In tackling the other issues, all the theories except the Neoclassical followed essentially the approach of the Accelerator theory. However, in developing the Neoclassical theory of investment, Jorgenson generalized the Accelerator in various directions. Firstly, he applied the tool of comparative dynamics to the existing neoclassical theory of optimal capital accumulation and then derived a relationship between desired capital stock and its determinants, i.e., output, price of output and the price of capital services. He introduced a model of replacement investment into the net investment model of the Accelerator and then generalized this into a model of gross investment expenditures having as its arguments the investment undertaken for the expansion of capital stock and the one undertaken for the replacement of worn-out capital. Thirdly, he generalized the geometric lag mechanism in the Accelerator case to a rational distributed lag in which the weights are simply non-negative and sum to unity, thus incorporating the case of geometrically declining weights as as a special case. In view of these extensions, Jorgenson and his associates have actually been regarded as providing the most complete statement of the theory of investment behaviour.

It should be remarked that in testing his investment theory on a wide variety of data, Jorgenson himself adopted the estimation technique of ordinary least squares or some modification of it. Once again, this produced sharp criticisms from researchers and led to attempts to provide unbiased estimates of Jorgenson's investment equation. In the chapter that follows, we discuss some of the popular distributed lag models and their suggested methods of estimation. This leads finally to a discussion of Jorgenson's rational distributed lags and the various approaches offered for their estimation.

CHAPTER III

ECONOMETRICS OF INVESTMENT BEHAVIOUR

Formulation of Distributed Lags

There exists already an extensive literature on distributed lags and their applicability in describing the investment process. Various arguments have been presented in some of this literature to support the claim that firms rarely adjust instantaneously to changes in their desired stocks of capital but over a given period. 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.

Most distributed lag schemes fall under one category or the other, that is, they are either finite lag schemes or infinite lag schemes. The first group includes schemes like the arithmetic lag proposed by Fisher, inverted-V by Deleeuw, and polynomial by Almon, while the second includes the geometric by Koyck, Pascal by Solow, rational by Jorgenson, and gamma by Tsurumi. These schemes are reviewed in what follows while their suggested methods of estimation and the application of rational distributed lags to the investment function derived in equation 31 of Chapter II are taken up in succeeding sections of this chapter.

Finite Lag distributions

A finite lag distribution shows the distributed lag effects of a variable x_t on another variable y_t over a finite time period. Thus, assuming k periods, we can write, $y_t = B_o x_t + B_1 x_{t-1} + B_2 x_{t-2} + \ldots$

$$\ldots\ldots\ldots\ldots + B_k x_{t-k} + \varepsilon_t \qquad (1)$$

where ε_t is an error term.

Since the estimation of equation (1) in its present form often introduces a high degree of multicollinearity it is usual in practice to impose some "structure" on the B's in the equation. Various suggestions given in the literature in this regard have led to the following alternative distributed lag schemes.

Professor Irving Fisher[1] introduced the arithmetic lag which assumes that the lag coefficients B_i decline arithmetically. Thus, we have

$$B_i = B(k + 1 - i) \qquad 0 \leq i \leq k \qquad (2)$$
$$= 0 \qquad \text{for } i > k$$

Substituting (2) into (1) gives

$$y_t = B \left(\sum_{i=o}^{k} (k + 1 - i)\, x_{t-i}\right) + \varepsilon_t$$
$$= BZ_t + \varepsilon_t \qquad \text{where } Z_t = \sum_{i=o}^{k} (k + 1 - i)x_{t-i}$$

This is a linear relationship whose estimation leads directly to the value of B which may be used in equation (2) to obtain estimates of the Bi.

The inverted - V lag distribution was suggested and used by DeLeeuw[2]. To simplify matters we may suppose that k is even, and $B_o = 0$, $B_k = 0$. We then have, $B_i = iB$ for $0 \leq i \leq \frac{k}{2}$ (3)

$$= (k-i)B \text{ for } \frac{k}{2} \leq i \leq k$$

Using these values equation (1) may then be transformed into

$$y_t = BZ_t + \varepsilon_t$$

1. I. Fisher, "note on a Short-Cut-method-for-Calculating Distributed Lags" International Statistical Institute Bulletin, 1937pp 323-327.
2. F. DeLeeuw, "The Demand for Capital Goods by Manufacturers: A study of Quaterly Time Series", Econometrica, 1962.

where

$$Z_t = \sum_{i=0}^{k/2} i x_{t-i} + \sum_{i=(k/2)+1}^{k} (k-i)\, x_{t-i}$$

The estimate of B which derives from regressing y_t on the "constructed" variable Z_t may then be used in (3) to obtain estimates of Bi. The lag pattern frequently described as Almon Polynomial lag was suggested and used by Shirley Almon[1] and is a generalization of the Fisherian linear lag on the assumption that the Bi follow a polynomial in i. To take a quadratic polynomial for illustration,

$$B_i = \alpha_o + \alpha_1 i + \alpha_2 i^2, \qquad (i = -1, o, 1 \ldots, k, k+1) \qquad (4)$$

Substituting this into (1) yields,

$$y_t = \sum_{i=0}^{k} (\alpha_o + \alpha_1 i + \alpha_2 i^2) x_{t-i} + \varepsilon_t$$

which can be concentrated as

$$y_t = \alpha_o Z_{ot} + \alpha_1 Z_1 t + \alpha_2 Z_{2t} + \varepsilon t \qquad (5)$$

where,

$$Z_{ot} = \sum_{i=o}^{k} x_{t-i}, \quad Z_{1t} = \sum_{i=o}^{k} i x_{t-i}, \quad Z_{2t} = \sum_{i=o}^{k} i^2 x_{t-i},$$

Thus, an ordinary least squares (O L S) regression of y_t on the constructed variables Z_{ot}, Z_{1t} and Z_{2t} will lead to estimates of the α's which can be used to obtain estimates of the B_i. It is usual,

1. S. Almon, "The Distributed lag between Capital Appropriations and Expenditures" Econometrica Jan. 1965, pp 178-196.

however, to assume some "end point constraints" like $B_i = o$ and $B_{k+i} = o$ which may be substituted into (1) to produce two relationships involving the α's in (4) $\alpha o - \alpha_1 + \alpha_2 = 0$

and $\alpha o + \alpha_1 (k+1) + \alpha_2 (k+1)^2 = 0$

These equations can be solved say for α_o and α_1 to get

$$\alpha o = -\alpha_2 (k+1) \qquad (6)$$

and

$$\alpha_1 = -\alpha_2 k \qquad (7)$$

which allow (5) to be simplified to

$$y_t = \alpha_2 Z_t + \varepsilon_t$$

where, $Zt = \Sigma(i^2 - ki - k - 1)\, x_{t-i}$

An OLS regression of y_t on Zt will then yield an estimate for α_2 which may be used in turn to obtain estimates of α_o and α_1. These latter estimates finally yield estimates of the B_i from (4).

The Almon lag specification has been criticized on a number of grounds including the assumption of end point constraints which cause the lag distribution to exhibit its "plausible" shapes, the fact that one really has no way of knowing the length k of the lag distribution and, also, if a distribution has a long tail a single polynomial of the Almon type may fail to reveal this effectively.[1]

Infinite lag distributions

Following the problems noted with the Almon-lag scheme particularly the choice of the lag k, the suggestion has been made to use an infinite

1. For some suggestions to remedy these difficulties, see G.S. Maddala, op.cit. p.358.

lag distribution whose weights decline after some time. Such a distribution can be derived by first rewriting equation (1) as

$$Y_t = \sum_{i=o}^{k} \beta i \, L^i xt + \varepsilon_t$$

where L is the lag operator such that $Lx_t = x_{t-1}$, $L^2 x_t = x_{t-2}$, etc. Thus, for the infinite lag case, we have

$$Y_t = \sum_{i=o}^{\infty} \beta_i L^i x_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

For reasons of limited data points which make it virtually impossible to estimate (8) in its present form it is usual to rewrite the equation in the form $Y_t = \beta \sum_{i=o}^{\infty} \omega i L^i x_t + \varepsilon_t$ (9)

with the usual restrictions

$$w_i > o, \; \sum_{i=o}^{\infty} wi = 1$$

Thus the w_i are treated as probabilities and use can be made of the probability generating function w(L) so that

$$w(L) = w_o + w_1 L + w_2 L^2 + \ldots\ldots\ldots\ldots\ldots\ldots$$

A number of infinite lag schemes have been suggested in the literature as follows:

The geometric lag scheme was suggested and used by Koyck[1] on the assumption that the distribution of the w_i follows a geometric pattern:

$$w_i = (1 - \lambda) \lambda^i \quad (10)$$

Substituting (10) into (9) yields,

1. L. M. Koyck, op cit.

$$y_t = \beta(1-\lambda) \sum_{i=o}^{\infty} \lambda^i L^i x_t + \varepsilon_t$$

which simplifies to,

$$y_t = \frac{\beta(1-\lambda)}{1-\lambda L} x_t + \varepsilon_t \qquad (11)$$

Equation (11) is the distributed lag form of the geometric lag scheme. An alternative formulation which yields an autoregressive model may be obtained through multiplying both sides of (11) by $(1-\lambda L)$ and simplifying to get,

$$y_t = \beta(1-\lambda)x_t + \lambda y_{t-1} + \varepsilon_t^* \qquad (12)$$

where, $\varepsilon_t^* = \varepsilon_t - \lambda\varepsilon_{t-1}$

The main shortcoming of the koyck scheme arises from the assumption that the major impact comes immediately and 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. Hence the Pascal lag distribution has been recommended as a remedy for this problem..

Solow proposed representing the distributed lag coefficients w_i by the coefficients of L^i in the negative binomial distribution. So, if[1]

$$\omega(L) = \frac{(1-\lambda)^r}{(1-\lambda L)^r} \qquad (13)$$

then

$$\omega_i = (1-\lambda)^r \binom{r+i-1}{i} \lambda^i = (1-\lambda)^r \frac{(r+i-1)!}{i!(r-1)!} \lambda^i \quad (i=o,1,2,..)$$

1. R. M. Solow, On a Family of Lag Distributions, Econometrica, April 1960, pp 393-406

The distributed lag form of the Solow scheme thus becomes

$$y_t = \frac{\beta(1-\lambda)^r}{(1-\lambda L)^r} x_t + \varepsilon_t \qquad (14)$$

or, $$y_t = \beta(1-\lambda)^r \left\{x_t + r\lambda x_{t-1} + \frac{r(r+1)\lambda^2}{2!} x_{t-2} + \ldots\right\} + \varepsilon_t$$

while the autoregressive form is

$$(1-\lambda L)^r y_t = \beta (1-\lambda)^r x_t + \varepsilon^*_t \qquad (15)$$

where, $\varepsilon^*_t = (1-\lambda L)^r \varepsilon_t$

For the case r = 2, equation (15) becomes

$$y_t = \beta(1-\lambda)^2 x_t + 2\lambda y_{t-1} - \lambda^2 y_{t-2} + \varepsilon^*_t$$

Again, Solow's negative binomial distributed lags face the estimation problem of choosing the integer r and, consequently, that of the nonlinearity of the parameters. Furthermore, if the actual lag distribution of the phenomenon being characterized shows a significant peak at the beginning a Pascal lag distribution may be unable to reveal same. Hence, Jorgenson proposed the rational distributed lags as a generalization of the Solow scheme.

Jorgenson suggested that any arbitrary lag function can be approximated by a rational distributed lag of the form

$$W(L) = \frac{u(L)}{v(L)} \qquad (16)$$

where L is the lag operator defined previously and

$$u(L) = \sum_{i=o}^{n} u_i L^i, \; V(L) = \sum_{j=o}^{m} v_j L^j, \; V_{o=1}, \; n<m. \qquad (16a)$$

The distributed lag form of Jorgenson's scheme is then,

$$y_t = \frac{u(L)}{V(L)} x_t + \varepsilon_t \quad t = 1,2, \ldots. T \qquad (17)$$

The error term ε_t is assumed to be normally distributed with zero mean and constant variance which may be compactly expressed as

$$\varepsilon_t \sim N(o, \sigma^2 I), \ \varepsilon = (\varepsilon_1, \varepsilon_2 \ldots \varepsilon_T)' \tag{17a}$$

On the other hand, the autoregressive form of the rational lag model is

$$V(L) y_t = U(L) x_t + \varepsilon_t^* \tag{18}$$

where,

$$\varepsilon_t^* = V(L)\varepsilon_t \tag{18a}$$

In order to express the rational distributed lag more fully, we may consider a quadratic case in which $u(L) = u_o + u_1 L + u_2 L^2$ and $V(L) = 1 + V_1 L + V_2 L^2$.

The final form of the distributed lag model is now

$$y_t = \frac{U_o + U_1 L + U_2 L^2}{1 + V_1 L + V_2 L^2} X_t + \varepsilon_t \tag{19}$$

while the autoregressive form is

$$(1 + V_1 L + V_2 L^2)\, y_t = (u_o + U_1 L + U_2 L^2)\, x_t + \varepsilon_t^*$$

or

$$y_t = U_o x_t + U_1 X_{t-1} + U_2 X_{t-2} - V_1 y_{t-1} - V_2 y_{t-2} + \varepsilon_t^* \tag{20}$$

where,

$$\varepsilon_t^* = \varepsilon_t + V_1 \varepsilon_{t-1} + V_2 \varepsilon_{t-2} \tag{20a}$$

An examination of equations (19) and (20) does show that the error properties of the models are quite different with the distributed lag form possessing a simple error structure and the second model an autoregressive error structure. In spite of this error problem involved in the latter case Jorgenson conducted a good number of his empirical studies on the basis of an ordinary least squares estimation of equation (20) thus ignoring the constraint imposed by (20a). However, since the residuals ε_t in (17) are assumed to be serially independent we would then expect the residuals in (20) to be serially dependent or autocorrelated. Some procedures suggested in the literature for the estimation of these models will be taken up in the next section. Before then it is necessary to review one more distributed lag model recently suggested by Tsurumi[1] as an alternative to the Koyck, Solow and Jorgenson distributed lag models.

Tsurumi proposed that the parameters of a distributed lag function be represented by a discrete approximation of the gamma function whose probability density function is given by

$$\omega_i = \frac{1}{\Gamma(s)} i^{s-1} e^{-i}, \qquad i>o,\ s>o, \tag{21}$$

where, $(1/\Gamma(S)) \int_0^\infty i^{s-1} e^{-i} di = 1$, and $w_o = o$ for $s<1$.

We then have that for different values of s, (w_i) has the unimodal distributions with the maximum value of w_i being reached at $i = s-1$.

If we now substitute (21) into (9) we have,

$$y_t = \frac{B}{\Gamma(S)} \sum_{i=o}^{\infty} i^{s-1} e^{-i} L^i x_t + \varepsilon_t = \beta W(L) x_t + \varepsilon_t. \tag{22}$$

1. H. Tsurumi, "A Note on Gamma Distributed Lags," International Econc ic Review, June 1971, pp 317-324.

There are three problems involved in (21) and its transformation into (22). The first is due to the condition that for $S<1$, $w_o = o$.

A solution to this problem as proposed by Maddala[1] is to substitute $(i+1)^{s-1}$ for i^{s-1} while (21) can also be generalized into

$$w_i = \frac{1}{\Gamma(s)} (i+1)^{s-1} e^{-\lambda i} \qquad 0 \leq \lambda < 1 \qquad (23).$$

The second and third problems are connected with the estimation of the parameters of the lag model. For this purpose Schmidt[2] suggests replacing $(s-1)$ by $\alpha/(1-\alpha)$ as a way of facilitating the search procedure for s in a maximum likelihood estimation context. Also, because the approximation contained in (22) involves using discrete data, $e^{-\lambda i}$ should be replaced by λ^{i}. Equation (23) will then take the form,

$$w_i = \frac{1}{\Gamma(s)} (i+1)^{\alpha/(1-\alpha)} \lambda^{i} \qquad o \leq \alpha \leq 1, \; o \leq \lambda < 1$$

Similarly, equation (22) will become

$$y_t = \frac{B}{\Gamma(S)} \sum_{i=o}^{\infty} (i+1)^{\alpha/(1-\alpha)} \lambda^{i} L^{i} x_t + \varepsilon_t = Bw(L)\, x_t + \varepsilon_t \qquad (24)$$

Varied as distributed lag schemes are, their suggested methods of estimation are no less varied as well depending upon whether the scheme

1. Maddala, opcit p. 368
2. P. Schmidt, "An Argument for the usefulness of the Gamma Distributed lag model", International Economic Review February 1974, pp 246-250.

being estimated is in the distributed lag or the autoregressive form. Some of these methods are now reviewed including the O.L.S, instrumental variables, two-step procedures, non-linear least squares and maximum likelihood methods.

Estimation of Distributed Lags

The estimation of finite lag models has already been taken up under each distributed lag scheme the main essence of which has been the construction of a "$\bar{Z}_t$" variable, or, in the Almon case some Z_t variables (depending on the degree of the polynomial involved), to which O.L.S. is applied to obtain estimates of the X's which are then used in turn to get the Bi.

In the case of infinite distributed lag schemes estimation is, however, not so easy either because non-linearities enter into the parameters of the final form of the lag model or because complications show up in the model's error structures as a by-product of the transformation process, or both problems may even occur simultaneously. Except for the gamma distributed lags whose estimation is often accomplished by some sort of non-linear technique[1]

1. In applying the gamma distributed lags to Jorgenson's investment function, Tsurumi used the modified nonlinear least squares method proposed by Marquardt. See H.Tsurumi, opcit, p.319 and D.W. Marquardt, "An Algorithm for least squares Estimation of Nonlinear Parameters," SIAM Journal on Applied Mathematics, XI (June, 1963), 431-441.

virtually all the other infinite lag models of the Koyck variety have undergone series of suggestions and counter-suggestions regarding their estimation procedures.

To see the nature of these suggestions consider the Koyck model again:

$$y_t = B(1-\lambda)\sum_{i=o}^{\infty}\lambda^i x_{t-i} + \varepsilon_t \tag{25}$$

Klein-s[1] proposal for a maximum likelihood estimation of this model may be described as follows:

Rewrite equation (25) as

$$y_t = \beta(1-\lambda)\sum_{i=o}^{t-1}\lambda^i x_{t-i} + \beta(1-\lambda)\sum_{i=t}^{\infty}\lambda^i x_{t-i} + \varepsilon_t \tag{26}$$

Putting i-t = j (or i = t + j) the second term of (26) can be written as

$$\beta(1-\lambda)\sum_{i=t}^{\infty}\lambda^i x_{t-i} = \lambda^t B(1-\lambda)\sum_{j=o}^{\infty}\lambda^j x_{-j} = \lambda^t \eta_o$$

where, $\eta_o = E(y_o) = \beta(1-\lambda)\sum_{i=o}^{\infty}\lambda^i x_{-i}$

and E is the expected value operator.

Like before, equation (26) can now be concentrated as

$$y_t = BZ_{1t} + \eta_o Z_{2t} + \varepsilon_t \tag{27}$$

$$\text{where } Z_{1t} = (1-\lambda)\sum_{i=o}^{t-1}\lambda^i x_{t-i}, \text{ and } Z_{2t} = \lambda^t \tag{28}$$

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1. L.R. Klein, "The Estimation of Distributed Lags," Econometrica, 26 Oct. 1958 pp 553-565

It is usual to call η_o the "truncation remainder" and, since $\eta_o = E(y_o)$ it is also frequently described as an "initial value parameter" for the purpose of estimation[1].

The maximum likelihood estimation procedure for (27) is carried out through search methods as follows: we select some values of λ for each of which we generate the "synthetic" variables Z_{1t} and Z_{2t} in (28), estimate B and η_o in (27) by O.L.S. regression and look at the residual sum of squares. The value of λ which gives the minimum residual sum of squares is the maximum likelihood (ML) estimate of λ while the corresponding estimates of B and η_o are the ML estimates of these parameters. Studies[2] have been conducted which suggest that simply because as t increases in value Z_{2t} approaches zero so that we lose information increasingly on η_o as the sample size increases. In fact, in some empirical works it is not uncommon to ignore such initial value parameters[3].

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1. See, for example, G.S. Maddala, op.cit pp. 361-362; G.S. Maddala and A.S. Rao, "Maximum likelihood Estimation of Solow's and Jorgenson's Distributed Lag Models," The Review of Economics and Statistics, Feb. 1971, pp 80-88; M.H. Pesaran, "The Small Sample problem of Truncation Remainders in the Estimation of Distributed Lag models with Autocorrelated Errors," International Economic Review, Feb. 1973 pp 120-131.

2. See for example M.H. Pesaran, opcit.

3. See for example, P. J. Dhrymes, L.R. Klein and K. Steiglitz, "Estimation of Distributed Lags," International Economic Review II (june 1970) pp. 235-250.

However, Maddala and also Maddala and Rao[1] have warned against the danger of ignoring η_o even for samples as large as 100 because this could yield estimates of B and λ very much different from what could have been obtained if η_o had been estimated. Another issue could arise if one has reasons to believe that the errors in (27) follow a first-order Markov scheme so that $\varepsilon_t = \rho\varepsilon_{t-1} + u_t$. In this case the search procedure can be used on both λ and ρ in accordance with the suggestion by Dhrymes[2]

The above search procedure does have some advantages over the iterative technique of Steiglitz and McBride[3] known in communications engineering as the "prefiltering" method in the sense that it provides a global minimum and involves only finite sums, while the prefiltered values y_t^*, x_t^*, x_t^{**} etc in the Steiglitz-McBride case are infinite sums which are estimated from finite sample data. To discuss briefly this iterative technique, we recall that the geometric lag can be written as

$$y_t = \frac{B(1-\lambda)}{1-\lambda L} x_t + \varepsilon_t \qquad (29)$$

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1. G. S. Maddala, op.cit, p 362 and, G.S. Maddala and A.S. Rao, op.cit p.84.

2. P.J. Dhrymes, "Distributed Lags", opcit pp 140-185 and "Efficient Estimation of Distributed Lags with Autocorrelated Errors" International Economic Review. 1969 pp 47-67.

3. K. Steiglitz and L.E. McBride, "A Technique for the Identification of Linear Systems, "IEEE Transactions on Automatic Control, AC-10 (Oct, 1965) pp 461-64.

The normal equations can then be derived as

$$\sum_{t=1}^{T} \left(y_t - \frac{B(1-\lambda)}{1-\lambda L} x_t\right) \frac{x_t}{1-\lambda L} = 0$$

$$\sum_{t=1}^{T} \left(y_t - \frac{B(1-\lambda)}{1-\lambda L} x_t\right) \frac{L\, x_t}{(1-\lambda L)^2} = 0 \qquad (30)$$

To solve these nonlinear equations using iterative algorithm, define prefiltered values of the variables as

$$y_t^* = \frac{y_t}{1-\lambda L}, \quad x_t^* = \frac{x_t}{1-\lambda L}, \quad x_t^{**} = \frac{x_t^*}{1-\lambda L} = \frac{x_t}{(1-\lambda L)^2}$$

The normal equations (30) can then be rewritten in terms of the prefiltered values and the iteration process can be carried out.[1]

The estimation of the geometric lag in the autoregressive form can proceed as follows. First, write the distributed lag model in the autoregressive form: $y_t = \lambda y_{t-1} + B(1-\lambda)\, X_t + \varepsilon_t^*$ (31)

where $\varepsilon_t^* = \varepsilon_t - \lambda\varepsilon_{t-1}$. Under the assumption that the residuals ε_t^* are serially independent, O.L.S. may be applied to (31) to obtain the parameters of the function. It should, however, be noted that the residuals ε_t^* are serially independent only if the original disturbances ε_t follow a first order markov scheme with the same parameter λ as ε_t^*

1. For details, see Steiglitz and McBride, op.cit, L.R. Klein, A textbook of Econometrics. Prentice-Hall, N.J. 1974 pp 117-118 and P.J. Dhrymes, opcit, pp 101-102.

implying that $\varepsilon_t = \lambda\varepsilon_{t-1} + u_t$, and u_t are serially independent. So if ε_t was serially independent to begin with ε_t^* will be serially dependent. Consequently, a straightforward application of O.L.S. to (31) in the presenc of autocorrelated errors may bias upward the value of λ and so create the impression that the lags are substantially distributed over time. In order to correct for autocorrelation, therefore, Liviatan[1] suggested an instrumental-variable method for the solution of (31) whereby x_{t-1} is used as an instrument for y_{t-1}. Hannan[2] has shown that even though Liviatan's estimates are consistent they are, in any case, inefficient in comparison with ML estimates.

The maximum likelihood procedure which has been discussed so far in the context of the geometric lag can also be extended to the Solow-type distributed lag model[3]. Since this extension is, however, not of immediate relevance to us we'ld rather pass on quickly to a brief discussion of the iterative and maximum likelihood methods which have been proposed for the estimation of Jorgenson's rational distributed lags.

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1. N. Liviatan, op.cit

2. E. J. Hannan, The Estimation of Relationships Involving Distributed Lags, Econometrica, 1965, pp 206-224

3. For details, See G.S. Maddala and A.S. Rao, op.cit.

In a paper, Dhrymes, Klein and Steiglitz[1] presented a "prefiltering" method for the estimation of Jorgenson's rational distributed lags. We may recall from equations (16) and (17) the general nature of such a lag model:

$$y_t = \frac{U(L)}{V(L)} x_t + \varepsilon_t \qquad t=1,\ 2,\ \ldots.\ T \tag{32}$$

$$\text{where } u(L)=\sum_{i=o}^{n} u_i L^i, \quad V(L)= \sum_{j=o}^{m} v_j L^j,\ V_o=1, \quad n < m \tag{32a}$$

and $\varepsilon \sim N(o,\sigma^2 I)$, $\varepsilon = (\varepsilon_1, \varepsilon_2, \ldots\ldots\ldots\ldots, \varepsilon_T)'$

Using maximum likelihood methods we note that the log likelihood function of the observations in (32) is given by

$$L(u,v,\sigma^2, y, x) = -\frac{T}{2}\ln(2\Pi) - \frac{T}{2}\ln\sigma^2 - \frac{1}{2\sigma^2} \left(y-\frac{u(L)}{v(L)}x\right)' \left(y-\frac{u(L)x}{v(L)}\right) \tag{33}$$

Where,

$$y=(y_1,y_2,\ldots\ldots y_T)',\ X = (x_1,x_2,\ \ldots.,\ x_T)'$$

$$u=(u_o,u_1,\ldots\ldots u_n)',\ V = (v_1,v_2,\ldots\ldots,\ V_m)'$$

Taking derivatives in (33) we obtain first order conditions for a maximum as:

$$\frac{\partial L}{\partial u_i} = \frac{1}{\sigma^2} \sum_{t=n+m+1}^{T} \left(y_t - \frac{u(L)}{V(L)} x_t\right) \frac{L^j}{V(L)} x_t = 0,\ j=o,1,2,\ldots,\ n.$$

$$\frac{\partial L}{\partial v_j} = \frac{1}{\sigma^2} \sum_{t=n+m+1}^{T} \left(y_t - \frac{u(L)}{V(L)} x_t\right) \frac{u(L)}{(V(L))^2} L^s x_t=0,\ s=1,2,\ldots m \tag{33a}$$

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1. P.J. Dhrymes, L.R. L.R. Klein and K. Steiglitz, "Estimation of Distributed Lags, "International Economic Review, 11 (June 1970) pp 235-250.

$$\frac{\partial L}{\partial \sigma^2} = -\frac{T}{2}\frac{1}{\sigma^2} + \frac{1}{\sigma 4}\sum_{t=n+m+1}^{T} (y_t - \frac{u(L)}{v(L)} x_t)^1 (y_t - \frac{u(L)}{v(L)} x_t) = 0$$

It can be seen that while the equations in (33a) are nonlinear in the parameters u_i and v_j they are linear in u_i for given v_j and they are linear in σ^2. A search procedure can then be undertaken over the permissible region of the parameter space for u_i given v_j, or both parameter estimates may be iterated for simultaneously. Estimates once derived for u_i and v_j will easily permit an estimate for σ^2. As was the case with the Koyck lag, the iterative algorithm will be based on the following filtered values of the original variables:

$$y_t^* = \frac{1}{V(L)} y_t, \quad x_t^* = \frac{1}{V(L)} x_t, \quad x_t^{**} = \frac{u(L)}{V(L)} x_t^*, \quad t=1,2, \ldots T \tag{34}$$

The variables in (34) may then be used to transform the first two equations in (33a) so that they become linear in parameters in the following way:

$$\sum_{t=n+m+1}^{T} (V(L)y_t^* - U(L)\, x_t^*)\, x_{t-j}^* = 0, j=o,1,2,\ldots. n \tag{34a}$$

$$\sum_{t=n+m+1}^{T} (V(L)y_t^* - U(L)x_t^*)\, x_{t-s}^{**} = 0, s=1,2,\ldots\ldots m \tag{34b}$$

It may also be noted as in the Koyok-Klein case that the Dhrymes-Klein-Steiglitz estimation procedure even though efficient suffers from the problem of setting the initial conditions equal to zero, that is,

$$x_{-i}^* = y_{-i}^* = 0$$

While the authors have argued that this may not be a "serious handicap"[1] when the sample size T is large, by implication, the restriction does pose a problem when T is relatively small. In such a situation, the estimation procedure proposed by Maddala and Rao[2] may have a stronger appeal.

The estimator suggested by Maddala and Rao is aimed at obtaining maximum likelihood values for the parameters of the equation in (32) in cases when the degree of the denominator polynomial V(L) is not so high, such as, V(L) being of a second degree.

To review the method rather briefly, we recall again equation (32)

$$y_t = \frac{U(L)}{V(L)} x_t + \varepsilon_t \qquad (35)$$

with the properties of the parameters of the model and of the error structure being retained as before. For the direct estimation of (35) we consider the case in which V(L) is a linear function[3] in L, that is

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1. P.J. Dhrymes, et al, op.cit p. 240

2. Maddala and Rao op.cit.

3. This is the case actually implemented later in the empirical section of our work. Maddala and Rao (op.cit p. 84) considered for illustration a quadratic case in L.

$V(L) = v_o - v_1 L = 1 - v_1 L$. This follows from the convention we adopted in (32a) whereby we can write,[1]

$$V(L) = 1 + \sum_{j=1}^{m} v_j L^j = 1 - V^*(L), \quad V^*(L) = -\sum_{j=1}^{m} v_j L^j.$$

Now, define $x_t^* = \frac{1}{V(L)} x_t$

By expanding the equation $V(L)x_t^* = x_t$ we get $x_t^* = x_t + v_1 x_{t-1}^*$ which we can use in a recursive fashion to generate the new variable x_t^* given x_t. As before, we immediately see that the initial condition x_o^* is not known[2] but may now be treated as an unknown parameter θ so that $x_o^* = \theta$. We then have,

$$x_1^* = x_1 + v_1 \theta$$

$$x_2^* = x_2 + v_1 x_1^* = x_2 + v_1 x_1 + v_1^2 \theta$$

$$x_3^* = x_3 + v_1 x_2^* = x_3 + v_1 x_2 + v_1^2 x_1 + v_1^3 \theta$$

$$x_t^* = x_t + v_1 x_{t-1}^* \quad \text{for } t \geq 4$$

These may be concentrated to

$$x_t^* = Z_{1t} + \theta Z_{2t} \tag{36}$$

Where,

$$Z_{1t} = x_1 \qquad \text{for } t=1$$

$$= x_2 + v_1 x_1 \qquad \text{for } t=2$$

1. See P.J. Dhrymes et,al, op.cit p. 240

2. As noted previously, Dhrymes, et.al. set their initial conditions equal to zero.

$= x_t + v_1 Z_{1,t-1}$ for $t \geq 3$

$Z_{2t} = v_1$ for $t=1$

$= V_1 2$ for $t=2$

$= V_1 Z_{2,t-1}$ for $t \geq 3$

Using the assumption in (32a) that the errors in (35) are independently and identically distributed (i.i.d) written $\varepsilon_t \sim N(0,\sigma^2 I)$, and putting (36) into (35) we can derive an expression for the likelihood function as

$$L \propto \frac{1}{\sigma T-n} \exp - \frac{1}{2\sigma^2} \sum_{t=n+1}^{T} (y_t - u(L)(Z_{1t} + \theta Z_{2t}))^2$$

where n is the degree of U(L). ML estimates may then be obtained by minimizing $\sum_{t=n+1}^{T} [y_t - U(L)(Z_{1t} + \theta Z_{2t})]^2$ (37)

In carrying out the actual computation one may proceed as follows. Firstly, if U(L) is of zero degree, that is, $U(L) = u_o$, then for each value of v_1 we generate Z_{1t}, Z_{2t}; regress y_t on Z_{1t} and Z_{2t}, and compute the residual sums of squares (RSS). The ML estimate of v_1, therefore, is that value of v_1 for which the RSS is a minimum. The regression coefficients which correspond to this minimum RSS are the ML estimates of u_o and $u_o\theta$ from which ML estimates of u_o and θ can be derived. Secondly, if U(L) is of a higher degree the situation becomes essentially non-linear.

In order to avoid using a nonlinear approach, however, one may proceed in an alternative manner. Assume again that U(L) is actually of the first degree so that $U(L) = u_o + u_1 L$.

One should first of all obtain a preliminary estimate of θ by taking $U(L)$ to be of zero degree. This value of θ can then be used to generate a new variable Z_t from $Z_t = Z_{1t} + \theta Z_{2t}$. The final regression to be estimated therefore is of the form $y_t = (u_o + u_1 L)(Z_t) + \varepsilon_t$, that is, $y_t = u_o Z_t + u_1 Z_{t-1} + \varepsilon_t$.

Following the suggestion by Griliches[1] which Maddala and Rao[2] also employed in their work one can search for v_1 in the range $o < v_1 < 2$ by varying v_1 say at intervals of 0.25.

The maximum likelihood procedure put forward by Maddala and Rao for the estimation of Jorgenson's rational distributed lags as reviewed so far is the method employed later in the empirical section of this study. Consequently, it is important even at this stage to introduce these rational lags into the investment functions which were developed in chapter II.

Rational Distributed Lags in Investment Functions

In order to see how the rational distributed lag enters the investment function let us recall the generalized accelerator equation (34) from chapter II: $I_t - \delta k_{t-1} = w(L)\Delta K_t^* + \varepsilon_t$ (38)

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1. Griliches, "Distributed lags - A survey", Econometrica, 35 (Jan'67)
2. G.S. Maddala and A.S. Rao op.cit p.85.

where W(L) is now the power series in the lag operator L and Δ is the difference operator such that $\Delta K_t^* = K_t^* - K_{t-1}^*$.
Comparing (35) and (38) one immediately sees that

$$y_t = I_t - \delta K_{t-1}, \quad w(L) = \frac{U(L)}{V(L)}, \quad x_t = \Delta K_t^*$$

and the error structures remain the same. Hence suitable substitutions into (38) for the desired capital stock K_t^* from the theories of investment behaviour presented in chapter II will lead to our final estimating equations as follows:

1. Accelerator Investment Function: Since desired capital is proportional to output, Qt, under the accelerator theory, we may write the complete accelerator theory of investment behaviour as

$$I_t - \delta K_{t-1} = \alpha W(L) \Delta Q_t + \varepsilon_t \qquad (39)$$

2. Liquidity Investment Function: under the liquidity theory of investment behaviour, desired capital is proportional to liquidity, L_t whereby we may write the complete theory as

$$I_t - \delta K_{t-1} = \alpha W(L) \Delta L_t + \varepsilon_t \qquad (40)$$

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:

$$I_t - \delta K_{t-1} = \alpha W(L)\Delta V_t + \varepsilon_t \qquad (41)$$

4. Neoclassical Investment Function: In the Neoclassical theory of investment behaviour desired capital is proportional to the value of output divided by the price of capital services whereby we may write the complete theory as

$$I_t - \delta K_{t-1} = \alpha W(L)\Delta(PQ/C)_t + \varepsilon_t \qquad (42)$$

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.

It should be noted that for our purpose of estimating equations (39) to (42), W(L) is taken to be linear in components so that

$$W(L) = (u_o + u_1 L)/(1 + V_1 L).$$

We estimate the parameters – α, u_o, u_1, v_1, δ – 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

$$u_o + u_1 - v_1 = 1 \text{ or } u_o + u_1 = 1 + v_1$$

This constraint then allows us to estimate the parameters —α, u_o, u_1, v_1, — from estimates of αu_o, αu_1, and v_1.

The rate of replacement, δ, which occurs in our final estimating equation above is estimated directly during the process of estimating capital stock. 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 $$IR_t = \delta K_{t-1} = I_t - (K_t - K_{t-1})$$

Summing for t=1 to t=T yields.

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

So that, $$\delta = \frac{\Sigma I_t - (K_T - K_0)}{\Sigma K_{t-1}}$$

CHAPTER IV

EMPIRICAL TEST OF THE MODEL

The distributed lag functions specified in the preceding chapter have been fitted to annual data from eight manufacturing industries in Nigeria for the sample period 1966 to 1976 representing the period for which comparable and consistent data were found available. The nature, characteristics and sources of these data are discussed in the next section below. 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, Paper and Paper Products, Rubber and Leather.

