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A simulation study of the Nigerian asset allowance policy: the impact of asset mortality

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A simulation study of the Nigerian asset allowance policy:

The impact of asset mortality

by

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I. INTRODUCTION

For the last two decades, industrialization has been a central theme in the Economic Development Programs of Nigeria. As a developing country, she has placed a high premium on economic self-reliance, large-scale provision of jobs for the masses, the reduction of leakages in the national economy,[1] and the development of local technical manpower. The resulting growth of the Nigerian Industry has been accompanied, among other side effects, by a progressive increase in the importation and use of capital equipment and machinery.

To encourage investment in capital goods, the Nigerian government has continuously offered various incentives to Industry. One such incentive is the National Capital Allowance Policy for the computation of annual income taxes, a surrogate for accelerated tax depreciation.

Tax depreciation is a procedure whereby industries are granted tax-free cash recovery, over time, of some initial expenditure on industrial fixed assets. A rational scheme of cash recovery attempts to follow the actual pattern of value erosion of the asset, at least on the average; an accelerated depreciation schedule attempts to advance the cash recovery beyond the pattern of value erosion, to the advantage of industry.

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[1]Leakages from the local industries to the world economy occur primarily from: (1) the importation (rather than local manufacture) of semi-finished goods as inputs to local manufacturers; and (2) export-based industries which manufacture semi-finished goods solely for export, thus forfeiting the potential forward gains of further processing and utilization (22).

Figure 1.1. Map of Nigeria showing present state structure

The current tax depreciation policy in Nigeria features all industrial equipment as homogeneous in service life characteristics; world-wide experience in industry points to the contrary. The impact of equipment mortality on the tax depreciation benefits, for different classes of industrial equipment employed in the Nigerian industry, is investigated by computer simulation in this study.

A. Historical Development of Nigerian Industry

Nigeria, Africa's most populous nation, lies on the West Coast of the Continent. Nigeria has an area of about 356,699 square miles, with an Atlantic coastline to the south, the Republic of Cameroun to the east, the Niger Republic to the North, and the Republic of Benin to the West. The country lies entirely within the tropics, between the parallels of 4^{o} and 14^{o} North and within the 15th meridian East of Greenwich.

Nigeria is a composite territory of nineteen states, as shown in Figure 1-1, which has grown out of the amalgamation in 1914 of the Colony and Protectorate of Southern Nigeria with the Protectorate of Northern Nigeria. There are three main ethnic groupings: the Housas in the North, the Ibos in the East, and the Yorubas in the West. English is the official language, but Housa, Ibo and Yoruba are widely spoken.

Nigerian economic history over the first three decades of the twentieth century, was characterized by an economic growth which was primarily stimulated by agricultural exports. Growth in agricultural production and export led to an expansion of the export marketing structure (19, p. 15). This period of gradual economic growth was suddenly interrupted by the world economic crisis of 1929 when international trade virtually collapsed.

A renewed expansion of exports in the mid-thirties came to a halt with the second world war.

Nigerian export earnings are derived not from agricultural products alone. Tin ore, columbite and tantalite production were of great strategic value prior to the crude oil boom. Tin from the Jos Plateau was extracted, cast into local furnaces by Hausa smelters and traded long before the colonial period (18, p. 350). The Royal Niger Company started explorations in 1902 and began tin mining in 1904. Rail routes were opened after 1911, and exports increased steeply until the depression of the 1930's. By 1967, there were 101 companies, syndicates, and private individuals holding 3,505 mining leases on 257,427 acres. The United Kingdom is the principal importer of Nigerian tin; in 1968 it received 85 per cent of its tin metal imports from Nigeria, which accounted for two-thirds of Nigeria's exports of tin metal. Nearly all the ore is smelted locally in Jos, Nigeria.

Nigeria furnishes the greater part of the world supply of columbite, an ore used in the production of heat-resistant steels for jet engines, gas turbines, and other products. Lead and zinc with some associated silver, are produced in the Abakiliki and Owerri areas of the country for export. Nigeria has a reserve of lead and zinc estimated at 76 million long tons (18, p. 30). The National mineral reserves also include an estimated 240 million long tons of coal and large reserves of iron ore and petroleum.

Before the mid-1950's the prospects for discoviring crude oil in Nigeria were generally regarded as poor. The first scan for oil was started in 1908 by a German firm, which abandoned the effort at the outbreak of the 1st World War. The search was revived in 1938 by Shell-British Petroleum consortium. After a five-year interval during World War II, exploration was intensified in 1946. The first commercial discovery was made in 1956 at Oloibiri, and oil was exported in 1958. By 1977 there were ten international oil companies holding oil prospecting licenses or oil mining leases in Nigeria.

Nigeria's modern industrialization is a phenomenon of the 1960's and 1970's. The number of industrial enterprises in Nigeria has increased rapidly and progressively since the second world war. The major contributory factors for this rapid expansion are: 1. the abundance of natural resources, and 2. the immense size of the domestic market. Nigeria's crude oil revenue stood at $7,900 million in 1976, or 90% of all foreign exchange earnings for that year. The process of modern industrialization grew out of the competition of foreign enterprises vying for the Nigerian market. The momentum of growth has since been sustained by the industrial policies of the Nigerian government (19, p. 22).

After petroleum production, manufacturing has been the fastest growing sector of the Nigerian economy since 1960. From a very low base, it has expanded at an annual rate of 11% at constant prices (18, p. 356). A well-developed system of transportation[1] has also given the country a head-start in industrialization, in comparison with most other developing countries.

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[1]The Nigerian transportation network includes: (a) 2,178 route-miles of railways with 240 steam locomotives, 89 diesel locomotives, 6,612 rail cars with a carrying capacity of 173,339 tons; (b) 55,500 miles of road network with tarred surfaces; (c) three international port networks; and (d) jet air transportation connecting the larger cities of the country (18, p. 35).

Basic industrial structural changes, with emphasis on industrial development, first began with the launching of the First National Development Plan, 1962-1968 plan period, by the Nigerian government (13). Successive Development Plans, the second and the third, have, like the first, had the central objective of utilizing the crude oil revenues to transform the National Economy into a modern state, both technologically and industrially (12, p. 135). The rapid expansion of the Nigerian industry has given rise to a correspondingly sharp increase in imports, mainly of machinery and transportation equipment (see Table 1-1).

B. Historical Development of the Asset Allowance Policy

The corporate form of business was practically non-existent in Nigeria prior to 1939, in contrast with the more advanced countries with corporate histories dating back a century or more. Before the introduction of corporate business into Nigeria, all income from businesses was treated as either personal income or as partnership income, for tax purposes. In the earlier years of corporate practice in Nigeria, there were only a few operating British joint stock companies, and they were either taxed in Britain, or they were subject to special tax arrangements.

The first Nigerian Income Tax Law was enacted in 1939. The law imposed no special rates for the depreciation of fixed assets, for tax computations. In fact, the law made a provision for a reasonable amount for the exhaustion, wear, and tear of the property owned by the company, including plant and machinery to be deducted for income tax computation. This law was repealed the following year, 1940.

Table 1.1. Nigerian imports by end use (at current-year prices) [a]

Year / Item	1971	1970	1969	1968	1967
Consumer goods	160.0	102.0	71.1	62.6	85.7
Machinery and equipment	228.8	155.6	85.9	66.6	66.1
Raw materials	123.8	93.4	57.0	41.7	44.0
Fuel	4.5	11.0	15.6	14.6	8.8
Passenger cars	14.7	6.9	2.7	2.9	7.9

[a]Values in this table are in millions of £N

The 1940 income tax ordinance effected no basic change in the income tax system, which remained at 12.5% of corporate taxable income. The capital allowance provisions still remained, as before, at the discretion of the company administration. Subsequent income tax ordinances in 1943, and in 1949, brought no change to the capital allowance provisions for Nigerian industry.

It was in the 1952 income tax ordinance that the Nigerian government imposed, for the first time, specific rates for the annual depreciation allowances for capital assets. The ordinance provided for an initial allowance in addition to an annual depreciation allowance for corporate fixed assets. In effect, corporations could claim 40% of the first cost of plant and equipment in the first year (25% for mining equipment or buildings). The law stipulated annual depreciation allowances of 10% for buildings and 15% or more for mining equipment thereafter. The annual allowances for expenditures on industrial machinery and equipment was again left to the discretion of company administration, in recognition of the heterogeneity of plant service life.