In this Chapter, empirical results are reported on the determinants of investment behaviour in these industries based on a maximum likelihood method of estimation. Since this method involves undertaking regression runs at two stages, we report and analyse the maximum likelihood estimates of the first and second stage regressions consecutively and also discuss the residuals of the fitted distributed lag functions on the basis of the Geary test statistic for serial correlation. Further tests are proposed and applied which discriminate among alternative theories of investment behaviour. On the basis of the ranking procedures used, the Liquidity Model is found to be superior to the Expected Profits, Neoclassical I, Neoclassical II and Accelerator models in the explanation of manufacturing investment behaviour.

THE DATA

In this section, methods are discussed for the measurement of the variables employed in the empirical section below and the sources of data utilized are also described.

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 cumulative private foreign investment (CPFI)[1] in each of the eight 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. The data on investment are annual series spanning the period 1966 to 1976.

Capital Stock and Depreciation

Benchmark figures were obtained for capital stock by taking net fixed assets for 1965 and 1976 for each industry and deflating them by the GFI deflators. With the CPFI expressed in constant prices and the two benchmark

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[1] Apart from the fact that private foreign investment dominated total private investment in Nigerian Manufacturing industries during our sample period, the findings from Severn's study have shown conclusively that "methods of investigation typically applied to domestic investment also apply to foreign investment .... Foreign and domestic investment are interrelated primarily through the financing mechanisms used, whereby top management allocates internally generated funds so as to maximize profit". See, A.K. Severn, "Investment and Financial Behaviour of American Direct Investors in Manufacturing", in F. Machlup, etal, International Mobility and Movement of Capital, NBER, NY, 1972, p.396. See also: C.P. Kindleberger, "The Theory of Direct Investment," in R.E. Baldwin and J.D. Richardson (eds), International Trade and Finance, Little, Brown & Co., Boston, 1974, pp. 270 - 272, where markets and internal source of finance are said to motivate direct investment; and finally, R.M. Stern, Balance of Payments, Aldine Publishing Co., Chicago, 1973, (ch 8, pp. 233 - 238: "Direct Foreign Investment").

figures of capital stock, we computed the remaining capital stock figures and replacement figures for each industry using the follow- 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:

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

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

$$\hat{\delta} = \frac{\Sigma I_t - (K_T - K_0)}{\Sigma K_{t-1}}$$

This value of $\hat{\delta}$ was used to compute powers of $(1 - \delta)$ from $(1 - \hat{\delta})^1$ to $(1 - \hat{\delta})^{11}$ for each industry and then substituted into the difference equation to obtain capital stock series for the other periods and all industries. So also the estimate for δ was used to compute replacement for all periods and industries. The computation of capital stock by the perpetual inventory method was rendered infeasible 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. The derivation of the deflators for the Neoclassical models is explained below.

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 level of net profit was 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

$$c_{t_1} = \frac{q_t}{1-u_t}\left[(1 - u_t n_t)\delta + r_t - \frac{\dot{q}_t}{q_t}\right]$$

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 obtained in the process of computing capital stock. Lack of data constrained ω and x to be zero.

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:

$$C_{t_2} = \frac{q_t}{1-u_t}\left[(1 - u_t n_t)\delta + r_t\right]$$

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 bank rate of interest as a measure of the cost of capital in both versions of the Neoclassical model.

The data for the preceding set of variables are reported in Appendix A. These are the basic data normally used in running the ordinary least squares regressions in the autoregressive form of the lag distribution implied by equation 20 of chapter III. However, some transformations of these basic data are necessary for the estimation of the rational distributed lag model by maximum likelihood method. Indeed, since the maximization procedure involves running regressions at two stages, the data required are also derived in two stages which may be summarized as follows.

It would be recalled from Chapter III that the essence of the first stage regression is to obtain maximum likelihood estimates for V_1, the regression coefficients for the variables Z_{1t} and Z_{2t}, and the unknown parameter θ, by estimating a function of the form

$$y_t = u_o Z_{1t} + u_o \theta Z_{2t}$$

for each industry under each theory of investment. Both synthetic variables Z_{1t} and Z_{2t} are generated recursively from relationships involving, in the first variable case, the original explanatory variables in the distributed lag model and assumed values for V_1, while in the second case only the assumed values for V_1 are involved. In developing the necessary data, we assumed V_1 to lie in the range $0.25 \leq V_1 \leq 1.75$ and then spaced the values at intervals of 0.25. Values of the dependent variable y_t were taken as annual net investment series obtained by subtracting annual replacement series from their corresponding series of gross investment expenditures. Using these data then seven regressions were performed for each industry under each theory of investment yielding a total of 280 regressions at the first stage. From the results obtained, the maximum likelihood estimate of V_1 is that value of V_1 for which the residual sum of squares is a minimum. The corresponding regression coefficients are taken to be maximum likelihood estimates of u_o and $u_o\theta$ from which ML estimates of u_o and θ are then derived.

In order to execute the second stage regression the preliminary estimate of θ is used to generate a new Z_t variable from the relationship $Z_t = Z_{1t} + \theta Z_{2t}$ where the Z_{1t} and Z_{2t} values are chosen so as to correspond to the ML value of V_1. The second stage regression then takes the form

$$y_t = u_o Z_t + u_1 Z_{t-1}$$

where y_t once again represents net investment.

The statistical data used in computing the 1st stage regressions are contained in Appendix B while the ones used for the second stage regressions are contained in Appendix C.

Sources of Data

The most important and also most authoritative 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 with a coverage of about 600 companies. Prior to indigenization which defined the extent of foreign/indigenous participation in businesses most Nigerian manufacturing businesses were either wholly-owned (100%) by foreigners or in partnership with Nigerians. Either way, foreign investment has been a predominant source of annual investment expenditures by such businesses.[1] The two primary sources of private investment statistics in Nigeria are the Federal Office of Statistics (F.O.S), (via the "Industrial Survey") and the Central Bank of Nigeria, CBN, (via the "Foreign Investment Survey").

From the standpoint of the investment theories we are seeking to test only the latter source (CBN) has a more up to date and comprehensive data on all the variables of interest because it is specifically an investment survey. To be more exact, the Industrial Survey has a reporting lag of about 4 years compared with about 2½ years in the CBN case. Also, F.O.S. survey reports data on three variables - sales, net capital expenditure and fixed assets - out of the ten variables required from one source while the CBN survey provides data on all the required variables. Consequently, the CBN survey and data are superior to those of the F.O.S. for our purpose.

Since 1961, the results of the CBN survey have generally been published in the Bank's Economic and Financial Review on an annual basis

[1] It should be noted that over time, the bulk of this investment was generated locally through retained earnings so that the distinction between private domestic and private foreign investment became rather tenuous.

with a lag of about two and a half 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 eight industry groups under the manufacturing sector.

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 -- minimum lending rate of interest -- which was obtained from various issues (1966 - 1976) of the Central Bank of Nigeria Annual Reports. A 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 1965 and 1976 and q_t as deflator.
Output, Q_t	=	Current sales
Liquidity, L_t	=	Profits after tax plus depreciation minus dividends paid divided by the investment goods deflator.
Expected Profit V_t	=	Current profit divided by the 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 tax purposes, n_t	=	Depreciation deducted in firm's account (summed over firms in the industry) divided by δ.
Rate of capital loss, $\frac{-\dot{q}}{q}$	=	Rate of change of investment goods deflator.

Analysis of the Regression Results

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, as well as one lagged value of net investment. Given the fact that the competing theories of investment behaviour have been standardized through the generalized accelerator mechanism, this in itself should facilitate a comparison of these theories in terms of how well they are able to explain the determination of investment by the selected group of Nigerian industries.

We now present and discuss the results of the two stage regressions undertaken for our sample of industries and alternative investment theories. In performing the first stage regression by maximum likelihood method, each of the five theories of investment was tested on transformed data for the eight selected industries. For each industry seven alternative regressions were run based on data generated recursively on the assumed values for V_1.. These then yielded regression results for a total of 280 equations as are reported in Tables 3 - 7 Maximum likelihood values of θ based on minimum residual sum of squares were then isolated from the estimated equations and used in generating data for the second stage regressions. Altogether, 40 regressions (eight for each theory) were performed at the second stage and the results are contained in Tables 8 - 12 The discussion which now follows analyses in some detail the results in Tables 3 - 7 and Tables 8 - 12 while in a succeeding section further analysis is undertaken for the comparative performance of our alternative investment theories.

Maximum Likelihood Estimates of the First Stage Regressions

Tables 3 - 7 show regression estimates and goodness-of-fit statistics derived from our first stage regressions using the maximum likelihood estimation method. Each table presents seven results for each of the eight industries under each theory of investment making a total of 56 single equation estimates for each table. Thus, Table 3 indicates the results for the Neoclassical I theory, Table 4 for Neoclassical II, Table 5 for Accelerator, and so on.

It will be recalled from the preceding chapter that the equation fitted is of the form

$$y_t = u_o z_{1t} + u_1 \theta z_{2t}$$

Net investment y_t, therefore, depends on the synthetic variables z_{1t} and z_{2t}. The figures reported in the Tables under each of these variables thus represent their respective coefficients while below each coefficient is the t-statistic. Estimates for θ are obtained by taking the ratio of the second coefficient to that of the first. The column indicated RSS gives the residual sum of squares for each regression run while the coefficient of determination for each run appears under the R^2 column.

As we examine each regression equation in the tables our principal interest centres on the values for RSS, θ, and V_1. Thus, from the seven equations under each industry the minimum residual sum of squares is selected. The value of V_1 corresponding to this minimum RSS is then picked as the ML value of V_1 for that industry. Also, the Corresponding θ value is the ML value for θ. If the minimum RSS for an industry corresponds to a value of V_1 = 1.00 such a value is by-passed in favour of the next minimum RSS since selecting a value of V_1 = 1.00 will cause the denominator of the rational distributed lag to be zero. Such a minimum RSS can of course be regarded as a rare event. Indeed, out of the 280 regression cases appearing in Tables 3 - 7 only one i.e. Textile industry under the Expected Profit shows minimum RSS at $V_1 = 1.00$ which implies a selection of $V_1 = 1.25$ as the ML value of V_1.

In order to illustrate the preceding ideas more clearly we select for analysis the Footwear industry under each investment theory. Beginning with Neoclassical I, we find that the minimum RSS is 5.07. Corresponding to this are the values of $V_1 = 1.50$, $\theta = -2.36$, and $R^2 = 0.89$. In the case of Neoclassical II the minimum RSS is 5.44 which yields ML values of $V_1 = 1.50$, $\theta = -3.32$ and $R^2 = 0.89$. As for the Accelerator, the minimum RSS is 5.59 while $V_1 = 1.50$, $\theta = -2.99$ and $R^2 = 0.88$. The Liquidity theory has, for its Footwear industry, a minimum RSS of 6.09 and the corresponding ML estimates are $V_1 = 1.50$ and $\theta = -530.67$ while $R^2 = 0.87$. Finally, under the Expected Profit theory the values obtained for the Footwear Industry are minimum RSS = 7.72, $V_1 = 1.50$, $\theta = 7.07$, and $R^2 = 0.84$.

A few of the inferences that could be drawn from the preceding analysis include the following:

(1) although $V_1 = 1.5$ for all theories, all other characteristics show substantial variations across theories as would suggest differences among the theories; (2) the variations were even more pronounced for the values of θ. For example, in the case of Neoclassical II, θ varied from a low of -10 to a high of 349083 from which an ML value of -3.32 was selected.

TABLE 3

MAXIMUM LIKELIHOOD RESULTS FOR THE FIRST STAGE REGRESSIONS:

NEOCLASSICAL I

INDUSTRY	REGRESSION		RESULTS		
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FOOD					
V_1 = 0.25	-0.1720 (-1.8238)	-27.1110 (-5.3889)	157.62	391.28	0.04
V_1 = 0.50	-0.0077 (-25.6623)	-3.7726 (-4.5055)	489.94	405.65	0.01
V_1 = 0.75	0.0322 (4.9006)	-31.8429 (-1.9363)	-988.90	380.30	0.06
V_1 = 1.00	0.0436 (1.1583)	-	-	373.75	0.08
V_1 = 1.25	0.1673 (1.5170)	-7.4667 (-2.7085)	-44.63	361.53	0.11
V_1^* = 1.50	-0.0005 (-0.6000)	0.3103 (0.6081)	-620.60	287.72	0.29
V_1 = 1.75	0.0010 (1.6000)	-0.0818 (-1.1760)	-81.00	362.15	0.11
BEVERAGES					
V_1 = 0.25	-0.1177 (-0.5021)	-86.0789 (-0.5585	731.34	54.06	0.46
V_1^* = 0.50	-0.1173 (-0.5149)	-13.1652 (-0.4342)	112.23	49.58	0.50
V_1 = 0.75	-0.1032 (-0.7539)	-12.4494 (-1.7900)	120.63	67.74	0.32
V_1 = 1.00	0.0312 (1.3494)	-	-	94.11	0.06
V_1 = 1.25	-0.1583 (-0.5616)	4.3213 (0.5077)	-27.29	55.23	0.45
V_1 = 1.50	-0.1741 (-0.6209)	2.6127 (0.6053)	-15.00	63.09	0.37
V_1 = 1.75	-	0.0070 (0.9589)	-	90.16	0.10

TABLE 3 (Cont'd)

NEOCLASSICAL I

INDUSTRY	REGRESSION RESULTS				
	z_{1t}	z_{2t}	θ	RSS	R^2
TEXTILES					
V_1 = 0.25	-0.0242 (-5.3388)	-158.2262 (-1.4349)	6538.27	1243.55	0.07
V_1 = 0.50	-0.0088 (-14.1477)	-24.9017 (-1.0939)	2829.73	1192.33	0.11
V_1 = 0.75	-0.0066 (-19.6515)	-18.0899 (-1.3958)	2740.89	1249.32	0.06
V_1 = 1.00	0.1077 (0.8025)	–	–	1240.85	0.07
V_1 = 1.25	0.0811 (1.8483)	-1.0505 (-5.1591)	-12.95	964.37	0.28
V_1^* = 1.50	0.1006 (1.0328)	-1.7401 (-1.2236)	-17.29	939.60	0.29
V_1 = 1.75	–	0.0371 (0.6739)	–	11052.43	0.21
FOOTWEAR					
V_1 = 0.25	0.0565 (3.2141)	-36.1055 (-1.1600)	-639.03	42.63	0.10
V_1 = 0.50	0.0646 (2.6285)	-6.7018 (-0.7019)	-103.74	36.87	0.22
V_1 = 0.75	-0.0671 (-2.8435)	-4.1301 (-69.4201)	61.55	42.45	0.10
V_1 = 1.00	0.0718 (0.2535)	–	–	16.24	0.65
V_1 = 1.25	-0.0756 (-1.2143)	0.8252 (3.2778)	-10.91	5.88	0.87
V_1^* = 1.50	0.0361 (0.8338)	-0.0851 (-1.9730)	-2.35	5.07	0.89
V_1 = 1.75	–	0.0138 (0.1522)	–	7.70	0.83

TABLE 3 (Cont'd)

NEOCLASSICAL I

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FURNITURE					
V_1 = 0.25	0.0326 (4.6411)	-57.5155 (-0.7598)	-1764.27	46.05	0.20
V_1 = 0.50	0.0341 (4.0879)	-9.3927 (-0.5073)	-275.44	36.85	0.36
V_1 = 0.75	0.0101 (16.8119)	-6.4192 (-0.7796)	-635.56	46.27	0.20
V_1 = 1.00	0.1722 (1.1611)	-	-	49.80	0.14
V_1^* = 1.25	- 0.1325 (-0.7789)	0.9147 (1.8170)	-6.9034	25.05	0.57
V_1 = 1.50	-0.0963 (-2.0280)	0.3148 (1.4558)	-3.26	32.18	0.44
V_1 = 1.75	-	0.0098 (0.4898)	-	38.09	0.34
PAPER					
V_1 = 0.25	-0.3273 (-0.5775)	-72.7740 (-0.6585)	222.34	54.32	0.39
V_1^* = 0.50	-0.3192 (-0.5614)	-10.7157 (- 0.5077)	33.57	48.50	0.45
V_1 = 0.75	-0.3514 (-0.5882)	-10.8807 (-0.5386)	30.96	54.92	0.38
V_1 = 1.00	0.0072 (20.8472)	-	-	89.71	0.00
V_1 = 1.25	-0.3393 (-0.8532)	2.5878 (0.8107)	-7.62	72.89	0.18
V_1 = 1.50	-0.3435 (-1.0376)	1.6200 (1.0348)	-4.71	79.14	0.11
V_1 = 1.75	-	-0.0031 (-5.6154)	-	89.41	0.00

TABLE 5 (Cont'd)

NEOCLASSICAL I

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
LEATHER					
V_1 = 0.25	-0.0084 (-3.2143)	-10.8308 (-0.7314)	1289.38	1.52	0.21
V_1^* = 0.50	-0.0111 (-2.0721)	-1.6918 (-0.5271)	150.37	1.27	0.34
V_1 = 0.75	-0.0111 (-2.2342)	-1.2468 (-0.7077)	112.32	1.49	0.22
V_1 = 1.00	0.0035 (6.4000)	-	-	1.93	0.00
V_1 = 1.25	-0.0260 (-1.3000)	0.1577 (1.0317)	-6.06	1.65	0.14
V_1 = 1.50	-0.0215 (-1.9442)	0.6909 (0.1839)	-32.13	1.82	0.05
V_1 = 1.75	-	0.0002 (3.6667)	-	1.92	0.01
RUBBER					
V_1 = 0.25	-0.1291 (-1.2595)	72.1968 (0.8589)	-559.23	92.43	0.20
V_1 = 0.50	-0.1878 (-0.8393)	11.1549 (0.6475)	-59.39	80.54	0.30
V_1 = 0.75	-0.1529 (-1.0863)	8.0212 (0.8460)	-52,46	89.87	0.22
V_1 = 1.00	-0.2139 (-0.8719)	-	-	99.90	0.14
V_1 = 1.25	-0.3917 (-0.4886)	0.6874 (0.8784)	-1.75	63.13	0.45
V_1^* = 1.50	-0.4907 (-0.4119)	1.3969 (0.4341)	-2.84	54.81	0.52
V_1 = 1.75	-	-0.0086 (-0.9069)	-	100.79	0.13

TABLE 4

MAXIMUM LIKELIHOOD RESULTS
FOR THE FIRST STAGE REGRESSIONS
NEOCLASSICAL II

INDUSTRY	REGRESSION RESULTS				
	Z1t	Z2t	θ	RSS	R^2
FOOD					
V_1 = 0.25	-0.2327 (-0.9225)	-17.4079 (- 7.1509)	74.80	349.42	0.14
V_1 = 0.50	-0.1824 (-1.1908)	- 8.4589 (-1. 9065)	46.37	368.61	0.09
V_1 = 0.75	0.0702 (3.7350)	6.4352 (3.6733)	91.66	403.94	0.01
V_1 = 1.00	0.0399 (1.3634)	-	-	382.87	0.06
V_1 = 1.25	0.0751 (3.8256)	- 2.9234 (- 4.4736)	-38.92	380.24	0.06
V_1^* = 1.50	0.0283 (0.9753)	- 0.7418 (- 1.0794)	-26.21	335.44	0.16
V_1 = 1.75	-	0.0065 (0.4213)	-	399.74	0.02
BEVERAGES					
V_1 = 0.25	-0.0179 (-8.0056)	-160.0611 (-1.4181)	8941.96	1247.00	0.07
V_1 = 0.50	-0.1723 (-32.7464)	-15.1993 (- 2.1545)	88.21	44.04	0.56
V_1 = 0.75	-0.1284 (-49.4727)	-12.6311 (- 0,5029)	98.37	60.71	0.39
V_1 = 1.00	0.0328 (0.8542)	-	-	92.12	0.08
V_1 = 1.25	-0.1474 (-0. 6370)	4.0457 (0.5714)	-27.44	59.36	0.40
V_1 = 1.50	-0.2053 (-0.5528)	3.0081 (0.5407)	-14.65	58.92	0.41
V_1^* = 1.75	0.0207 (0.3382)	-0.0540 (-0.3907)	-2.60	39.76	0.60

TABLE 4 (Cont'd)

NEOCLASSICAL II

INDUSTRY			REGRESSION RESULTS				
			Z_{1t}	Z_{2t}	θ	RSS	R^2
		TEXTILE					
V_1	=	0.25	0.0140 (14.9643)	-163.3539 (- 1.4030)	-11668.13	1247.80	0.06
V_1	=	0.50	0.0352 (5.7670)	- 23.4530 (- 1.2231)	- 666.27	1188.08	0.11
V_1	=	0.75	-0.0071 (-3.1972)	- 17.2143 (- 1.4609)	2424.54	1232.50	0.08
V_1	=	1.00	0.1764 (1.0924)	-	-	1166.90	0.12
V^*_1	=	1.25	0.0560 (2.8964)	- 0.1939 (- 30.6008)	-3.46	987.89	0.26
V_1	=	1.50	-0.0138 (-7.1884)	0.0723 (1.4804)	-5.23	1007.54	0.24
V_1	=	1.75	-	0.0371 (1.4816)	-	1052.44	0.22
		FOOTWEAR					
V_1	=	0.25	0.0001 (3.3333)	- 34.9083 (- 1.2026)	-349083.00	42.63	0.10
V_1	=	0.50	0.0001 (3.3333)	- 6.7534 (- 0.7125)	- 67534.00	37.16	0.22
V_1	=	0.75	-0.1012 (-1.9901)	- 3.9926 (- 1.1527)	39.45	41.70	0.12
V_1	=	1.00	0.0221 (0.8701)	-	-	43.55	0.29
V_1	=	1.25	-0.0818 (-1.2641)	0.8320 (0.3183)	-10.17	5.92	0.87
V^*_1	=	1.50	-0.1085 (-1.0719)	0.3599 (0.7279)	- 3.31	5.44	0.88
V_1	=	1.75	-	0.0138 (6.5714)	-	7.71	0.83

TABLE 4 (Cont'd)

NEOCLASSICAL II

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FURNITURE					
V_1 = 0.25	0.0546 (3.0147)	-57.1033 (-0.7617)	-1045.84	45.64	0.21
V_1 = 0.50	0.0545 (2.8587)	-9.2197 (-0.5196)	-169.16	36.52	0.37
V_1 = 0.75	-0.1732 (-1.0277)	-4.8938 (-0.4414)	28.25	32.59	0.25
V_1 = 1.00	0.1998 (1.2899)	-	-	48.17	0.17
V^*_1 = 1.25	0.0429 (0.7753)	0.2607 (2.5428)	6.07	25.65	0.41
V_1 = 1.50	0.0349 (6.5903)	-0.0114 (-0.0205)	-0.32	27.18	0.37
V_1 = 1.75	-	0.0085 (2.0732)	-	28.51	0.34
PAPER					
V_1 = 0.25	-0.3410 (-0.6613)	-71.6644 (-0.6819)	210.15	56.51	0.35
V^*_1 = 0.50	-0.3320 (-0.6346)	-10.6232 (-5.3099)	31.99	50.35	0.42
V_1 = 0.75	-0.2555 (-1.0645)	-7.2770 (-0.8196)	28.48	68.91	0.23
V_1 = 1.00	0.0197 (0.1234)	-	-	89.56	0.00
V_1 = 1.25	-0.3700 (-0.7751)	1.5158 (0.7247)	-4.09	70.45	0.21
V_1 = 1.50	-0.3834 (-1.0477)	1.7243 (1.0450)	-4.49	79.32	0.11
V_1 = 1.75	-	-0.0013 (-5.6154)	-	89.41	0.00

TABLE 4 (Cont'd)

NEOCLASSICAL II

INDUSTRY		REGRESSION RESULTS				
		Z_{1t}	Z_{2t}	θ	RSS	R^2
LEATHER						
V_1 =	0.25	0.0442 (0.9910)	-8.1645 (-0.9625)	- 184.71	1.34	0.30
V_1* =	0.50	0.0121 (3.5537)	-1.4941 (-0.6830)	- 123.47	1.30	0.32
V_1 =	0.75	-0.0117 (-2.5043)	-1.2532 (-0.7105)	107.11	1.50	0.22
V_1 =	1.00	0.0072 (2.9149)	-	-	1.92	0.01
V_1 =	1.25	-0.0280 (-1.4036)	0.1508 (1.0975)	-5.38	1.67	0.13
V_1 =	1.50	-0.0235 (-0.4806)	0.0640 (0.5124)	-2.72	1.83	0.05
V_1 =	1.75	- -	0.0003 (3.6667)	-	1.92	0.00
RUBBER						
V_1 =	0.25	-0.1623 (-1.0647)	71.7953 (0.8480)	-442.36	89.48	0.23
V_1 =	0.50	-0.2292 (-1.8857)	93.2628 (1.8233)	-406.90	75.15	0.35
V_1 =	0.75	-0.2064 (-0.8459)	75.4311 (0.8839)	-365.46	84.71	0.27
V_1 =	1.00	-0.3231 (-0.5809)	-	-	84.87	0.27
V_1* =	1.25	-0.4431 (-0.4261)	0.9792 (1.5137)	- 2.20	56.47	0.51
V_1 =	1.50	-	-0.0704 (-0.9077)	-	100.98	0.13
V_1 =	1.75	-	-0.0088 (-1.7045)	-	100.79	0.13

TABLE 5

MAXIMUM LIKELIHOOD RESULTS

FOR THE FIRST STAGE REGRESSIONS

ACCELERATOR

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FOOD					
V_1 = 0.25	-0.2873 (-1.3471)	-38.5611 (- 3.5904)	134.21	378.17	0.07
V_1 = 0.50	-0.2656 (-1.4578)	-13.7158 (- 1.5532)	51.64	380.19	0.06
V_1* = 0.75	0.4476 (0.8231)	38.9176 (0.8618)	86.94	337.02	0.17
V_1 = 1.00	0.0328 (1.9878)	-	-	396.12	0.03
V_1 = 1.25	-	0.4912 (1.3952)	-	383.97	0.06
V_1 = 1.50	-	0.0715 (1.7622)	-	392.82	0.03
V_1 = 1.75	-	(2.3692)	-	399.74	0.02
BEVERAGES					
V_1 = 0.25	-0.0405 (- 0.9778)	-71.0051 (- 0.7509)	1753.21	73.93	0.26
V_1* = 0.50	-0.0424 (-1.0472)	-11.7567 (- 0.5636)	277.28	67.46	0.32
V_1 = 0.75	-0.0187 (-3.8686)	-8.4063 (-0.8325)	449.53	83.28	0.17
V_1 = 1.00	0.0283 (1.3640)	-	-	94.23	0.06
V_1* = 1.25	-0.0600 (-1.1350)	1.7807 (0.8693)	-29.67	72.24	0.28
V_1 = 1.50	-0.0700 (-0.9671)	0.6896 (0.8766)	- 9.85	75.01	0.25
V_1 = 1.75	-	0.0070 (1.0429)	-	90.16	0.10

TABLE 5 (Contd.)

ACCELERATOR

INDUSTRY	REGRESSION		RESULTS		
	Z_{1t}	Z_{2t}	θ	RSS.	R^2
TEXTILES					
V_1 = 0.25	- 0.0261 (- 6.6015)	- 157.0277 (- 1.4565)	6016.38	1245.70	0.07
V_1 = 0.50	0.0228 (7.2895)	- 26.0685 (- 1.0665)	-1143.35	1189.99	0.11
V_1 = 0.75	0.0034 (54.6176)	- 41.8068 (- 1.1963)	-12296.11	1218.76	0.09
V_1 = 1.00	0.1764 (1.0923)	-	-	1166.90	0.13
V_1^* = 1.25	0.1159 (1.7023)	- 2.0837 (- 3.2319)	- 17.97	957.59	0.28
V_1 = 1.50	-0.0352 (-5.9205)	- 1.2090 (- 4.3548)	34.34	1016.59	0.24
V_1 = 1.75	-	0.0371 (0.0207)	-	1052.43	0.21
FOOTWEAR					
V_1 = 0.25	0.0589 (3.8625)	- 36.2413 (- 1.1587)	-615.30	42.81	0.10
V_1 = 0.50	0.0498 (4.2631)	- 6.7304 (- 0.7166)	-135.14	37.30	0.21
V_1 = 0.75	-0.0952 (-2.4086)	- 4.0703 (- 1.1379)	42.75	42.16	0.11
V_1 = 1.00	-0.0197 (-13.2234)	-	-	47.65	0.00
V_1 = 1.25	-0.0768 (-1.4648)	0.8043 (0.3289)	-10.47	6.06	0.87
V_1^* 1.50	-0.0927 (-1.2330)	0.2775 (0.7204)	- 2.99	5.59	0.88
V_1 = 1.75	- -	0.0138 (0.1594)	-	7.77	0.83

TABLE 5 (Cont'd)

ACCELERATOR

INDUSTRY		REGRESSION RESULTS				
		Z_{1t}	Z_{2t}	θ	RSS	R^2
FURNITURE						
V_1* =	0.25	0.0051 (13.8824)	-10.1243 (- 0.7536)	1985.15	1.54	0.20
V_1 =	0.50	0.0067 (18.0000)	- 9.4989 (- 0.5019)	-1417.74	37.13	0.36
V_1 =	0.75	-0.0229 (-6.4498)	-6.6756 (- 0.7449)	291.51	46.16	0.20
V_1 =	1.00	0.1200 (1.1692)	-	-	53.31	0.08
V_1 =	1.25	-0.1054 (-1.2922)	1.1092 (-0.6720)	-10.52	25.08	0.56
V_1 =	1.50	0.1267 (1.1673)	-0.2216 (-1.6480)	- 1.74	30.14	0.48
V_1 =	1.75	-	0.0098 (0.4898)	-	38.09	0.34
PAPER						
V_1 =	0.25	-0.3192 (-0.6344)	-72.9986 (-0.6756)	228.69	57.26	0.36
V_1^* =	0.50	-0.3026 (-0.6262)	-10.7767 (-0.5312)	35.61	51.71	0.42
V_1 =	0.75	-0.3284 (-0.6668)	-10.9706 (-0.5653)	33.40	58.74	0.34
V_1 =	1.00	-0.1028 (-2.0233)	-	-	87.07	0.02
V_1 =	1.25	-0.1906 (-1.2964)	1.3605 (1.1732)	- 7.13	80.38	0.10
V_1 =	1.50	-0.2026 (-0.0788)	1.0140 (1.9088)	- 5.00	86.29	0.03
V_1 =	1.75	-	-0.0013 (-5.6158)	-	89.41	0.00

TABLE : 5 (Contd.)
ACCELERATOR

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
LEATHER					
V_1 = 0.25	0.0050 (0.1719)	-10.1243 (- 0.7585)	-19.91	1.54	0.20
V_1 = 0.50	-0.0132 (-4.7045)	- 1.6640 (- 0.5456)	126.06	1.31	0.32
V_1 = 0.75	-0.0085 (-7.7765)	- 1.2083 (- 0.7426)	145.57	1.53	0.20
V_1 = 1.00	0.0220 (2.6000)	-	-	1.90	0.01
V_1 = 1.25	-0.0518 (-1.7761)	0.1273 (1.3040)	- 2.45	1.71	0.11
V_1* = 1.50	0.1722 (0.5157)	-0.1035 (- 0.5401)	- 0.60	1.23	0.36
V_1 = 1.75	-	0.0002 (4.4498)	-	1.92	0.00
RUBBER					
V_1 = 0.25	-0.1343 (-0.9784)	68.1779 (0.8492)	-507.65	87.97	0.24
V_1 = 0.50	-0.1701 (-0.7143)	11.0797 (0.6264)	- 65.13	75.64	0.34
V_1 = 0.75	-0.1527 (-0.8376)	7.6921 (0.8481)	- 50.37	83.71	0.28
V_1 = 1.00	-0.2052 (-0.7081)	-	-	93.11	0.19
V_1* = 1.25	-0.3371 (-0.4135)	1.2223 (0.5899)	-3.62	55.11	0.52
V_1 = 1.50	-0.3443 (-0.5118)	1.4001 (0.5389)	-4. 06	65.34	0.43
V_1 = 1.75	-	-0.0086 (-0.9069)	-	100.79	0.13

TABLE 6

LIQUIDITY

INDUSTRY		REGRESSION RESULTS			
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FOOD					
V_1 = 0.25	-0.0003 (-0.6667)	106.8466 (1.3163)	-356155.33	336.60	0.17
V_1 = 0.50	-0.0003 (-0.6667)	9.1018 (1.8656)	- 30339.33	324.12	0.20
V_1* = 0.75	-0.0005 (-0.4000)	17.4390 (0.7902)	- 34878.00	253.27	0.38
V_1 = 1.00	-0.0004 (-0.2308)	-	-	305.54	0.25
V_1 = 1.25	-0.0005 (-0.6000)	4.8148 (0.6024)	- 9629.60	287.96	0.29
V_1 = 1.50	-	0.0715 (3.0230)	-	392.82	0.03
V_1 = 1.75	-	0.0065 (2.3692)	-	399.74	0.02
BEVERAGES					
V_1 = 0.25	-0.0002 (-1.5000)	-72.4705 (-0.7947)	362352.50	79.34	0.45
V_1 = 0.50	-0.0002 (-1.5000)	-11.4904	57452.00	69.70	0.55
V_1 = 0.75	-0.0001 (-3.0000)	-8.5579 (-0.8073)	85579.00	82.48	0.42
V_1 = 1.00	0.0001 (0.4762)	-	-	96.71	0.19
V_1* = 1.25	-0.0006 (-0.5000)	2.3506 (0.4960)	- 3917.66	57.11	0.65
V_1 = 1.50	-0.0007 (-0.5714)	1.1821 (0.5441)	- 1689.57	60.38	0.63
V_1 = 1.75	-	0.0070 (1.0429)	-	90.16	0.32

TABLE 6 Cont.

LIQUIDITY

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
TEXTILES					
V_1 = 0.25	0.0010 (0.4000)	−148.8518 (− 0.7732)	−148851.80	584.29	0.56
V_1 = 0.50	0.0013 (0.2308)	− 16.6233 (− 0.9247)	−12787.15	378.46	0.71
V_1* = 0.75	0.0015 (0.2000)	− 5.9092 (− 1.9186)	− 3939.46	243.10	0.81
V_1 = 1.00	0.0012 (0.1667)	−	−	305.29	0.77
V_1 = 1.25	0.0001 (2.000)	0.8044 (1.4746)	8044.00	1146.22	0.14
V_1 = 1.50	0.0019 (0.2632)	−5.0466 (−0.6739)	−2656.10	312.31	0.76
V_1 = 1.75	−	0.0371 (1.4840)	−	1052.43	0.21
FOOTWEAR					
V_1 = 0.25	−0.0022 (−0.9545)	−30.6204 (− 1.2957)	13918.36	37.64	0.21
V_1 = 0.50	−0.0015 (−1.8000)	−6.6204 (− 0.7091)	4413.60	36.03	0.24
V_1 = 0.75	0.0014 (2.8571)	− 3.0896 (−1.7170)	−2206.85	42.45	0.10
V_1 = 1.00	0.0022 (1.5000)	−	−	44.69	0.06
V_1 = 1.25	−0.0009 (−1.6667)	0.8169 (0.3933)	−907.66	6.15	0.87
V_1* = 1.50	−0.0003 (−6.0000)	0.1592 (1.5220)	−530.66	6.09	0.87
V_1 = 1.75	−	0.0138 (0.1522)	−	7.71	0.83

TABLE 6 (Contd.)