The next major change to the Nigerian tax depreciation law came about with the income tax amendment law of 1958. It added another category of capital expenditure, namely plantation expenditure. The initial capital allowance for this category was 20%, and the annual depreciation charges were to be determined by company administration. The depreciation rates were generally scaled down by the income tax ordinance of 1966. In 1976, the initial allowances were 15% for industrial buildings, 20% for plant, vehicles, machinery and mining structures, and 25% for plantation facilities. Subsequent annual allowances, calculated on the declining balance, were 12.5% on all plant, machinery and mining equipment, 10% on industrial buildings, and 5% on other buildings (see Table 1-2).

C. Purpose and Scope of the Study

In general, average service life varies among different categories of industrial equipment and, with it, the pattern of value erosion with time. While some industrial machinery and equipment are only capable of rendering useful economic service for an average of a few years, such as six or seven years, some other categories of equipment have relatively protracted longevity.

Economic considerations, especially in an inflationary economy,[1] dictate that, for a businessman-beneficiary, a stream of future cash benefits should be advanced as much as possible. Consequently, there is a tendency for businessmen in such economies to prefer to invest in ventures of short duration, such as trading and merchandising. One of the objectives of accelerated depreciation schedules, such as the Nigerian Asset Allowance schedule, is to sufficiently advance the recovery of invested capital on plant and equipment to the point of attraction for investors.

Nigerian industry, for the purpose of this study, has been split up into six sectors. Each sector comprises the employers of similar (with respect to service life characteristics) machinery and equipment. The

[1]The annual rate of inflation in Nigeria ranges from 20% to 30% (6, p. 1). Very rapid inflation is more common in developing countries. This is no accident. The very urgency of the desire to develop rapidly results in a tendency for demand to outrun supply. Furthermore, lagging supply in the sectors which are less attractive to investors, particularly agriculture, results in sectoral price rises which tend to transmit themselves accross the economy.

Table 1.2. Rates of capital allowances (% of original oost)

Year / Item	1952	1967	1978
Initial allowance	40.0	15.0	20.0
Annual allowance	Unspecified[a]	10.0	12.5

[a]Although the fixing of the rates of annual allowances was left to the discretion of the administration at this period, the rate in practice was subject to a maximum of 33.33 %.

The objective of the study is to investigate the relative merits of the asset allowance policy for each of the sectors of the Nigerian industry. Specifically, the hypotheses being tested are:

1. That the Nigerian Asset Allowance Policy bestows different financial benefits on the industrial sectors.
2. An alternative depreciation schedule exists which is freer of this sectoral bias, and yet grants to industry as a whole at least as much acceleration of the recovery of invested capital as does the current policy.

II. ASSET MORTALITY CONCEPTS

The concepts of average life, elapsed life, and remaining life expectancy, as they apply to human beings, is aptly illustrated in A. E. Housman's presentation (8, p. 10.1):

"Now of my threescore years and ten,
Twenty will not come again,
And take from seventy springs a score,
It only leaves me fifty more."

The concepts of equipment mortality are closely related to the more comprehensible theories of human mortality. Considering the human individual as a unit, it is obvious that the span of unit life, from birth to demise, generally varies from one unit to another. While for some individuals the life span is reduced to zero by infant mortality, for some others it could well approach a century. It is well to note that the span of life for each individual comprises both periods of activity and periods of passivity or relative rest.[1] In other words, the realized life of an individual unit is a result of the composite effects of the different degrees of activity of its life span. For the human life span, birth marks the beginning; termination is at demise. The extinction of the human unit from the mortal stage does not preclude the continued existence of the unit elsewhere, possibly in other forms of existence. So it is, too, with assets and the concepts of the service life of an asset in an industrial

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[1] Periods of active work include times spent at work, in the games field, time spent in travelling from one place to another, etc. Periods of passivity include relaxation periods and time spent sleeping.

undertaking. The service life of an asset is the period of service within the industry for a specific purpose.

A. Industrial Property Records

Valuation studies on investments in physical property, as well as life analysis studies on industrial property units, rely heavily on accurate and up-to-date physical property accounts showing description, location, item original cost, and groups of physical property inventory. These records are stored for previous years as well as for the current year. In the absence of a satisfactory property ledger, the analyst would have to conduct extensive field inventories, correspondence, and search to develop workable data.

Property ledgers are subsidiary to property fiscal accounts of the accounting balance sheet. In some instances, they are independent of the balance sheet accounts. The fiscal accounts are the source of balance sheet information, while the property ledgers show detailed descriptions and costs of the physical properties by many subdivisions and classifications. With this dual system of accounting, work orders for construction and for plant retirements can be adequately analyzed using information obtainable from the property ledgers.

The operation of property ledgers, in most cases, necessitates cost allocations for additions to and subtractions from the many detailed classifications of items of equipment. For instance, the total cost of a building must be appropriately allocated to foundations, wiring, air conditioning equipment, etc., by type of material, as well as by function. In this case, as with most construction projects, frequent reference to construction plans and specifications is normal for the posting of the property ledger.

An efficient property accounting system will provide, on a continuing basis, the following pieces of property information (17, p. 42):

1. Property description with technical specifications and costs of components;
2. Property classification by location and function. This will, among other uses, facilitate property identification in inventory checks;
3. A continuous inventory maintained through a system of prompt work-order analysis by which property added is brought into the record and retired property is removed on the accounts by proper debit and credit entries respectively;
4. Dates of additions and retirements of property from which satisfactory analysis of retirements can be made to determine the mortality characteristics of the property group;
5. Realized salvage values as well as the costs of removal at retirement for the different classes or groups of property;
6. The amounts of the overhead costs and a breakdown of their allocations;
7. Itemization of the units of construction and assembly to show both quantities and unit costs to enable the determination of cost indexes;

8. Record of work order numbers, construction contracts, and construction plans, as a means of cross referencing to the original sources of supporting information. Samples of satisfactory property ledgers are shown in Tables 2-1 and 2-2 for item and vintage accounting respectively. In item accounting, records are kept separately for each item of property. On the other hand, a vintage is a group of property belonging to the same account classification (mainly functional classification) installed in the same accounting interval. A single account is kept for a vintage as though it were a single unit of property.

B. Property Accounting

Industrial property accounts, by their nature, can quickly become inaccurate due to omissions of physical alterations to plant and equipment on the fiscal accounts. Administrative procedures must be established which will obviate these omissions. Frequent audits and close supervision will assure the procedures are being followed.

The success of a property accounting procedure depends on close coordination between design, construction, and auditing departments. New construction, equipment additions, alterations and retirements of units or parts of units of existing property are actually undertaken only after detailed work orders are issued by the proper authority. Each work order states in detail the work to be added or the old property to be removed, with estimates of removal costs or of the costs of the additions. When the

Table 2.1. Sample property ledger form for unit accounting

Unit: Distribution poles	Date installed: 1930
Manufacturer: Minnesota & Ontario Paper Co.	Location: Sac City street system
Supplier: Same	Division: Sac City distribution
Mfg's serial no.:	Account: 354 poles, towers, and fixtures
Rating or size: 35 ft, Class 4	Subaccount:
Type or model: Western red cedar, butt-treated	Assigned no.: E-196

Date	Reference and explanations	No. in service	No. installed / No. retired	Unit cost f.o.b. or stores	Unit instal-lation cost	Total unit cost in-stalled	Cost in-stalled / Cost retired	Cost of units remain-ing in service
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mar. 2, 1930	Work order 2049	50	50	$15.70	$3.24	$18.94	$ 947.00	$ 947.00
June 8, 1930		130	80	15.20	3.24	18.44	1,475.20	2,422.20
July 17, 1930		150	20	15.20	3.24	18.44	368.80	2,791.00
Aug. 20, 1930		179	29	15.20	3.24	18.44	534.76	3,325.76
Dec. 11, 1930		309	130	14.40	3.24	17.64	2,293.20	5,618.96
Dec. 31, 1930	General overheads at 5.263 %						295.73	5,914.69
	Average unit cost of 309 poles			14.94	3.24	19.1414		
July 6, 1935	Work order A-635	308	*1*				*19.14*	5,895.55
Feb. 6, 1937	Work order A-637	307	*1*				*19.14*	5,876.41
Sep. 3, 1940	Work order A-640	304	*3*				*57.42*	5,818.99
Apr. 16, 1943	Work order A-643	301	*3*				*57.42*	5,761.57
Aug. 18, 1944	Work order A-644	300	*1*				*19.14*	5,742.43
May 6, 1946	Work order 6091	290	*10*				*191.41*	5,551.02
July 14, 1947	Work order A-647	281	*9*				*172.27*	5,378.75
Sep. 30, 1948	W.O. A-648, 6898	266	*15*				*287.12*	5,091.63
Oct. 16, 1949	Work order A-649	252	*14*				*267.98*	4,823.65
May 19, 1950	Work order A-650	246	*6*				*114.86*	4,708.80
Nov. 22, 1951	W.O. A-651, 7282	230	*16*				*306.26*	4,402.54

NOTE: In this table, retirements are indicated by italic figures.

Table 2.2. Sample property ledger form for vintage aocounting

Unit: Permuit water softener	Date installed: Oct. 5, 1931
Manufacturer: Crane Mfg. Co., Chicago	Location: Power plant building
Supplier: Midwest Supply Co., Des Moines	Division: Sac City power plant
Mfg's serial no.: 341 289-12	Account: 316 misc. power plant equipment
Rating or size: 12,000 gal per day	Subaccount:
Type or model: E-4	Assigned no.: P-321

Date	Reference and explanations	Quantity and unit	Item and description	Cost f.o.b. or stores	Installation costs	Cost installed / Cost retired	Cost of items remaining in service
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Oct. 29, 1931	Work order 3064	1	12,000-gal Permuit softener	$4,290.00	$310.00	$4,600.00	$4,600.00
			Piping as follows:				
		10′	6″ C.I.B. & S.	9.65			
		1	6″ T bell	11.00			
		1	6″ gate valve bell	24.00			
		178′	4″ C.I.B. & S.	91.60			
		4	4″ 90-deg bell	19.70			
		1	4″ 45-deg bell	4.80			
		1	4″ T bell	7.70			
		2	4″ gate valve bell	24.00			
		1	4″ float valve bell	60.00			
		1	4″ × 4″ × 2″ Y bell	6.50			
		1	4″ × 4″ × 2″ T bell	7.15			
		20′	2″ C.I.B. & S.	3.50			
		1	2″ 90-deg bell	4.50			
		1	2″ gate valve bell	7.50			
		22′	2½″ steel pipe through reservoir	8.10			
		2	2½″ 45-deg elbows	1.70			
			Total piping	$ 291.40	104.00	395.40	4,995.40
Dec. 31, 1931	General overheads at 6.1%					304.72	5,300.12
Dec. 1, 1941	Work order 4178	1	6″ gate valve bell (broken)	*24.00*	*8.56*	*32.56*	
			Overheads at 6.1%			*1.98*	5,265.58
		1	6″ gate valve bell (replacement)	20.90	10.20	31.10	5,296.68
Dec. 31, 1941	General overheads at 8.0%					2.49	5,299.17
Oct. 8, 1951	Retirement work order 5082		Entire softener sold for salvage to J. H. Blank Co., Chicago			*5,299.17*	0.00
			Cost of removal of softener			126.40	126.40
			Sale price for salvage			*175.00*	*48.60*

NOTE: In this table, retirements are indicated by italic figures.

work has been completed, the construction department prepares a final report with the details of the work done and of the costs incurred. With this record, the accounting department makes the debit and credit entries into the appropriate accounts.

If this procedure is strictly followed, the property ledger will be in agreement with the fiscal plant records. It is good practice to prove the property ledger against the fiscal accounts periodically, at least once each year. Similarly, periodic checks of property in the ledger against property actually existing will help to improve the accuracy of the property accounting records on a continuing basis. This becomes very significant in the case of industries with outside locations where field workers occasionally dispose of equipment without first going through formal administrative procedures.

Property records are best maintained on an original cost basis, although the cost may be revised or adjusted in accordance with sound judgement at the time it is established. The recording of investment cost allows a wide range of uses for property records.

C. Uses of Property Records

The uses to industry of sound property records go beyong meeting the needs of property life analysis. Good property records are of importance in the following business functions (3, p. 17).

1. Accurate property records provide a basis for the valuation of the fixed assets of a corporation for the income statement. Property appraisal values become useful when new funds are being sought from banks and investors.

2. Property records provide the basis for the computation of the economic depreciation of fixed assets. A realistic depreciation procedure helps management in the pricing of products, and in properly assessing company periodic profits.
3. Property records provide an evidence of ownership of property. This is important for a firm whose assets are spread over a wide geographic area, and especially valuable in the settlement of insurance claims, and in legal disputes over property titles.
4. Accurate property records facilitate the computation of sale values of property at disposal. This results from the fact that the cost details of the components of the property being sold are available in the records.
5. Engineering economy studies and equipment replacement decisions are greatly facilitated by accurate property accounting records. Estimates of future cash flows of existing equipment will be improved if accurate data are available on the past cash flows realized with the equipment, or with similar units of equipment.
6. Detailed property records can provide a basis for property insurance. The establishment of property insurance value and of insurance claims, in the event of damage, are facilitated.
7. Property accounting records are essential for determination of income tax depreciation deductions for capital assets of the corporation.

8. Essential data for a life analysis study of a group or category of fixed assets can be easily extracted from an adequate property record. These data include the age distribution of the surviving plant at the beginning of an accounting interval, usually January 1, and the age distributions of retirements for a number of consecutive years.[1] The age distribution of additions of used assets is an integral part of the basic data required for equipment mortality studies.

Care must be exercised in the extraction of mortality data from the books to ensure that: (1) errors have been corrected; (2) adjustments have been made for transfers and reclassification of plant and equipment; and (3) retirements caused by unusual and/or non-recurring events or reasons have been taken into consideration. Table 2-3 is a sample mortality data obtained from the property records of a U. S. Public Utility Corporation.

D. Equipment Service Life

Industrial equipment, in general, could be thought of as having two different lives. One life, the absolute life of the equipment which is governed by the physical conditions of the machine and its ability to produce even at costs that would make its continued use economically unjustifiable; the other life, the service life of the equipment which is governed by the economic considerations of retention or replacement with

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[1]In practice, experience bands of from 3 to about 10 consecutive years yield good results.

Table 2.3. Sample mortality data for a U.S. public utility company

Year		Total Plant in Service Jan. 1	Total Ret's During Year	Current Year	Age of Plant .5	1.5	2.5
	Year of Placement			1963	1962	1961	1960
1963	Plant in Service	629589			147652	174391	167555
	Additions			143521			
	Initial & Term. Exp.						
	Retirements		152231	2893	2514	0	9388
	Year of Placement			1964	1963	1962	1961
1964	Plant in Service	620879			140628	145138	174391
	Additions			159293			
	Initial & Term. Exp.						
	Retirements		166133	0	2851	0	2563
	Year of Placement			1965	1964	1963	1962
1965	Plant in Service	614039			159293	137777	145138
	Additions			148881			
	Initial & Term. Exp.						
	Retirements		177017	0	0	3101	2089
	Year of Placement			1966	1965	1964	1963
1966	Plant in Service	585903			148881	159293	134676
	Additions			155385			
	Initial & Term. Exp.						
	Retirements		156774	4570	0	7598	3942
	Year of Placement			1967	1966	1965	1964
1967	Plant in Service	584514			150815	148881	151695
	Additions			84001			
	Initial & Term. Exp.						
	Retirements		108161	0	0	0	5820
	Year of Placement			1968	1967	1966	1965
1968	Plant in Service	560354			84001	150815	148881
	Additions			66850			
	Initial & Term. Exp.						
	Retirements		[illegible]	0	0	5427	5526
	Year of Placement				1968	1967	1966
1969	Plant in Service	548123			66850	84001	145388

Table 2.3 (Continued)

Remaining January 1							
3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
1959	1958						
118762	21229						
116208	21228						
1960	1959	1958					
158167	2554	1					
158166	2553	0					
1961	1960	1959	1958				
175828	1	1	1				
171827	0	0	0				
1962	1961	1960	1959	1958			
143049	1	1	1	1			
140664	0	0	0	0			
1963	1962	1961	1960	1959	1958		
130734	2385	1	1	1	1		
99957	2384	0	0	0	0		
1964	1963	1962	1961	1960	1959	1958	
145875	30777	1	1	1	1	1	
40294	27834	0	0	0	0	0	
1965	1964	1963	1962	1961	1960	1959	1958
143355	105581	2943	1	1	1	1	1

improved alternatives. The former life is of little consequence in equipment management. A machine may still be capable of extruding components identical in number and quantity with those that it turned out in its first year, decades ago, but at an extremely exhorbitant cost, in comparison with present alternatives for doing the same job. Such a unit of equipment, if retired on the dictates of economic reasoning, as is most likely in a well-organized equipment management program, shall have reached the end of its service life, even though it is still capable of producing, and may still be put to use in the same or some other fashion in another enterprise.