LIQUIDITY

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FURNITURE					
V_1 = 0.25	0.0014 (0.9545)	-43.9441 (- 1.2957)	-31388.64	36.38	0.37
V_1 = 0.50	0.0011 (0.8182)	- 7.2862 (- 0.6392)	- 6623.81	30.38	0.47
V_1 = 0.75	0.0012 (0.6667)	- 3.9065 (- 1.1593)	- 3255.41	34.73	0.40
V_1 = 1.00	0.0015 (0.4667)	- -	-	36.16	0.37
V_1^* = 1.25	-0.0009 (-1.1111)	1.2479 (0.6668)	- 1386.55	24.62	0.57
V_1 = 1.50	-0.0014 (-1.1667)	0.6546 (0.7430)	- 467.57	27.63	0.52
V_1 = 1.75	- -	0.0097 (2.0208)	-	28.09	0.34
PAPER					
V_1 = 0.25	0.0017 (1.0588)	-45.4474 (- 1.2213)	-26733.76	69.40	0.22
V_1 = 0.50	0.0003 (5.0000)	-8.3995 (- 0.8520)	-27998.33	70.03	0.21
V_1 = 0.75	0.0001 (11.0000)	- 6.3828 (- 1.0388)	-63828.00	77.52	0.13
V_1 = 1.00	0.0003 (2.3333)	-	-	87.43	0.02
V_1^* = 1.25	-0.0027 (-0.7037)	2.9844 (0.6813)	- 1105.33	67.98	0.24
V_1 = 1.50	-0.0033 (-0.6970)	1.8032 (0.6970)	- 546.42	69.34	0.22
V_1 = 1.75	-	-0.0013 (-5.6154)	-	89.41	0.00

TABLE 6 (Cont'd)

LIQUIDITY

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
LEATHER					
V_1 = 0.25	- 0.0010 (- 1.6000)	-11.3869 (-0.6847)	11386.90	1.45	0.25
V_1^* = 0.50	- 0.0021 (- 0.7143)	- 1.8423 (- 0.4370)	877.28	1.02	0.47
V_1 = 0.75	- 0.0021 (-0. 8095)	- 1.4236 (- 0.5740)	677.90	1.24	0.35
V_1 = 1.00	- 0.0001 (-15.0000)	-	-	1.94	0.00
V_1 = 1.25	- 0.0044 (- 0.5000)	0.3750 (0.4515)	-85.22	1.12	0.42
V_1 = 1.50	- 0.0048 (- 0.5417)	0.2185 (0.5355)	-45.52	1.27	0.34
V_1 = 1.75	- -	0.0002 (5.5000)	-	1.92	0.00
RUBBER PRODUCTS					
V_1^* = 0.25	0.0022 (0.5455)	66.8010 (0.8939)	30364.09	86.70	0.25
V_1 = 0.50	0.0018 (1.0000)	6.0771 (1.2835)	3376.16	93.83	0.19
V_1 = 0.75	0.0008 (3.3750)	8.4248 (0.9188)	10531.00	99.30	0.14
V_1 = 1.00	0.0003 (6.0000)	-	-	116.04	0.00
V_1 = 1.25	0.0010 (2.2000)	-0.9586 (-1.3524)	- 958.60	97.96	0.15
V_1 = 1.50	0.0011 (2.2723)	-0.5393 (-1.9965)	- 490.27	98.31	0.15
V_1 = 1.75	-	-0.0086 (-0.8837)	-	100.79	0.13

TABLE 7

MAXIMUM LIKELIHOOD RESULTS FOR THE FIRST STAGE REGRESSIONS: EXPECTED PROFIT

INDUSTRY	REGRESSION RESULTS				
	z_{1t}	z_{2t}	θ	RSS	R^2
FOOD					
V_1 = 0.25	-0.0003 (-0.6667)	99.3227 (1.3809)	-331075.66	344.58	0.15
V_1 = 0.50	-0.0002 (-1.0000)	2.9508 (5.8020)	-14754.00	370.76	0.09
V_1^* = 0.75	-0.0005 (-0.4000)	16.7921 (0.8439)	-33584.20	267.93	0.34
V_1 = 1.00	-0.0004 (-1.3333)	-	-	321.44	0.21
V_1 = 1.25	-0.0001 (-1.4285)	1.3990 (0.6542)	1399.00	296.20	0.27
V_1 = 1.50	-	-0.4336 (-1.1245)	-	353.44	0.13
V_1 = 1.75	0.0001 (5.0000)	-0.0900 (-1.2278)	900.00	271.33	0.20
BEVERAGES					
V_1 = 0.25	-0.0004 (-0.5000)	-67.6974 (-0.7060)	169243.50	60.16	0.40
V_1^* = 0.50	-0.0005 (-0.6000)	-10.2610 (-0.5459)	20522.00	51.55	0.48
V_1 = 0.75	-0.0006 (-0.5000)	-10.7927 (-0.5114)	17987.83	54.46	0.45
V_1 = 1.00	-0.0001 (-4.0000)	0.0000 -	-	100.05	0.00
V_1 = 1.25	0.0001 (1.0000)	0.1556 (3.2995)	1556.00	87.43	0.13
V_1 = 1.50	0.0001 (3.3333)	0.0292 (3.9349)	292.00	87.41	0.13
V_1 = 1.75	0.0001 (1.0000)	-0.0266 (-2.9173)	-266.00	89.11	0.11

TABLE 7 (Cont'd)

Expected Profit

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
TEXTILES					
V_1 = 2.25	0.0008 (1.7777)	-182.4139 (-1.6775)	-228017.37	838.76	0.37
V_1 = 0.50	0.0001 (12.0000)	-26.7916 (-1.1037)	-267916.00	1188.84	0.11
V_1 = 0.75	0.0000 (0.1493)	-43.1969 (-1.2153)	-431969.00	1217.60	0.09
V_1 = 1.00	0.0013 (0.2308)	-	-	443.80	0.66
V_1* = 1.25	0.0003 (0.6667)	1.1889 (1.1429)	3963.00	544.44	0.51
V_1 = 1.50	-	0.5325 (0.6032)	-	691.11	0.48
V_1 = 1.75	0.0001 (5.0000)	0.0130 (1.7769)	7.69	589.43	0.56
FOOT WEAR					
V_1 = 0.25	-0.0011 (-2.8182)	-35.9246 (-1.1623)	32658.72	42.39	0.11
V_1 = 0.50	-0.0018 (-1.6111)	-6.4931 (-0.7202)	3607.27	35.73	0.25
V_1 = 0.75	-0.0029 (-3.5000)	-4.5072 (-1.0078)	1554.20	38.73	0.18
V_1 = 1.00	0.0001 (3.5000)	-	-	47.22	0.00
V_1 = 1.25	0.0036 (0.2500)	-0.0593 (-3.1399)	-16.47	13.26	0.72
V_1^* = 1.50	0.0015 (1.5000)	0.0106 (3.1226)	7.06	7.71	0.83
V_1 = 1.75	0.0001 (5.0000)	0.0085 (2.3647)	85.00	8.97	0.81

TABLE 7 (Cont'd)

EXPECTED PROFIT

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
FURNITURE					
V_1 = 0.25	0.0018 (1.0000)	-65.6988 (-1.1725)	-36499.33	137.31	0.23
V_1 = 0.50	0.0021 (0.6667)	-9.4081 (-0.9012)	-4480.04	103.62	0.42
V_1 = 0.75	0.0026 (0.5238)	-3.7729 (-1.8308)	-1451.11	84.19	0.53
V_1 = 1.00	0.0024 (0.1667)	-	-	55.56	0.69
V_1 = 1.25	0.0014 (7.0000)	-0.3515 (-1.3451)	-251.07	28.34	0.84
V_1^* = 1.50	0.0006 (0.1667)	-0.0691 (-0.8393)	-115.16	23.88	0.86
V_1 = 1.75	0.0003 (1.0000)	-0.0128 (-3.7500)	-42.66	26.58	0.85
PAPER					
V_1 = 0.25	0.0019 (1.0526)	-42.3308 (-1.3172)	-22279.36	68.23	0.23
V_1 = 0.50	0.0007 (2.7143)	-7.8409 (-0.9329)	-11201.28	68.18	0.23
V_1 = 0.75	0.0004 (3.7500)	-5.5988 (-1.2494)	-13997.00	75.98	0.14
V_1 = 1.00	0.0004 (0.5263)	-	-	85.22	0.04
V_1^* = 1.25	-0.0001 (-3.0000)	0.7572 (0.4914)	-7572.00	55.03	0.38
V_1 = 1.50	-0.0001 (-1.0000)	0.1635 (0.5774)	-1635.00	62.14	0.30
V_1 = 1.75	-0.0004 (-1.5000)	0.0637 (1.2465)	-159.25	81.06	0.08

TABLE 7 (Cont'd)

EXPECTED PROFIT

INDUSTRY	REGRESSION RESULTS				
	Z_{1t}	Z_{2t}	θ	RSS	R^2
LEATHER					
V_1 = 0.25	-0.0008 (-1.5000)	-10.5122 (-0.7062)	13140.25	1.44	0.25
V_1^* = 0.50	-0.0013 (-0.0013)	-1.7843 (-0.4703)	1372.53	1.12	0.42
V_1 = 0.75	-0.0013 (-1.0769)	-1.3758 (-0.6275)	1058.30	1.38	0.28
V_1 = 1.00	-0.0001 (-11.4308)	-	-	1.93	0.00
V_1 = 1.25	-0.0002 (-4.0000)	0.0736 (0.0917)	-368.00	1.64	0.15
V_1 = 1.50	-0.0001 (-2.0000)	0.0112 (1.4643)	-112.00	1.79	0.07
V_1 = 1.75	-0.0012 (-0.6667)	0.0148 (0.6689)	-12.33	1.46	0.24
RUBBER					
V_1^* = 0.25	0.0014 (0.5286)	51.2045 (0.9837)	36574.64	65.94	0.43
V_1 = 0.50	0.0003 (5.3333)	9.5149 (0.8318)	31716.33	96.31	0.17
V_1 = 0.75	0.0013 (0.8462)	8.1097 (0.8038)	6238.23	83.05	0.28
V_1 = 1.00	0.0005 (2.6000)	-	-	113.89	0.02
V_1 = 1.25	-0.0005 (-1.2000)	0.2200 (2.8591)	-440.00	105.56	0.09
V_1 = 1.50	-0.0001 (-1.0000)	-0.2312 (-1.0748)	2312.00	90.96	0.21
V_1 = 1.75	0.0002 (2.0000)	-0.0661 (-1.2148)	-330.50	92.16	0.20

The ranges of θ for the Liquidity and Expected Profit theories are -2206 to 13918 and -16 to 32658 respectively. These estimates of θ certainly suggest that setting the value of θ to zero in the estimation process as recommended by Klein, Steiglitz and Dhrymes will be misleading and seriously bias the final results as well; (3) Even though the value of R^2 ranged from about 0.50 to a little over 0.80 from theory to theory, the value of R^2 corresponding to minimum RSS exceeded 0.80 in each case thus indicating strong associations between the dependent and explanatory variables.

All the foregoing analysis done for the Footwear industry can indeed be generalized for the remaining seven industries. Such a generalization is, however, saved for now since not much new information will in fact be unfolded otherwise. Suffice it to say then that the ML estimate of θ for each industry was selected and then used to generate new data sets for the second stage regressions which form the basis of our next discussion.

Maximum Likelihood Estimates of the Second Stage Regressions

Estimates obtained from our second stage regression runs are contained in Tables 8 - 12. As the tables reveal, we have determined the best distributed lag functions for each of our competing theories and for each of the eight sampled industries based on available data for the period 1966 to 1976. The term "best" is used here in the sense that the residuals from the computed regressions were shown to exhibit randomness in virtually all of the forty cases but two. Although the regression residuals are analysed in greater detail later, one could conclude even now that the maximum likelihood estimation of the distributed lag functions in the distributed lag form has been more efficient than the ordinary least squares estimation of the same functions which we carried out in the auto-regressive form and, therefore, had to abandon owing to the presence of serial correlations in the residuals.

In each of Tables 8 - 12 the derived coefficients for each industry under each theory are reported with the t-ratio appearing in parenthesis below each regression coefficient. Altogether, forty regression equations were estimated. The usual significance test may be applied in several cases to determine whether or not a particular regression coefficient is significant. With seven degrees of freedom as we have, a computed t-ratio is significant if it exceeds 1.42 at 10 per cent probability level or 1.89 at 5 per cent probability level. It should, however, be recalled that the sign which a particular coefficient attracts could be as important if not more important than its significance level especially from the point of view of the required convergence of the distributed lag weights.

Additional information contained in Tables 8 - 12 include the previously calculated values for the V_1's, and the goodness-of-fit statistics, namely, the coefficient of determination R^2, and the Geary test for determining the randomness or otherwise of regression residuals. These goodness-of-fit statistics including the standard errors of estimate are also reported later in Table 14 to facilitate a comparison of the investment theories. Using these criteria, as well as the derived t-ratios judgement 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 8 - 12 we recall the equation fitted for the second stage regression to be of the form:

$$y_t = u_o Z_t + u_1 Z_{t-1}$$

where y_t represents net investment at time t, Z_t represents current change in desired capital, and Z_{t-1} stands for the lagged change in desired capital. Given the relationship between desired capital and its determinants under each theory of investment, Z_t ultimately stands for the current change in the following variables: Output Q_t, Liquidity L_t, Expected Profit V_t, and the value of output deflated by user cost $(\frac{PQ}{c})t$. Similarly, Z_{t-1} stands for the lagged change in the value of these variables. Substituting, therefore, the appropriate variables for Z_t, Z_{t-1} and y_t, in the specific example of the Accelerator theory we would expect our distributed lag function to take the final form:

$$I_t - \delta k_{t-1} = \frac{B + \alpha u_o(Q_t - Q_{t-1}) + \alpha u_1(Q_{t-1} - Q_{t-2})}{1 - V_1 L}$$

where L is the lag operator.

In Tables 8 - 12 numerical values have been determined for each of the unknown parameters - B, αu_o, αu_1, V_1 - of this function. To take the Textile example under the Accelerator theory in Table 10 we notice that B = 3.4129, αu_o = 0.0539, αu_1 = 0.0921, V_1 = 1.2500. Further individual estimates of α, u_o, u_1, may be obtained by applying the linear restrictions stated previously in Chapter II. This exercise is infact taken up later in Chapter V for some of the theories and industries investigated so far. Meanwhile, for the purpose of seeing the variations in the regression coefficients from one theory to the other and thus allowing much broader interpretation, we present the Textile results for the five alternative theories.

Beginning with the Expected Profit theory, Table 8, shows the following distributed lag function for the Textile industry:

Expected Profit Model

$$I_t - \delta k_{t-1} = \frac{-0.1457 + 0.0009\,(V_t - V_{t-1}) - 0.0008(V_{t-1} - V_{t-2})}{1-1.2500L}$$

Similarly, under the Liquidity theory in Table 9, we have the following fitted function:

Liquidity Model

$$I_t - \delta k_{t-1} = \frac{2.5167 + 0.0015\,(L_t - L_{t-1}) + 0.0003(L_{t-1} - L_{t-2})}{1 - 0.7500L}$$

The distributed lag function for the Accelerator theory is:

Accelerator Model

$$I_t - \delta k_{t-1} = \frac{3.4129+0.0539(Q_t - Q_{t-1}) + 0.0921(Q_{t-1} - Q_{t-2})}{1 - 1.2500L}$$

TABLE 8
MAXIMUM LIKELIHOOD RESULTS FOR THE SECOND STAGE REGRESSIONS

EXPECTED PROFIT

INDUSTRY	REGRESSION RESULTS					
	B	$V_t - V_{t-1}$	$V_{t-1} - V_{t-2}$	V_1	R^2	τ^1
FOOD	7.8896 (2.7527)	-0.0000 (-0.4582)	-0.0000 (-0.0241)	0.7500	0.0593	4
BEVERAGES	5.9862 (4.2798)	-0.0005 (-2.3504)	-0.0002 (-0.7797)	0.5000	0.5187	5
TEXTILE	-0.1457 (-0.0250)	0.0009 (2. 5517)	-0.0008 (-1.9939)	1.2500	0.6106	4
FOOTWEAR	-0.1109 (-0.1997)	0.0012 (1.3272)	0.0004 (0.2852)	1.5000	0.8458	5
FURNITURE	0.5071 (0.6295)	0.0024 (3.1136)	-0.0033 (-2.7898)	1.5000	0.7149	5
PAPER	3.4636 (1.3562)	0.0013 (0.6710)	-0.0016 (-0.6777)	1.2500	0.0776	4
LEATHER	1.1483 (7.0513)	-0.0015 (-1.8133)	-0.0009 (-1.7779)	0.5000	0.6311	7
RUBBER	4.4854 (3.6579)	0.0022 (2.8858)	-0.0016 (-1.6425)	0.2500	0.5823	6

TABLE 9

MAXIMUM LIKELIHOOD RESULTS FOR THE SECOND STAGE REGRESSIONS

LIQUIDITY

INDUSTRY	REGRESSION RESULTS					
	B	$L_t - L_{t-1}$	$L_{t-1} - L_{t-2}$	V_1	R^2	τ^1
FOOD	9.3445 (4.2161)	-0.0005 (-2.2433)	-0.0001 (-0.5230)	0.7500	0.4739	2
BEVERAGES	1.6327 (0.5098)	-0.0003 (-1.7797)	-0.0000 (-0.0691)	1.2500	0.3687	6
TEXTILE	2.5167 (0.9225)	0.0015 (5.8869)	0.0003 (1.3402)	0.7500	0.8546	4
FOOTWEAR	0.0915 (0.1869)	-0.0005 (-0.4690)	0.0003 (0.2047)	1.5000	0.8699	5
FURNITURE	0.4559 (0.3483)	0.0008 (0. 7138)	-0.0007 (-0.5049)	1.2500	0.4698	4
PAPER	-5.1119 (-1.6451)	0.0011 (1.8339)	-0.0050 (-3.2043)	1.2500	0.6322	5
LEATHER	1.2247 (7.6457)	-0.0021 (-2.0396)	-0.0015 (-2.0803)	0.5000	0.6936	7
RUBBER	3.0926 (2.0795)	0.0018 (1.1050)	0.0011 (0.6503)	0.2500	0.2683	6

TABLE 10

MAXIMUM LIKELIHOOD RESULTS FOR THE SECOND STAGE REGRESSIONS

ACCELERATOR

INDUSTRY	REGRESSION RESULTS					
	B	Q_t-Q_{t-1}	$Q_{t-1}-Q_{t-2}$	V_1	R^2	τ^1
FOOD	-25.2214 (-1.0390)	0.3339 (0.7968)	0.2978 (0.7246)	0.7500	0.2322	4
BEVERAGES	5.7473 (3.1570)	-0.0576 (-1.5144)	0.0003 (0.1351)	0.5000	0.2849	6
TEXTILE	3.4129 (0.4408)	0.0539 (0.2901)	0.0921 (0.4385)	1.2500	0.2841	5
FOOTWEAR	0.3102 (0.6995)	-0.0686 (-0.8067)	-0.0352 (-0.2856)	1.5000	0.8779	4
FURNITURE	3.2646 (3.5932)	0.0731 (0.5850)	0.0140 (0.4239)	0.2500	0.2716	4
PAPER	4.7620 (2.1954)	0.1215 (0.5195)	-0.1946 (-0.5320)	0.5000	0.0507	4
LEATHER	0.2297 (0.8776)	0.0986 (1.0069)	0.1354 (1.5273)	1.5000	0.4906	4
RUBBER	6.8565 (4.2365)	-0.3680 (-2.2761)	-0.0017 (-0.0111)	1.2500	0.5006	6

TABLE 11

MAXIMUM LIKELIHOOD RESULTS FOR THE SECOND STAGE REGRESSIONS

NEOCLASSICAL I

INDUSTRY	REGRESSION RESULTS					
	B	$(P\frac{Q}{c})_t-(P\frac{Q}{c})_{t-1}$	$(P\frac{Q}{c})_{t-1}-(P\frac{Q}{c})_{t-2}$	V_1	R^2	τ^1
FOOD	2.8194 (0.7904)	-0.0005 (-1.7029)	-0.0001 (-0.4593)	1.5000	0.3652	6
BEVERAGES	6.4074 (3.6109)	-0.1317 (-2.2435)	0.0182 (0.3639)	0.5000	0.4659	3
TEXTILE	2.6186 (0.3584)	0.1016 (1.0447)	0.0113 (0.0944)	1.5000	0.3125	5
FOOTWEAR	0.1927 (0.4597)	0.0323 (1.8064)	-0.0258 (-0.9764)	1.5000	0.8987	5
FURNITURE	0.9671 (0.8799)	-0.0630 (-0.6055)	-0.0502 (-0.3291)	1.2500	0.4670	4
PAPER	4.9232 (2.6629)	-0.0002 (-0.1480)	-0.1583 (-0.8820)	0.5000	0.1303	4
LEATHER	1.0173 (5.3287)	-0.0106 (-0.4421)	-0.0068 (-0.5573)	0.5000	0.4257	5
RUBBER	8.1387 (4.4383)	-0.5807 (-2.5475)	-0.0780 (-0.3927)	1.5000	0.5620	6

TABLE 12

MAXIMUM LIKELIHOOD RESULTS FOR THE SECOND STAGE REGRESSIONS

NEOCLASSICAL II

INDUSTRY	REGRESSION RESULTS					
	B	$(P\frac{Q}{c})_t-(P\frac{Q}{c})_{t-1}$	$(P\frac{Q}{c})_{t-1}-(P\frac{Q}{c})_{t-2}$	V_1	R^2	τ^1
FOOD	8.4446 (3.2802)	0.0236 (0.9360)	0.0239 (0.8823)	1.5000	0.2254	2
BEVERAGES	4.0627 (3.9264)	-0.0061 (-0.9584)	– 0.0081 (1.2172)	1.7500	0.3762	3
TEXTILE	3.5652 (0.4191)	0.0114 (-0.8417)	0.0575 (0.3616)	1.2500	0.2485	5
FOOTWEAR	-0.4624 (-0.5830)	-0.0775 (-2.3143)	-0.0571 (-1.2058)	1.5000	-0.7568	6
FURNITURE	-1.0669 (-0.7064)	0.0665 (0.5319)	0.1876 (1.2541)	1.2500	0.5823	4
PAPER	5.9854 (3.8483)	-0.3292 (-1.5083)	-0.0233 (-0.1236)	0.5000	0.3802	4
LEATHER	0.7989 (3.6749)	0.0186 (0.4863)	0.0019 (0.0846)	0.5000	0.3621	5
RUBBER	7.0158 (4.2478)	-0.4536 (-2.2151)	-0.0728 (-0.3594)	1.2500	0.5021	6

Under the Neoclassical I Model in Table 11, the distributed lag function for the Textile industry is:

Neoclassical Model I

$$I_t - \delta k_{t-1} = \frac{2.6186 + 0.1016\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + 0.0113\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right)}{1 - 1.5000L}$$

Finally for the Neoclassical II model we have

Neoclassical Model II

$$I_t - \delta k_{t-1} = \frac{3.5652 + 0.0114\left(\frac{P_tQ_t}{c_t} - \frac{P_{t-1}Q_{t-1}}{c_{t-1}}\right) + 0.0575\left(\frac{P_{t-1}Q_{t-1}}{c_{t-1}} - \frac{P_{t-2}Q_{t-2}}{c_{t-2}}\right)}{1 - 1.2500L}$$

A number of inferences can be derived from the preceding distributed lag functions of which the most obvious is the fact that alternative theories of investment show substantial variation in their characterization of investment expenditures for the Textile Industry. Beginning with the constant term we find this to be generally positive and to lie in the range 2.5 to 3.5 for all the theories excepting Expected Profit with a negative value much below unity i.e. -0.1457. Also, the numerator coefficients possess the expected positive sign generally, the exception being Expected Profit theory with a negative coefficient for its second variable, namely, the lagged change in desired capital.

However, despite the fact that each numerator coefficient is numerically smaller than unity which gives some promise for the convergence of the distributed lag weights, large variations seem to exist in the coefficients from one theory to the other. For example, the coefficient for the current change in desired capital varies from a low of 0.0009 for Expected Profit to a high of 0.1016 for Neoclassical I while for the lagged change in desired capital the range of variation is -0.0008 to 0.0921. A comparison of the numerator coefficients with their corresponding t-ratios as reported in Tables 8 - 12, shows that some of them are significant at the 5 per cent probability level while the others are significant at the 10 per cent probability level. Choice examples of these are the first and second numerator coefficients of the Expected Profit theory which are significant at the 5 and 10 per cent probability levels respectively. We could also observe that differences in the theories are also reflected in the values of the denominator coefficient which varies from 0.75 to 1.50 for the five theories tested on data for the Textile industry. Finally, we consider the R^2 statistic for the Textile Industry and observe substantial variations in the explanatory powers of alternative theories ranging from a low of 25 per cent for the Neoclassical II model to a high of 85 per cent for the Liquidity model.

Based on regression coefficients and goodness-of-fit statistics one may conduct similar interpretations as the foregoing for the remaining seven industries under each theory of investment. Indeed an all-embracing type of comparison of the investment theories from the view point of their performance is undertaken in a section following our analysis of regression residuals.

Analysis of Residuals

One obvious peculiarity with the Durbin-Watson (D.W.) 'd' statistic[1] normally used in testing for serial correlation in regression disturbances is that the test is inapplicable when observations are fewer than fifteen. Other problems with 'd' include the inconclusive region of the D.W. table, i.e, the interval $d_L < d < d_u$ or $(4-d_u) < d < (4-d_L)$ of the table and the fact that in a distributed lag situation such as ours a suitable transformation of 'd' to an 'h' statistic[2] as required for testing, is also handicapped by the fact that the 'h' test is designed for large samples in which the number of observations must exceed thirty.

In these circumstances, therefore, we resort to a non-parametric test for serial correlation which was recently developed by Geary[3]. The simple mechanics of the test is as follows. Assume that we have a set of regression residuals from one run. These residuals are examined and the number of sign changes τ^1 is noted. Given the number of observations T for the particular regression, we then compare τ^1 with tabulated minimum and maximum values of τ at specified probability levels.

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1. J. Durbin and G.S. Watson, "Testing for Serial Correlation in Least Squares Regression, I & II", Biometrika, 37 (1950), 409 and 38 (1951), 145.
2. J. Durbin, "Testing for Serial Correlation in Least-Squares Regression when some of the Regressors are Lagged Dependent Variables" Econometrica, Vol. 38, pp. 410-421, 1970.
3. R. C. Geary, "Relative Efficiency of Count of Sign Changes for Assessing Residual Autorregression in Least Squares Regression, "Biometrika, 57 (1970), 123.

If the inequality τ min $\leq$ $\tau^1 \leq \tau$ max holds from our comparison where τ min and τ max represent minimum and maximum values of τ respectively, we then accept the hypothesis of random distribution of the residuals at the tested probability level. If, on the other hand, the inequality fails, we of course accept the alternative hypothesis of positive serial correlation. This then is the manner by which an ordinary count of sign changes leads to a decision regarding the presence or absence of serial correlation of residuals at a prescribed significance level.

Geary himself conducted a Monte Garlo experiment for the case T = 40 and found the count of residual sign changes to be practically as efficient as the Durbin-Watson test. More recently, however, Habibagahi and Pratschke[1] compared the power of the Von Neumann ratio, Durbin-Watson and Geary tests and concluded as follows:

> "the Geary test is particularly useful. Statistical data, especially time series, typically has more than 30 observations, and the Geary test is almost as powerful as either Von Neumann or Durbin-Watson for Large T. Furthermore, the regression residuals are generally available to analysts, and the counting of sign changes provides a simple, quick and easy

1. H. Habibagahi and J. L. Pratschke, "A Comparison of the Power of the Von Neumann Ratio, Durbin-Watson and Geary Tests", Review of Economics and Statistics, Vol. 54, pp 179-185, 1972.

method of testing for autocorrelation without having to have recourse to the computations required for Durbin-Watson"[1]

One useful by-product of the work by Habibagahi and Pratschke is their Table 1[2] which extends the original number of observations considered by Geary to between 3 and 55 at the 1 and 5 per cent probability levels. To illustrate the usefulness of the extended table to our fitted distributed lag functions we take for example, the Textile industry in Table 8 . In order for the hypothesis of randomly distributed errors to be accepted for the case T = 9, we expect the number of sign changes in the regression residuals to lie between 2 and 5 (inclusive) at 5 per cent probability level, and to attain a maximum value of 6 at 1 per cent probability level. Comparing $\tau^1 = 4$ with tabulated τ at 5 per cent probability level we find the null hypothesis of randomly distributed disturbances to be supported for the Textile industry under the Expected Profit theory.

A generalization of this test to the forty regression cases reported in Tables 8 - 12 produces the following summary results: 29 out of 40 cases showed evidence of randomly distributed disturbances at 5 per cent probability level; 9 showed the evidence at the 1 per cent probability level, while 2 cases showed evidence of positive serial correlation. We may therefore, conclude that the estimation of our distributed lag functions

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1. ibid, p. 184
2. ibid, p. 180

by the maximum likelihood method has generally produced randomly distributed residuals.

In the section which now follows, we take up the ranking of alternative theories of investment as were tested in the preceding section of this chapter. Such a ranking will, hopefully, lead to a decision as to the theory providing the best explanation of investment behaviour in Nigerian manufacturing industries.

A Comparison of Alternative Theories

So far, a sizeable amount of work has been done on the empirical study of investment behaviour at the individual firm or industry level. By contrast, much fewer studies appear to have examined the relative performance of alternative theories of investment as a way of elucidating the question of which theory provides a better or, in fact, the best explanation of investment behaviour. Notable among these studies, however, are those of Jorgenson and Siebert, Jorgenson, Hunter & Nadiri, Wynn and Holden, and Bischoff.[1]

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[1] See D.W. Jorgenson & C.B. Siebert, "A Comparison of Alternative Theories of Corporate Investment Behaviour"; D.W. Jorgenson, J. Hunter and M.I. Nadiri, "The Predictive Performance of Econometric Models of Quarterly Investment Behaviour," Econometrica Vol. 38, pp. 213-24; R.F. Wynn and K. Holden, op. cit.; and C.W. Bischoff, "Business Investment in the 1970's: A Comparison of Models, "Brookings Pap ers on Economic Activity, 1:1971, pp. 13-58.

The study by Jorgenson and Siebert is a comparison of five theories of investment on the basis of annual data for fifteen corporations in the United States for the period 1949-63 and a combined data series for 1937-47 and 1949-63. The study by Bischoff was essentially aimed at projecting future levels of business investment in the United States using construction and equipment expenditure. Nevertheless, the author still found the need to try "a variety of different models" because, as of the date he was writing (that is 1971), "no consensus has developed among economists about the determinants of investment."[1] Wynn and Holden, on the other hand, set out "to illustrate the testing of various theories of investment behaviour within a unified framework" based on the procedure adopted by Jorgenson and Siebert, and, on annual data for the United Kingdom for the period 1958-70. Common to all these studies then is the choice of investment theories and the econometric procedure used in characterising the underlying distributed lag process. In particular, the theories examined have included the Accelerator, Liquidity, Expected Profits, Neoclassical I, and Neoclassical II, as well as the Federal Reserve-MIT-Penn (FMP) model in the case of Bischoff's study. A rational distributed lag has also provided the basis for the lag generating mechanism. Conclusions obtained from some of these earlier results could therefore be compared with the results obtained from this present study.

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[1] C.W. Bischoff, ibid. p.13.

As a way of discriminating among alternative theories of investment a number of "performance criteria" have been developed and utilized in the comparative studies mentioned above. These criteria include: (i) minimum residual variance; (ii) analysis of the fitted coefficients of changes in desired capital and (iii) the goodness-of-fit statistic, R^2. In applying the residual variance criterion to measure relative performance among alternative specifications of the theory of investment behaviour the decision rule is to select the theory of investment behaviour whose residual variance is the least as providing the best explanation of investment behaviour which of course implies that the errors themselves must be randomly distributed. When supplementing this rule with the rule of the fitted coefficients one focuses attention on the coefficients of changes in desired capital since this is the most important way to distinguish the theories of investment in Chapter II. Each of the fitted distributed lag functions is then examined both for its number and significance of coefficients of changes in desired capital. Conclusions from this examination are then supplemented by an analysis of the goodness-of-fit statistic i.e. the R^2 statistic.

The preceding performance criteria are now applied in discriminating among the five theories specified and tested in this study. We begin with an analysis of fitted coefficients of changes in desired capital as summarized in Table 13. The upper half of the table shows the number of coefficients of changes in desired capital that entered the regression function for all the industries included in our sample while the lower half of the table indicates the number of coefficients of changes in desired capital entering the distributed lag function with a t-ratio significant at 5 per cent or 10 per cent level for all the eight sampled industries.

TABLE 13

Number of Coefficients of Desired Capital

Model	ΔX_t	ΔX_{t-1}	Total
Accelerator	8	8	16
Liquidity	8	7	15
Expected Profit	7	7	14
Neoclassical I	8	8	16
Neoclassical II	8	8	16

Number of significant Coefficients

Model	ΔX_t	ΔX_{t-1}	Total
Accelerator	2	1	3
Liquidity	5	2	7
Expected Profit	5	4	9
Neoclassical I	4	0	4
Neoclassical II	3	0	3

The notation ΔX_t has been used in the table for the current change in desired capital while ΔX_{t-1} stands for the lagged change in desired capital. The figures appearing under each symbol are then the respective numbers of coefficients interpreted accordingly. If one selects the Accelerator model for illustration, Table 12 may be interpreted as follows: for the eight industries considered, the Accelerator theory had a total of eight coefficients for the current as well as for the lagged change in desired capital making a total of 16. Out of the eight coefficients in each case, 2 coefficients for the current change in desired capital and 1 for the lagged change in desired capital had t-ratios that were significant at 5 or 10 per cent.

A closer examination of Table 13 leads to the following conclusions: (i) each theory of investment behaviour (except liquidity and Expected Profit) has 8 coefficients of current change in desired capital and 8 of lagged change in desired capital making a total of 16 for each theory; (ii) out of this total number the significant coefficients were 3 for the Accelerator, 4 for Neoclassical I and 3 for Neoclassical II theories of investment; (iii) the liquidity theory has 8 coefficients of current change in desired capital and 7 of lagged change in desired capital making a total of 15 while the numbers are 7 and 7 respectively making a total of 14 for the Expected Profit theory; (iv) out of these total numbers, the significant coefficients were 7 for liquidity and 9 for Expected Profit theories of investment. On the basis of the number of coefficients of desired capital entering the distributed lag function we may rank the investment theories as follows:

1. Neoclassical I, Neoclassical II, Accelerator
2. Liquidity
3. Expected Profit.

This ranking implies that three theories, namely Neoclassical I, Neoclassical II and Accelerator share the first position in providing the best explanation of investment behaviour at the level of individual manufacturing industries while Liquidity and Expected Profit occupy second and third positions respectively. As we consider the number of significant coefficients, however, we find a dramatic shift in the preceding ranking to the following:

1. Expected Profit
2. Liquidity
3. Neoclassical I
4. Neoclassical II, Accelerator.

This time, Expected Profit emerges in the first position followed by Liquidity and Neoclassical I in second and third positions respectively while the last position is shared by Neoclassical II and the Accelerator theories.

In order to provide a more quantitative basis for further assessing the relative performance of alternative theories of investment behaviour some statistical measures of goodnes of fit, including the coefficient of multiple determination, R^2, the standard error of estimate, S, and the Geary Statistic, τ, are provided in Table 14 for all theories of investment behaviour considered. Although the coefficient of multiple determination is presented in a form not adjusted for degrees of freedom this does not seem to weaken its usefulness as a standard of comparison for the five investment theories since the degrees of freedom are the same for each fitted distributed lag function. The standard error of estimate is, in any case, adjusted for degrees of freedom and the findings based on this could reinforce those from the R^2. A computed Geary statistic, τ', provides a basis of comparison as to the degree of randomness of the errors among the theories of investment considered since a computed 'τ' value for 9 observations is required to lie between 2 and 5 (inclusive of end-points) at the 5 per cent probability level of error, or attain a maximum value of 6 at the 1 per cent probability level. It will be seen later that only in two out of forty regression cases were these critical values violated which leads us to the preliminary conclusion that the maximum likelihood estimation of the investment functions in the distributed lag form sufficiently surmounted the problem of auto correlated residuals.

TABLE 14

Industry and Model	Goodness of Fit statistics R^2	S	τ^1
FOOD INDUSTRY			
Accelerator	0.2322	7.1862	4
Liquidity	0.4739	5.9484	2
Expected Profit	0.0593	7.9543	4
Neoclassical I	0.3652	6.5343	6
Neoclassical II	0.2254	7.2177	2
BEVERAGE INDUSTRY			
Accelerator	0.2849	3.2758	6
Liquidity	0.3687	3.0777	6
Expected Profit	0.5187	2.6874	5
Neoclassical I	0.4659	2.8310	3
Neoclassical II	0.3762	3.0595	3
TEXTILE INDUSTRY			
Accelerator	0.2841	12.3784	5
Liquidity	0.8546	5.5782	4
Expected Profit	0.6106	9.1291	4
Neoclassical I	0.3125	12.1304	5
Neoclassical II	0.2485	12.6826	5
FOOTWEAR INDUSTRY			
Accelerator	0.8779	0.9613	4
Liquidity	0.8699	0.9924	5
Expected Profit	0.8458	1.0804	5
Neoclassical I	0.8987	4.6004	5
Neoclassical II	0.7568	1.3569	6

TABLE 14 (Cont'd)

Industry and Model	Goodness of Fit Statistics R^2	S	T^1
FURNITURE INDUSTRY			
Accelerator	0.2716	2.5030	4
Liquidity	0.4698	2.1354	4
Expected Profit	0.7149	1.5659	5
Neoclassical I	0.4670	2.1411	4
Neoclassical II	0.5823	1.8953	4
PAPER INDUSTRY			
Accelerator	0.0507	3.6338	4
Liquidity	0.6322	2.2618	5
Expected Profit	0.0776	3.5819	4
Neoclassical I	0.1303	3.4781	4
Neoclassical II	0.3802	2.9362	4
LEATHER INDUSTRY			
Accelerator	0.4906	0.3835	4
Liquidity	0.6936	0.2974	7
Expected Profit	0.6311	0.3264	7
Neoclassical I	0.4257	0.4072	5
Neoclassical II	0.3621	0.4292	5
RUBBER INDUSTRY			
Accelerator	0.5006	3.0100	6
Liquidity	0.2683	3.6434	6
Expected Profit	0.5823	2.7529	6
Neoclassical I	0.5620	2.8190	6
Neoclassical II	o.5021	3.0054	6

We now turn to analyse the coefficient of determination, R^2, for the fitted distributed lag functions as contained in Table 14. A summary of the frequency distribution of R^2 by type of investment model is presented in Table 15. More specifically, the upper half of Table 15 classifies the values of R^2 into five groups for each type of investment model. Since the theoretical values of R^2 are supposed to range from 0 per cent to 100 per cent, indicating polarized cases of "no relationship" and "perfect relationship" respectively, the experimental outcomes of R^2 have been grouped into those falling (i) above 80 per cent, (ii) between 60 and 80 per cent, (iii) between 40 and 60 per cent, (iv) between 20 and 40 per cent, and (v) below 20 per cent. The distribution includes all the cases favourable to each investment model over the sample space of industries considered. The lower half of Table 15 then presents the results of the ranking done for the frequency distribution of the R^2 values. Ranks are distributed among the five groups of R^2 in the order of 5, 4, 3, 2, 1, and are used to multiply their respective row values in order to obtain the scores given in the lower half of the table. From the last row of Table 15 the overall performance of each model can be seen in relation to the others. Thus, Liquidity emerges with 28 points and is followed by Expected Profit (25 points), Neoclassical I (22), Neoclassical II (20), and Accelerator (20).

TABLE 15

FREQUENCY DISTRIBUTION OF R^2 BY TYPE OF MODEL

Model

Range of R^2	Rank	Accelerator	Liquidity	Expected Profit	Neoclassical I	Neoclassical II
Above 80	5	1	2	1	1	0
60 - 80	4	0	2	3	0	1
40 - 60	3	2	2	2	4	2
20 - 40	2	4	2	0	2	5
Less than 20	1	1	0	2	1	0

DISTRIBUTION OF NUMBER OF SCORES

Model

Range of R^2	Accelerator	Liquidity	Expected Profit	Neoclassical I	Neoclassical II
Above 80	5	10	5	5	0
60 - 80	0	8	12	0	4
40 - 60	6	6	6	12	6
20 - 40	8	4	0	4	10
Less than 20	1	0	2	1	0
Total	20	28	25	22	20

In terms of their explanatory powers, alternative investment theories may now be ranked as follows:

1. Liquidity
2. Expected Profit
3. Neoclassical I
4. Neoclassical II, Accelerator.

Next, we consider the relative performance of alternative investment models on the basis of the minimum standard error criterion. For this purpose, the values of the standard error of estimate given in Table 14 are used to rank alternative theories and the results are reported in Table 16. There are two ways in which one can interpret the indicated ranks. The first approach which we refer to as the "inferiority rank" proceeds by considering the entries along the columns while the second approach also called the "superiority rank" considers the enteries along the rows. The figures given in each column represent the number of industries out of eight for which the investment theory presented at the top of the table has a larger standard error than the theory shown on the left hand side of the table while the converse holds true for the rows. Thus if we select the Liquidity theory for illustration the column under this theory shows that the Liquidity theory has a larger standard error than (i) the Accelerator (for 2 out of 8 industries); (ii) the Expected Profit, (for 3 out of 8 industries); (iii) Neoclassical I (for 3 out of 8 industries) and (iv) Neoclassical II (3 out of 8 industries). All the entries have accordingly been summed up by column and by row. The column totals which show cases of comparatively large standard errors suggest that the smaller the column total the higher the rank of its associated theory. Row totals, on the other hand, indicate that the larger the row total, the higher the rank of its associated theory.

TABLE 16

STANDARD ERROR CRITERION OF MODEL RANKING

Model	Accele-rator	Liqui-dity	Expected profit	Neoclas-sical I	Neoclas-sical II	Total
Accelerator		2	2	2	4	10
Liquidity	6		5	5	5	21
Expected Profit	6	3		6	6	21
Neoclassi-cal I	6	3	2		5	16
Neoclassi-cal II	3	3	2	3		11
Total	21	11	11	16	20	

Applying both the principle of "inferiority rank" and that of "superiority rank" to the standard errors of estimate for each theory of investment behaviour for all industries, we obtain consistent results whereby we can rank alternative theories of investment behaviour as follows:-

1. Liquidity, Expected Profit
2. Neoclassical I
3. Neoclassical II
4. Accelerator.

At this juncture it is useful to summarise the results obtained from our analysis of the comparative performance of five theories of investment behaviour and to pass on overall judgement as to their respective explanatory abilities. Using the criterion of the number coefficients of desired capital we had obtained the following ranking for the theories:

1. Neoclassical I, Neoclassical II, Accelerator
2. Liquidity,
3. Expected Profit

This ranking shows a multiple tie between Neoclassical I, Neoclassical II, and Accelerator while Liquidity occupies the second position. The last position is taken by Expected Profit. On the other hand, the ranking done on the basis of significant coefficients produced the following results :

1. Expected Profit
2. Liquidity
3. Neoclassical I
4. Neoclassical II, Accelerator

Next, the coefficient of multiple determination yielded a ranking in which Liqudity emerged superior as follows:

1. Liquidity
2. Expected Profit
3. Neoclassical I
4. Neoclassical II, Accelerator

Finally, the "superiority rank" and "Inferiority rank" approaches led to the following ranking:

1. Liquidity, Expected Profit
2. Neoclassical I
3. Neoclassical II
4. Accelerator

From a visual inspection of these four sets of results it is clear that no uniform pattern has really emerged from the ranking of alternative theories of investment behaviour. It would appear, therefore, that an overall judgement can only be made if the four sets of results are themselves ranked. This is the exercise carried out in Table 17 below.

TABLE 17

OVERALL DISTRIBUTION OF OCCURENCES

		Model				
Position	Rank	Accelerator	Liquidity	Expected Profits	Neoclassical I	Neoclassical II
1	4	1	2	2	1	1
2	3	0	2	1	1	0
3	2	0	0	1	2	1
4	1	3	0	0	0	2

RANKED SCORES

	Model				
Position	Accelerator	Liquidity	Expected Profit	Neoclassical I	Neoclassical II
1	4	8	8	4	4
2	0	6	3	3	0
3	0	0	2	4	2
4	3	0	0	0	2
Total	7	14	13	11	8

The upper half of Table 17 shows the number of times a particular model of investment occupied the first, second, third or fourth position on the four ranking lists. Thus, it can be seen that the Liquidity model, for example, won the first position twice and the second position twice. If ranks are distributed among the positions in a descending order of importance, i.e. 4,3,2,1 and used to multiply their respective row values, we then obtain the scores given in the lower half of Table 17. Using now, the last row of Table 17 we finally arrive at an overall ranking of the five models of investment behaviour tested in this study as follows:

1. Liquidity,
2. Expected Profit
3. Neoclassical I
4. Neoclassical II
5. Accelerator

From this overall ranking we can conclude that the best explanation of investment behaviour by manufacturing industries in Nigeria during the period of analysis has been provided by the Liquidity theory, with the Expected Profit theory following closely. Neoclassical I theory occupies the third position which then emphasizes the importance of including capital gains (or losses) in the price of capital services used in deflating the value of output. Fourth in explanatory importance is Neoclassical II model which is akin to the Neoclassical I model except for the exclusion of capital gains. The Accelerator model then comes last.

These results may now be compared with those earlier obtained by previous investigators in this area. In their comparative study of fifteen corporations in the United States, Jorgenson and Siebert[1] had found the Neoclassical I model to be superior to Neoclassical II while Expected Profit, Accelerator and Liquidity models foolowed in that order.

This finding was also corroborated in the study by Jorgenson, Hunter and Nadiri. Bischoff, in his study of US investment in structures and equipment had concluded that the FMP model, a variant of Neoclassical I model had performed best relative to the others. Wynn and Holden found support for the crude Accelerator in their own tests using aggregate capital formation series for the United Kingdom. Francis Scotland[2] ran his tests using Canadian aggregate investment data for machinery and equipment and non-residential structures for the period 1962 to 1977. He reported that although his results reflected "the importance of output as the underlying determinant of investment, all the models were basically similar in their ability to track investment" while the Neoclassical model stood out as "the most tractable in terms of analysis" (being) "the most appropriate framework for determining the effects of monetary policy on investment".

The observed performance of the Liquidity model in the Nigerian case may be explained by the fact that for a growing economy such as ours the optimum size of industry tends to be small initially thus heightening the importance of internally generated funds[3] for the financing of investment

[1] D.W. Jorgenson and C.B. Siebert, "A Comparison of Alternative Theories of Investment Behaviour," op.cit. see also D.W. Jorgenson, J. Hunter and M.I. Nadiri, op. cit.

[2] F.Scotland, Investment: A Survey of Models with some Implications for the Effects of Monetary Policy, Ottawa, Bank of Canada, Dec. 1981, (Bank of Canada Technical Report 29).

[3] A big boost to such funds occured in several instances during the period covered by this study when stringent exchange control measures were adopted by government leading to the suspension of transfers in respect of dividends, profits, management agency fees, etc. See Central Bank of Nigeria, Annual Reports, (1966-1976)

expenditures in the specific context of relatively underdeveloped money and capital markets. Consequently, such financial considerations may well dominate others like sales changes, tax policy, or fiscal incentives. An additional explanation could be due to a probable sensitivity of the models to the type of data used in the sense that retained earnings tended to have dominated much of private foreign investment during the period of our analysis. This impression concerning choice of data tends to be reinforced by the non-homogeneity in the results reported for the countries cited above among others. Finally, the result obtained could further reflect sensitivity to the number and types of performance criteria utilized in discriminating among alternative investment models.

Having regard, therefore, to the foregoing caveats, the issue of which model actually possesses "the best" explanatory power in an econometric investigation such as we performed may not necessarily be regarded as closed. New bodies of data generated from time to time will permit a comparison of the results obtained from testing such data with present results either for validation or otherwise. In any event, it would appear rather pertinent to observe that the relative importance of the models could even lie in their individual ability to tract changes in policy instruments, ignoring other considerations. In this sense, the Neoclassical models have been adjudged superior to others in specific investigations. Consequently, this versatility of the Neoclassical models is rigorously tested in the chapter that follows.

Summary

This chapter has presented an empirical test of the rational distributed lag functions earlier specified in chapter III aimed at yielding evidence on the determinants of investment behaviour in selected Nigerian manufacturing industries including Food, Beverages, Textile, Footwear, Furniture and Fixtures, Paper and paper Products, Rubber, and Leather. The five theories of investment which were tested are: Accelerator, Liquidity, Expected profit, Neoclassical I and Neoclassical II. For each industry relevant annual data were obtained for such variables as investment, sales, capital stock, depreciation, output, liquidity, profit and price of capital services. These variables were then transformed where necessary for the purpose of estimating the rational distributed lag functions by the maximum likelihood (ML) method.

The ML method involved undertaking regression runs at two stages. In the stage one regression, the numerator of the rational distributed lag, U(L), was assumed to be of zero degree and then a function of the form,

$$y_t = u_o Z_{1t} + u_o \theta Z_{2t}$$

was fitted for each industry under each theory of investment behaviour where y_t is net investment expenditure. From this regression, ML estimates for V_1, the regression coefficients for the variables Z_{1t} and Z_{2t}, and the parameter θ were derived. Of course, data for the Z_{1t} and Z_{2t} variables had earlier been generated by assuming V_1 to lie in the range $0.25 \leq V_1 \leq 1.75$ and then spacing the values at intervals of 0.25. In order to execute the second stage regression the derived estimate of Θ was used to generate a Z_t variable from the relationship $Z_t = Z_{1t} + \Theta Z_{2t}$ where the Z_{1t} and Z_{2t} values were chosen so as to correspond to the ML value of V_1.

Assuming U (L) to be of first degree, the stage two regression then took the form

$$Y_t = u_0 Z_t + u_1 Z_{t-1}$$

where y_t once again represented net investment expenditure, Z_t the current change in desired capital, and Z_{t-1} the lagged change in desired capital. Given the relationship between desired capital and its determinants under each theory of investment, Z_t ultimately stood for the current change in the following variables: Output Q_t, Liquidity L_t, Expected Profit V_t, and the value of output deflated by user cost $(P\frac{Q}{c})_t$.

On the basis of the first stage function and the generated data, seven regressions were performed for each industry under each of the five theories of investment thus producing a total of 280 single equation results. Each fitted regression equation was examined for its values of RSS, Θ, and V_1 so that the minimum RSS from each group of seven (single equation) results was selected. The values of V_1 and Θ corresponding to this minimum RSS were then picked as the ML values for V_1 and Θ.

Using the footwear industry for example, we found V_1 to be equal to 1.5 for all the theories. The values of Θ however varied substantially across theories, as could suggest differences among the theories tested. Taking the case of Neoclassical II theory and the Footwear industry as an example, we found that Θ varied numerically from a low of -3.31 to a high of -349083 from which an ML value of -3.31 was selected. Similar ranges were noticed for the other theories which led us to conclude that the value of Θ should hot be set to zero in the estimation process as recommended by Klein, Steiglitz and Dhrymes, other-wise the final results would be seriously biased. Furthermore, it was found at the first stage level that the value of $\bar{R}^2$ corresponding to minimum RSS exceeded 0.80 in the case of the Footwear industry under each theory thus indicating strong associations between the dependent and independent variables.

At the second stage level we determined the best distributed lag functions for each of our competing theories and for each of the eight sampled industries based on the available data for the period 1966 to 1976. Of the forty regressions fitted, thirty eight showed randomly distributed residuals when tested on the basis of the Geary test statistic which led us to conclude that the ML estimation of the distributed lag functions in the distributed lag form turned out to be more efficient than the OLS estimation of the same functions which we carried out in the autoregressive form and had to abandon owing to the presence of serially correlated residuals.

Using the example of the textile industry, we derived the following inferences from our second stage regressions:

(i) the constant term was generally positive and fell in the range 2.5 to 3.5 for all the theories excepting Expected Profit with a value of -0.1457;

(ii) the numerator coefficients of the rational distributed lag functions possessed the expected positive sign generally with the exception of Expected Profit theory which had a negative coefficient for its second variable, i.e. - the lagged change in desired capital;

(iii) despite the fact that each numerator coefficient was numerically smaller than unity as required, all the coefficients varied substantially from theory to theory and were significant at 5 or 10 per cent probability levels;

(iv) differences in alternative theories were further reflected in the value of the denominator coefficient V_1 which varied from 0.75 to 1.50 for the five theories tested on data for the Textile industry;

(v) the $\bar{R}^2$ statistic indicated substantial variations in the explanatory powers of alternative theories with a range of 25 to 85 per cent.

Although the preceding inferences were based on the Textile industry, all-embracing type of comparison of the investment theories from the standpoint of their performance was undertaken using performance criteria which had previously been applied in similar situations by Jorgenson and associates, Wynn and Holden, and Bischoff. The criteria included minimum residual variance, analysis of the fitted coefficients of changes in desired capital, and the goodness-of-fit statistic, R^2.

All these criteria were applied in discriminating among the five theories of investment with each criterion yielding a particular ranking for alternative theories of investment. For example, the ranking procedure done for the $\bar{R}^2$ Statistic as a performance criterion showed that the Liquidity theory was superior to the other theories while the ranking done on the basis of significant coefficients showed that the Expected Profit theory was superior to the other theories in the explanation of investment behaviour. On the whole, four sets of results were obtained from the four performance criteria used. However, as could be expected, no uniform pattern of results actually emerged from the ranking of alternative theories of investment behaviour. Consequently, all the four sets of results had to be ranked. This overall ranking led us to conclude that the best explanation of investment behaviour by manufacturing industries in Nigeria during the period of our analysis was provided by the Liquidity theory. Expected Profit theory followed in the order of importance while Neoclassical I was superior to Neoclassical II. Of course, the Accelerator theory occupied the last position.

These findings should be seen to differ in some respects from those earlier obtained in previous studies done for the United States, British, and Canadian economies where the Neoclassical I, Accelerator, and Output theories respectively were found to provide the best explanation of investment behaviour. Overall, it would appear that the findings obtained across industries could be sensitive not only to the choice of data, but perhaps, also to the number and types of performance criteria utilized. In the final analysis, the superiority of an investment model could lie even more in its ability to track policy changes relative to other models, than in other considerations.

CHAPTER V

ANALYSIS OF DISTRIBUTED LAGS AND POLICY ISSUES

Introduction

We turn finally in this chapter to an examination of the policy implications which may be derived from the empirical results reported in the preceding chapter. Indeed, a number of economic policy measures can be based on the results obtained from a regression fitted to the relationship between net investment and its underlying determinants. More so, the appropriate timing of economic policy may yield desirable effects on the economy if the pattern of the lags associated with investment expenditures were to be precisely estimated.

The time pattern of investment behaviour should indicate whether the lags in investment expenditures are short, long or substantially distributed over time. From the point of view of an economic policy which is intended to steer the economy along a stable, non-cyclical path by stimulating the level of investment it is desirable to have a fairly short lag between changes in the instruments of policy and the resulting level of actual investment expenditures. On the other hand, if the lag between the changes in policy and actual investment spending is long, policy measures may produce the unintended effect of destabilizing rather than stabilizing the economy by giving the wrong signals to policy makers. Finally, economic policy making may also benefit from a knowledge of the form of the lag between changes in policy measures and the level of investment expenditure that comes about. If the effects of policy changes on investment are "highly concentrated" in time, policy makers will need to access the appropriate time for the implementation of their policies. On the other hand, the more the effects are diffused over time the less will policy makers have to worry about the timing of their policies.

A number of studies in the literature have attempted to measure the "average lag" or, the "mean lag", between investment expenditure and its determinants using annual or quarterly data.[1] Similarly, while a few other studies have attempted to characterize the form of the lag distribution underlying investment behaviour,[2] the long run response of investment has, in any case, been given scanty attention. What is, perhaps, more disturbing is the fact that evidence in these categories of studies has accumulated rather fast for developed countries and slow, if anything, for developing countries.

In this chapter, estimates are derived for (i) the average lag between changes in determinants of investment and actual investment spending and, (ii) the long run response of investment to changes in its determinants. The form or time shape of the lag distribution underlying investment behaviour is also determined while some comparative static results are obtained for the relationships between investment, the desired level of capital, and their determinants. Consequently policy implications from the estimated time lags and shapes are also derived.

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[1]See, E. Kuh, "Theory and Institutions in the Study of Investment Behaviour," American Economic Review, 53 (May 1963), 260-268; D.W. Jorgenson & C.D. Siebert, "Optimal Capital Accumulation," op.cit., D.W. Jorgenson and J.A. Stephenson, "The Time Structure of Investment Behaviour in United States Manufacturing, 1947-1960", Review of Economics and Statistics, vol. 49, (Feb. 1967).

[2]See, L. M. Koyck, op. cit. and R.M. Solow, op. cit.

Time Structure of Investment Behaviour

In order to characterize the time pattern of the investment process in the Nigerian manufacturing industries, we employ regression results contained in the preceding chapter. More specifically we select for analysis five manufacturing industries - Leather, Food, Footwear, Textiles, and Rubber - whose coefficients were found to satisfy precisely the non-negativity constraints stipulated earlier in Chapter II. These industries represent three theories of investment, namely, Accelerator, Liquidity, and Neoclassical II. But while the analysis of the time pattern of response is done for all the industries, only the Leather industry is examined further with respect to its comparative static features since it emerges strictly from a Neoclassical model.

We begin by estimating the average lag between changes in the determinants of investment behaviour and actual investment expenditures. For this purpose it is essential to derive estimates of the coefficients u_o and u_1 from the relevant equations as reported in Tables 8 - 12. To take the fitted Neoclassical II function of the Leather Industry for illustration it is seen that the estimate for αu_o is 0.0186; for u_1 it is 0.0019. From previous calculations in chapter IV, the estimate for $-v_1$ is -0.5000, while for δ (the annual rate of replacement) it is 0.296. Observing the rule in Chapter III that $\Sigma w_\tau = 1$ so that $\Sigma u_\tau = \Sigma v_\tau$, it is possible to obtain final estimates of the parameters α, u_o, u_1 and v_1. These coefficients are, in fact, estimated to be:

$$\alpha = 0.0137, \; u_o = 1.3577, \; u_1 = 0.1387, \; v_1 = 0.5000 \text{ and } v_o = 1$$

(by normalization). In order to derive the mean lag or average lag,[1] these final coefficients are substituted into the following relationship:

$$\text{Average Lag} = \frac{u_1}{u_o + u_1} + \frac{v_1}{1-v_1}$$

Similarly the longrun response[2] of investment to changes in its underlying determinants may be derived from the relationship:

$$\text{Long-run Response} = \frac{u_o + u_1}{1 - v_1}$$

Both average lags and long run responses have been calculated for the Leather, Textile, Rubber, Food and Footwear industries using the Neoclassical II model for Leather, Liquidity for Textile and Rubber, and Accelerator model for Food and Footwear. The results are shown in Table 18.

Calculations of the distributed lag weights,[3] w_τ, from the final coefficients, u_τ and v_τ, of the relevant regressions are necessary for any further characterization of the time structure of the investment process. Thus, if we denote by w_o the weight corresponding to lag 0,

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[1]See G.S. Maddala and A.S. Rao, "Maximum Likelihood Estimation of Solow's and Jorgenson's Distributed Lag Models," The Review of Economics and Statistics, Vol. LIII, 1971 p.85; P.J. Dhrymes, L.R. Klein, and K. Steiglitz,"Estimation of Distributed Lags," International Economic Review, Vol. II, No. 2, June, 1970, p. 249 and G.S. Maddala, Econometrics, McGraw Hill, Inc., USA, 1971, pp.370 - 378.

[2]See Maddala and Rao, ibid.

[3]See A. Griliches op. cit. p.23 and Jorgenson (1966, p.146) "Rational Distributed Lags....."

w_1 the weight corresponding to lag 1, and so on up to w_5 we obtain a series of weights corresponding to each lag from the following relationships:

$$w_o = \frac{u_o}{u_o + u_1}(1 - v_1)$$

$$w_1 = \frac{u_1}{u_o + u_1}(1 - v_1) + v_1 w_o$$

and, $$w_\tau = v_1 w_{\tau-1} \quad \text{for} \quad \tau > 1$$

The sequence of weights w_τ have been determined for lags 0 to 5 and since all the weights must sum to unity for convergence of the series, the rest of the weights may be obtained by subtracting the sum of the six estimated weights from unity. Following Jorgenson & Siebert[1] we refer to this estimate as the "Remaining Lag" in Table18 and also show estimates of the first six weights. It may be recalled from the theoretical formulations in Chapter II that the sequence of weights w_τ actually describes a distributed lag relationship between net investment and changes in desired capital.

We can of course proceed one step further and calculate a second group of coefficients, k_τ, which measure the distributed lag

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[1]D.W. Jorgenson and C.D. Siebert, "Optimal Capital Accumulation"

relationship between gross investment and changes in desired capital. These k_τ coefficients are particularly important for assessing the effects of changes in the determinants of desired capital. In the case of the Neoclassical I model, for instance, it will be recalled that the price of capital services is one of the determinants of desired capital. On the other hand, the price of capital services also depends on tax policy so that calculations of the k_τ coefficients measure the relative influence of changes in tax policy on investment behaviour. Estimates of k_τ for each of our five industries as reported in Table 18 have been obtained from the relationships[1]: $k_o = w_o$, $k_1 = w_1 - (1-\delta)w_o$, $k_2 = w_2 - 1(1-\delta)w_1$, ..., where k_o corresponds to lag o, k_1 to lag 1, and so on.

The third set of coefficients, z_θ, which are calculated and also reported in Table 18 for the five industries, measure the response of gross investment (or the proportionate changes in both expansion and replacement due) to a change in desired capital that persists for, say, θ periods previous to the current time. For this purpose the series of cumulative sums z_θ have been calculated from the k_τ series using the formula[2]:

$$z_\theta = \sum_{\tau=0}^{\theta} K_\tau = w_\theta + \delta \sum_{\tau=0}^{\theta-1} w_\tau$$

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[1] See D.W. Jorgenson and C.D. Siebert, "Optimal Capital Accumulation" p.1144.

[2] D.W. Jorgenson and C.D. Siebert, ibid.

In this relationship, w_θ (i.e. net investment) is the change in gross investment that results from changing desired capital by one unit θ periods earlier, while $\delta\Sigma w_\tau$ is the replacement of investments which had already been undertaken. For completeness, the sequence of coefficients, denoted R_τ are also calculated either directly or as the difference between z_τ and w_τ, and are shown in Table 18 so as to facilitate a discussion of the role of replacement in the investment process. Taking the food industry, as an example, we easily see that 0.1321 is an estimate for z_o while 0.3311 is an estimate for z_1. Thus, if the desired level of

TABLE 18

TIME FORM OF LAGGED RESPONSE

Lag(τ)	Neoclassical II			
Leather	w_τ	K_τ	z_τ	R_τ
0	0.4537	0.4537	0.4537	0.0000
1	0.2732	-0.0462	0.4075	0.1343
2	0.1366	-0.0557	0.3518	0.2152
3	0.0683	-0.0279	0.3290	0.2607
4	0.0342	-0.0139	0.3151	0.2809
5	0.0171	-0.0070	0.3081	0.2910
Remaining	0.1535			
δ	0.2960			
Average Lag	1.0927			
Longrun Response	2.9928			

TABLE 18 (cont'd)

TIME FORM OF LAGGED RESPONSE

Lag (τ)		Accelerator		
Food	w_τ	K_τ	Z_τ	R_τ
0	0.1321	0.1321	0.1321	0.0000
1	0.2170	0.1990	0.3311	0.1141
2	0.1628	0.1333	0.4644	0.3016
3	0.1221	0.1000	0.5644	0.4423
4	0.0916	0.0750	0.6394	0.5478
5	0.0687	0.0562	0.6956	0.6269
Remaining	0.2057			
δ	0.8640			
Average Lag	3.4714			
Longrun	6.9992			
Footwear				
0	0.6294	0.6294	0.6294	0.0000
1	0.2780	0.2610	0.8904	0.6124
2	0.0695	0.0620	0.9524	0.8829
3	0.0174	0.0155	0.9679	0.9505
4	0.0043	0.0038	0.9717	0.9674
5	0.0011	0.0010	0.9727	0.9716
Remaining	0.0003			
δ	0.9730			
Average Lag	0.4941			
Longrun Response	1.6663			

TABLE 18 (Cont'd)

TIME FORM OF LAGGED RESPONSE

Liquidity

Lag (τ)	w_τ	k_τ	z_τ	R_τ
Textiles				
0	0.2083	0.2083	0.2083	0.0000
1	0.1979	0.1506	0.3589	0.1610
2	0.1484	0.1035	0.4624	0.3140
3	0.1113	0.0776	0.5400	0.4287
4	0.0833	0.0644	0.6044	0.5211
5	0.0625	0.0436	0.6480	0.5855
Remaining	0.1883			
δ	0.7730			
Average Lag	3.1667			
Long Run Response	7.2000			
Rubber				
0	0.4655	0.4655	0.4655	0.0000
1	0.4009	0.3790	0.8445	0.4436
2	0.1002	0.0814	0.9259	0.8257
3	0.0251	0.0204	0.9463	0.9212
4	0.0063	0.0051	0.9514	0.9451
5	0.0016	0.0013	0.9527	0.9511
Remaining	0.0004			
δ	0.9530			
Average Lag	0.7126			
Long Run Response	1.6812			

capital services changes in period t, by one unit gross investment will change accordingly in period t + 1 by 0.3311. Of this change, the proportionate share due to investment for expansion is 0.2170 and, for replacement, it is 0.1141. Continuing the process, one finds that the proportionate change in gross investment actually approaches the rate of replacement, δ, as a limit. This discussion may be generalized for the remaining four industries.

Beginning with Leather, we notice that a change in desired capital services in the first period leads to a proportionate change in gross investment of the order of 0.4537 made up entirely of investment for expansion. By the end of the sixth period, the proportionate change in gross investment is 0.3081 which is due largely to investment for replacement with a negligible proportion, 0.0171, for expansion purposes. This pattern of behaviour is also true of the Footwear, Textile and Rubber industries such that the peak response in net investment (i.e. for expansion) occurs within the first year - the only exception being food with a peak occuring in the second year. In all cases, however, after the expiration of say, the first two years, the response of investment for replacement purposes begins to dominate the response of investment for expansion purposes. From this observed behaviour of the lag structure underlying the investment process we may conclude that replacement investment should be taken into consideration when formulating an investment policy for counter cyclical ends.

After the preceding discussion of the time pattern of investment behaviour we now go on to characterize the form of the lag distribution in each of the five industries. For this purpose, we make use of the computations of average lag also appearing in Table 18. Thus, the average lags are: 1.09 years (or 4.4 quarters) for Leather, 3.47 years (or 13.9 quarters) for Food, 0.49 years (or 2.0 quarters) for Footwear, 3.17 years (or 12,7 quarters) for Textiles, and 0.71 years (or 2.9 quarters) for Rubber. Most of the industries therefore show average lag between changes in desired capital and net investment expenditures of between six months and a little over one year, with a spread of up to three and a half years for others. Also, all industries show differences between the average lag and the year of peak response. For Leather, Food and Textiles the average lag exceeds the peak year while for Footwear and Rubber the average lag falls short of the peak year. The differences in all the cases actually range between three months and two years. Since no industry shows average lag coincident with the peak year, we may conclude that the lag distributions from industry to industry are non-symmetric. Consequently, several of the lag patterns indicated in Chapter III the "arithmetic", "inverted - V", etc, cannot adequately be used to describe the lag patterns underlying investment behaviour in the Nigerian manufacturing industries.

We may now summarize our findings on the time pattern of investment behaviour and the form of the lag distributions in Nigerian manufacturing industries. As computed, the average lag for new plants and for sizeable additions to existing plants ranges between six months and about three years (or two and twelve quarters) from the time it is decided to undertake a project to the actual completion of the construction work. For most industries, a substantial amount of investment expenditures takes place in the very first year that a change in desired capital manifests itself. After the expiration of say, the first two years, however, the response of investment for replacement purposes begins to dominate the response of investment for expansion purposes. For all the cases considered, the differences between the average lag and the the peak year range between three months (i.e. one quarter) and two years (i.e eight quarters). We may, therefore, conclude that the lag distributions from industry to industry are non-symmetric. These findings have wide ranging policy implications which are taken up in the final section of this chapter.

Meanwhile, we may compare our results with those obtained for the United States in recent years. Jorgenson and Stephenson[1] found the average lag for

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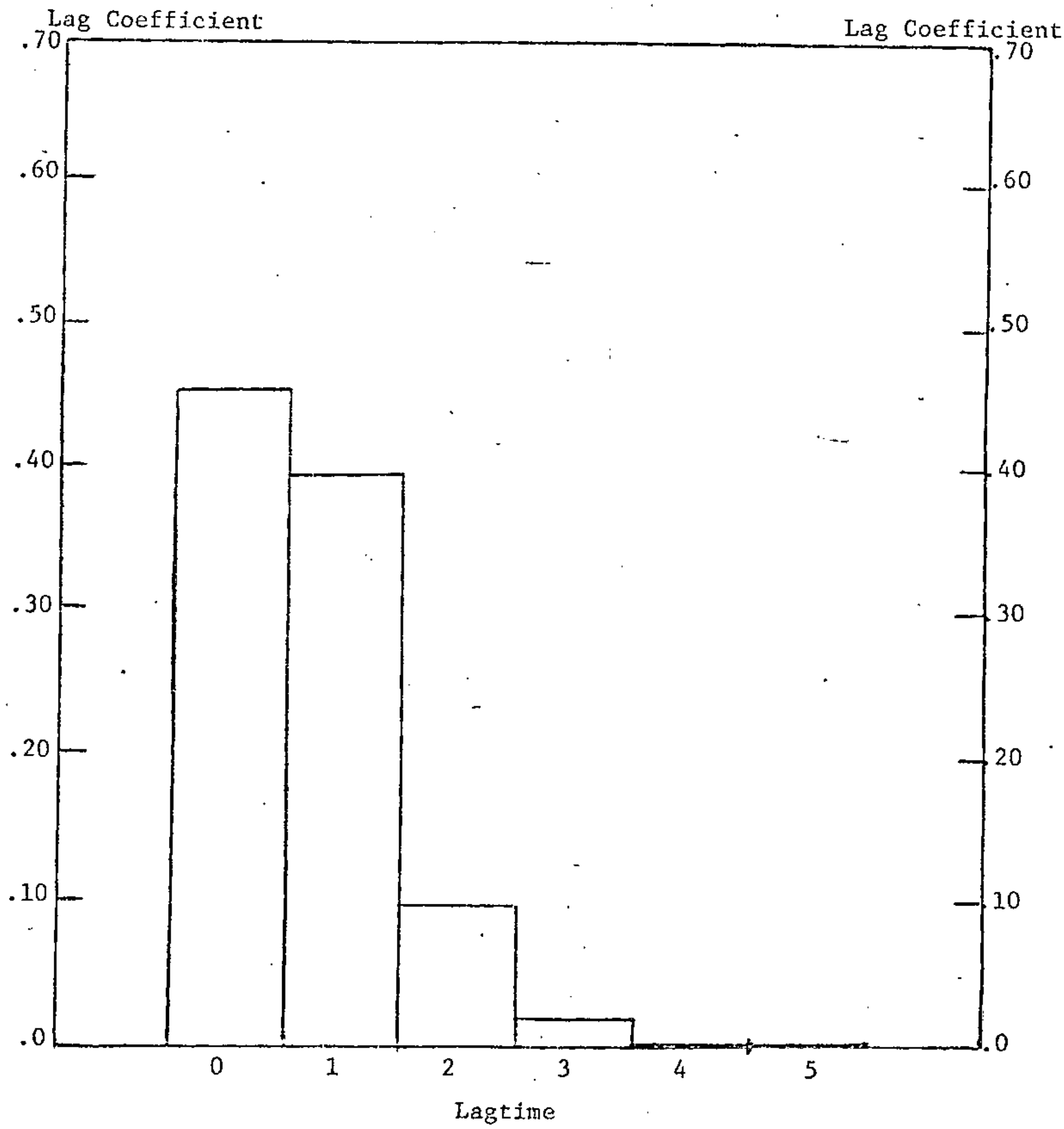
1 See D.W. Jorgenson and J.A. Stephenson, "The Time Structure of Investment Behaviour in United States Manufacturing, 1947-1960," op.cit. pp. 16-27; D.W. Jorgenson and C.D. Siebert, "Optimal Capital Accumulation and Corporate Investment Behaviour" op.cit. pp. 1123-51, and Hall and Jorgenson, op.cit. pp. 40-43.

manufacturing to be two years while for individual industries it ranged from 1.5 to 2.75 years. Jorgenson and Siebert estimated the mean lag for individual firms in the manufacturing industries as ranging from one to two years. In a later study, Hall and Jorgenson found a "new estimate" for the mean lag for manufacturing structures to be 1.86 years as against a previous estimate of 3.84 years. The form of the lag distribution in those studies was also found to be asymmetrical. We therefore, conclude that our results agree substantially with results obtained from similar studies done for the United States of America in recent years. Unfortunately, however, we are so far unaware of estimates of mean lags and the time structure of investment behaviour in the manufacturing industries of developing countries with which our findings may be compared at this moment. Such a comparison could probably have produced additional interesting conclusions.

The time pattern of investment behaviour which was characterised in Table 18 is sketched in charts 1-10 for the five industries. From the diagrams it can be seen that the time form of lagged response varies from industry to industry just in agreement with our discussion of Table 18. For Leather, Footwear and Rubber, the response of investment reaches a peak in the first year, while for Food the peak occurs in the second year.