In general, retirements of capital assets are brought about by three fundamental factors: (1) accidental damage; (2) operational economics; and (3) situations unrelated to the property which may arise as a result of the requirement of a public authority, or an abandoned enterprise. Accidental retirements arise from events such as fire and explosion, operational negligence causing total breakdowns, or rapid deteriorations that are technically impossible to correct without massive and unwarranted expenditure.

Property retirements on economic grounds are a result of the decision of management or other employees of an organization that the equipment or machinery should be retired. This could be the consequence of an elaborate economy study which reveals that substantial savings would be achieved by replacing an existing equipment with a more sophisticated improvement designed with the most modern technology, or it could be as a result of a "hunch" of a department head that the equipment should be disposed of, or it could be that the maintenance department estimates that it would cost far more to fix it than to buy a new one. The decision maker in this case may or may not have a clear understanding of the economic theory underlying a replacement decision; but he makes it, and the machine is eventually retired, probably with much of its absolute life still not dispensed.

If property retirements are based on sound economic rationale, using accurate data and employing sensible estimates, the service life of the equipment will approach the economic service life. Economic service life is that span of equipment use which minimizes the total annual costs of using the equipment.[1]

E. Industrial Property Survivor Curves

If a group of similar equipment is put to service at the same time (or in the same accounting period), the items of equipment comprising the group will invariably be retired with some dispersion in timing. The study of retirement dispersion patterns for different types of industrial equipment is facilitated by the use of survivor curves. The following is a definition of terms used in the study of industrial property retirement characteristics using the survivor and related curves (17, p. 142):

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[1]The total cost is the sum of the following: (1) the annual equivalent of capital costs: and (2) the annual equivalent of the operating inferiority of the existing equipment over successive annual best challengers. George Terborgh has demonstrated that this total annual equivalent cost is approximated by the following useful working formula (11):

$$\text{Total Cost} \doteq \frac{g(n-1)}{2} + \frac{(c-s)}{n} + \frac{i(c+s)}{2}$$

Where g = annual inferiority gradient
n = average service life
c = original equipment cost
s = estimated net salvage
i = discount rate

a. Original data This is a record of cost data, and of installation and retirement history relating to both the retirements from and the survivors of some equipment group.

b. Vintage group This is a collection of units of property installed in service at the same time, or at least during the same accounting interval.

c. Age For a single item of property, age is the lapsed time from the date of its installation to the observation date. For a group of property, average age is the average of the ages of the separate units comprising the group.

d. Service life The service life of an item of equipment is the period of time (or service) extending from the date of its installation to the date of its retirement from service.

e. Probable life The probable service life of a unit of property is that period of time extending from its date of installation to the forecast date when it probably will be retired from service. The probable average service life of a group of units is the average of the probable service lives of the individual units comprising the group. The probable life curve shows the probable average life of the survivors at any age on the survivor curve.

f. Expectancy The life expectancy of a unit of property is that unit of time extending from the observation date (usually the present) to the forecast date of retirement of the property unit.

g. Survivor curves A survivor curve shows the value or amount of property surviving in service, out of an original group, at successive ages. The ordinates to the curve give at any particular age the percentage (or amount) surviving in service. The abscissa is measured in years or other suitable measure of service. The original survivor curve is the curve drawn through the points calculated from the original data without adjustment. Since this original data is generally irregular, it is usually smoothed to produce an adjusted curve. The original survivor curve is generally a stub curve, that is, one which does not extend to zero percent surviving because of lack of retirement data.

h. Age interval An age interval is measured from the beginning of one age period to the beginning of the next consecutive period (usually a year or other similar unit). For calculation purposes, the units installed during an age interval are assumed to have been installed simultaneously at the middle of the interval.

i. Frequency curve When the percent surviving is read at the beginning of each successive age interval and the differences in these successive readings plotted at ages corresponding to the mid-points of the intervals, the resulting points form the frequency curve. The year in which the frequency curve has the greatest ordinate is the modal year. The survivor curve is usually generalized to apply to any amount of original group of property by expressing the survivors in percentages of the original installation. Figure 2-1 shows the general form of a survivor curve with a generalized ordinate, and the related curves. Sometimes the abscissa of the survivor curve is also generalized by expressing it in percent of the average service life of the property group. The generalized survivor curve is expressible into a mathematical function (17, p. 410). These functions separate survivor curves into three classes which can be distinguished by the modal position of the related frequency curve: for

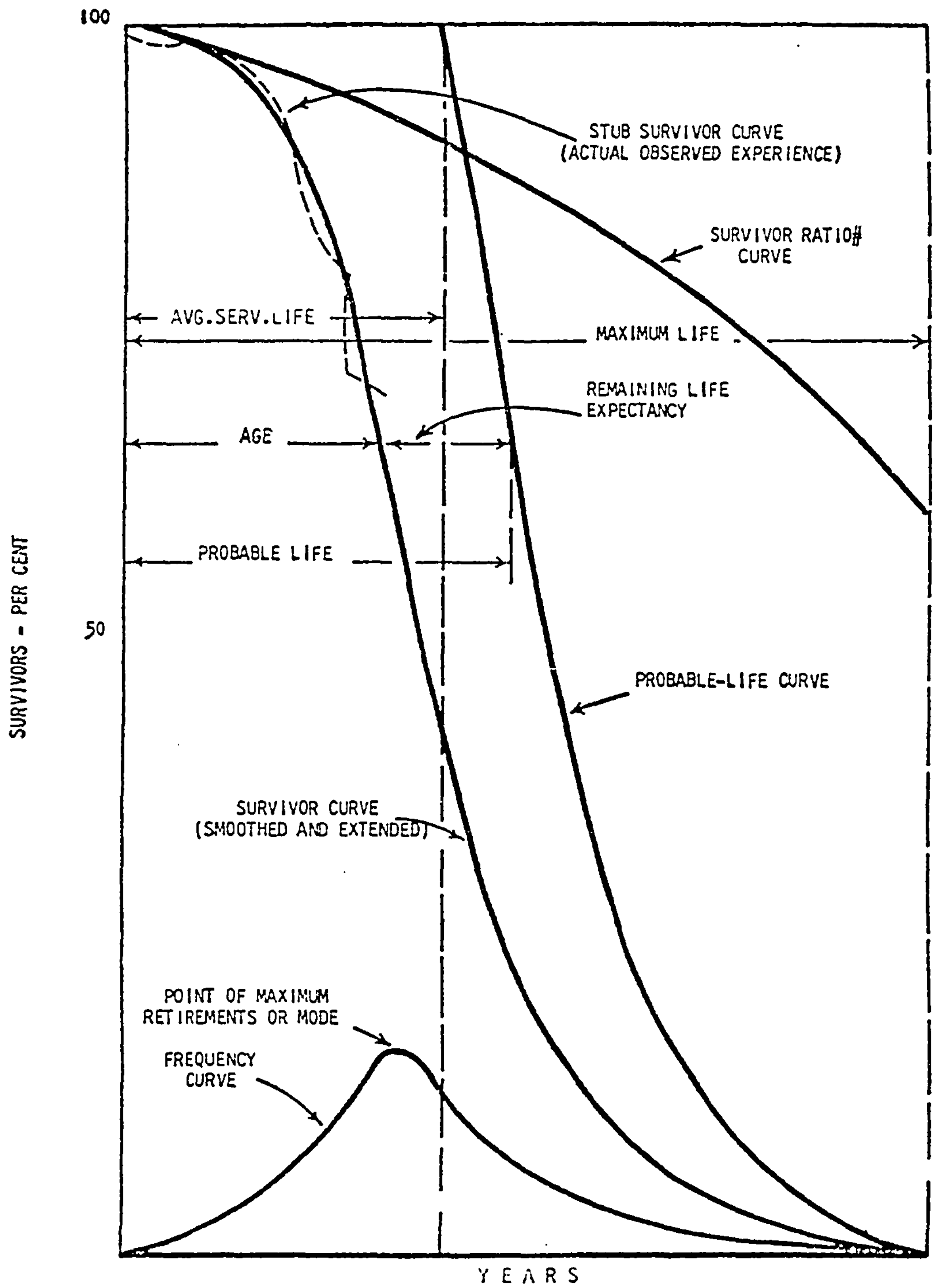

Figure 2.1. Equipment survivor and related curves

the left modal curves, the modal year is less than the average service life of the group; for the symmetrical surves, it is equal to the average service life; and for the right modal curves, the modal year of the frequency curve is greater than the average service life.