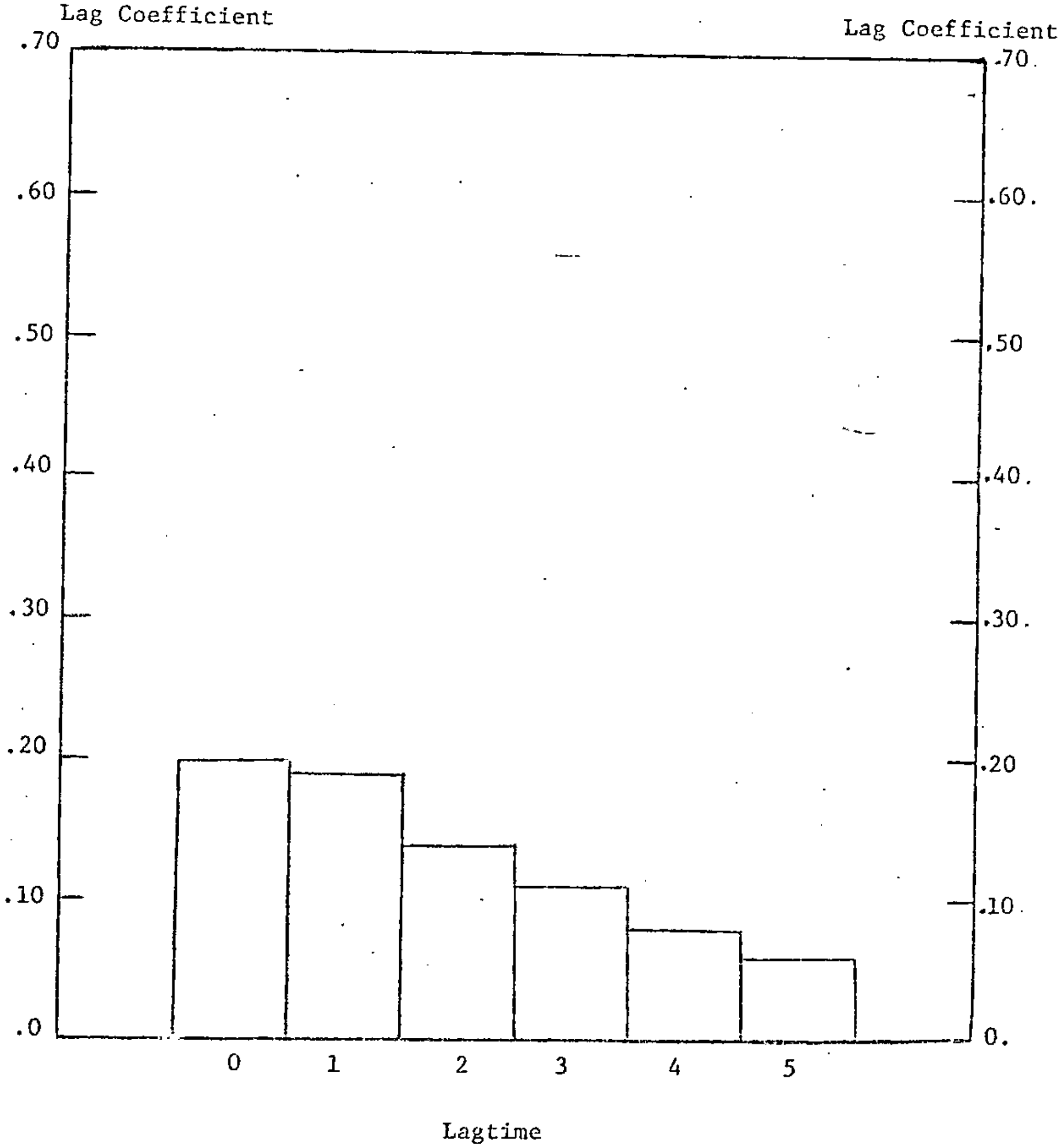
TIME FORM OF LAGGED RESPONSE (W_T)

RUBBER



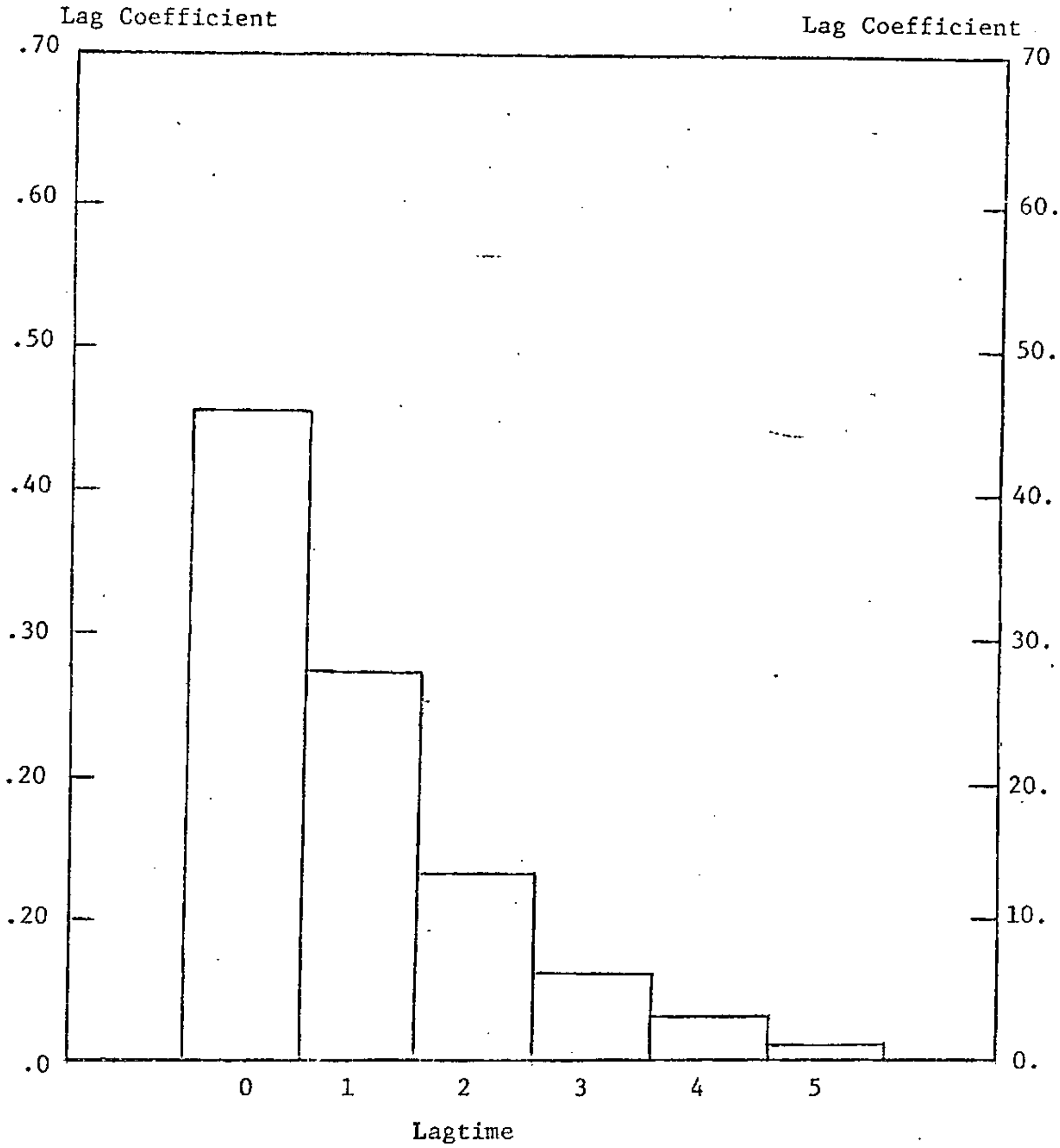
TIME FORM OF LAGGED RESPONSE (W_T)

TEXTILES



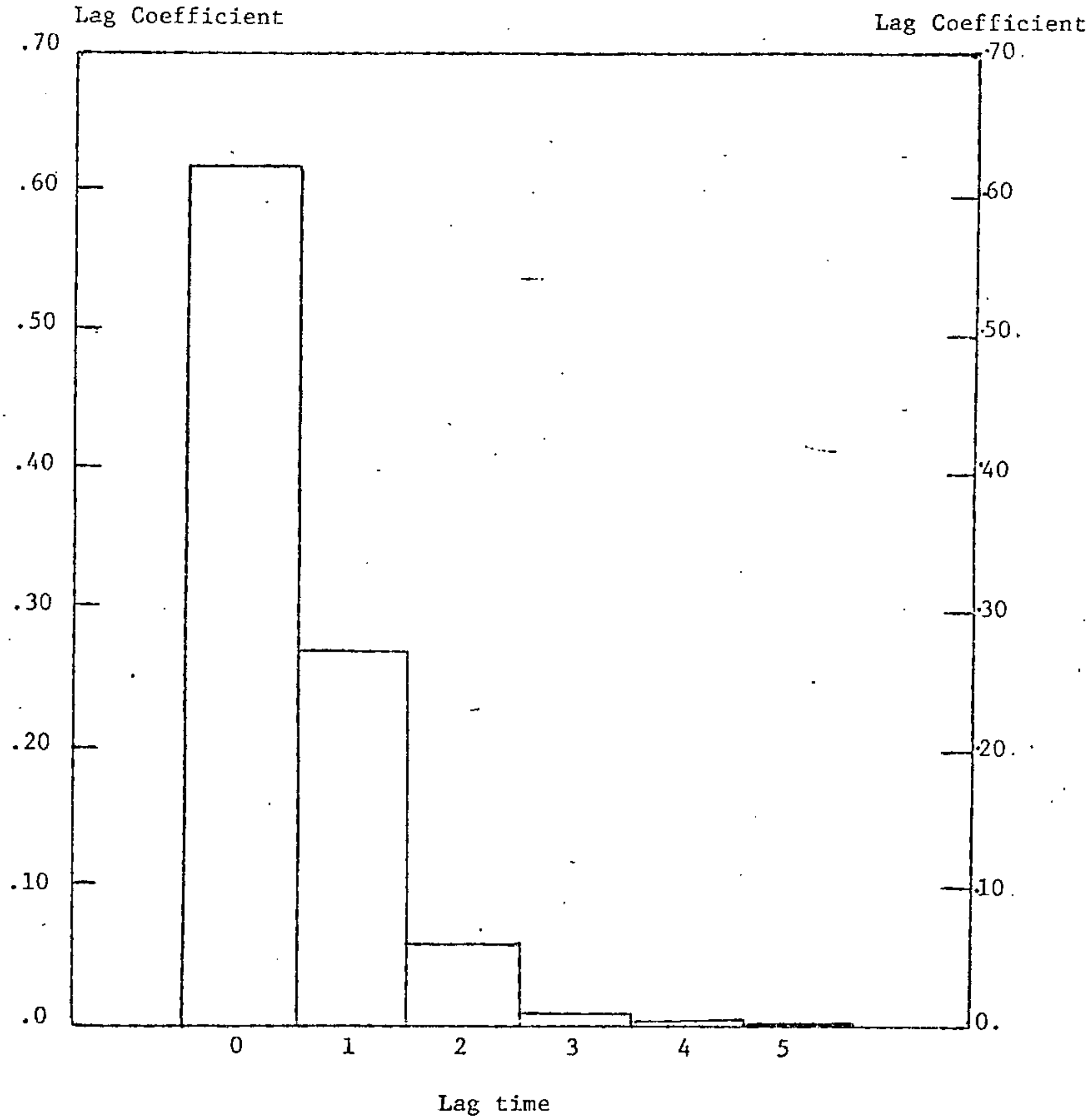
TIME FORM OF LAGGED RESPONSE (W_τ)

LEATHER



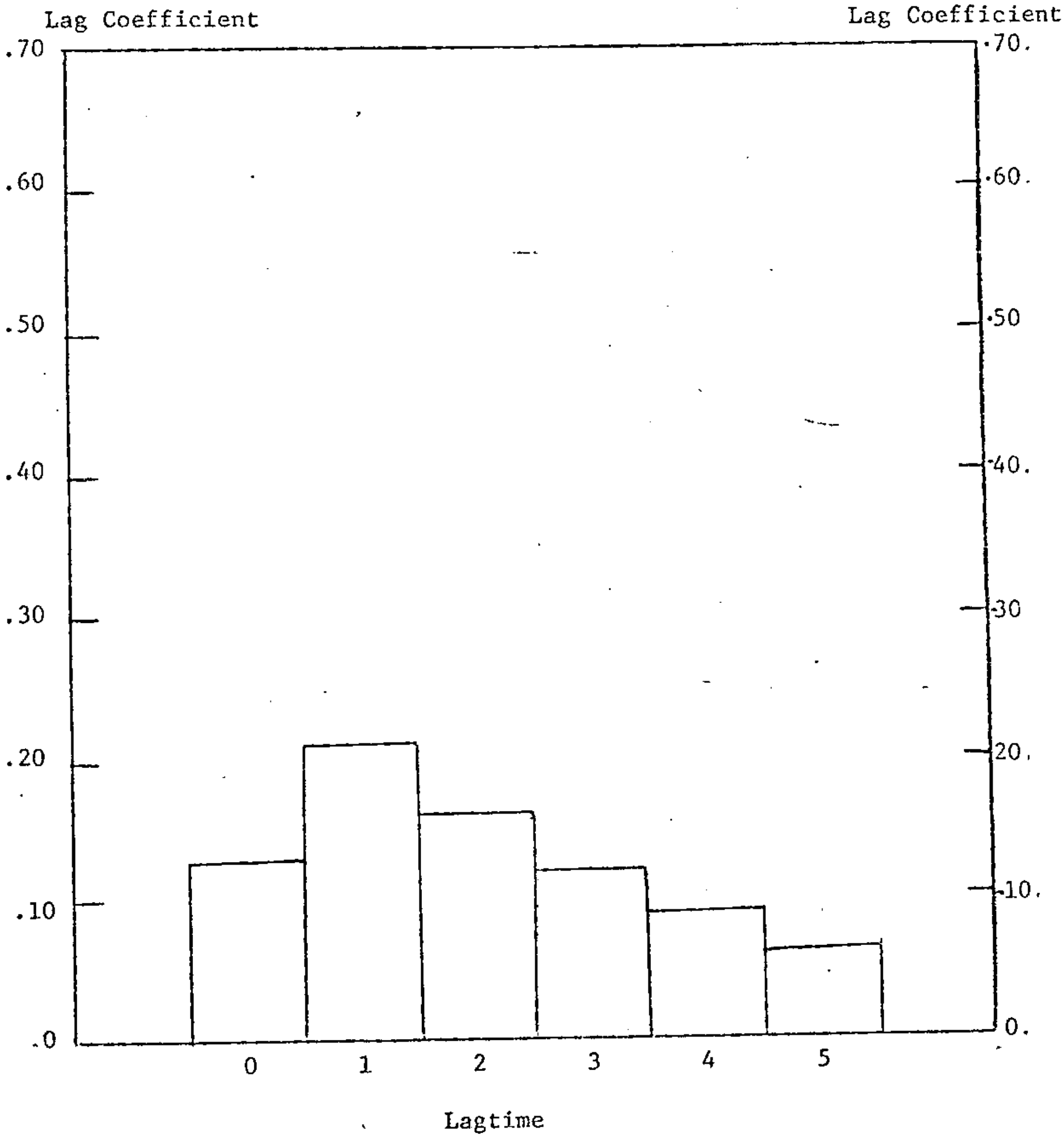
TIME FORM OF LAGGED RESPONSE (W_T)

FOOT WEAR



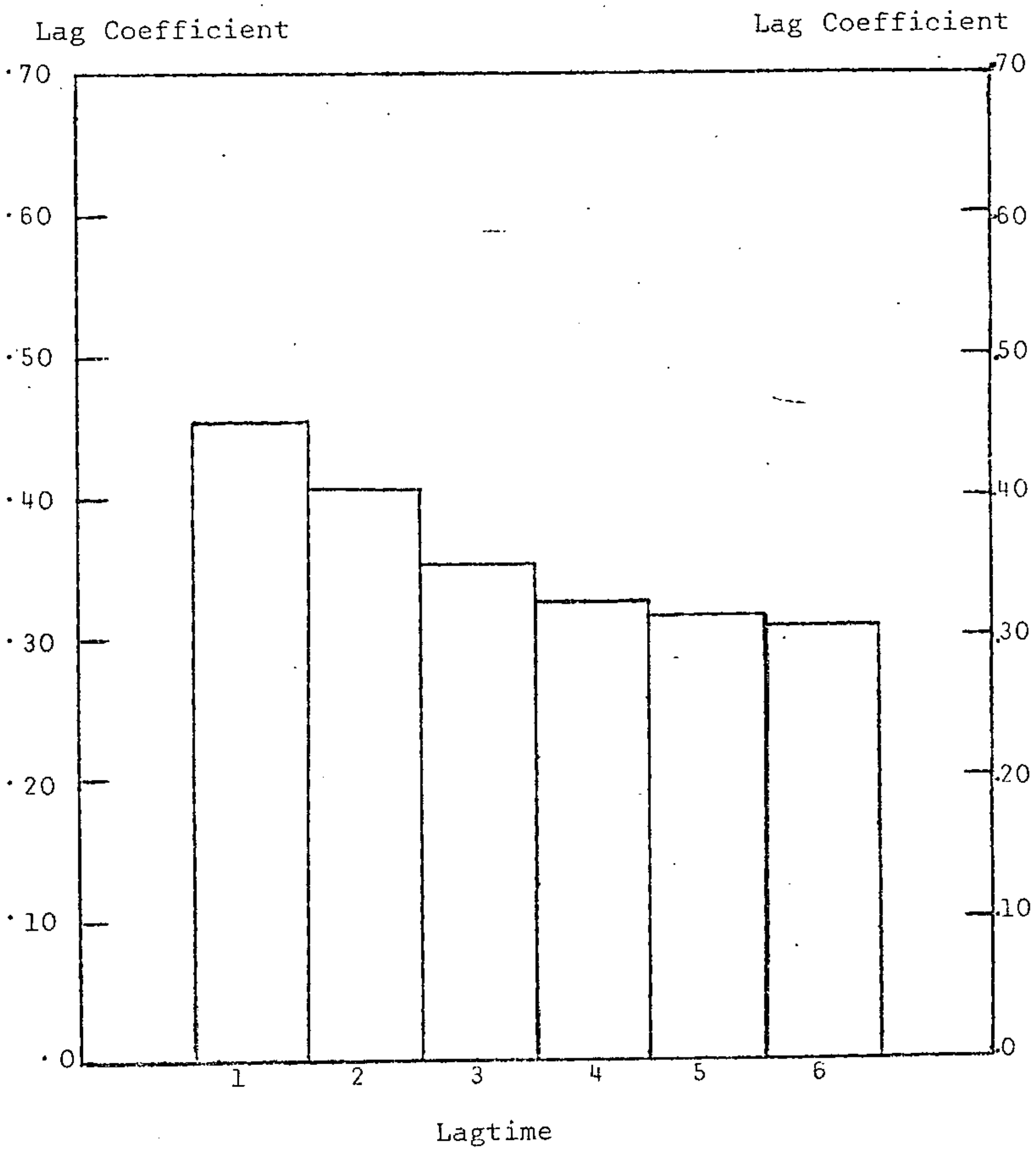
TIME FORM OF LAGGED RESPONSE (Wτ)

FOOD



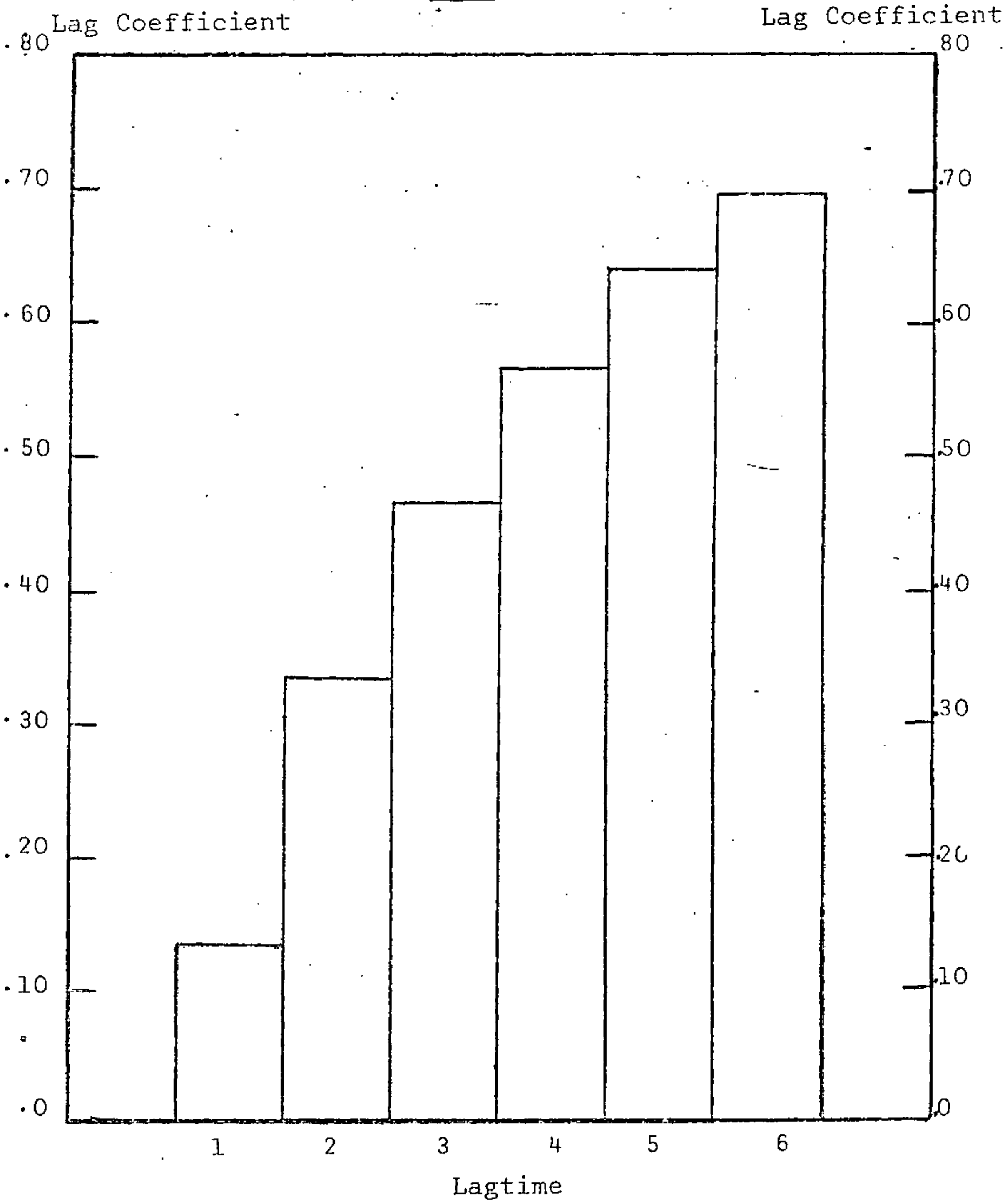
TIME FORM OF LAGGED RESPONSE ($Z\tau$)

LEATHER

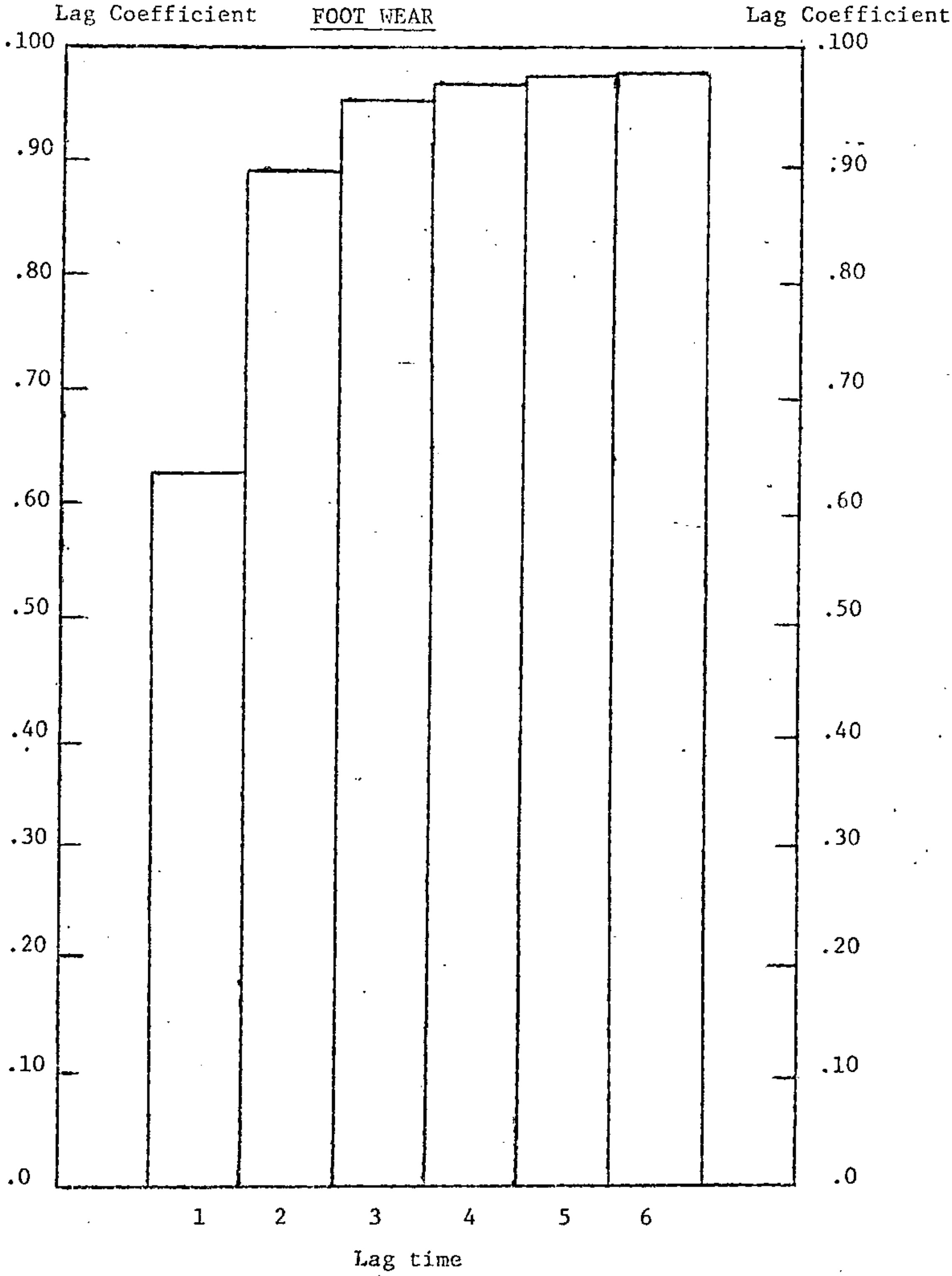


TIME FORM OF LAGGED RESPONSE (Zτ)

FOOD

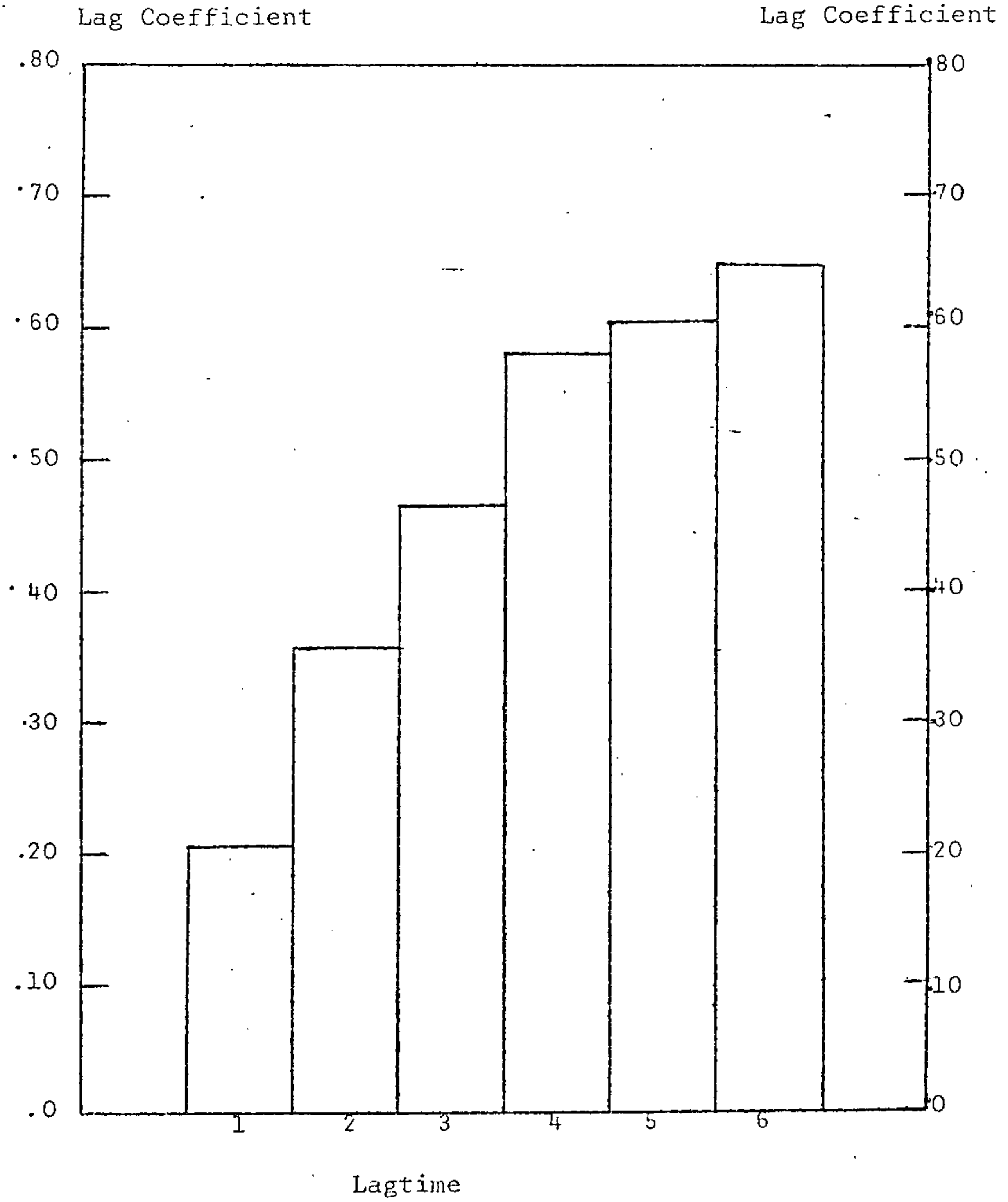


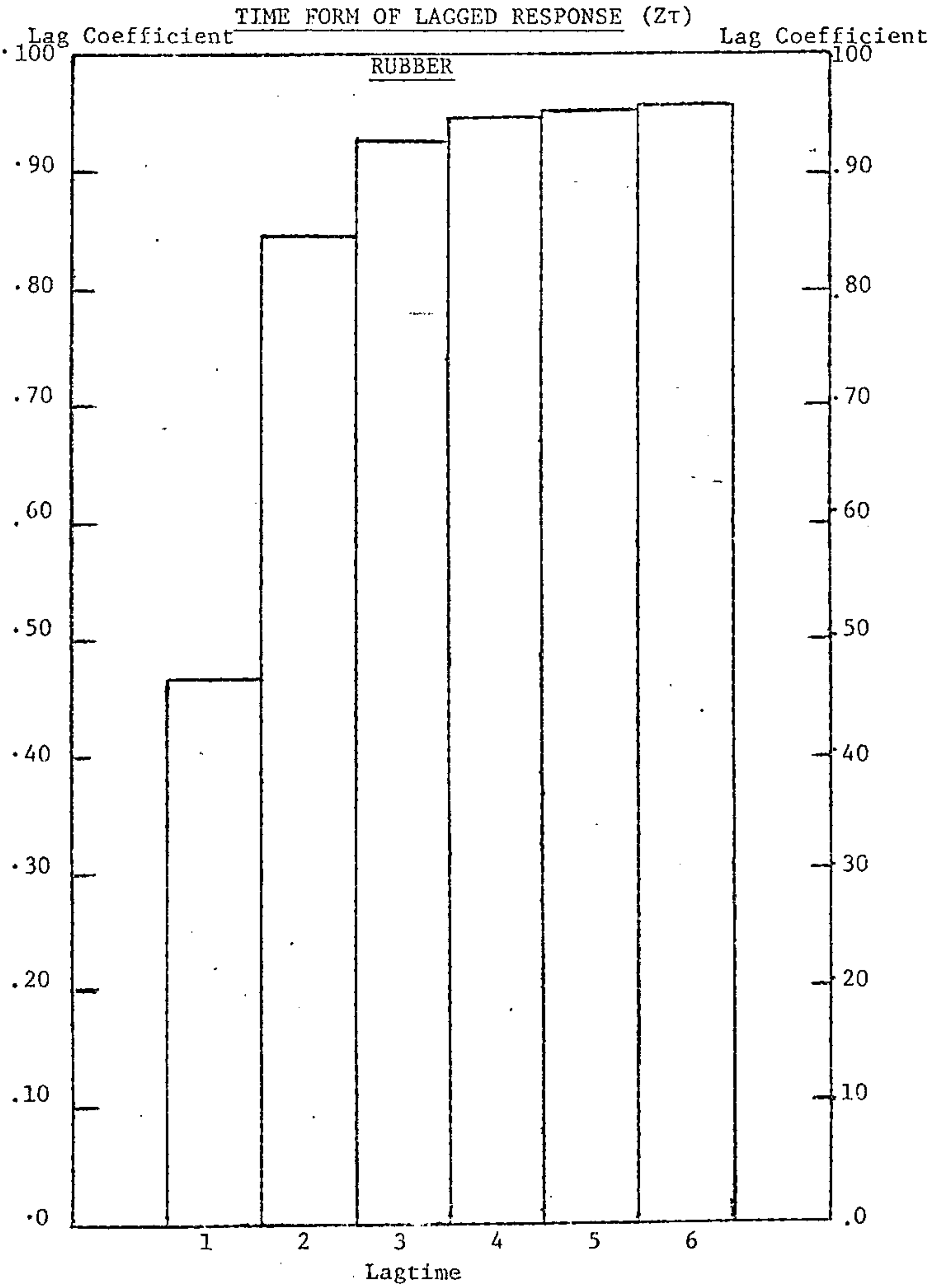
TIME FORM OF LAGGED RESPONSE (Zτ)



TIME FORM OF LAGGED RESPONSE (Zτ)

TEXTILES




TIME FORM OF LAGGED RESPONSE (Zτ)
RUBBER
Lag Coefficient
Lag Coefficient
·100
·90
·80
·70
·60
·50
·40
·30
·20
·10
·0
100
.90
.80
·70
·60
.50
·40
30
20
10
.0
1
2
3
4
5
6
Lagtime

In the case of Textiles, there is virtually an extended peak from the first to the second year - thus approximating closely the pattern observed for Food. This similarity is also reinforced by average lags of the order of thirteen quarters observed for the Textile and Food industries respectively. But since the Leather, Footwear and Rubber industries indicate, on the other hand, average lags quite below five quarters, we can infer that the lags are much shorter for these three industries than for the other two - Textile and Food.

From some intuitive understanding of the working of the Nigerian economy one may hazard some explanation for the observed pattern of investment behaviour in these industries. The case of Food and Textile where the lags in investment are much longer is due to the fact that businessmen do not consider that a sudden change in the demand for these products will assume a permanent character until some time (may be, one-and-a-half years) has actually elapsed. This uncertainty further derives from the special preference of Nigerians for foreign textile and food vis-avis locally produced ones. The common examples are Austrian lace as opposed to Nigerian lace, "George" textile and African prints, "American Uncle Ben's" rice and Nigerian rice, Norwegian Stockfish and Ibru fish, etc. Consequently, investment spending in the Food and Textile industries exhibits substantial lags even though the long run responses (as shown below) which reflect the propensity of Nigerians to consume the products are quite large too. A converse argument which needs not be pursued here can also be advanced for the Leather, Footwear and Rubber industries. However, more important from the point of view of the relationship between aggregate demand and investment expenditures we may infer the following phenomenon usually characteristic of short and long lags. Specifically, if the observed situation of short lags predominates in the Nigerian manufacturing industries we would expect that for the most part, investment expenditure first rises and then falls so that a change in the demand for capital will have an initial effect of stimulating the level of aggregate demand and depressing it thereafter. If the observed second situation of long lags prevails, on the other hand, we would expect for the most part that investment expenditure responds rather sluggishly and reaches a peak after a fairly long lag. Consequently, a change in the demand for capital stimulates aggregate demand from rather low levels and proceeds monotonically towards its longrun equilibrium level. However, there may well be reasons for supposing that both of these situations may coexist in the Nigerian manufacturing sector in which case the stimulation of investment will tend to produce differential effects on aggregate demand. These results have obvious consequences for policy making which are taken up later in this chapter.

For now, two other sets of results are discussed, namely, the longrun impact and the elasticity of output. The longrun effects of changes in desired capital on investment expenditures were reported for each industry in Table 18 and are now summarized as follows: Leather (2.99), Food (6.99), Footwear (1.67), Textiles (7.20), and Rubber (1.68). The impact is therefore in the range of 1.7 to 7.2 for all the industries implying that in the long run, a unit change in desired capital will increase investment by between 1.7 and 7.2 units. If this range is considered wide enough so as to be representative of total manufacturing we could conclude that for the Nigerian manufacturing industries the long run response of investment to a unit change in desired capital is of the order of 1.7 to 7.2 which should be regarded as fairly large elasticities for purposes of policy.

The elasticity of output with respect to capital, α, was obtained for each industry during the process of deriving final estimates of the regression constants, namely, U_o and U_1. The results are summarized in Table 19 below.

TABLE 19

ELASTICITY OF OUTPUT WITH RESPECT TO CAPITAL INPUT

Industries	Elasticity (α)
Leather	0.0137
Food	0.3610
Footwear	0.0697
Textiles	0.0010
Rubber	0.0023

It will be observed that the responses of output to unit changes in capital input vary substantially from industry to industry with a low of 0.001 to a high of 0.361. Specifically, the responses are 0.0137 (Leather), 0.3610 (Food), 0.0697 (Footwear), 0.0010 (Textile), and 0.0023 (Rubber). Thus, a 10 per cent change in the capital input variable will change output by the following magnitudes in the respective industries:

0.14 (Leather), 3.61 (Food), 0.70 (Footwear), 0.01 (Textile) and 0.02 per cent (Rubber). The response of output to changes in the capital input variable thus varies from industry to industry being highest for Food, and lowest for Textile. These estimates are however suspected to be on the low side. Jorgenson and Stephenson[1] in a similar situation had obtained equally low estimates ranging from 0.0052 to 0.2639 for seventeen industry groupings in the United States.[2] On the whole, however, the simple estimates which we have derived permit us to adopt a finer classification of, "more capital using" or "heavy" industries for Food and Footwear, and "less capital using" or "Light" industries for Rubber, Leather and Textile. Such a classification will soon be found useful from a policy standpoint.

Comparative Static Analysis of Investment Behaviour

We now undertake a comparative static analysis of investment behaviour in the Leather industry[3]. Because only the Neoclassical theory can be used for this purpose among the theories of investment considered in this study, we restrict attention to the Neoclassical II theory which excludes capital gains or losses in the measurement of the price of capital services. Also, the Leather industry is selected because it happened to be the only industry under the Neoclassical II theory that satisfied the specified constraints so

[1] D.W. Jorgenson and J.A. Stephenson, "Investment Behaviour in U.S. Manufacturing Manufacturing ...." op. cit p. 215.

[2] Such underestimates have been traced to possible aggregation problems, failure to account for variations in the rate of utilization of capital, etc. See Helliwell, op cit., p.18.

[3] For results on United States' data see D.W. Jorgenson, "Anticipations and Investment Behaviour," in J.S. Duesenberry, et. al, (eds), The Brookings Quarterly Econometric Model of the United States, Rand McNally & Co., U.S.A., 1965, pp. 86 - 89.

that use can now be made quite readily of its results of the time pattern of investment response worked out in the preceding section.

The objective of our comparative static analysis is two fold: firstly, we intend to measure the responses of demand for capital to changes in each element of the tax structure and market factors as summarized in the equation determining the price of capital services and the one determining the demand for capital in Chapter II; secondly, we use the derived estimates plus estimates from the time structure analysis to derive short and long-term responses of investment to changes in the elements of the tax structure and market forces.

We recall from Chapter II that the demand for capital may be defined as $K^* = \frac{\alpha p Q}{c}$, while the price of capital services, c, also follows the definition, $c = \frac{q}{1-u}\left[(1-un)\,\delta + r\right]$. Using the tool of partial derivatives on these equations we have the following results:

(i) the response of demand for capital to a change in the rate of interest is: $\frac{\partial k^*}{\partial r} = \frac{\partial k^*}{\partial c} \cdot \frac{dc}{dr} = \frac{-\alpha p Q}{c^2} \cdot \frac{q}{1-U} < 0$

(ii) the response of demand for capital to a change in the price of investment goods is: $\frac{\partial k^*}{\partial q} = \frac{\partial k^*}{\partial c} \cdot \frac{dc}{\partial q} = -\frac{\alpha p Q}{c^2} \cdot \frac{1}{1-u}(r + \delta - u\hat{\delta}) < 0$

(iii) the change in demand for capital due to a change in the price of output is:

$$\frac{\partial k^*}{\partial p} = \frac{\alpha Q}{c} > 0$$

(iv) the effect of a change in the tax rate on demand for capital is: $\frac{\partial k^*}{\partial u} = \frac{\partial k^*}{\partial c} \cdot \frac{\partial c}{\partial u} = \frac{-\alpha p Q}{c^2} \quad \frac{q}{(1-u)^2} \left[(1-n)\delta + r) \right] < 0$

(v) the effect of accelerated depreciation allowances on demand for capital is:

$$\frac{\partial K^*}{\partial n} = \frac{\partial k^*}{\partial c}\,\frac{\partial c}{\partial n} = \frac{\alpha\,pQ}{c^2}\cdot\ \frac{q}{1-u}\cdot\ u\delta\ >o$$

By recalling the relationship between investment expenditures and desired capital as depicted in Table18, the preceding results may be extended to cover the comparative static relationship of investment to its underlying determinants as follows:

(i) the response of investment to a change in the rate of interest is:

$$\frac{\partial I}{\partial r} = \frac{\partial I}{\partial k^*}\cdot\frac{\partial k^*}{\partial r} <o$$

(ii) the response of investment to a change in the price of investment goods is:

$$\frac{\partial I}{\partial q} = \frac{\partial I}{\partial k^*}\cdot\frac{\partial k^*}{\partial q} <o$$

(iii) the change in investment due to a change in the price of output is:

$$\frac{\partial I}{\partial p} = \frac{\partial I}{\partial k^*}\cdot\frac{\partial k^*}{\partial p} >o$$

(iv) the effect of a change in the tax rate on investment is:

$$\frac{\partial I}{\partial u} = \frac{\partial I}{\partial k^*}\cdot\frac{\partial k^*}{\partial u} <o$$

(v) the effect of accelerated depreciation allowances on investment is:

$$\frac{\partial I}{\partial n} = \frac{\partial I}{\partial k^*}\cdot\frac{\partial k^*}{\partial n} >o$$

In order to demarcate these responses into short and long term effects we make use of the short run estimate of z_T, namely, z_T with lag zero appearing in Table 18 and its long run estimate, δ, as short and longterm approximations of $\frac{\partial I}{\partial k}$ respectively. Hence, the short term response of investment to a change in the interest rate will be given by,

$$\frac{\partial I}{\partial r} = z_T \cdot \frac{\partial k^*}{\partial r}$$

while the long term response is given by,

$$\frac{\partial I}{\partial r} = \delta \cdot \frac{\partial k^*}{\partial r}$$

By the same procedure, short and long term responses of investment to other market conditions and the tax structure are easily derived. Indeed, the details of these responses have been worked out and the final results presented in Tables 20 and 21. For this purpose all the variables appearing in the comparative static equations except α (obtainable from Table 19 were set at their 1976 levels.

TABLE 20

Response of demand for capital to changes in market conditions and the tax structure - Leather Industry

Market Conditions	Response
$\frac{\partial k^*}{\partial r}$	- 0.8976
$\frac{\partial k^*}{\partial q}$	- 0.2114
$\frac{\partial k^*}{\partial P}$	0.2123

Table 20 (Contd.)

Tax Structure	Response
$\frac{\partial k^*}{\partial u}$	- 0.0004
$\frac{\partial k^*}{\partial n}$	0.0359

Considering the response of demand for capital to changes in market conditions we find from Table 20 that a unit decrease in the rate of interest will raise the demand for capital by 0.8976 units; similarly, a unit decrease in the price of investment goods will raise the demand for capital by 0.2114 units while a unit change in the price of output will lead to a corresponding change of 0.2123 units in the demand for capital. With respect to the effects of changes in the tax structure on the demand for capital we find that a unit decrease in the tax rate will lead to an almost negligible increase of 0.0004 units in the demand for capital while a unit liberalization in depreciation allowances will lead to a corresponding increase of 0.0359 units in the demand for capital. This analysis may be summarized by observing that the response of the demand for capital services to changes in market conditions and the tax structure varies widely from variable to variable being largest for the rate of interest, about equal for the price of investment goods and the price of output, somewhat low for the liberalization of depreciation allowances and virtually zero for the tax rate. Since these responses are only intermediate to the final aim of determining the response of investment expenditures to market conditions and the tax structure we now discuss the final estimates.

On Table 21, short and long-term responses of investment to changes in market conditions and the tax structure have been calculated and may be interpreted as follows;

be interpreted as follows:

(i) A unit decrease in the rate of interest will increase investment expenditures by 0.4072 units in the short run and by 0.2657 units in the long run;

TABLE 21

Short and Long-term responses of Investment to changes in market conditions and the Tax Structure - Leather Industry

Market Conditions	Short term Response	Long term Response
$\frac{\partial I}{\partial r}$	- 0.4072	- 0.2657
$\frac{\partial I}{\partial q}$	- 0.0959	- 0.0626
$\frac{\partial I}{\partial p}$	0.0963	0.0628
Tax Structure		
$\frac{\partial I}{\partial u}$	- 0.0002	- 0.0001
$\frac{\partial I}{\partial n}$	0.0163	0.0106

(ii) a unit decrease in the price of investment goods will increase investment expenditure by 0.0959 units in the short run and by 0.0626 units in the long run;

(iii) a unit change in the price of output will change investment demand by 0.0963 and 0.0628 units in the short and long terms respectively;

(iv) a decrease (increase) in the tax rate by one unit will increase (decrease) investment by 0.0002 units in the short run and by 0.0001 unit in the long run;

(v) a liberalization of depreciation allowances by one unit through the provision of accelerated depreciation facility will have the effect of increasing investment expenditure by 0.0163 units in the short run and by 0.0106 units in the long run.

Summarising these results, we find that short run responses are generally much larger than long run responses; that responses of investment to market conditions are much larger than the responses to tax policy; that, under market conditions, the rate of interest tends to exercise the most potent influence on investment while the price of investment goods and the price of output exercise numerically equal but neutralizing effects on investment; and, that, under the tax structure, the tax rate is virtually impotent while accelerated depreciation does have some effect on investment demand.

While these results are strictly true of the Leather industry they nevertheless have much wider applicability to the manufacturing sector of the Nigerian economy as a whole. This should come as no surprise judging from our previous results which tend to indicate that most of the industries exhibit common characteristics. Consequently, policy implications from these results also have wider applicability to the broader objectives of macroeconomic policy. Such implications are part of the ones discussed in the next section below.

Policy Issues

The preceding results of average lags, longrun responses, elasticities of output, time forms of lagged response, and comparative static analysis, have some policy implications which are now discussed. To facilitate our discussion it seems necessary to bring together the results obtained in various sections of this chapter.

The analysis of mean lags does suggest that the manufacturing industries may be classified into two broad groups, namely, those with short lags of between two and five quarters, and those with long lags extending up to twelve quarters. Thus the average lag for new plants and for substantial additions to existing plants extends between two and twelve quarters for the manufacturing sector from the moment it is decided to undertake a project to the actual completion of the construction work. Whereas a substantial amount of investment expenditure takes place in the very year that a change in desired capital shows up, after about two years have elapsed larger proportions of investment will be devoted to replacement than for expansion. Consequently, replacement investment must be taken into account when formulating policies with countercyclical ends in view. Since for all the industries considered the average lags differed from the peak years, the lag distributions were also found to be asymmetrical. Both the length and forms of the underlying lag distributions in the industries, as just summarized have implications for the nature and timing of economic policy as will soon be discussed.

Estimates of the elasticity of output with respect to capital input showed varying degrees of response of output to capital from industry to industry whereby we found it necessary to classify the industries into two groups - "light" and " heavy" industries-based on their relative degrees of capital productivity. This distinction has some policy significance as indicated below.

From the comparative static exercise done strictly for the Leather industry but with results taken to have wider applicability under some fairly restrictive assumptions, we come up with the following policy issues on the relationship between investment and its underlying determinants:

(i) market forces tend to exercise much greater influence on investment demand than tax policies;

(ii) of the market forces, the rate of interest which is the price of credit and instrument of monetary policy in Nigeria turns out to be most powerful in regulating investment activity in the manufacturing sector;

(iii) both the price of output and price of investment goods exhibit neutralizing effects on investment demand such that an increase in the price of investment goods will leave the level of investment demand unaltered as long as enterpreneurs are in a position to effect an equiproportionate increase in the price(s) of their product(s). Thus, in an inflationary situation where the price of investment goods may also be rising and capable of choking off investment demand thereby retarding economic growth, businessmen are likely to adopt counteracting measures including alterations in the prices of their products thus ensuring a continuity of their investment plans.

Considering the elements of the tax structure, it would appear as if the rate of corporate taxation is a rather weak instrument for the promotion of investment expenditure. Consequently, very generous tax concessions including low tax rates and accelerated depreciation allowances will serve more to deplete potential government revenue than raise substantially the level of investment demand. This observation should however not be taken to imply a total discouragement of fiscal incentives for investment promotion but that such incentives should be regarded as supplementary to other more potent factors, such as market conditions, when appraising policies for growth or stabilization purposes.

Following from the preceding overall summary of our findings in this chapter and some discussions of policy issues, two other central issues that merit consideration are the channel by which policy affects investment demand and the effectiveness of policy for stabilization or growth purposes. These considerations finally lead to a set of recommendations that may be of interest to the Federal Government of Nigeria.

Under the Neoclassical II model the desired level of capital is made to depend on three major variables - the rental price of capital input, the price of output and the level of output. In turn, the rental price of capital input depends essentially on five other variables - the cost of capital, the tax rate, the price of investment goods, the level of capital allowances (or, broadly, the investment tax credit) and the tax treatment of depreciation allowances. Through the medium of the rental price of capital input, therefore, tax and monetary policies exert their influence on investment behaviour. Thus, a change in the tax rate or the level of capital allowances or the cost of capital for instance, will affect the rental price of capital input which in turn, will affect the level of desired capital stock, leading finally to a change in investment. In concrete terms, if the rate of interest falls by say 10 percentage points while other determinants of desired capital, and, therefore, of investment expenditures remain unchanged, then gross investment consisting mainly of new plants and additions to existing plants in the Leather industry will increase by 4.07 percentage points in the short run and reach a peak within the first year of the change in policy after which gross investment then declines. Net investment also follows the same pattern. However, a difference had been noticed between the average lag and the year of peak response in net investment so that lag distribution is non-symmetric. Therefore, after the decline in net investment gross investment will continue, in the meantime to be affected by the new monetary measure of the interest rate because of expenditures being undertaken for replacement purposes. This pattern of behaviour naturally corresponds to the behaviour characterized in the preceding sections of this Chapter.

Given this "transmission mechanism,"[1] therefore, deliberate policies for economic growth such as, the fiscal incentives reviewed in Chapter I, reductions in company income tax, variations in the rate of interest, and other similar policies, may succeed in stimulating investment expenditures and consequently the level of aggregate demand. Evidence from this study suggests that since lag distributions are non-symmetric and short term responses tend to be larger than longterm responses the same set of growth inducing measures will produce differential effects on separate categories of industries as between "light" and "heavy" industries, for example. In particular, while an investment boom is occuring in the light and intermediate products industries during the first two to four quarters of a change in policy and thereby stimulating aggregate demand, investment expenditure is only just beginning to gather momentum in the heavy industries stimulating aggregate demand as well. If the initial investment boom in the light industries leads policy makers to the mistaken

[1]This is a convenient phrase to adopt here but should not be taken as throwing much light on the celebrated controversy between the Keynesians and Monetarists since, strictly speaking, we have not constructed an aggregate model for the Nigerian economy.

impression that the economy is being overheated there may well be a temptation for a reversal of policies. Such a turn-about in policy will naturally prove disastrous at a time when investment in one branch of manufacturing happens to be on the down turn and is only just picking up in another branch. Indeed, the ideal policy review, say, in the second year of the first policy action should focus more on measures to arrest the possible down turn of investment in the light industries thereby sustaining the overall level of aggregate demand. In view of this scenario, policy makers will achieve thier growth or stabilization objectives better by striking an appropriate time for the implementation of their policies.

From a different perspective, evidence presented in this study does suggest that a unit increase in the level of desired capital caused probably by a tax policy change, will increase investment expenditure in the light industries by about 1.7 to 7.0 units and in the heavy industries by about 1.7 to 7.2 units, or more generally, by a range of 1.7 to 7.2 units for total manufacturing. Estimates of these elasticities then provide some indication to policy makers as to the probable magnitudes of policy intervention as well as the magnitudes of policy consequences.

Finally, the derived estimates of average lags, longrun responses and the general time pattern of investment behaviour may be seen to shed light on the general problems of development as expounded earlier in Chapter I. Investment is not only linked closely to growth, the pattern of growth that emerges very much reflects society's choice of technique and overall industrial strategy.

Summary

In this chapter, we have argued the case that economic policy making can benefit from a knowledge of the lag structure underlying the investment process simply because changes in policy instruments have direct effects on investment spending while investment expenditure in turn affects aggregate demand. Hence, the policy maker should know both the time pattern of investment behaviour as well as the form of the lag distributions. For an economic policy measure to be stabilizing, there is need for fairly short lags between changes in policy instruments and actual investment expenditure. If, in the alternative, long lags actually prevail, policy measures are then likely to be destabilizing. These tendencies occur in such a way that, given a situation of short lags, investment expenditure first rises and then falls so that a change in the demand for capital will, initially, stimulate investment demand only to depress it thereafter. On the other hand, when long lags prevail investment expenditure will, for the most part, respond rather sluggishly and reach a peak after a fairly long lag. Hence, a change in the demand for capital will stimulate aggregate demand from rather low levels and proceed gradually towards its longrun equilibrium level.

Apart from the preceding relationships based on the size of the mean or average lag, economic policy making may also benefit from a knowledge of the form of the lag between changes in policy measures and investment spending which will be determined by the symmetry or non-symmetry of the lag distributions. So, if the effects of policy changes on investment are highly concentrated in time implying non-symmetric distribution, the policy maker needs to strike an appropriate time for the implementation of his policies. Of course, if the effects of policy measures are diffused over time, the policy maker really has no need to worry about the timing of his policies.

These possibilities were investigated in this chapter through the computation of average lags and distributed lag co-efficients such as ω_τ, k_τ, z_τ, and R_τ. The ω_τ coefficients normally describe the distributed lag relationship between net investment and changes in desired capital; the k_τ coefficients which measure the distributed lag relationship between gross investment and changes in desired capital help to indicate the percentage share of the change in gross investment due to expansion purposes and are also good for assessing the effects on investment behaviour of changes in the determinants of desired capital; the z_τ coefficients measure the response of gross investment to a change in desired capital that persists for τ periods before now; and, finally, R_τ indicates the role of replacement in the investment process thus measuring the percentage share of the change in gross investment due to replacement. Following these computations, we then derived the elasticity of output with respect to capital input from industry to industry and also carried out a comparative static analysis of investment behaviour specifically for the leather industry. A summary of the findings and conclusions from these investigations now follows:

Under the examination of the time pattern of investment behaviour it was found that the Footwear, Leather, and Rubber industries exhibited much similar pattern such that the peak response in net investment (i.e for expansion) occured within the first year, while the Food industry had a peak occuring in the second year and, the Textile industry, an extended peak from the first to the second year. In all cases, however, after an initial two year period had expired, the response of investment for replacement purposes began to dominate the response of investment for expansion purposes.. This observed behaviour of the lag structure underlying the investment process then led us to conclude that policy makers should take into account replacement investment when formulating an investment policy for counter cyclical ends.

In characterising the form of the lag distribution, the computed values of the average lags were employed. For the respective industries, average lags were found to be: 1.09 years for Leather, 0.49 years for Footwear, 0.71 years for Rubber, 3.17 for Textile and 3.47 years for Food. Most of the industries, therefore, showed average lag between changes in desired capital and net investment expenditures of between 0.5 years (i.e. 6 months) and a little over one year with a spread of up to three and a half years for others thus indicating the time elapsed between the decision to instal new plants and expand existing capacity, and the actual completion of the construction work. All the five industries showed differences between the average lag and the year of peak response. The average lag exceeded the peak year in the case of Leather, Food and Textiles while it fell short of the peak year for Footwear and Rubber. In all cases the differences between the average lag and the peak year ranged between three months and two years. Since the average lag and the peak year never coincided for any industry, we concluded that the lag distributions from industry to industry were non-symmetric. Consequently, several of the lag patterns normally used to characterize investment behaviour in the literature such as, the "arithmetic", "inverted - V", etc, cannot adequately be employed to describe the lag patterns underlying investment behaviour in the Nigerian manufacturing industries.

The responses of output to unit changes in capital input were found to vary substantially from industry to industry with a low of 0.001 to a high of 0.361. In specific terms, the responses were: 0.001 (Textile), 0.0023 (Rubber), 0.0137 (Leather), 0.0697 (Footwear) and 0.3610 (Food). Much as these estimates could be regarded as low having been obtained indirectly, they nevertheless provieed some indication of the degree of capital productivity across industries. This also led us to crudely classify the industries into two groups - "very capital using" (or, "heavy industries" such as Food and Footwear), and "Less capital using" (or "Light industries" such as Rubber, Leather and Textile) for the convenience of discussing policy issues latter.

Under the comparative static analysis of investment behaviour we characterized two major responses i.e. the response of the demand for capital to changes in market conditions and the tax structure, as well as short and long term responses of investment to changes in market conditions and the tax structure. A summary of the results shows that the response of the demand for capital services was largest for the rate of interest, roughly the same for the price of output and price of investment goods, fairly low for the liberalization of depreciation allowances and negligible for the tax rate. In general, the short term responses of investment were much larger than the long term responses; the responses of investment to market conditions were much larger than the responses to tax policy; under market conditions, the rate of interest tended to exercise the greatest influence on investment while the price of investment goods and the price of output exercised numerically equal but neutralizing effects on investment, and finally, under the tax structure the tax rate was virtually ineffective while accelerated depreciation did have some effect on investment demand. In the chapter that follows, some of the policy implications from these findings are fully taken up.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

Summary

The primary aim of this study was to conduct an empirical investigation into the determinants of investment behaviour in Nigerian manufacturing industries based on private foreign investment data for a sample of eight manufacturing industries over the period 1966 to 1976. The industries are Food, Beverages, Textiles, Footwear, Furniture, Paper, Leather and Rubber. Our examination was motivated mainly by the following set of considerations: (i) the need to provide quantitative evidence as to the role of the tax structure and market conditions in stimulating manufacturing investment thereby seeing the medium through which policies could be injected for the purpose of affecting aggregate demand thus promoting longrun growth or shortrun countercyclical objectives; (ii) the need to determine the lag structure underlying the investment process such as the time pattern of investment response and the form of the lag distributions whereby the policy maker could gain some information as to the stabilization role of his policies and, hence the necessity or otherwise to worry about the timing of his policies; and, finally, (iii) the need to discriminate among several competing models of investment behaviour thus elucidating this controversy on the basis of data for a typical developing country like Nigeria.

The point of departure in the study then was a review of both the literature on the general problems of economic development, and the evidence on the extent to which capital formation and industrialization had determined the course of economic growth in some of the developed countries of the world. Following from this was a discussion of some of the policy instruments such as the fiscal incentives which also influenced the industrial and general development of the economy. The study then went on to review the existing theories and models of investment behaviour which were then translated into behavioural equations for purposes of empirical testing. Following the series of tests undertaken and discriminatory procedures adopted, judgement was made as to the theory yielding the best explanation of investment behaviour. The results were then finally analysed as to their policy implications.

After this sequential review of the substance of this study we now proceed to discuss the methodological framework which was adopted, the major findings obtained and conclusions reached.

In order to investigate the determinants of investment in Nigerian manufacturing industries, we selected five competing theories and models of investment behaviour for examination and testing. These included the Accelerator, Liquidity, Expected Profit, Neoclassical I, and Neoclassical II. Sources of disagreements among the theories were rooted 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 time structure of the investment process and,

(iv) the nature of replacement investment.

Thus, the desired level of capital has been specified alternatively as dependent upon output, liquidity, expected profit, and the value of output deflated by user cost. The basis of the lag generating mechanism has been the rational distributed lag while estimation has been conducted using the maximum likelihood (ML) method.

The ML method involved undertaking regression runs at two stages. In the stage one regression, the numerator of the rational distributed lag, U(L), was assumed to be of zero degree and a function of the form,

$$y_t = u_o Z_{1t} + u_o \theta Z_{2t}$$

was then fitted for each industry under each theory of investment where y_t is net investment expenditure. From this regression ML estimates for V_1, the regression coefficients for the variables Z_{1t} and Z_{2t}, and the parameter θ were derived. In order to execute the second stage regression the derived estimate of θ was used to generate a Z_t variable from the relationship $Z_t = Z_{1t} + \theta Z_{2t}$ where the Z_{1t} and Z_{2t} values were chosen so as to correspond to the ML value of V_1. Assuming U(L) to be of first degree, the stage two regression then took the form

$$y_t = u_o Z_t + u_1 Z_{t-1}$$

where y_t once again represented net investment expenditure, Z_t the current change in desired capital, and Z_{t-1} the lagged change in desired capital. Given the relationship between desired capital and its determinants under each theory of investment, Z_t ultimately stood for the current change in the following variables: Output Q_t, Liquidity L_t, Expected Profit V_t, and the value of output deflated by user cost $(P\frac{Q}{c})_t$.

On the basis of the first stage function and the generated data, seven regressions were performed for each industry under each of the five theories of investment thus producing a total of 280 single equation results. Each fitted regression equation was examined for its values of RSS, Θ, and V_1 so that the minimum R.S.S. from each group of seven (single equation) results was selected. The values of V_1 and Θ corresponding to this minimum R.S.S. were then picked as the ML values for V_1 and Θ.

At the second stage level we determined the best distributed lag functions for each of our competing theories and for each of the eight sampled industries based on available data for the period 1966 to 1976. Of the forty regressions fitted, thirty eight showed randomly distributed residuals when tested on the basis of the Geary test statistic whereby we conclude that the ML estimation of the distributed lag functions in the distributed lag form has been more efficient than the OLS estimation of the same functions which we carried out in the auto-regressive form and had to abandon owing to the presence of serially correlated residuals.

Using the Footwear industry for example, we found from the first stage ML regression that V_1 was equal to 1.5 for all the theories. The values of Θ however varied substantially across theories, as could suggest differences among the theories tested. Taking the case of

Neoclassical II theory and the Footwear industry as an example, we found that Θ varied numerically from a low of -3.31 to a high of -349083 from which an ML value of -3.31 was selected. Similar ranges were noticed for the other theories whereby we conclude that the value of θ should not be set to zero in the estimation process as recommended by Klein, Steiglitz and Dhrymes, other-wise the final results would be seriously biased. Also, at the first stage level it was found that the value of R^2 corresponding to minimum RSS exceeded 0.80 in the case of the Footwear industry under each theory thus indicating strong associations between the dependent and independent variables.

Using the example of the textile industry, we derived the following inferences from our second stage regressions:

(i) the numerator coefficients of the rational distributed lag functions possessed the expected positive sign generally with the exception of expected profit theory which had a negative coefficient for its second variable, i.e. - the lagged change in desired capital;

(ii) despite the fact that each numerator coefficient was numerically smaller than unity as required, all the coefficients varied substantially from theory to theory and were significant at 5 or 10 per cent probability levels;

(iii) differences in alternative theories were further reflected in the values of the denominator coefficient V_1 which varied from 0.75 to 1.50 for the five theories tested on data for the Textile industry;

(iv) the $\bar{R}^2$ statistic indicated substantial variations in the explanatory powers of alternative theories with a range of 25 to 85 per cent.

Although the preceding inferences were based on the Textile industry, an all-embracing type of comparison of the investment theories from the standpoint of their performance was undertaken using performance criteria which had previously been applied in similar situations. The criteria included minimum residual variance, analysis of the fitted coefficients of changes in desired capital, and the goodness-of-fit statistic, $\bar{R}^2$.

All these criteria were applied in discriminating among the four theories with each criterion yielding a particular ranking for alternative theories of investment. On the whole, four sets of ranked results were obtained from the four performance criteria used. However, as could be expected, no uniform pattern of results actually emerged from the ranking of alternative theories of investment behaviour. Consequently, all the four sets of results were themselves ranked. This overall ranking led us to conclude that the best explanation of investment behaviour by manufacturing industries in Nigeria during the period of our analysis was provided by the Liquidity theory with the Expected Profit theory following closely. Neoclassical I theory occupied the third position and was, therefore, superior to Neoclassical II. Of course, the Accelerator theory took the last position.

Further analysis of the regression results led to computations of average lags and distributed lag coefficients such as w_τ, k_τ, z_τ, and R_τ. The w_τ coefficients normally describe the distributed lag relationship between net investment and changes in desired capital; the k_τ coefficients which measure the distributed lag relationship between gross investment and changes in desired capital help to indicate the percentage share of the change in gross investment due to expansion purposes and are also good for assessing the effects on investment behaviour of changes in the determinants of desired capital; the z_τ coefficients measure the response of gross investment to a change in desired capital that persists for θ period before now; and, finally, R_τ indicates the role of replacement in the investment process thus measuring the per-

[illegible]

centage share of the change in gross investment due to replacement. Following these computations, we then derived the elasticity of output with respect to capital input from industry to industry and also carried out a comparative static analysis of investment behaviour specifically for the Leather industry. A summary of the findings and conclusions from these investigations now follows:

Under the examination of the time pattern of investment behaviour it was found that the Footwear, Leather and Rubber industries exhibited much similar pattern such that the peak response in net investment (i.e. for expansion) occured within the first year, while the Food industry had a peak occuring in the second year and, the Textile industry, an extended peak from the first to the second year. In all cases, however, after an initial two year period had expired, the response of investment for replacement purposes began to dominate the response of investment for expansion purposes. This observed behaviour of the lag structure underlying the investment process then leads us to conclude that policy makers should take into account replacement investment when formulating an investment policy for counter cyclical ends.

In characterising the form of the lag distribution, the computed values of the average lags were employed. Most of the industries showed average lag between changes in desired capital and net investment expenditures of between 0.5 years (i.e. 6 months) and a little over one year with a spread of up to three and a half years for others thus indicating the time elapsed between the decision to instal new plants and expand existing capacity, and the actual completion of the construction work. All the five industries showed differences between the average lag and the year of peak response. The average lag exceeded the peak year in the case of Leather, Food and Textiles while it fell short of the peak year for Footwear and Rubber. In all cases the differences between the average lag and the peak year ranged between three months and two years. Since the average lag and the peak year never coincided for any industry, we conclude that the lag distributions from industry to industry were non-symmetric. Consequently, several of the lag patterns normally used to characterize investment behaviour in the literature such as, the "arithmetic", "inverted - V", etc, cannot adequately be employed to describe the lag patterns underlying investment behaviour in the Nigerian manufacturing industries.

The responses of output to unit changes in capital input were found to vary substantially from industry to industry with a low of 0.001 to a high of 0.361. Much as these estimates could be regarded as low having been obtained indirectly, they nevertheless provided some indication of the degree of capital productivity across industries whereby we may classify the industries into two groups - "very capital using" (or, "heavy industries") and "less capital using" (or "light industries").

Under the comparative static analysis of investment behaviour we characterized two major responses i.e. the response of the demand for capital to changes in market conditions and the tax structure, as well as short and long term responses of investment to changes in market conditions and the tax structure. A summary of the results shows that the response of the demand for capital services was largest for the rate of interest, roughly the same for the price of output and price of investment goods, fairly low for the liberalization of depreciation allowances and negligible for the tax rate. In general, the short term responses of investment were much larger than the long term responses; the responses of investment to market conditions were much larger than the responses to tax policy; under market conditions the rate of interest tended to exercise the greatest influence on investment while the price of investment goods and the price of output exercised numerically equal but neutralizing effects on investment, and finally, under the tax structure the tax rate was ineffective while accelerated depreciation did have some effect on investment demand.

Recommendations

The policy implications to be drawn from the responses of investment to its determinants are fairly clear and include the following:

(i) the rate of corporate taxation is questionable as a powerful instrument for the promotion of investment expenditure. Consequently, very generous tax concessions such as low tax rates and accelerated depreciation will succeed in eroding potential government revenue much faster than they raise the level of investment demand;

(ii) fiscal incentives for investment promotion should be regarded as supplementary to other more powerful factors such as market conditions when appraising policies for growth or stabilization purposes;

(iii) as a result of the demonstrated neutralizing effects of the price of output and the price of investment goods on investment expenditures it follows that the price [illegible] of investment goods is also an important indicator to be watched closely by policy makers because of its potential ability to generate inflationary spiral in the domestic economy;

(iv) an inflationary spiral may occur because businessmen increase their product prices in response either to an increase in the manufacturer's price of the imported capital equipment or to an increase in the price of investment goods caused by variations in import duties. In the first case, the operators of the Comprehensive Import Supervision Scheme (C.I.S.S) should be able to introduce very strict vigilance on the price trends of capital goods so as to increasingly ward off the possibility of imported inflation; in the second case, import duties which alter the landing price of capital goods should be varied from time to time in a purposeful manner so as to affect product prices in pursuit of growth or countercyclical objectives;

(v) following the observed behaviour of the lag structure underlying the investment process policy makers are urged to take into account replacement investment when formulating an investment policy for countercyclical ends;

(vi) since investment expenditures tend to fall into stages with definite time patterns indicating short and asymmetrical lag distributions policy makers certainly need to access the appropriate time for the implementation of their policies, thereby ensuring a minimization of the gap between their growth or stabilization targets and actual outcomes; and,

(vii) since the preceding issues are rather basic and involve some technical calculations that need to be made from time to time, it is recommended that (a) the Federal Government considers as a matter of urgency the setting up of a powerful body to be called, "THE COMMISSION ON CAPITAL AND INVESTMENT" which will undertake a comprehensive study of the manufacturing industries in Nigeria aimed at determining the stock of existing capital by firm and industry, the type of capital goods maintained, the nature of annual investment and the pattern of replacement investment; (b) periodic studies should be undertaken by the Commission to derive quantitative estimates of average lags by industry, Longrun responses by industry, the general time pattern of the investment process, and the comparative static relationship of investment to its underlying determinants; (c) finally, the role of tax incentives on capital spending should be quantitatively determined so as to provide a basis for their periodic review.

A P P E N D I X E S

APPENDIX A

BASIC DATA FOR THE REGRESSION ANALYSIS

In this appendix we report the basic data used in running the regressions in Chapter IV. Thus, figures on an industry basis are shown in Tables A1 - A20 for the following variables - investment expenditure, investment goods deflator, capital stock, output, liquidity, net profit, price of capital services, rate of depreciation, cost of capital, tax rate, rate of capital loss and the proportion of depreciation deductible from income for tax purposes. Each of these is now further discussed briefly:

Investment

Table A1 shows deflated cumulative private foreign investment (CPFI) in each of the eight industry groups for the period 1966 to 1976. The deflator used was the investment goods price index obtained from the ratio of nominal gross fixed investment to that of gross fixed investment at constant prices. Annual gross investment expenditures denoted I_t were then represented by deflated CPFI series by type of industry. In order to obtain corresponding net investment series, denoted $I_t - \delta K_{t-1}$, figures of replacement investment, δK_{t-1}, had to be netted out of the gross investment series on an annual and industry basis. The resulting figures of net investment are reported in Table A2.

Capital Stock and Depreciation

Annual figures of capital stock by industry are contained in Table A3. The derivation process started with benchmark figures of capital stock taken to be net fixed assets for 1965 and 1976 for each industry and deflated by the GFI deflators. Using these benchmark figures as presented in Table A4 and the CPFI series expressed in constant prices, we computed the remaining capital stock figures and replacement figures for each indsustry 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:

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

where K_0 and K_t are initial and terminal values of capital stock. Thus, estimates of capital stock year by year were obtained by substituting various values of t into this difference equation. For example, for t = 1, 2, 3, 4 we have the following solutions,

$$K_1 = (1-\delta)^1 K_o + I_1$$

$$K_2 = (1-\delta)^2 K_o + (1-\delta) I_1 + I_2$$

$$K_3 = (1-\delta)^3 K_o + (1-\delta)^2 I_1 + (1-\delta) I_2 + I_3$$

$$K_4 = (1-\delta)^4 K_o + (1-\delta)^3 I_1 + (1-\delta)^2 I_2 + (1-\delta) I_3 + I_4$$

An estimate for δ for each industry was obtained from the replacement model as,

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

This value of δ was used to compute powers of $(1-\delta)$ from $(1-\delta)^1$ to $(1-\delta)^{11}$ for each industry and then substituted back into the difference equation to obtain capital stock series for the other periods and all industries. So also the estimate for δ was used to compute replacement for all periods and industries. The values of δ for the eight industries appear in Table A5 while the values of the powers of $(1-\delta)$ are contained in Table A6. Using the example of the Food Industry in the latter table it will be noticed that the entry for $(1-\delta)^4$ is 0.34E-03 which may be written fully as 0.00034, thus indicating that the convention E - 03 was only used to suggest three decimal places of zero before the first non-zero digit. Other similar cells in the table are to be interpreted appropriately.

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. The output variable in the Accelerator model was deflated by the GFI deflator in the absence of a wholesale price index for each industry and the figures are contained in Table A7. The derivation of the deflators for the Neoclassical models is explained below.

Liquidity

The liquidity variable employed was measured by profits after taxes plus depreciation less dividends paid and then deflated by the GFI deflator. The resulting figures appear in Table A8

Net Profit

In the Expected Profit model current level of net profit was used as a measure of expected profit and deflated by the GFI deflator. The figures are contained in Table A9.

User cost and the cost of capital

For the Neoclassical model I which includes capital gains and Neoclassical model II which excludes it, the price of capital services which is the denominator of the desired capital stock is defined respectively as:

$$c_{t_1} = \frac{q_t}{1-u_t}\left[(1 - u_t n_t)\delta + r_t - \frac{\dot{q}_t}{q_t}\right]$$

and, $c_{t_2} = \frac{q_t}{1-u_t}\left[(1-u_t n_t)\delta + r_t\right]$

It would be recalled from Chapter II that $n_t = \frac{\hat{\delta}}{\delta}$ where $\hat{\delta}$ represents the ratio of depreciation allowances to fixed assets and δ is the calculated rate of depreciation. Substituting $\frac{\hat{\delta}}{\delta}$ for n_t implies that c_{t_2} may be written as, $c_{t_2} = \frac{q_t}{1-u_t}\left[r_t + \delta - u_t\hat{\delta}\right]$

Consequently, c_{t_1} can be derived from c_{t_2} as follows:

$$c_{t_1} = c_{t_2} - \frac{\dot{q}_t}{q_t}\,(q_{t}/1-u_t)$$

By these approaches, it is thus needless to calculate n_t, and c_{t_1} is also obtainable more conveniently. Both c_{t_1} and c_{t_2} were used to deflate the sales figures in order to arrive at data for Neoclassical I and Neoclassical II variables as shown in Tables A10 and A11 respectively. The GFI deflator was used to measure the price of investment goods, q; the rate of depreciation, δ, was obtained as shown previously while the rate of change of the GFI deflator $\frac{\dot{q}}{q}$ 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. All the preceding information have been tabulated as follows: Table A12 shows annual series for the price of investment goods, q_t, capital gains $(\dot{q}/q)t$ and the cost of capital, r_t. Table A13 shows annual series for the rate of corporate taxation u_t by type of industry while annual depreciation allowances appear in Table A14. The series for $\hat{\delta}$ i.e. the ratio of depreciation allowances to fixed assets in current prices are contained in Table A15. The product $u_t \hat{\delta}$ then appears in Table A16 annually and by type of industrial grouping. The ratio $\frac{q_t}{1-u_t}$ called the ratio factor is contained in Table A17 while the algebraic sum $r_t + \delta - u_t\hat{\delta}$ appears in Table A18 and has been termed the sum-difference-factor for ease of reference. Finally, the price of capital services for Neoclassical I, i.e. c_{t_1}, and for Neoclassical II, i.e. c_{t_2}, appear in Table A19 and A20 respectively.