In 1935, the Iowa Engineering Experimental Station Bulletin Number 125 of Iowa State University proposed 18 generalized survivor curves. These 18 Iowa Type Curves, as they came to be called, were developed after analyzing a massive amount of statistical data. Other systems of identifying the commonly encountered patterns of property retirement are also in use, but the Iowa Type Curves are most convenient, and the best known (15, p. 129). The number of these Iowa Type curves has been increased through the years. At the time of the present study, there were a total of thirty-one distinct Iowa Type curves.

F. Analysis of Mortality Characteristics

The measurement of the consumption of the usefulness of a depreciable asset is based primarily on the age and physical condition, and on the probable service life of the asset. For a property group, the average service life of the group will be the appropriate parameter sought; for an item of property, the probable service life of the item will be useful in determining the remaining usefulness. If the typical survivor curve for a group of equipment is known, the probable life and the retirement frequency curves can be easily derived therefrom. Thus the essential elements of the retirement dispersion can be determined for that group of equipment.

A knowledge of the remaining usefulness in a group of industrial property is of practical importance in the following cases:

a. Engineering economy studies A knowledge of the remaining usefulness in an item of property is of importance in replacement decisions involving studies of the comparative advantage of an existing equipment with improved alternatives.

b. Capital budgeting Very often in industry funds must be appropriated in advance of each year, or years, for the upkeep of the productive capacity of, or the simple replacement of, expected retirements from the equipment base. Such appropriations may be aimed at maintaining a constant level of equipment services or at increasing, or less likely, decreasing the level of service by some desired amount. A knowledge of the retirement characteristics of the property group will facilitate such studies.

c. Depreciation studies Depreciation studies, whether for the income measurement of the operations of the firm, or for valuation purposes, are facilitated by a knowledge of the mortality characteristics of the equipment under consideration.

d. Simulation studies In some intances, such as modelling in the analysis of the merits of different national depreciation policies, a knowledge of the mortality characteristics of the group of equipment under consideration is of fundamental importance.

There are three actuarial[1] methods for calculating property survivor curves: the individual unit method, the original group method, and the retirement rate method.

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[1]Actuarial methods of property life analysis refer to the statistical methods of analysis which are based on the survivor curve; this is similar to the method used by the insurance actuaries, whence the name, in determining human life expectance and the corresponding insurance premium rates.

1. Individual unit method

Sometimes the original data show only the number of units retired in a given year or a series of years, and their ages at retirement. The survivor curve which results from such data shows the percentage of the original group which continued in service to any given age. It should be noted that, with this method, the retirement characteristics of the surviving units during the observation period are not taken into consideration. The average service life obtained from the survivor curve using this method is, in fact, the average age of the retirements which could otherwise have been calculated by simply dividing the sum of the total service, in unit-years, by the total number of units retired.

2. Original-group methods

There are three original group methods of analysis of property retirements:

a. Single original group method;

b. Composite original group method;

c. Multiple original group method

a. Single original group method With this procedure, the original data are available for a single vintage only, and shows the amount of the original vintage remaining in service at successive later observation dates from the time of installation. The survivor curve which results from such data describes solely the retirement experience of the single vintage on which the data were based. The retirement behavior of all other vintage groups of the same equipment category are not taken into consideration in this procedure.

b. Multiple original-group method The single original group method described above can be expanded to include the retirement experience of several vintage groups over the same observation period. The data will show the number of each vintage group remaining in service during the observation period, from which a survivor curve can be plotted, each original group furnishing one point on the curve. This procedure is called the multiple-original group method which utilizes a series of original groups and a single observation date.

The multiple original group method takes into consideration the units still in service as well as those retired from service during the observation period. However, it does not give any weight to the rate at which the units were retired from any one group since nothing is known about the number of units retired from each vintage in the observation year; it is simply known that there is a certain number of original units of each vintage group still in service at the observation date. Since each vintage provides one point on the survivor curve the method will yield a very irregular survivor curve if the total number of vintages on which the data were based is small, less than ten (27, p. 49).

e. Composite original-group method When the number of units in an original group is so small as to be unreliable, the retirement experience of more than one vintage group may be combined, using the single original group procedure, and summing retirement experiences of different vintages at equal ages. This method is called the composite original-group method, and it's especially desireable if the original vintage groups were installed in a series of consecutive years, or if the property consists of old groups of large numbers of property.

3. The retirement rate method

Of the actuarial methods outlined above, the retirement rate (sometimes called the annual rate method) is of greatest practical importance. Its merits include:

1. The retirement at one age need not necessarily influence those at other ages, in contrast with the chain relationship that exists with the observed life table;
2. No fundamental law of mortality characteristics need be assumed beyond that of the elementary law that the collective effect of the forces of retirement demand that the older an item becomes, the more likely it is to be retired;
3. Experience has shown that a simple type of equation can be used to adequately describe the retirement ratio curve;
4. The survivor curve obtained by this method does not describe the history of any particular vintage. It is rather a composite curve obtained from the retirement experience of different vintages, and indicates a more general mortality pattern suggested by the retirement experience of the vintages studied.

With the retirement ratio method, the composite annual retirement ratios are first calculated from the raw data as a function of the age of the property. These ratios are then weighted by the number or value of plant exposed to retirement in the raw data, and then smoothed by the conventional method of least squares curve fitting (APPENDIX).

A computer program is normally set up to fit the weighted retirement ratios to polynomial functions, usually for the first, second and third degree polinomials. A survivor curve is computed using the best fitting polinomial function thus determined. This survivor curve is then compared to a set of standard survivor curves, such as the set of thirty-one Iowa Type Curves, for the survivor curve which best conforms with the data. The goodness-of-fit test is used as a selection criterion, in which the average deviation between the data and the assumed function is minimized. Again, this matching process can be facilitated by the use of the computer.

G. Reliability of Actuarial Methods

Four general factors affect the reliability of the survivor curve obtained by the actuarial methods described above in representing the actual mortality characteristics of a group of industrial property:

1. The length of the original survivor curve (stub survivor curve) will affect the accuracy in the determination of the most representative standard survivor curve. A short stub survivor curve is apt to yield less accurate results.

2. The regularity and smoothness of the original survivor curve will affect the accuracy of the results. If the points on the original survivor curve are widely scattered, more than one type survivor curve might well fit the scattered data points.

3. If the future retirements of the remaining units of the property follow a natural law, or are based on circumstances similar to the factors causing retirement in the observation period used in the analysis, reliable results could be obtained. The results of the analysis are likely to be inaccurate in predicting plant retirement behavior if future retirements are prompted by a predominance of sudden and unusual causes. The judgement

of the analyst is usually required to temper the results from actuarial life analyses if such results are to be used in forecasting future plant retirement behavior.

4. The reliability of the data on which the analysis is based will greatly affect the probable accuracy of the results.

III. INCENTIVE DEPRECIATION CONCEPTS

In a taxless economy, capital investments generate annual revenues from goods and services rendered to the economy at annual costs to the firm. The resulting stream of cash flows enables the firm to make decisions on the optimal timing of capital investments. The introduction of tax depreciation procedures could have the effect of biasing the optimal investment timing. For example, a tax procedure that causes firms to dispose of property at an unduly early age in the interest of tax advantages is undesirable. This chapter discusses the development of practical alternative depreciation policies which would not bias the optimal investment timing. The distribution biases of the policies, including the current policy, are investigated by simulation in subsequent chapters.

A. Business Climate for Capital Investment

Business firms make investments in plant and equipment only when there is an adequate incentive; either that there is a strong promise of profit from investing, or that there is a strong convincing evidence that a loss will be sustained by not investing. When the prospect for profit is sufficient to compensate for the use and risk of the money required, business firms will invest in the tools of production and hire people to utilize those tools. When this prospect dims, there will be a lower level of investment which in turn breeds unemployment and economic slow-down. If the prospect for profit is completely eliminated, new investment will tend to a standstill. Thus, a close relationship seems to exist, in free competitive economies, between capital expenditures and the corporate hopes for profit.