TABLE A1

GROSS INVESTMENT EXPENDITURES, I_t (₦' million)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1965	18.1	14.0	12.4	0.5	0.7	2.0	0.3	8.4
1966	13.4	14.3	9.7	0.5	1.7	2.6	0.3	9.5
1967	24.0	12.6	15.2	1.4	1.8	4.2	0.4	16.2
1968	19.4	15.0	21.6	1.6	2.0	3.4	0.4	5.8
1969	22.6	17.0	25.2	1.8	2.2	3.8	0.4	6.8
1970	19.2	18.8	40.0	2.0	3.0	11.2	1.6	4.0
1971	43.7	29.5	64.1	2.5	8.3	17.3	2.1	13.4
1972	43.2	24.9	67.1	5.2	13.5	10.5	2.5	16.1
1973	48.5	32.8	68.5	7.1	14.7	16.4	2.7	20.1
1974	25.2	18.4	58.3	13.7	6.0	1.8	4.1	7.8
1975	51.2	23.1	125.0	7.2	14.8	9.6	3.3	7.6
1976	56.7	33.1	139.3	19.3	9.0	10.5	4.1	6.4

TABLE A2

NET INVESTMENT EXPENDITURES

$(y_t = I_t - \delta k_{t-1})$ ₦ million

INDUSTRIES	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Food	9.68	13.66	0.68	2.62	17.65	1.91	2.71	17.29	14.93	4.25
Beverages	0.54	1.74	0.79	1.11	7.61	2.47	4.61	10.27	1.20	5.84
Textiles	4.63	6.51	2.83	11.95	19.60	6.61	0.28	8.60	42.53	14.25
Footwear	0.72	0.54	0.11	0.13	0.50	2.30	1.72	4.98	3.71	6.78
Furniture & Fixtures	0.17	0.14	0.01	0.59	3.98	4.09	0.69	6.516	5.74	4.19
Paper & Paper Products	1.20	0.66	0.04	5.92	5.26	4.95	3.24	10.25	3.55	0.71
Leather & Leather Products	0.28	0.19	0.10	1.10	1.04	1.04	0.79	1.51	0.40	0.68
Rubber Products	6.78	9.80	0.07	2.51	6.83	2.37	2.52	9.10	0.78	1.10

TABLE A3

CAPITAL STOCK BY INDUSTRIAL GROUPING K_t

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Product	Leather & Leather Works	Rubber Products
1966	15.326	14.803	12.794	0.807	1.593	3.409	0.340	9.122
1967	25.007	14.298	17.422	1.219	1.762	4.607	0.622	15.902
1968	21.368	16.035	23.941	1.830	1.897	3.951	0.808	6.112
1969	21.615	16.776	26.775	1.945	1.915	3.909	0.718	6.045
1970	18.658	17.886	38.735	2.429	2.501	9.827	1.945	3.549
1971	36.310	25.499	58.335	2.330	6.482	15.089	2.992	10.522
1972	38.227	23.033	64.942	4.559	10.420	10.730	4.046	12.898
1973	40.939	27.649	65.229	6.281	11.119	13.990	4.828	15.418
1974	23.645	17.373	56.667	11.272	4.604	3.735	6.339	6.319
1975	37.913	18.575	99.196	7.564	10.344	7.441	6.742	5.545
1976	42.256	24.408	113.457	14.337	6.154	8.068	7.422	4.436

TABLE A4

FIXED ASSET EXPENDITURE (DEFLATED) ₦' MILLION

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1965	22.624	12.738	17.300	1.521	1.426	5.894	0.095	9.316
1966	19.470	14.625	14808	1.554	1.462	3.656	0.091	10.055
1967	22.445	17.860	20.248	1.242	1.242	5.444	0.287	16.905
1968	22.940	17.669	29.880	2.220	2.220	3.330	0.278	7.493
1969	27.604	21.253	35.902	2.456	1.524	4.064	0.254	8.975
1970	31.918	26.204	44.571	4.000	2.929	14.449	0.816	6.612
1971	26.043	14.297	36.090	2.087	3.014	10.510	0.464	3.400
1972	42.835	22.031	56.086	3.698	6.934	15.177	1.233	13.482
1973	31.982	27.634	51.953	6.927	6.485	15.107	1.548	7.738
1974	46.270	39.096	93.902	16.499	11.406	4.735	4.017	15.202
1975	27.334	85.485	55.734	4.419	6.007	4.626	11.464	3.038
1976	25.979	80.744	53.446	4.178	5.744	4.373	10.117	3.002

TABLE A5

COMPUTED RATES OF DEPRECIATION (δ)

Industries	δ
Food	0.864
Beverages	0.849
Textiles	0.773
Footwear	0.770
Furniture & Fixtures	0.973
Paper	0.825
Leather	0.296
Rubber	0.953

TABLE A6

POWERS OF (1 − δ)

(1−δ)	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
$(1-\delta)^{11}$	0.30E-09	0.83E-09	0.87E-08	0.96E-07	0.55E-017	0.46E-08	0.21E-01	0.22E-014
$(1-\delta)^{10}$	0.22E-08	0.45E-07	0.37E-06	0.41E-06	0.20E-015	0.27E-07	0.30E-01	0.51E-013
$(1-\delta)^{9}$	0.16E-07	0.30E-06	0.16E-05	0.18E-05	0.76E-014	0.15E-06	0.43E-01	0.11E-011
$(1-\delta)^{8}$	0.12E-06	0.20E-05	0.72E-05	0.78E-05	0.28E-012	0.88E-06	0.60E-01	0.20E-010
$(1-\delta)^{7}$	0.85E-06	0.14E-05	0.32E-04	0.34E-04	0.10E-010	0.50E-05	0.86E-01	0.50E-09
$(1-\delta)^{6}$	0.63E-05	0.11E-04	0.14E-03	0.15E-03	0.38E-09	0.29E-04	0.1220	0.10E-07
$(1-\delta)^{5}$	0.47E-04	0.79E-04	0.62E-03	0.64E-03	0.14E-07	0.16E-03	0.1730	0.22E-06
$(1-\delta)^{4}$	0.34E-03	0.60E-03	0.27E-02	0.28E-02	0.53E-06	0.94E-03	0.2460	0.47E-05
$(1-\delta)^{3}$	0.25E-02	0.34E-02	0.12E-01	0.12E-01	0.20E-04	0.54E-02	0.3490	0.10E-03
$(1-\delta)^{2}$	0.19E-01	0.23E-01	0.52E-01	0.53E-01	0.73E-03	0.31E-01	0.4950	0.22E-02
$(1-\delta)^{1}$	0.1360	0.1510	0.2270	0.2300	0.27E-01	0.1750	0.7040	0.47E-01
$(1-\delta)^{0}$	1	1	1	1	1	1	1	1

TABLE A7

ACCELERATOR SALES (DEFLATED) ₦'MILLION

Industry	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Food	25.8	32.7	57.5	80.6	92.1	103.2	122.0	138.2	159.2	168.7	175.4
Beverages	14.1	15.6	29.5	0.1	77.2	29.2	55.3	66.7	71.7	91.4	96.2
Textiles	6.5	18.6	49.9	93.8	84.7	39.1	42.8	47.5	62.3	86.3	81.1
Foodtwear	1.6	1.7	4.4	11.5	8.3	2.0	2.9	2.7	4.1	6.0	6.7
Furniture & Fixt.	5.4	5.6	9.4	22.4	11.9	8.7	11.3	11.6	13.8	25.3	21.5
Paper & Paper Prodts.	3.4	3.7	7.8	19.8	15.2	15.4	12.6	15.5	20.0	25.1	30.9
Leather & Leather Wks.	0.7	1.6	1.2	2.8	5.0	1.2	1.5	1.4	4.8	5.7	9.9
Rubber Prodts.	3.5	4.6	10.8	28.1	18.0	3.4	3.9	5.5	6.6	13.1	13.3

TABLE A8

LIQUIDITY (DEFLATED) ₦'Million

Industry	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Food	2.0914	22.0459	22.0287	14.7409	7.3657	6.0224	27.8952	28.8180	9.8694	13.7921	11.7892
Beverages	2.5722	2.3037	5.5180	2.9128	6.2033	7.9436	6.2750	7.4665	9.1836	21.0131	12.2415
Textiles	1.1243	2.9637	5.6059	0.2295	7.3698	8.2906	5.6278	9.8983	9.7755	31.4589	15.2859
Footwear	0.0841	0.1203	0.1758	0.2456	0.5045	0.9985	0.4630	0.1820	0.4943	0.5552	0.5914
Furniture & Fixt.	0.5210	0.5473	0.8418	1.0313	1.6441	1.3261	1.5223	1.3493	2.0222	4.2921	4.6409
Paper & P. Product.	0.5036	0.7507	0.9177	1.2989	1.4776	1.6499	1.6156	1.9757	3.5473	4.7155	5.2272
Leather	0.1170	0.1261	0.1748	0.2041	0.2171	0.1530	0.2974	0.1923	0.2245	0.4765	0.4034
Rubber	0.6124	0.7364	0.9954	1.0838	2.0245	2.7249	1.7643	1.7207	2.1319	2.3322	0.7076

TABLE A9

NET PROFIT (DEFLATED) ₦' MILLION

Industry	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Food	3.5960	23.6734	22.6984	15.5402	8.7592	6.5773	29.0578	29.6975	12.4649	17.1170	14.0157
Beverages	4.2523	3.9943	7.1656	10.8027	7.2914	9.3192	10.8929	12.7825	9.1923	17.8046	9.5535
Textiles	0.6846	3.8472	6.7854	9.9856	10.8073	8.8215	4.9445	6.6705	10.4943	28.8211	10.9439
Footwear	0.0037	0.0363	0.0777	0.1473	0.3576	0.8238	0.2858	0.0342	0.3221	0.3198	0.3439
Furniture & Fixture	0.4205	0.5253	0.8085	0.9467	1.5608	0.8532	1.0639	0.9920	1.7654	3.6533	3.8401
Paper & P. Prodts.	0.4324	0.5578	0.7530	1.3514	1.4751	1.5131	1.5139	1.7847	3.3092	4.2714	4.5803
Leather	0.0969	0.1070	0.1332	0.1490	0.1502	0.1028	0.3035	0.2022	0.1865	0.5083	0.3101
Rubber	0.7751	1.0105	1.2859	1.4953	2.5714	3.2890	2.3968	2.5484	3.2231	2.7825	0.3166

TABLE A10

NEOCLASSICAL I ₦ MILLION

Industry	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Food	28.8	32.3	61.5	86.0	88.6	102.9	116.6	140.5	156.3	171.9	154.0
Beverages	11.7	12.0	22.8	51.1	58.3	26.0	49.9	67.1	70.4	87.2	93.0
Textiles	7.9	15.1	53.4	120.1	92.6	44.2	41.6	48.9	61.7	91.2	80.8
Footwear	2.0	1.6	5.3	13.9	9.6	2.4	3.3	3.3	4.9	7.4	8.4
Furniture & Fixture	4.9	4.3	7.8	18.4	9.6	7.0	8.2	8.1	11.9	21.2	16.9
Paper & Paper Products	3.6	3.7	8.2	19.5	13.2	15.1	11.3	14.6	18.7	22.4	29.9
Leather & Leather Wks.	2.2	4.8	3.5	10.6	12.4	3.8	3.9	4.1	12.5	14.8	26.3
Rubber Products	3.5	4.4	8.7	24.0	10.6	2.3	3.3	4.7	5.2	4.6	7.3

TABLE A11

NEOCLASSICAL II ₦' MILLION

Industry	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Food	27.5	33.9	59.4	78.2	85.1	96.8	116.2	133.6	151.8	140.6	147.9
Beverages	11.2	12.6	23.6	46.3	55.9	24.4	49.8	63.7	68.3	84.6	89.3
Textiles	7.5	15.9	51.3	108.0	88.5	41.2	41.5	46.1	59.7	88.2	77.1
Footwear	1.9	1.9	5.1	12.5	9.2	2.3	3.3	3.1	4.7	7.2	8.1
Furniture & Fixt.	4.8	4.6	7.5	16.9	9.2	6.7	8.2	7.7	11.6	20.6	16.3
Paper & Paper Products	3.4	3.9	7.9	17.6	12.7	14.1	11.2	13.8	18.2	21.7	28.5
Leather & Leather Wks.	1.9	4.2	3.2	7.6	11.1	3.2	3.8	3.6	11.5	13.7	23.6
Rubber Prod.	3.4	4.3	8.4	22.1	10.3	2.2	3.3	4.5	5.1	10.3	9.7

TABLE A12

PRICE OF INVESTMENT GOODS, CAPITAL GAINS AND COST OF CAPITAL

Year	q_t	$\dot{q}_t / q_t$	r_t
1965	1.052	-	-
1966	1.094	0.040	0.075
1967	1.047	-0.045	0.073
1968	1.081	0.033	0.073
1969	1.181	0.085	0.070
1970	1.225	0.037	0.070
1971	1.294	0.056	0.070
1972	1.298	0.003	0.070
1973	1.357	0.046	0.070
1974	1.394	0.027	0.070
1975	1.448	0.027	0.063
1976	1.532	0.037	0.065

TABLE A13

INCOME TAX RATE BY INDUSTRIAL GROUPING

U_t

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1966	0.040	0.276	0.023	0	0.072	0.065	0	0
1967	0.028	0.274	0.289	0.026	0.185	0.066	0	0
1968	0.032	0.272	0.136	0.037	0.176	0.096	0	0.207
1969	0.089	0.462	0.030	0.096	0.233	0.223	0.198	0.204
1970	0.133	0.351	0.124	0.078	0.203	0.259	0.229	0.421
1971	0.121	0.249	0.118	0.054	0.239	0.186	0.037	0.348
1972	0.106	0.184	0.191	0.050	0.260	0.216	0.103	0.146
1973	0.093	0.132	0.197	0.036	0.328	0.213	0.074	0.157
1974	0.106	0.134	0.200	0.034	0.126	0.217	0.126	0.213
1975	0.238	0.173	0.187	0.020	0.193	0.274	0.142	0.235
1976	0.221	0.157	0.234	0.000	0.251	0.216	0.135	0.290

TABLE A14

DEPRECIATION ALLOWANCE

₦ million

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1966	0.072	0.562	0.691	0.088	0.110	0.142	0.022	0.032
1967	0.226	0.780	0.691	0.088	0.108	0.316	0.020	0.020
1968	0.290	0.979	0.728	0.106	0.178	0.332	0.045	0.070
1969	0.284	1.094	0.963	0.144	0.200	0.400	0.065	0.068
1970	0.303	2.115	1.725	0.220	0.252	0.548	0.082	0.080
1971	0.327	1.441	2.621	0.226	0.712	0.719	0.085	0.214
1972	0.394	2.059	2.802	0.296	0.846	0.761	0.073	0.715
1973	0.423	2.867	6.158	0.332	0.938	0.791	0.080	0.329
1974	0.419	3.684	5.499	0.332	1.077	1.416	0.094	0.422
1975	0.399	6.846	13.662	0.350	1.645	0.940	0.091	0.548
1976	0.914	4.118	11.406	0.379	1.804	1.257	0.237	0.632

TABLE A15

RATIO OF DEPRECIATION ALLOWANCE (IN CURRENT PRICES) TO FIXED ASSETS

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1966	0.003	0.035	0.043	0.052	0.069	0.036	0.220	0.003
1967	0.001	0.042	0.033	0.059	0.083	0.055	0.067	0.001
1968	0.012	0.051	0.023	0.044	0.074	0.092	0.150	0.009
1969	0.009	0.044	0.023	0.050	0.111	0.083	0.217	0.006
1970	0.008	0.066	0.032	0.045	0.070	0.031	0.082	0.010
1971	0.010	0.078	0.056	0.084	0.183	0.053	0.142	0.049
1972	0.007	0.072	0.038	0.062	0.085	0.039	0.046	0.010
1973	0.010	0.076	0.087	0.035	0.107	0.039	0.038	0.031
1974	0.007	0.068	0.042	0.014	0.068	0.215	0.017	0.020
1975	0.010	0.055	0.169	0.055	0.189	0.140	0.000	0.125
1976	0.023	0.033	0.139	0.059	0.205	0.188	0.002	0.137

TABLE A16

THE PRODUCT FACTOR IN CALCULATING THE PRICE OF CAPITAL SERVICES $U_t\ \delta$

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtues	Paper & Paper Products	Leather & Leather Works	Rubber Products
1966	0.00012	0.00966	0.00099	0	0.00499	0.00234	0	0
1967	0.00003	0.01151	0.00954	0.00153	0.01536	0.00363	0	0
1968	0.00038	0.01387	0.00313	0.00163	0.01302	0.00883	0.	0.00186
1969	0.00080	0.02033	0.00069	0.00480	0.02586	0.01851	0.04297	0.00122
1970	0.00106	0.02317	0.00397	0.00351	0.01421	0.00803	0.01878	0.00421
1971	0.00121	0.01942	0.00661	0.00454	0.04374	0.00986	0.00525	0.01705
1972	0.00074	0.01325	0.00726	0.00310	0.02210	0.00842	0.00474	0.00146
1973	0.00093	0.01003	0.01714	0.00126	0.03510	0.00831	0.00281	0.00487
1974	0.00074	0.00911	0.00840	0.00048	0.00857	0.04666	0.00214	0.00426
1975	0.00238	0.00952	0.03160	0.00110	0.03648	0.03836	0.00001	0.02938
1976	0.00508	0.00518	0.03253	0	0.05146	0.04061	0.00027	0.03973

TABLE A17

THE RATIO FACTOR IN CALCULATING THE PRICE OF CAPITAL SERVICES $\frac{q_t}{1-u_t}$

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	leather & Leather Works	Rubber Products
1966	1.091	1.511	1.120	1.094	1.179	1.170	1.094	1.094
1967	1.076	1.443	1.473	1.075	1.285	1.121	1.094	1.094
1968	1.116	1.486	1.252	1.122	1.312	1.196	1.094	1.362
1969	1.297	2.193	1.218	1.306	1.540	1.520	1.473	1.473
1970	1.413	1.888	1.398	1.329	1.537	1.653	1.589	2.116
1971	1.472	1.723	1.467	1.368	1.700	1.590	1.383	1.985
1972	1.452	1.591	1.604	1.366	1.754	1.656	1.447	1.520
1973	1.496	1.563	1.690	1.408	2.019	1.724	1.465	1.610
1974	1.559	1.610	1.743	1.443	1.595	1.780	1.595	1.771
1975	1.879	1.732	1.761	1.461	1.774	1.972	1.669	1.872
1976	1.966	1.817	2.000	1.532	2.045	1.954	1.771	2.157

TABLE A18

THE SUM-DIFFERENCE FACTOR IN CALCULATING THE PRICE OF CAPITAL SERVICES

$r_t + \delta - u_t \hat{\delta}$

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1966	0.938	0.914	0.847	0.845	1.043	0.898	0.371	1.028
1967	0.939	0.912	0.838	0.843	1.032	0.896	0.371	1.028
1968	0.939	0.908	0.839	0.841	1.033	0.889	0.369	1.024
1969	0.938	0.899	0.842	0.835	1.017	0.876	0.296	1.022
1970	0.938	0.896	0.839	0.836	1.029	0.887	0.347	1.019
1971	0.938	0.899	0.836	0.835	0.999	0.885	0.360	1.006
1972	0.938	0.906	0.835	0.837	1.020	0.886	0.361	1.022
1973	0.938	0.909	0.826	0.838	1.008	0.886	0.363	1.018
1974	0.938	0.909	0.834	0.839	1.034	0.848	0.364	1.019
1975	0.924	0.902	0.804	0.831	0.999	0.849	0.358	0.986
1976	0.923	0.909	0.805	0.835	0.986	0.849	0.360	0.978

TABLE A 19

PRICE OF CAPITAL SERVICES FOR NEOCLASSICAL I, C_{tI}

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1966	0.98068	1.32113	0.90385	0.88067	1.18257	1.00346	0.36211	1.08087
1967	1.05878	1.38166	1.29455	1.12338	1.38479	1.05639	0.35661	1.07540
1968	1.01065	1.39852	1.01020	0.90699	1.31197	1.02398	0.36759	1.34993
1969	1.10661	1.78438	0.92240	0.97976	1.43549	1.20306	0.31085	1.37988
1970	1.27297	1.62147	1.12123	1.06252	1.52438	1.40499	0.49294	2.07747
1971	1.29799	1.45347	1.14483	1.06629	1.60354	1.31833	0.42147	1.88565
1972	1.35799	1.43627	1.33572	1.13910	1.78540	1.46321	0.51839	1.54818
1973	1.33453	1.34882	1.31796	1.11618	1.94209	1.44935	0.46468	1.56518
1974	1.42066	1.42145	1.40765	1.17247	1.60686	1.46200	0.53729	1.75637
1975	1.68665	1.51635	1.36898	1.17596	1.72525	1.62225	0.55409	1.79643
1976	1.74422	1.58436	1.53694	1.22254	1.94219	1.58749	0.57336	2.03098

TABLE A 20

PRICE OF CAPITAL SERVICES FOR NEOCLASSICAL II, C_{t2}

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Works	Rubber Products
1966	1.02432	1.38157	0.94865	0.92443	1.22973	1.05026	0.40587	1.12463
1967	1.01036	1.31672	1.22826	0.90673	1.32696	1.00483	0.40587	1.12463
1968	1.04748	1.34948	1.05152	0.94402	1.35527	1.06345	0.40369	1.39488
1969	1.21685	1.97078	1.02593	1.09077	1.56639	1.33226	0.43605	1.50508
1970	1.32525	1.69133	1.17296	1.11169	1.58125	1.46616	0.55173	2.15576
1971	1.38043	1.54996	1.22698	1.14290	1.69874	1.40737	0.49892	1.99681
1972	1.36235	1.44104	1.34053	1.14320	1.79066	1.46818	0.52274	1.55274
1973	1.40335	1.42072	1.39570	1.18095	2.03495	1.52865	0.53207	1.63924
1974	1.46275	1.46492	1.45471	1.21143	1.64992	1.51006	0.58036	1.80419
1975	1.73738	1.56311	1.41653	1.21541	1.77315	1.67549	0.59915	1.84697
1976	1.81698	1.65160	1.61094	1.27922	2.01787	1.65979	0.63889	2.11081

APPENDIX B

DATA FOR THE FIRST STAGE MAXIMUM LIKELIHOOD REGRESSIONS

The data reported in Appendix A are the ones normally used when executing the rational distributed lag functions in the autoregressive form. However, these basic data need to be transformed in order to estimate the rational distributed lag model by the maximum likelihood (ML) method. Consistent with the maximization procedure which involves running regressions at two stages the data required are also derived in two stages.

In this appendix, we report the data utilized for the first stage regressions whose results were summarized in Tables 3 - 7 of Chapter IV. As previously discussed in Chapters III and IV the synthetic variables Z_{1t} and Z_{2t} for each industry under each model of investment were generated recursively from relationships involving, in the Z_{1t} case, the original explanatory variable in the distributed lag model and assumed values for V_1, while in the Z_{2t} case, only the assumed values for V_1 were involved. In developing the necessary data, V_1 was assumed to lie in the range $0.25 \leq V_1 \leq 1.75$ and we then spaced the values at intervals of 0.25 yielding alternatively, V_1 = 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75. Thus for various values of t, we have

$$Z_{1t} = X_1, \qquad Z_{2t} = V_1 \qquad \text{for } t = 1$$

$$= X_2 + V_1 X_1, \qquad = V_1^2 \qquad \text{for } t = 2$$

$$= X_t + V_1 Z_{1t-1}, \qquad = V_1 Z_{2,t-1} \qquad \text{for } t \geq 3$$

Accordingly, we report data for the Z_{1t} variable of the Neoclassical I model in Tables B1 - B7 where Table B1 is based on $V_1 = 0.25$, Table B2 is based on $V_1 = 0.50$, and so on. Similarly, Z_{1t} data appear in Tables B8 - B14 for the Neoclassical II model, Tables B15 - B21 for the Accelerator model, etc. Finally, Table B36 contains data for the Z_{2t} variable.

TABLE B1

NEOCLASSICAL I, Z It (V_i = 0.25)

Year	Food	Beverages	Textiles	Footwear	Furn. & Fixt	Paper & Paper Prodts.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	-0.44	-0.73	0.10	2.56	0.85
1968	30.13	10.87	40.14	3.59	3.35	4.53	-0.63	4.54
1969	32.02	31.02	76.70	9.50	11.44	12.43	6.94	16.60
1970	10.59	14.95	-8.32	-1.93	-5.94	-3.19	3.54	-9.24
1971	16.97	-28.56	-50.48	-7.68	-4.05	1.10	-7.72	-10.61
1972	17.91	16.76	-15.27	-1.02	0.15	-3.53	-1.83	-1.65
1973	28.38	21.39	3.50	-0.26	-0.08	2.42	-0.26	1.02
1974	22.89	8.65	13.67	1.54	3.80	4.70	8.34	0.73
1975	21.32	18.96	32.92	2.88	10.25	4.88	4.38	-0.42
1976	12.62	10.54	-2.17	1.72	-1.74	8.72	12.60	2.60

TABLE B2

NEOCLASSICAL I Zit (VI = 0.5)

Year	Food	Beverages	Textiles	Footwear	Furn. & Fixtures	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	-0.44	-0.73	0.10	2.56	0.85
1968	31.01	10.96	41.94	3.48	3.17	4.56	0.01	4.76
1969	40.00	33.78	87.67	10.34	12.19	13.58	7.11	17.68
1970	22.58	24.09	16.34	0.87	-2.60	0.49	5.36	-4.56
1971	25.61	-20.25	-40.23	-6.76	-3.86	2.15	-5.92	-10.58
1972	26.48	13.77	-22.72	-2.48	-0.77	-2.72	-2.86	-4.29
1973	37.14	24.09	18.66	-1.24	-0.51	1.94	-1.23	-0.72
1974	34.37	15.36	22.13	2.22	4.08	5.07	9.02	0.12
1975	32.79	24.48	40.57	3.61	11.34	6.24	6.81	0.54
1976	-1.50	18.04	9.89	2.81	1.37	10.62	14.91	2.43

TABLE B3

NEOCLASSICAL I Z1t (VI = 0.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Pro.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	-0.44	-0.73	0.10	2.56	0.85
1968	31.83	11.05	43.70	3.37	2.99	4.59	0.65	4.97
1969	48.36	36.59	99.48	11.13	12.84	14.74	7.59	19.03
1970	38.85	34.64	47.11	4.05	0.83	4.75	7.49	0.87
1971	43.46	-6.32	-13.07	-4.17	-1.94	5.46	-2.98	-7.65
1972	46.26	19.16	-12.40	-2.23	-0.29	0.30	-2.14	-4.74
1973	58.60	31.57	-2.00	-1.67	-0.34	3.52	-1.40	-2.12
1974	59.75	26.98	11.30	0.35	3.57	6.74	7.35	-1.10
1975	60.41	37.03	37.97	2.76	11.97	8.76	7.81	-1.43
1976	27.41	33.57	18.08	3.07	4.68	14.07	17.36	1.63

TABLE B4

NEOCLASSICAL I Z1t (VI = 1.0)

Year	Food	Beverages	Textiles	Footwear	Furniture &Fixtures	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	−0.44	−0.73	0.10	2.56	0.86
1968	32.74	11.14	45.54	3.26	2.81	4.61	1.29	5.18
1969	57.23	39.44	112.24	11.86	13.41	15.91	8.39	20.48
1970	59.81	46.64	84.74	7.56	4.61	9.61	10.19	7.08
1971	74.13	14.34	36.34	0.36	2.05	11.51	1.59	−1.22
1972	87.82	38.24	33.74	51.26	3.21	7.71	1.69	−0.22
1973	111.76	55.44	41.04	51.26	3.09	11.01	1.89	1.21
1974	127.59	58.74	53.84	52.86	6.91	15.11	10.29	1.69
1975	143.10	75.54	83.34	55.36	16.21	18.81	12.59	1.09
1976	125.26	81.34	72.94	56.36	11.91	26.31	24.09	3.79

TABLE: B5

NEOCLASSICAL I Ƶlt (VI = 1.25)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	-0.44	-0.73	0.10	2.56	0.85
1968	33.66	11.23	47.34	3.15	2.63	4.63	1.93	5.39
1969	66.57	42.34	125.88	12.54	13.89	17.09	9.51	22.04
1970	85.79	60.12	129.84	11.37	8.56	15.06	13.69	14.15
1971	121.56	42.85	113.90	7.01	8.14	20.73	8.52	9.38
1972	165.62	77.46	139.78	9.66	11.33	22.11	10.74	12.73
1973	230.92	114.03	182.02	12.08	14.04	30.94	13.63	17.35
1974	305.45	145.84	240.33	16.70	15.05	42.78	25.43	22.16
1975	397.42	199.09	329.91	32.38	28.11	57.17	34.08	27.10
1976	478.87	254.66	401.99	30.22	30.84	78.97	54.11	36.58

TABLE B6

NEOCLASSICAL I [illegible] Zlt (VI = 1.5)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	-0.44	-0.73	0.10	2.56	0.85
1968	47.36	11.32	49.14	3.04	2.34	4.66	2.57	5.61
1969	95.53	45.28	140.41	8.26	14.11	18.29	10.96	23.71
1970	145.88	75.12	183.12	8.09	12.37	21.14	18.24	22.16
1971	233.14	80.38	226.26	4.49	16.00	33.61	18.76	24.94
1972	363.38	144.47	223.68	58.31	22.84	46.62	28.04	36.41
1973	568.97	233.91	342.82	86.47	34.14	73.33	42.26	53.19
1974	869.26	354.16	527.03	132.80	55.03	113.95	71.79	79.30
1975	1319.49	548.04	820.05	201.71	91.85	174.63	109.99	118.35
1976	39540.57	827.86	1219.67	303.56	133.47	269.45	176.48	175.72

TABLE B7

NEOCLASSICAL I Z1t (VI = 1.75)

Year	Food	Beverages	Textiles	Footwear	Furn. & Fixt.	Paper & Paper Prodt.	Leather & Leather wks	Rubber Products
1967	3.54	0.36	7.20	-0.44	-0.73	0.10	2.56	0.85
1968	35.44	11.40	50.91	2.93	2.26	4.68	3.21	5.82
1969	86.51	48.39	155.86	13.75	14.56	19.49	12.72	25.49
1970	154.01	91.72	245.25	19.73	16.68	27.81	24.06	31.21
1971	283.82	128.26	380.79	27.36	26.63	50.57	33.51	46.32
1972	510.36	248.30	663.63	48.73	47.76	84.70	58.74	82.06
1973	916.90	451.75	1168.61	85.28	83.46	151.53	103.00	144.04
1974	1620.41	793.88	2057.91	150.84	149.88	269.28	188.65	251.59
1975	2851.36	1406.06	3630.80	266.47	271.59	474.94	332.44	439.68
1976	4971.90	2466.30	6343.56	467.32	470.98	838.65	593.27	772.14

TABLE B8

NEOCLASSICAL II Z_{it} (VI = 0.25)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	6.32	1.46	8.40	0.03	-0.35	0.45	2.22	0.89
1968	27.11	11.40	37.43	3.11	2.99	4.13	-0.41	4.34
1969	25.63	25.49	68.09	8.17	10.07	10.69	3.39	14.76
1970	13.29	16.02	-2.48	-1.25	-5.10	-2.20	4.34	-8.12
1971	14.98	-27.53	-47.87	-8.15	-3.86	0.90	6.77	-10 .08
1972	23.17	18.56	-11.73	6.50	1.24	-2.74	2.31	-1 .43
1973	28.20	18.51	1.73	1.43	-0.18	1.94	0.33	0.86
1974	25.28	9.19	14.03	1.94	3.87	4.84	8.01	0.81
1975	-4.91	18.68	31.94	2.93	9.97	4.77	4.19	5.39
1976	6.04	-7.13	19.05	1.62	-1.85	7.92	10.99	0.72

TABLE B9

NEOCLASSICAL II $\hat{Z}_{it}$ (VI = 0.5)

Year	Food	Beverages	Textiles	Footwear	Furniture &Fixt.	Paper & Paper Prod.	Leather &Leather Wks	Rubber Products.
1967	6.32	1.46	8.40	0.03	-0.35	0.45	2.22	0.89
1968	28.69	11.76	39.53	3.12	2.91	4.25	0.14	4.57
1969	33.20	28.52	78.50	8.95	10.78	11.79	4.42	15.96
1970	23.49	23.91	58.75	1.19	-2.23	1.03	5.74	-3.83
1971	23.41	-9.93	76.63	-6.31	-3.70	1.97	5.08	-9.97
1972	31.13	20.48	38.55	-2.11	3.41	-1.98	3.12	6.08
1973	37.98	24.11	23.94	-1.25	1.22	1.64	1.30	4.26
1974	37.22	16.61	25.57	0.96	4.53	5.17	8.58	2.72
1975	7.38	24.69	41.22	2.93	11.27	6.16	6.48	6.55
1976	10.96	16.94	31.68	2.36	1.30	9.81	13.18	2.65

TABLE B10

NEOCLASSICAL II Ẑ1t (VI = 0.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prodts.	Leather & Leather wks	Rubber Products
1967	6.32	1.46	8.40	0.03	-0.35	0.45	2.22	0.89
1968	30.27	12.13	41.63	3.12	2.82	4.36	2.64	4.74
1969	41.55	31.73	89.95	9.73	11.44	12.93	6.33	17.23
1970	38.05	33.45	47.96	4.01	0.96	4.83	8.23	1.11
1971	40.20	-6.45	-11.28	-3.89	-1.86	5.07	-1.67	-7.22
1972	49.57	20.60	-8.22	-1.88	0.16	0.83	-0.63	-4.33
1973	59.59	29.32	-1.51	-3.29	-0.37	3.25	-1.10	-2.03
1974	62.92	26.55	12.47	-0.89	2.47	6.80	7.10	-0.93
1975	35.96	38.29	37.78	1.78	4.32	8.66	7.52	4.49
1976	34.24	15.42	39.41	2.23	-1.10	13.23	15.58	2.74

TABLE B11

NEOCLASSICAL II Z1t (VI = 1.0)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	6.32	1.46	8.40	0.03	-0.35	0.45	2.22	0.89
1968	31.85	12.49	43.73	3.13	2.73	4.47	1.25	5.01
1969	50.70	35.13	102.46	10.53	12.05	14.13	5.60	18.69
1970	57.59	44.78	82.96	7.23	4.43	9.26	9.09	6.88
1971	69.25	13.24	35.71	0.33	1.85	10.71	1.24	-1.17
1972	88.67	38.68	35.95	1.37	3.41	7.74	1.86	-0.08
1973	111.08	52.55	40.61	1.81	2.92	10.37	1.60	1.14
1974	129.31	66.42	54.21	2.76	6.84	14.72	9.53	1.73
1975	118.08	82.80	82.64	4.63	15.84	18.29	11.72	6.92
1976	125.35	87.41	93.71	5.52	11.50	25.02	21.66	6.29

TABLE: B12

NEOCLASSICAL II Zlt (VI = 1.25)

Year	Food	Beverages	Textiles	Footwear	Furn. & Fixt.	Paper & Paper Prod.	Leather & Leather wks.	Rubber Products
1967	6.32	1.46	8.40	0.03	0.35	0.45	2.22	0.89
1968	33.43	16.10	45.83	3.14	2.64	4.58	1.81	5.23
1969	60.64	42.77	116.02	11.31	12.62	15.39	6.61	20.21
1970	82.69	63.11	125.52	10.85	8.16	14.36	11.76	13.45
1971	115.02	47.35	109.65	6.66	7.62	19.45	6.84	8.76
1972	162.19	84.63	137.30	9.37	11.09	21.23	9.17	12.04
1973	226.40	119.65	176.29	11.52	13.37	29.23	11.20	16.27
1974	301.23	154.13	233.96	15.98	20.63	40.89	21.93	20.93
1975	365.31	209.04	320.88	22.43	34.79	54.68	29.60	31.35
1976	463.91	249.52	412.17	28.92	39.15	75.08	46.94	38.56

TABLE B13

NEOCLASSICAL II Ƶlt (Vl = 1.50)