Tax laws affect corporate profits. But in no way are they the sole determinants of domestic investment.[1] Tax laws are a part of the business climate, and unless they are peculiarly bad, they are not likely to be the dominant part. Business climate consists of, not only the tax laws and provision, and the economic situations and forcasts which can be reduced to pecuniary calculations, but also of a complex mixture of tradition, law, and the actual and the presumed attitudes in government, industry, and the general public.

B. Depreciation Policy and Optimal Investment Timing

Tax incentives, though not the sole determinants of business investment, are an essential part and factor, and have been employed by free competitive economies, large and small, to foster business investment.

Most of the industrial nations of Western Europe, and also the United States of America, Canada, and Japan, provide some form of special incentives to industry to invest and modernize. Some use unrealistically short average service lives for depreciation allowances, similar to the five-year amortization which the United States had once used in defense emergency. Some others provide special write-offs in the first year, usually called initial allowances.

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[1]In a paper he presented at the symposium "Fiscal Policy and Business Capital Formation," sponsored by the American Enterprise Institute for Public Policy Research, Dan T. Smith contended that, as one corporate chairman put it, "If the general investment climate is good, we can assume that the tax system, whatever its peculiar structure or rates, will be acceptable; but no amount of special tax advantages can overcome the fears of a generally bad situation" (1, p. 20).

It is assumed that if the Nigerian industry is to be competitive with overseas economies, special comparable incentives should be provided for business investors, both foreign and indigenous. An equitable and rational incentive policy, together with modernized administrative procedures, will place her manufacturers on equal footing with foreign competitors, at least as far as investment in machinery and equipment is concerned.

In an industry in which taxes are absent, capital investments produce streams of cash receipts and outlays, including net salvage, and the decision rule is to maximize the present worth of the lumpy stream of cash flows. Sunk investment costs enter this cash stream only to the extent that they contribute to the current expenses and possible future net salvage.

As soon as taxes are introduced to the industry, the concurrent write-off procedure immediately introduces variations to the cash streams of the investment alternatives. It is assumed, in the absence of unusual national economic circumstances, that a desirable depreciation policy will make the investment selection, with regard to expected life, the same as obtained in the taxless situation. The incidence of technological change will be incorporated in the derivations. The following is an exploration of depreciation functions that can satisfy this investment criterion (21).

Let $R_o(t)$ = net revenue of the sunk investment at time t

$M_o(L_o)$ = market value of the sunk investment at the end of time L_o from now

L_o = timing of new investment

L = optimal service life for a future chain of similar assets.

Then, the present worth of the future cash stream, V, is given by

$$V = \int_o^{L_o} R_o(t)e^{-rt}dt + M_o(L_o)e^{-rL_o} + e^{-rL_o}V^* \ldots\ldots \tag{3.1}$$

where

r = discount factor and,

$$V^* = \sum_{k=0}^{\infty} e^{-rkL}\{\int_o^{L} R(L_o+kL,t)e^{-rt}dt - C + M(L)e^{-rL}\} \tag{3.2}$$

where k is a shift parameter which permits the effect of technological change to be represented; and C = the initial investment in each of the future assets.

The objective function, V, is optimized by setting

$$\frac{\partial V}{\partial L} = 0, \quad \text{and} \quad \frac{\partial V}{\partial L_o} \leq 0,$$

which gives

$$\frac{1}{r}\{R_o(L_o) + M_o'(L_o) + \frac{\partial V^*}{\partial L_o}\} - V^* \leq M_o(L_o) \tag{3.3}$$

where $M_o'(L_o) = \frac{\partial M_o(L_o)}{\partial L_o}$

This is the "programming" form of the condition for replacing as asset: an old asset should be replaced by its most attractive alternative when the net contribution to the present worth of the firm caused by holding the asset an additional period, usually one year, does not exceed the market value of the asset.

Equation (3.3) above is the condition for maximizing the taxless present value, V.

Consider now the policy requiring the firm to follow some specified depreciation policy.

Let α = tax rate

d_o = tax depreciation function for the sunk investment u years old at the beginning of the planning period

d = tax depreciation function for the chain of future replacement investment.

Then $d_o = f\{C_o, M_o(L_o),\ u+t\}$ (3.4)

$d = f\{C, M(L),\ t\}$ (3.5)

Then the present value of the profits after taxes becomes

$$W = \int_0^{L_o} R_o(t)e^{-rt}dt + M_o(L_o)e^{-rL_o}$$

$$+ e^{-rL_o}V* - \alpha\{\int_0^{L_o}\{R_o(t)-d_o\}e^{-rt}dt + e^{-rL_o}Y*\} \qquad (3.6)$$

where

$$Y* = \sum_{k=0}^{\infty} e^{-rkL} \int_0^{L_o}\{R(L_o+kL,t)-d\}e^{-rt}dt \qquad (3.7)$$

If we define

$$A = \int_0^{L_o} d_o e^{-rt}dt + M_o(L_o)e^{-rL_o} + e^{-rL_o}A*, \text{ and}$$

$$A* = \sum_{k=0}^{\infty} e^{-rkL}\{\int_0^{L} de^{-rt}dt - C + M(L)e^{-rL}\} \qquad (3.8)$$

Then the objective function, W, can be expressed as

$$W = (1-\alpha)V + \alpha A \qquad (3.9)$$

Maximizing W with respect to L_o and L, we get

$$(1-\alpha)\frac{\partial V}{\partial L_o} \leq \alpha\{d_o e^{-rL_o} + \int_0^{L_o}\frac{\partial d_o}{\partial L_o}e^{-rt}dt + M_o'(L_o)e^{-rL_o}$$

$$-rM_o(L_o)e^{-rL_o} - re^{-rL_o}A*\} \qquad (3.10)$$

and

$$(1-\alpha)\frac{\partial V}{\partial L} = \frac{-\alpha e^{-rL_o}}{1-e^{-rL}} \{de^{-rL} + \int_o^L \frac{\partial d}{\partial L} e^{-rt} dt + M'(L)e^{-rL} - rM(L)e^{-rL}$$

$$-rM(L)e^{-rL} - re^{-rL}A^*\} \qquad (3.11)$$

Equations (3.10) and (3.11) above are the conditions for optimizing the present value of the after-tax profits in the presence of a tax depreciation policy. Using these two equations we can investigate for depreciation functions which will produce no bias in the investment decision rules set by equation (3.3). It has been shown (21) that the conditions for such bias not to appear arise under the following circumstances:

1) d = Q, that is, the taxless case:

$$2) \quad d = \begin{cases} C, & t = 0 \\ 0, & 0<t<L \\ -M(L), & t = L \end{cases}$$

which is the proposal for immediate expensing of capital outlays;

3) the depreciation function be such that its present value over the optimal life of the asset plus the present worth of its net salvage at the end of the optimal life equals the asset's initial cost. This will imply depreciation functions which allow a par value capital recovery in excess of the initial investment, and which is in contradiction with accepted tax depreciation practice. The same condition is satisfied if the depreciation function is a linear transformation of the net annual revenue,

(that is, the pattern of annual depreciation charges conforms with the pattern of estimated annual service values) and salvage is negligible.[1]

George Terborgh (23, p. 149) has suggested the orthodox double declining balance method as a good practical substitute for a depreciation function that traces the pattern of value erosion for industrial equipment and machinery, excluding industrial buildings and structures.

Since this study is concerned with industrial equipment and machinery, the double declining balance method has been used as a practical substitute for a general value-realistic depreciation policy, in this study.

The modified double declining balance method which differs from the orthodox method only in its treatment of net salvage values in vintage accounting would be more in conformity with the value-realistic depreciation pattern than the current policy which disregards the differences in service life expectancy between different kinds of equipment. Thus the current policy would tend to introduce more bias to the investment decision rules than the modified double declining balance method.

The investment tax credit policy is also modelled as a possible substitute for the current policy. The corresponding depreciation function is a sum of two independent functions; one part an immediate expense, and the other the orthodox double declining balance method. Thus, this policy would also tend to introduce less bias to the investment decision rules than the current policy.

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[1]The salvage values are assumed negligible in the Nigerian industrial machinery market, in this study.

C. Accounting for Depreciation

It is commonly emphasized in accounting literature that depreciation accounting is a process of cost allocation, not of valuation, and that it differs in this respect from engineering appraisal practice. The following comments by the Committee on Terminology of the American Institute of Accountants further illuminates the point (2, p. 25):

> "Depreciation accounting... aims to distribute the cost or other basic value of tangible capital assets, less salvage, if any, over the estimated useful life of the asset (which may be a group of assets) in a systematic and rational manner. It is a process of allocation, not of valuation. Depreciation for the year is the portion of the total charge under such a system that is allocated to the year."

In practice, the cost allocation system cannot be designed to reflect the year to year changes in the value of each individual asset. The cost of the periodic appraisals that would be required for such an exercise would militate against its adoption for whatever reason of equity. For sure, the decline in value of individual assets is most likely to be jerky, uneven, and controversial, due partly to the irregularity of physical deterioration and obsolescence, and partly to the impact of other sporadic and accidental factors of retirement. While a write-off procedure that accurately traces the value movement of each individual asset is bound to be unsystematic and inconsistent, it is perfectly possible to have procedures that satisfy the requirements of orderliness and consistency, and nevertheless reflect in their general contour and time distribution the typical or representative pattern of value erosion of that group of assets.

D. Straight Line Depreciation

The straight line depreciation method allocates the depreciable base (the difference between the first cost new and the estimated salvage) of a property unit uniformly throughout its service life, except when the estimate of service life is changed. It is the depreciation method prescribed by many regulatory agencies for the regulated industries, such as the electric power corporations of the United State of America.

The mathematical formula for the straight line, item depreciation is given by:

$$D_x = (B-V_2)/n$$

where

D_x = annual depreciation allocation

B = depreciation base = original cost new of the item

V_s = estimated net salvage

n = probable service life of the unit of property

and the unallocated balance at the end of year s,

$$B_x = (B-V_s)\left(\frac{n-x}{n}\right) + V_s$$

where $\frac{n-x}{n}$ = expectancy life factor at age x.

The formula for a straight line vintage group depreciation procedure is:

$$D_x = \frac{(B_{x-1} + B_x)}{2} (d)$$

where

$d = (1-s)/PASL$

$PASL$ = probable average service life

B_{x-1} = plant balance at the beginning of year x

B_x = plant balance at the end of x

D_x = depreciation allocation for year x.

The straight line depreciation method is subject to the weakness that the actual loss of value of industrial equipment may be far greater in the earlier than in the later years of service life,[1] a fact which the procedure does not compromise.

E. Declining Balance Depreciation

The declining balance procedure for cost allocation for tax purposes has been widely prevalent in Great Britain and the British Commonwealth countries. It is a variation of the straight line depreciation concept: the fixed annual rate of depreciation is applied to the unallocated balance of the base instead of to the original cost new. The formula for the procedure applied to an item of property is:

$$D_x = B(f)(1-f)^{(x-1)}$$

where

f = the fixed accrual rate for the xth year

n = probable service life of the unit

B = the original cost new of the unit

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[1]George Terborgh (23, p. 47) has suggested that any realistic cost allocation procedure for industrial equipment should get rid of at least one half of the initial value over the first third of the service life, and at least two thirds of the initial value over the first half of the service life.

D_x = the depreciation allocation for the xth year,

and the unallocated base at the end of the xth year, $NB_x = B(1-f)^2$.

If the accrual rate, f, equals $\frac{2}{n}$, then the procedure becomes the double declining balance method. Three variates of the declining balance method were modelled in this study:

a. Orthodox double declining balance. This is the procedure prescribed by the United States Treasury, published on September 28, 1954, for tax depreciation computation in vintage accounting, the realized net salvage values from annual retirements come into the annual depreciation allowance only in the terminal year of the vintage.

b. Modified double declining balance. This is a proposed double declining balance procedure for Nigeria, which will conform with the current accounting practice there. In this procedure, the annual retirements from each vintage are fully depreciated, that is, the annual depreciation allowance includes a recovery for the undepreciated portion of all retirements. This treatment of annual retirements is in line with the current accounting practice under the existing policy. It is assumed that this modification of the double declining balance procedure will facilitate accounting practice during adoption.

c. Current Nigerian policy. In this declining balance procedure, a total incentive first year allowance of 32.5% of first cost is granted with subsequent annual allowances of 12.5% of the declining balance. The 12.5% fixed rate does not, however, reflect the expected longevity of the asset. Retirements are fully depreciated at the end of the corresponding accounting year.

F. Immediate Expensing of Capital Expenditures

The idea of expensing expenditures on capital assets is not new (4, p. 138). Joel Dean argues its merits in 1956 (9, p. 79). Harold Bierman has advanced the following argument in favor of immediate expensing of capital expenditures (9, p. 87):

1. The simplicity of the procedure in contrast with the practical complexities of the more orthodox tax provisions.
2. It would be more easily understood by the people for whom such provisions are intended: the businessmen, and more so in situations where subjective evaluations play a significant role in investment decisions.
3. Such a procedure would make investments in plant and equipment comparable from a tax standpoint, to other corporate assets such as research and development, or advertising, and in the case of developing economies, it would make expenditures in income producing capital assets comparable to capital expenditures on other corporate assets such as merchandising inventories.
4. It would alleviate the plight of the small firm which has opportunities for rapid expansion but is not big enough to have ready and reasonable access to capital markets.

G. Investment Credit

This is a procedure in which the firm is granted a tax reduction equal to a fixed percentage of the cost of the investment in capital assets in the year in which the investment took place. This tax reduction has no bearing or effect on the normal or prescribed tax depreciation procedure. The proponents of investment credit policies contend that (10, p. 23):

1. The investment tax credit utilizes the principle of an allowance over and above 100% of the original cost, thus somewhat softening the effects of inflation, particularly in highly inflationary economies.
2. In comparison to fast depreciation, the advantage to firms in using investment tax credit is absolute, and not merely one in the timing of cash flow.[1]
3. Another unique advantage over accelerated depreciation is that it is less likely to increase inflation, as it is not interpreted as a production cost.

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[1]A study prepared for its members by the Machinery and Allied Products Institute, MAPI, found that on a typical 15 year asset, an 8% investment credit has the same effect on profitability as a special 40% first year initial depreciation write-off (10).

IV. MODELLING

This chapter focuses on the formulation of the parameters and values used in building the models for this study and on the description of the procedures adopted in each of the two simulation studies.

A. Formulation of Model Parameters

This study required the establishment of the following values which were required for the simulation models developed for the analysis:

1. Equipment groups;
2. Retirement dispersion pattern;
3. Salvage value;
4. Planning horizon;
5. Growth rate;
6. Capitalization rate.

1. Grouping of assets

Nigeria is an importer of virtually all the capital equipment used by her industries. From the Nigerian annual trade reports[1] it was possible to classify her capital equipment consumption into the following six equal-life groups:

a. Group number 1 This is made up of pumps and compressors and similar mechanical equipment, with an average annual addition, by importation, of $49 m; and construction machinery with an average annual addition of $215 m.

[1]The total annual value of imports were given, by equipment category, for four consecutive years (25).

b. Group number 2 In this group are materials handling equipment, fork lifts and industrial trucks, with an average annual addition of $9.9m; conveyors, hoists and similar equipment with an average annual addition of $21.7m.

c. Group number 3 This is comprised of cooling and air conditioning equipment with an average annual addition of $42m; electromedical and radiological equipment with an average annual addition of $5.1m; accounting machinery and computers with an average annual addition of $13m; automobile maintenance equipment with an average annual addition of $11.7m; other medical equipment with an average annual addition of $20m.

d. Group number 4 This group is made up of duplicating and addressing machines with an average annual addition of $18.4m.

e. Group number 5 This consists of agricultural equipment with an average annual addition of $47.9m; and business equipment and systems with an average annual addition of $5.3m.

f. Group number 6 The last group consists of printing and book binding machinery with an average annual addition of $18.4m.

The group average service lives for groups 1, 2, 3, 4, 5, and 6 were estimated as 7, 8, 10, 12, 15, and 17 years respectively, using the United States asset guidelines (7).

2. Retirement dispersion pattern

To simulate annual plant retirements from each of the industrial equipment groups above, over the simulation period of twenty years, it was necessary to select typical retirement patterns described by Iowa Type

Curves. The Iowa Type L_2, R_2 and S_2 curves were selected as representative of the three common classes of property retirement patterns (17, p. 410; see Section V. A. below).