Year	Food	Beverages	Textiles	Footwear	Furn. & Fixt.	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	6.32	1.46	8.40	0.03	-0.35	0.45	2.22	0.89
1968	35.06	13.22	47.93	3.15	2.56	4.70	2.36	54.55
1969	71.44	42.47	130.63	12.12	13.16	16.71	7.89	95.50
1970	114.04	73.36	176.45	14.89	12.12	20.20	15.33	131.44
1971	182.72	78.50	217.43	15.44	15.60	31.75	15.15	189.11
1972	29.35	143.19	326.39	24.20	24.96	44.66	23.35	284.76
1973	462.66	228.65	494.25	36.11	36.95	69.62	34.77	428.36
1974	712.22	347.54	754.98	56.75	59.35	108.78	60.09	643.13
1975	1057.92	537.69	1160.90	86.08	94.37	166.74	92.33	969.89
1976	1592.92	811.15	1752.42	130.01	137.22	256.84	148.44	1454.21

TABLE B 14

NEOCLASSICAL II Zlt (VI = 1.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	6.32	1.46	8.40	0.03	-0.35	0.45	2.22	0.89
1968	36.59	13.59	50.03	3.15	2.47	4.81	2.92	5.68
1969	82.88	46.42	146.28	12.91	13.64	18.07	9.45	23.61
1970	151.93	90.89	236.49	19.30	16.25	26.75	20.03	29.61
1971	156.70	127.52	366.61	26.88	25.86	48.27	27.20	43.57
1972	293.65	248.60	641.80	48.07	46.81	81.50	48.22	77.35
1973	536.29	448.91	1127.82	83.93	81.43	145.25	84.13	136.58
1974	956.74	803.83	1987.29	148.47	146.47	258.54	155.16	239.60
1975	1663.06	801.97	3506.18	262.27	247.24	456.01	273.72	424.48
1976	2903.09	1391.65	6146.88	459.87	437.01	804.75	488.95	742.22

TABLE B15

ACCELERATOR SALES Z1t (VI = 0.25)

Year	Food	Beverages	Textiles	Footwear	Furn & Fixt.	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	26.53	14.28	34.33	2.73	3.85	4.18	-0.18	6.48
1969	29.73	-25.46	52.48	7.78	13.96	13.05	1.56	18.92
1970	18.93	70.04	4.02	-1.26	-7.01	-1.34	2.59	-5.37
1971	15.83	-30.49	-44.00	-6.62	-4.95	-0.14	-3.15	-15.94
1972	22.76	18.48	-7.30	-0.76	1.36	-2.84	-0.49	-3.49
1973	21.69	16.02	2.88	-0.39	0.64	2.19	-0.22	0.73
1974	26.72	9.01	15.52	1.30	2.36	5.05	3.35	1.28
1975	16.08	21.95	27.88	2.23	12.09	6.36	1.74	6.82
1976	10.72	10.29	1.77	1.26	-0.78	7.39	4.64	1.91

TABLE B16

ACCELERATOR SALES Z1t (VI = 0.5)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixt.	Paper & Paper Prod.	Leather & Leather wks	Rubber Products
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	28.25	14.65	37.35	2.75	3.90	4.25	0.05	6.75
1969	37.23	-21.70	62.58	8.48	14.95	14.13	1.63	20.68
1970	30.11	65.55	22.19	1.04	-3.05	2.46	3.01	0.23
1971	26.16	-15.22	-33.80	-5.78	-4.73	1.43	-2.29	-14.48
1972	31.88	18.49	-13.20	-1.99	0.24	-2.08	-0.85	-6.74
1973	31.94	20.65	-1.92	-0.80	0.42	1.86	-0.33	-1.77
1974	37.27	15.32	13.85	1.00	11.71	5.43	3.24	0.21
1975	28.03	27.36	30.93	2.40	2.41	7.82	2.52	6.61
1976	20.72	18.48	10.26	1.90	-2.59	9.71	5.76	3.51

TABLE B17

ACCELERATOR SALES Zlt (VI = 0.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prod.	Leather & Leather wks.	Rubber Products.
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	29.98	15.03	40.38	2.78	3.95	4.33	0.28	7.03
1969	45.59	-17.76	74.19	9.19	15.96	15.25	1.81	22.57
1970	45.69	63.08	46.54	3.69	1.47	6.84	3.56	6.83
1971	45.37	-0.69	-10.10	-3.53	2.10	5.33	-1.13	-9.48
1972	52.83	25.58	11.28	-1.75	1.03	1.20	-0.55	-6.61
1973	55.62	30.59	13.16	-1.51	1.07	3.80	-0.51	-3.36
1974	63.02	27.94	24.67	0.27	3.00	7.35	3.02	-1.42
1975	56.67	40.66	42.50	2.10	13.75	10.61	3.17	5.44
1976	49.20	35.30	26.68	2.28	6.51	13.76	6.58	4.28

TABLE : B18

ACCELERATOR SALES Zlt (VI = 1.0)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prod.	Leather & Leather wks.	Rubber Products.
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	31.71	15.46	43.40	2.80	4.01	5.42	0.50	7.33
1969	54.82	-13.63	87.31	9.92	17.03	17.42	2.14	24.61
1970	12.33	62.77	78.23	6.72	6.50	12.81	4.33	14.50
1971	23.41	14.77	33.24	0.40	3.31	13.03	0.50	-0.10
1972	42.22	40.87	36.92	1.31	5.92	12.20	0.84	0.62
1973	68.24	52.27	41.63	1.10	4.23	9.32	0.73	2.26
1974	89.54	47.27	56.41	2.52	6.40	4.83	4.11	3.30
1975	98.90	66.97	80.40	4.41	17.92	9.93	5.02	9.80
1976	105.61	71.77	75.21	5.10	14.11	15.70	9.26	3.05

TABLE B19

ACCELERATOR SALES Zlt (VI = 1.25)

Year	Food	Beverages	Textiles	Footwear	Furniture Fixts.	Paper & Paper Products	Leather & Leather wks.	Rubber Products.
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	33.43	15.78	46.43	2.83	4.05	4.48	0.73	7.58
1969	64.89	-9.31	101.94	10.64	18.06	17.60	2.51	26.78
1970	92.61	64.76	118.33	10.10	12.08	17.40	5.34	23.38
1971	126.86	32.95	102.91	6.33	11.90	21.95	2.88	14.63
1972	177.38	67.29	132.34	8.81	17.48	19.16	3.90	18.79
1973	237.73	95.51	170.13	10.81	22.15	26.85	4.78	25.09
1974	318.46	124.39	227.46	14.91	29.89	38.06	9.38	32.46
1975	407.48	175.19	308.33	20.04	48.86	52.68	12.63	47.08
1976	516.05	223.79	380.21	26.95	57.28	71.65	19.99	59.05

TABLE B20

ACCELERATOR SALES Z1t (V1 = 1.50)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	35.15	16.15	49.45	2.85	4.10	4.55	0.95	7.85
1969	73.16	-4.80	118.08	11.38	19.15	18.83	3.03	29.08
1970	125.20	69.21	168.01	13.86	18.23	23.64	6.74	33.51
1971	198.85	37.62	207.02	14.49	24.15	35.26	6.31	35.67
1972	317.22	82.52	306.83	20.84	33.63	50.09	9.77	53.01
1973	491.85	135.20	455.55	31.05	50.14	78.04	14.55	77.91
1974	759.08	207.79	668.52	45.18	73.01	121.55	18.43	115.76
1975	1,148.02	331.39	978.78	65.86	98.01	187.43	26.74	167.14
1976	1,728.73	501.88	1,463.26	103.40	143.21	283.94	35.91	250.51

TABLE. B21

ACCELERATOR SALES Złt (V1 = 1.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	6.90	1.50	12.14	0.12	0.23	0.36	0.92	1.10
1968	36.91	16.52	52.50	2.91	4.62	4.23	1.24	8.16
1969	87.76	-0.20	135.82	12.20	20.19	20.46	3.70	31.55
1970	164.90	76.11	228.61	18.26	30.66	25.29	8.76	45.00
1971	299.72	85.23	355.11	25.69	53.84	40.90	11.42	64.24
1972	543.30	175.20	625.14	45.76	91.46	74.29	20.35	112.90
1973	966.86	318.02	1,098.60	79.85	162.93	130.28	35.40	199.26
1974	1,713.24	561.51	1,937.49	141.14	289.60	230.15	65.42	349.73
1975	3,007.59	1,002.34	3,414.56	248.80	511.96	414.29	115.46	618.50
1976	5,269.80	1,758.86	5,970.20	436.12	901.68	721.10	206.29	1,082.68

TABLE B22

LIQUIDITY δ1t (V1 = 0.25)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	19,954.50	-268.51	1,839.42	36.20	26.33	247.11	9.14	124.02
1968	4,971.41	3,147.22	3,102.10	64.62	301.13	228.84	51.02	290.03
1969	-6,045.02	-1,818.43	-4,600.93	86.04	264.85	438.46	42.13	160.92
1970	-8,886.51	2,835.93	5,990.14	280.42	679.06	288.39	23.56	983.05
1971	-3,564.91	2,449.32	2,418.33	564.15	-148.34	244.46	-58.25	946.22
1972	21,170.50	-256.34	-2,058.01	-676.56	159.13	-26.84	157.02	-724.01
1973	6,215.41	1,127.42	3,755.93	-450.12	-133.24	366.56	-65.33	-224.61
1974	-17,394.76	1,998.96	816.22	-424.84	639.63	1,663.21	48.65	355.10
1975	-425.92	12,329.21	21,887.4	-45.32	2,429.81	1,584.01	264.22	289.13
1976	-2,109.43	-5,689.30	-9,701.23	24.96	956.35	907.76	-7.15	1,552.31

TABLE B23

LIQUIDITY Zlt (V1 = 0.50)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	19,954.51	-268.52	1,839.46	36.23	26.35	247.14	9.12	124.01
1968	9,960.10	3,348.65	3,586.91	73.65	307.84	290.62	53.35	321.04
1969	-2,307.83	-930.92	-3,583.03	106.62	343.44	526.53	56.04	248.95
1970	-8,529.12	2,825.14	5,379.35	312.23	784.54	442.09	41.08	1,065.26
1971	-5,607.90	3,152.92	3,610.53	650.14	74.35	393.36	-43.67	1,233.08
1972	19,068.91	707.95	-857.66	-210.53	233.48	-162.49	122.16	-344.17
1973	10,457.22	1,545.51	3,841.74	-386.32	-56.35	441.04	-43.83	-215.17
1974	-13,720.00	2,489.93	1,798.16	119.25	644.84	1,792.13	10.32	303.41
1975	-2,937.31	13,074.55	22,582.14	120.56	2,592.31	2,064.30	257.23	352.01
1976	-3,471.62	-2,234.48	-3,881.83	96.59	1,644.92	1,543.93	55.54	-1,448.60

TABLE: B24

LIQUIDITY Z1t (V1 = 0.75)

Year	Food	Beverages	Textiles	Footwear	Funiture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	19,954.51	-268.52	1,839.46	36.23	26.35	247.14	9.12	124.01
1968	14,748.72	3,012.93	4,021.82	82.74	314.26	352.32	55.55	352.08
1969	3,923.74	-345.52	-2,360.13	131.82	425.20	645.41	70.94	352.42
1970	-4,432.42	3,031.41	5,370.25	357.83	931.76	662.88	66.23	1,205.05
1971	-4,667.61	4,013.92	4,948.50	762.44	380.85	669.42	-14.54	1,604.21
1972	18,372.10	2,141.81	1,048.63	36.32	481.85	-467.81	133.56	242.63
1973	14,701.94	2,797.92	5,056.09	253.82	188.43	710.72	-49.85	138.46
1974	-7,922.25	3,815.51	3,669.90	502.71	814.24	2,104.62	--5.23	515.01
1975	-2,019.01	14,691.12	24,435.81	437.92	2,880.63	2,746.04	248.13	586.62
1976	-3,517.25	2,246.71	3,153.94	364.63	2,509.32	2,571.71	112.94	-1,184.75

TABLE B25

LIQUIDITY Z1t (VI = 1.00)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prod.	Leather & Leather wks.	Rubber Products.
1967	19954.51	-268.52	1839.46	36.23	26.35	247.14	9.12	124.01
1968	19937.33	2945.81	4481.65	91.74	320.82	414.15	57.86	383.02
1969	12649.52	340.06	-894.81	161.53	510.35	795.36	87.14	471.43
1970	5274.32	3631.13	6245.52	420.41	1123.13	974.04	100.16	1412.19
1971	3931.10	5371.41	7166.31	914.42	805.15	1146.36	36.07	2112.58
1972	25803.81	4502.82	4503.56	378.94	1001.35	1112.06	180.43	1151.94
1973	26726.61	5694.32	8774.10	97.93	828.37	1471.86	75.31	1108.32
1974	7778.03	7411.44	8651.21	410.22	1501.23	3043.45	107.56	1519.53
1975	11700.72	19240.09	30334.16	471.13	3771.12	4211.64	359.05	1719.86
1976	9697.84	10469.32	15161.61	507.35	4119.96	4723.33	286.46	95.23

TABLE B26

LIQUIDITY Zlt (VI = 1:25)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prod.	Leather & Leather wks	Rubber Products.
1967	19954.51	-268.52	1839.46	36.23	26.35	247.14	9.12	124.01
1968	24925.93	2878.74	4941.53	100.86	327.44	475.92	60.15	414.06
1969	23869.61	993.20	800.52	195.85	598.84	976.13	104.46	605.93
1970	22461.08	4532.01	8140.96	503.75	1361.30	1398.81	143.52	1698.14
1971	26734.01	7405.39	11096.92	1123.63	1383.61	1920.82	115.36	2823.02
1972	55290.33	8388.01	11208.31	869.02	1925.70	2366.71	288.55	2568.23
1973	70035.71	11676.55	68280.19	805.33	2234.02	3318.26	255.53	3166.72
1974	68596.03	16312.71	22728.30	1318.76	3465.51	5719.40	351.63	4369.68
1975	89667.71	32220.40	50093.81	1709.51	6601.82	8317.51	691.54	5662.30
1976	110081.70	31503.96	47444.32	2173.14	8601.15	10908.60	791.33	5453.32

TABLE: B27

LIQUIDITY Zlt (VI = 1.50)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper Paper Prod.	Leather & Leather wks	Rubber Products
1967	19954.51	-268.52	1839.46	36.24	26.35	247.14	9.12	124.01
1968	29914.62	2811.63	5401.32	109.85	334.01	537.72	62.46	445.02
1969	37584.01	1612.21	2725.66	234.53	690.56	1187.83	122.94	755.93
1970	49000.93	5708.86	11228.73	610.74	1648.65	1960.41	197.43	2074.65
1971	72158.11	10303.15	17763.91	1410.15	2154.19	3112.92	232.05	3812.31
1972	130109.92	14586.71	23983.13	1579.72	3428.06	4635.13	492.42	4757.91
1973	196087.63	23071.61	40245.21	2088.61	4970.03	7312.52	633.56	7093.32
1974	275182.84	36324.52	60245.02	3445.22	8127.92	12540.41	982.51	11051.20
1975	416696.93	66316.31	112050.93	5228.73	14461.81	19978.83	1725.80	16777.14
1976	623042.56	90702.92	152903.44	7879.31	22041.56	30479.76	2515.62	23541.13

TABLE: B28

LIQUDITY Z1t (V1 = 1.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	19954.51	-268.53	1839.46	36.24	26.35	247.14	9.12	124.01
1968	34903.20	2744.43	5861.24	118.95	340.53	599.46	64.62	476.03
1969	53792.81	2197.54	4880.71	277.93	785.42	1430.21	142.45	921.41
1970	86762.01	7136.13	15681.52	745.24	1987.35	2681.62	262.24	2553.03
1971	150490.06	14228.51	28363.41	1798.13	3159.82	4865.11	394.83	5168.26
1972	285231.44	24031.32	46973.25	2611.21	5725.93	8479.16	835.31	8083.81
1973	500077.82	43246.31	86473.64	4288.60	9847.36	15199.10	1356.72	14103.14
1974	856187.63	77398.10	151206.02	7817.42	17905.71	28170.01	2406.42	25091.06
1975	1502251.08	147276.26	286293.94	13741.44	33604.09	50465.00	4463.26	44110.16
1976	2626936.34	248961.82	485841.36	24083.76	59157.41	88826.71	7737.55	75569.00

TABLE B29

NET PROFIT Zlt (VI = 0.25)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixture	Paper & Peper Prod.	Leather & Leather wks.	Rubber Products
1967	20077.41	-258.02	3162.63	32.66	104.85	125.43	10.15	235.40
1968	4044.41	3106.82	3728.91	49.62	309.43	226.64	28.75	2812.95
1969	-6147.10	4413.62	4132.40	82.03	215.66	655.05	23.05	912.60
1970	-8317.80	-2407.95	1854.81	230.85	668.06	287.50	7.03	1304.35
1971	-4261.46	1425.80	-1522.11	523.93	-540.60	109.95	-45.70	1043.74
1972	21415.20	1930.25	-4257.50	-407.00	75.64	28.32	189.34	-631.35
1973	5993.53	2372.20	611.63	-353.45	-53.02	277.96	-54.00	-6.25
1974	-15734.20	-2997.22	3989.16	119.60	1653.03	1594.04	-29.20	773.35
1975	718.63	7863.06	19324.10	47.64	2301.25	1360.76	313.85	-247.39
1976	-2921.72	-6285.48	-13046.25	36.05	762.10	649.13	-119.80	-2527.74

TABLE B30

NET PROFIT Zlt (VI = 0.50)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prod.	Leather & Leather wks.	Rubber Products.
1967	20077.41	-258.02	3162.63	32.66	104.85	125.43	10.15	235.40
1968	-975.11	3042.32	4519.51	57.72	335.63	257.94	31.25	393.15
1969.	-6670.70	5158.25	5459.95	98.45	306.16	727.35	31.43	405.95
1970	-10116.25	-932.17	3551.68	259.53	767.12	487.38	16.91	1279.08
1971	-7240.03	1561.71	-209.96	595.96	-324.05	281.69	-38.94	1357.14
1972	18860.49	2354.56	-3772.02	-240.02	48.67	141.64	181.23	-213.64
1973	10069.95	3066.88	-160.01	-371.61	-47.56	341.62	-10.68	44.78
1974	-12197.63	-2056.76	3743.80	102.09	1642.42	1695.36	-21.04	797.19
1975	-1446.72	6555.34	2010.71	48.75	2709.11	1809.86	310.58	-42.00
1976	-3824.66	-4973.43	-7822.85	48.48	1541.36	1213.83	-42.91	2444.90

TABLE B 31

NET PROFIT Zlt (VI = 0.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prodts.	Leather & Leather wks.	Rubber Products
1967	20077.41	-258.02	3162.63	32.66	104.85	125.43	10.15	235.40
1968	14083.19	2977.81	5310.29	65.94	361.84	289.36	33.86	452.05
1969	3404.10	5870.52	7182.90	119.03	409.66	815.45	41.25	548.40
1970	-4227.92	891.63	6208.91	299.65	921.32	735.30	32.10	1487.41
1971	-5352.81	2696.50	2670.93	690.96	-1660.10	589.51	-23.36	1833.26
1972	18465.90	3596.11	-1873.82	-19.80	198.32	442.96	183.25	482.70
1973	14489.12	4586.72	320.76	-266.52	76.81	603.05	36.14	513.16
1974	-6365.80	-150.20	4063.50	88.01	1723.80	1976.81	11.42	1160.00
1975	-122.31	8499.71	2137.41	63.76	3180.82	2444.81	329.76	429.40
1976	-3193.05	-1876.34	-16274.22	71.92	2572.40	2142.52	49.15	-2143.96

TABLE B32

NET PROFIT Zlt (VI = 1.00)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prodts.	Leather & Leat. wks.	Rubber Products.
1967	20077.41	-258.02	3162.63	32.66	104.85	125.43	10.15	235.40
1968	19102.44	2913.35	6100.82	74.06	388.09	320.62	36.33	510.85
1969	11944.26	6550.41	9301.05	143.67	526.22	919.01	52.18	720.26
1970	5163.20	-230.62	10122.73	353.91	1140.34	1042.71	53.35	1796.36
1971	2981.31	1797.25	8136.96	820.15	432.73	1080.76	5.91	2513.92
1972	25461.82	3370.93	4259.92	282.13	643.46	1081.59	206.63	1621.75
1973	26101.56	5260.52	5985.94	30.55	571.51	1352.33	105.30	1773.31
1974	8868.93	1670.36	9809.73	318.42	2237.73	2876.85	89.64	2548.12
1975	13521.05	10282.63	28136.51	316.12	4125.64	3839.01	410.7.33	2107.52
1976	10419.71	2031.52	10259.31	340.25	4312.26	4147.91	212.54	-358.42

TABLE B33

NET PROFIT Zlt (VI = 1.25)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixts.	Paper & Paper Prod.	Leather & Leath. wks.	Rubber Products.
1967	20077.41	-258.02	3162.63	32.66	104.85	125.43	10.15	235.40
1968	24121.82	2848.83	6891.52	82.24	414.23	352.00	38.86	569.75
1969	22994.10	7198.14	11814.66	172.43	656.08	1038.44	64.36	921.50
1970	21961.63	5486.30	15590.03	425.85	1434.10	1421.79	81.64	2228.06
1971	25270.10	8885.71	17501.72	998.50	1085.03	1815.10	54.64	3502.61
1972	54068.11	12680.80	18000.15	710.16	1567.09	2269.78	269.80	3486.10
1973	68224.81	17740.62	24226.14	636.00	1886.96	3108.05	235.80	4509.21
1974	68048.40	18585.68	34106.40	1082.96	4024.83	5409.54	278.15	6411.32
1975	89712.62	31844.34	60959.83	1351.35	6918.90	7724.10	668.78	7573.50
1976	109039.5	31554.30	58322.62	1713.20	8835.4	9964.00	637.76	7001.08

TABLE B 34

NET. PROFIT Zlt (VI = 1.50)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixture	Paper & Paper Prod.	Leather & Leather Wks.	Rubber Products
1967	20,077.41	-258.02	3,162.63	32.66	104.85	125.43	10.15	235.40
1968	29,141.12	2,784.33	7,682.15	90.36	440.42	383.34	41.35	628.56
1969	36,553.45	7,813.55	14,723.35	204.05	798.83	1,173.35	77.83	1,152.15
1970	48,049.18	8,209.03	22,906.73	516.38	1,812.36	1,883.73	117.94	2,804.33
1971	69,891.87	14,341.35	32,374.29	1,240.76	2,010.85	2,863.59	224.38	4,924.10
1972	127,317.81	23,085.72	44,684.44	1,323.14	3,226.98	4,296.18	537.16	6,493.94
1973	191,616.41	36,518.18	68,752.66	1,071.54	4,768.56	6,715.07	704.43	9,892.51
1974	287,424.61	51,187.06	106,952.79	1,895.21	8,819.04	11,597.11	1,040.95	15,613.57
1975	435,789.02	85,392.89	178,755.99	2,840.52	15,116.46	18,357.85	1,882.52	22,979.75
1976	650,582.22	119,838.24	250,256.78	4,284.88	22,861.49	27,845.49	2,625.30	32,003.73

TABLE B35

NET PROFIT Zlt (VI = 1.75)

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixture	Paper & Paper Prod.	Leather & Leather wks.	Rubber Products
1967	20077.41	-258.02	3162.63	32.66	104.85	125.43	10.15	235.40
1978	34100.50	2719.81	8472.82	98.53	466.66	414.72	43.91	687.41
1979	52622.72	8396.80	18027.61	242.05	954.82	1324.13	92.62	1412.41
1970	85308.71	11183.16	32370.00	633.83	2285.05	2440.91	163.33	3547.84
1971	147108.30	21598.20	54661.71	1575.46	3291.23	4309.65	238.42	6926.31
1972	279920.10	39370.22	91781.02	2219.04	5970.31	7542.61	617.93	11228.84
1973	490499.74	70788.22	162342.80	3631.71	10376.10	13470.42	980.05	19802.01
1974	841141.92	120289.26	287923.71	6643.40	19824.41	25097.72	1699.36	35428.33
1975	1476650.45	219118.43	522193.36	11623.75	36580.66	44883.21	3294.93	61558.95
1976	2581036.93	375206.15	895961.10	20365.61	64202.92	78854.56	5567.93	105262.21

TABLE B36

DATA FOR THE SYNTHETIC VARIABLE Z_{2t}

Year	0.25	0.5	0.75	1.0	1.25	1.5	1.75
1967	0.0625	0.2500	0.5625	1.0000	1.5625	2.2500	3.0625
1968	0.0156	0.1250	0.1406	1.0000	1.9531	3.3750	5.3594
1969	0.0039	0.0625	0.0352	1.0000	2.4414	5.0625	9.3789
1970	0.0009	0.0313	0.0080	1.0000	3.0518	7.5938	16.4131
1971	0.0002	0.0156	0.0222	1.0000	3.8147	11.3906	28.7229
1972	0.00006	0.0078	0.0006	1.0000	4.7683	17.0859	50.2651
1973	0.00002	0.0039	0.00014	1.0000	5.9605	25.6289	87.9639
1974	0.000005	0.0020	0.000030	1.0000	7.4506	38.4434	153.9368
1975	0.000001	0.0010	0.000009	1.0000	9.3132	57.6650	269.3900
1976	0.000000	0.0005	0.000008	1.0000	11.6415	86.4977	471.4325

APPENDIX C

DATA FOR THE SECOND STAGE MAXIMUM LIKELIHOOD REGRESSIONS

In this Appendix, we report the data utilized for the second stage maximum likelihood (ML) regressions whose results appeared in Tables 8 - 12 The data were obtained firstly by using the maximum likelihood values of θ obtained from the first stage regressions to generate a new Z_t variable from the relationship $Z_t = Z_{1t} + \theta Z_{2t}$ where the Z_{1t} and Z_{2t} values were chosen so as to correspond to the maximum likelihood value of V_1. For example, under the Neoclassical I model from Table 3 the following ML values for the Food industry were obtained: $V_1{*} = 1.50$, $\theta = -620.60$. From Table B6 the series corresponding to $V_1 = 1.50$ for the food industry were then picked to represent the series for Z_{1t}. The Z_{2t} series were picked from column 6 in Table B36 which corresponds to $V_1 = 1.50$. Z_t for the Food industry under the Neoclassical I model was then generated according to the preceding relationship. Finally, Z_{t-1} series were generated from the Z_t series and both were used as explanatory variables in the second stage regression.

Tables C1 - C10 then contain the data for the Z_t and Z_{t-1} variables for the five models and eight industries.

TABLE CI

DATA FOR THE SECOND STAGE ML REGRESSIONS:

NEOCLASSICAL I. Z_t

Year	Food	Beve-rages	Textiles	Footwear	Funiture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1967	-927.36	56.48	-18.75	3.10	-5.63	16.88	77.75	-3.42
1968	-1349.04	39.02	10.22	8.34	-5.02	12.95	37.60	-0.80
1969	-1999.00	47.81	82.07	16.22	3.08	17.78	25.91	14.10
1970	-2995.91	31.10	95.55	20.02	-4.18	2.59	14.76	7.75
1971	-4479.57	-16.74	94.93	22.39	-8.82	3.20	-1.21	3.32
1972	-6705.63	15.52	26.65	85.16	-14.40	-2.20	-0.51	3.98
1973	-10034.54	24.97	47.28	126.75	-21.71	2.20	-0.06	4.55
1974	-15036.04	15.80	83.72	193.22	-28.75	5.20	9.61	6.34
1975	-22538.48	24.70	155.09	292.33	-33.82	6.31	7.11	8.91
1976	353753.61	18.15	222.23	439.49	-55.04	10.65	15.06	11.57

TABLE C2

DATA FOR THE SECOND STAGE ML REGRESSIONS:

NEOCLASSICAL I_ϕ Z_{t-1}

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1968	-927.36	56.48	-18.75	3.10	-5.63	16.88	77.75	-3.42
1969	-1349.04	39.02	10.22	8.34	-5.02	12.95	37.60	-0.80
1970	-1999.00	47.81	82.07	16.22	3.08	17.78	25.91	14.10
1971	-2995.91	31.10	95.55	20.02	-4.18	2.59	14.76	7.75
1972	-4479.57	-16.74	94.93	22.39	-8.82	3.20	-1.21	3.32
1973	-6705.63	15.52	26.65	85.16	-14.40	-2.20	-0.51	3.98
1974	-10034.54	24.97	47.28	126.75	-21.71	2.20	-0.06	4.55
1975	-15036.04	15.80	83.72	193.22	-28.75	5.20	9.61	6.34
1976	-22538.48	24.70	155.09	292.33	-33.82	6.31	7.11	8.91

TABLE C3

DATA FOR THE SECOND STAGE ML REGRESSIONS:

NEOCLASSICAL II. Z_t

Year	Food	Beve- rages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1967	-32.99	-6.53	-20.69	--4.95	9.15	16.45	-59.52	-2.56
1968	-23.92	-0.39	39.07	-4.31	9.23	12.25	-30.73	0.91
1969	-17.03	21.95	107.57	-28.08	2.22	15.79	-11.01	14.82
1970	-18.66	-48.07	114.95	-1.90	10.39	3.03	2.02	6.71
1971	-16.33	52.59	96.44	-9.75	15.56	2.97	1.14	0.33
1972	-269.22	117.47	120.79	-13.58	17.89	-3.01	1.19	1.50
1973	14.80	219.44	155.65	-20.57	22.85	1.89	0.04	3.10
1974	40.44	+402.26	208.16	-28.26	24.65	5.29	8.10	4.47
1975	49.42	99.21	288.63	-41.44	21.81	6.22	6.23	10.77
1976	81.40	161.82	371.86	-61.27	31.59	9.84	13.06	12.83

TABLE C4

DATA FOR THE SECOND STAGE ML REGRESSIONS:

NEOCLASSICAL II, z_{t-1}

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1968	-32.99	-6.53	-20.69	-4.95	9.15	16.45	-59.52	-2.56
1969	-23.92	-0.39	39.07	-4.31	9.23	12.25	-30.73	0.91
1970	-17.03	21.95	107.57	-28.08	2.22	15.79	-11.01	14.82
1971	-18.66	-48.07	114.95	-1.90	10.39	3.03	2.02	6.71
1972	-16.33	52.59	96.44	-9.75	15.56	2.97	1.14	0.33
1973	-269.22	117.47	120.79	-13.58	17.89	-3.01	1.19	1.50
1974	14.80	219.44	155.65	-20.57	22.85	1.89	0.04	3.10
1975	40.44	-402.26	208.16	-28.26	24.65	5.29	8.10	4.47
1976	49.42	99.21	288.63	-41.44	21.81	6.22	6.23	10.77

TABLE C5

DATA FOR THE SECOND STAGE ML REGRESSIONS:

ACCELERATOR, z_t

Year	Food	Beve-rages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1967	55.81	140.14	-15.99	-4.37	-123.87	18.17	0.00	-4.57
1968	42.17	83.97	11.32	-3.89	-27.12	13.45	-0.40	0.49
1969	48.65	12.96	58.05	1.28	6.22	23.28	1.00	17.93
1970	46.46	82.88	63.46	-1.29	-8.79	25.87	3.69	12.31
1971	45.56	-6.54	34.33	-8.24	-5.35	36.37	1.75	0.79
1972	52.88	22.82	46.61	-13.26	1.24	50.65	2.92	1.50
1973	55.63	22.81	62.97	-20.10	0.60	78.32	4.28	3.48
1974	63.02	16.40	93.51	-31.54	2.35	121.69	3.03	5.44
1975	56.67	27.91	140.89	-49.22	12.09	187.50	3.64	13.31
1976	49.20	18.76	170.91	-69.22	-0.78	283.98	1.25	16.84

TABLE C6

DATA FOR THE SECOND STAGE ML REGRESSIONS:

ACCELERATOR, Z_{t-1}

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1968	55.81	140.14	-15.99	-4.37	-123.87	18.17	0.00	-4.57
1969	42.17	83.97	11.32	-3.89	-27.12	13.45	-0.40	0.49
1970	48.65	12.96	58.05	1.28	6.22	23.28	1.00	17.93
1971	46.46	82.88	63.46	-1.29	-8.79	25.87	3.69	12.31
1972	45.56	-6.54	34.33	-8.24	-5.35	36.37	1.75	0.79
1973	52.88	22.82	46.61	-13.26	1.24	50.65	2.92	1.50
1974	55.63	22.81	62.97	-20.10	0.60	78.32	4.28	3.48
1975	63.02	16.40	93.51	-31.54	2.35	121.69	3.03	5.44
1976	56.67	27.91	140.89	-49.22	12.09	187.50	3.64	13.31

TABLE C7

DATA FOR THE SECOND STAGE ML REGRESSIONS:

LIQUIDITY, z_t

Year	Food	Beve-rages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1967	335.12	-6389.88	-376.55	-759.80	2192.85	-1479.94	447.65	2021.78
1968	10044.87	-4772.86	3467.91	-1084.20	3035.53	-1682.90	272.62	763.71
1969	2696.03	-8571.40	-2498.77	-1556.50	3983.99	-1722.42	165.66	279.34
1970	-4739.35	-7423.94	5335.53	-2075.80	5592.80	-1974.44	95.83	1010.38
1971	-4744.34	-7539.35	4939.83	-2619.68	6672.92	-2295.68	16.14	952.29
1972	18393.03	-10292.26	1046.24	-4464.91	8537.22	-2903.84	136.29	-722.19
1973	14697.06	-11674.78	5056.35	-6978.32	10498.61	-3270.06	-36.96	-224.00
1974	-7923.30	-12876.28	3669.78	-10155.20	13796.21	-2515.97	13.72	354.95
1975	-2019.32	-4265.64	24435.77	-15171.93	19515.13	-1976.65	258.96	289.10
1976	-3517.53	-14103.36	3153.87	-22721.65	24742.79	-1959.10	56.38	-1552.31

TABLE C8

DATA FOR THE SECOND STAGE ML REGRESSIONS:

LIQUIDITY, Z_{t-1}

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products
1968	335.12	-6389.88	-376.55	-759.80	2192.85	-1479.94	447.65	2021.78
1969	10044.87	-4772.86	3467.91	-1084.20	3035.53	-1682.90	272.62	763.71
1970	2696.03	-8571.40	-2498.77	-1556.50	3983.99	-1722.42	165.66	279.34
1971	-4739.35	-7423.94	5335.53	-2075.80	5592.80	-1974.44	95.83	1010.38
1972	-4744.34	-7539.35	4939.83	-2619.68	6672.92	-2295.68	16.14	952.29
1973	18393.03	-10292.26	1046.24	-4464.91	8537.22	-2903.84	136.29	-722.19
1974	14697.06	-11674.78	5056.35	-6978.32	10498.61	-3270.06	-36.96	-224.00
1975	-7923.30	-12876.28	3669.78	-10155.20	13796.21	-2515.97	13.72	354.95
1976	-2019.32	-4265.64	24435.77	-15171.93	19515.13	-1976.65	258.96	289.10

TABLE C9

DATA FOR THE SECOND STAGE ML REGRESSIONS:

EXPECTED PROFIT, z_t

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products.
1967	1186.29	10003.00	9354.79	43.20	-67.95	-11705.85	696.28	2521.32
1968	9361.17	8172.80	14631.64	105.93	181.27	-14436.87	374.39	3383.46
1969	2221.94	7723.50	21489.87	227.90	410.11	-17447.86	203.00	1055.24
1970	-4523.44	350.46	27684.28	552.14	1229.27	-21686.53	102.69	1337.22
1971	-5426.69	919.37	32619.36	1294.42	1136.30	-27069.81	4.02	1051.01
1972	18445.75	2674.70	36896.87	1403.63	1915.16	-33835.87	202.64	-629.11
1973	14484.44	3226.95	47847.56	1192.28	2800.83	-42024.91	0.03	-5.47
1974	-6366.81	-1976.72	63632.73	2076.32	5867.44	-51006.44	-15.69	773.12
1975	-122.60	6596.38	97867.01	3112.19	10689.06	-62795.50	307.83	-247.26
1976	-3193.27	-4952.91	104457.86	4692.38	16220.39	-78185.44	-41.54	-2527.70

TABLE C10

DATA FOR THE SECOND STAGE ML REGRESSIONS:

EXPECTED PROFIT, $\hat{z}_{t-1}$

Year	Food	Beverages	Textiles	Footwear	Furniture & Fixtures	Paper & Paper Products	Leather & Leather Works	Rubber Products.
1968	1186.29	10003.00	9354.79	43.20	-67.95	-11705.85	696.28	2521.32
1969	9361.17	8172.80	14631.64	105.93	181.27	-14436.87	374.39	3383.46
1970	2221.94	7723.50	21489.87	227.90	410.11	-17447.86	203.00	1055.24
1971	-4523.44	350.46	27684.28	552.14	1229.27	-21686.53	102.69	1337.22
1972	-5426.69	919.37	32619.36	1294.42	1136.30	-27069.81	4.02	1051.01
1973	18445.75	2674.70	36896.87	1403.63	1915.16	-33835.87	202.64	-629.11
1974	14484.44	3226.95	47847.56	1192.28	2800.83	-42024.91	0.03	-5.47
1975	-6366.81	-1976.72	63632.73	2076.32	5867.44	-51006.44	-15.69	773.12
1976	-122.60	6596.38	97867.01	3112.19	10689.06	-62795.50	307.83	-247.26

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