3. Salvage Values

Part of the difficulty in establishing salvage ratios (net salvage divided by the original cost) in Nigeria is that there is virtually no second-hand market for used industrial machinery. Since capital goods are imported, there are no local organizations specializing in purchasing used equipment for reconditioning and subsequent resale, it was decided to assume a zero salvage ratio for the simulation runs.

4. Simulation Period

A simulation period of twenty years was adopted for this study. It was felt that a shorter period may tend to bias the results in favor of the users of the equipment groups with the shorter average service lives.

5. Growth rate

There was no published census of the value of the present survivors of machinery and equipment employed in Nigerian industries, nor of the rate of growth of the annual plant balances. However, figures were available on the projected annual additions (or annual consumptions) of machinery and equipment for Nigerian industries for the six consecutive years 1974-1980 (14, p. 59), with an average annual addition of $346.68m. This rate of annual additions together with the assumed plant retirement characteristics were used to simulate the industrial plant for the simulation horizon of twenty years.

6. Discount rate

Inflation-free dollars were used in the 20-year simulation period of this study. Thus, the simulated growth rate was with respect to the dollars of the first year.

Yield rates among Nigerian firms are assumed to range from 38% to 56%, with an average annual inflation rate of 25% (6, p.1). Thus, the appropriate corresponding range of discount factors (yield rates) to use in finding the present worths of the cash benefits becomes 10% to 25%, using the following formula (20, p. 547):

$$j = \frac{i - I}{1.0 + I} \tag{4.1}$$

where i = discount rate with inflation

j = discount rate without inflation

I = inflation rate.

B. Modelling of the Present Policy

When a firm purchases an item of depreciable asset, the firm automatically qualifies, by most orthodox tax accounting laws, for a total par value reduction in tax liability equal to the original investment in the asset. The timing and pattern of that capital recovery differs according to governmental regulations and policies.

The first simulation model investigated the equity consideration in the distribution of the discounted cash benefits resulting from the current policy to the users of the different life-classes of industrial equipment. In the plant simulation program[1] the cost of each purchase of equipment varied randomly from \$50,000 to \$150,000 per unit.[2] The annual plant retirements were also generated for each year using the same P.G.M. program. The annual tax savings for each industrial group for the simulation period were analyzed using the discounted cash flow method (5, p. 35).

The value of the financial benefit was measured by comparing the present values of the cash benefits for each industry with the present value of the simulated cash benefits which would result if the recovery pattern were to just conform with the pattern of value erosion as realistically as possible. The orthodox double declining balance method of cost allocation has been suggested as a good practical substitute for this realistic depreciation pattern, by George Tergorgh (3, p. 149), for industrial equipment and machinery, and that has been adopted for this comparative study.

A computer program was developed to calculate the annual tax benefits for each industrial group under the current policy; section I. B. as follows:

$$H_{xi} = 0.325(B_i) + 0.675(R_{xi}) \qquad \text{for } x=1 \qquad (4.2)$$

$$H_{xi} = 0.125\ (\text{Beginning net book balance})_{xi} + K_{xi}\ (\text{retirements in year } x) \qquad \text{for } x>1 \qquad (4.3)$$

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[1]Erbe, H. C., developed a computer package for the Industrial Engineering Department, Iowa State Unviersity, Ames. It consists of seven independent programs used in comparing actuarial and simulated plant-record methods of property life analysis. A program of this package, the Plant Generator Program, and the list program from tape number 2 were used to generate equipment retirements in this study, deterministically.

[2]An average equipment unit cost of \$100,000 was used in this study to avoid biases that may be introduced by using different unit costs for different categories of equipment.

where

H_{xi} = cash benefit from the ith vintage for year x.

B_i = original installation of vintage group i

R_{xi} = retirements from the ith vintage in year x

$$K_{xi} = 1 - \left(\frac{\text{depreciation reserve for vintage i at the start of x}}{\text{first cost of vintage i}}\right)$$

The resulting stream of cash benefits, at the end of each of the twenty years of simulation period, for each equipment group, was discounted to the beginning of the first period to get the present equivalent cash benefits. A range of discount values was used. The present equivalent cash benefits for the different equipment groups were then compared with what each group would receive from a realistic non-incentive scheme.

C. Modelling of Alternative Policies

This model is a natural sequel to the results of the preceding model described above. It is desired here to develop a simulation model for comparative studies of alternative practical tax incentive policies. At each discount rate, the total cash benefit (discounted) bestowed on the entire ensemble of Nigerian industries was determined under the current capital allowance policy. The total discounted cash benefits bestowed on the whole of the Nigerian industry was also determined by simulation under alternative tax incentive schemes. Each simulation run followed the same procedure as in model one above. Using the results of the total industry benefits it was determined, by simple comparisons, if the total industry benefit under the current incentive scheme was higher than the benefit from the alternative schemes.

Using the same results it could be determined, as in model one above, if the alternative tax incentive schemes improved the distribution bias among the users of the different classes of equipment. Specifically, the alternative policies investigated were:

a. Orthodox double declining balance method;

b. Modified double declining balance method;

c. Immediate expensing; and d. Investment credit.

The declining balance methods differ only in their treatments of the end of year retirements in the accounting equation. The modified version is designed to conform with the current accounting practice with respect to annual retirements from each vintage, to facilitate accounting adoption in the event of a policy revision. The computer algorithm for the modified double declining balance method was based on the following relationship:

$$D_{xi} = (2/n)(\text{Beginning net book})_{xi} + K_{xi}\ (\text{Retirements})_{xi}$$

where D_{xi} = capital allowance from the ith vintage in the xth accounting year

n = probable average service life of the vintage group

$K_{xi} = (1 - \frac{\text{depreciation reserve}}{\text{first cost}})$ for the ith vintage at the beginning of year x.

The computer algorithm for the orthodox double declining balance method was based on the following relationship:

$$D_{xi} = (2/n)(\text{beginning net book})_{xi} \quad \text{for all } x<T$$

$$= (\text{beginning net book})_{xi} \quad \text{for } x = T$$

where T = terminal year of the vintage group i n = average service life of the vintage group

x = 1, 2, 3, ..., T

The policy of immediate expensing of capital expenditures was approximated by allowing firms to write-off capital expenditures equally over the first three years of the service life. This was done to avoid the complication of those firms which will be unable to generate sufficient revenues in the early years. It was assumed that a two year write-off period would be insufficient for some poorly managed larger indigenous businesses, while greater than three years approaches the service life of the shorter-lived equipment. The computer program for this simulation algorithm was based on the following relationship:

$$D_{xi} = (B_i)/3 \qquad \text{for} \qquad x = 1, 2, 3.$$

The two per cent investment tax credit was modelled and found to yield total industry cash benefits which had smaller present worths than the current policy. Thus, the 3% investment tax credit policy in conjunction with the orthodox double declining balance was modelled as an alternative policy.

V. DISCUSSION OF RESULTS

The results of the two simulation models are presented and discussed in this chapter. It is resolved into the following topical sections:

A. Results from the first model;

B. Results from the second model.

A. Results from the First Model

Tables 5.1 to 5.4 provide comparisons of the present worths of the annual cash allowances resulting from the current policy with those resulting from the orthodox double declining balance procedure. These results are based on an assumed Iowa Type R_2 dispersion for all equipment, for the different discount rates used (10%, 15%, 20%, and 25%). Table 5.13 presents the effects of the current policy, as percentage changes, on the benefits that would result from the orthodox double declining balance method. The latter benefits, from the consideration of the general trend of value erosion, are assumed to represent the minimum acceptable values for capital allowance. The current policy bestows a negative incremental change to users of group one equipment (with an average service life of 7 years) at a discount factor of 10% for the Iowa Type R_2 dispersion pattern. That implies that the current policy falls short of the minimum acceptable capital recovery requirements, for this sector of the Nigerian industry. At the same time, users of longer-lived equipment, for example group six equipment (average service life, 17 years) receive an incremental benefit of +21.4%.

Table 5.13 reveals further that, for all four discount factors used in this study, the users of equipment group two (with an average service life of 8 years) barely attain a break-even value with the minimum acceptable requirements; the incremental benefits range from 0.6% to 0.7%, that is, less than 1%. Users of longer-lived equipment, on the other hand, for all four discount factors used, derive more generous cash incentive benefits from the current policy ranging from +3.7% for equipment group three (with an average service life of 10 years) to +21.4% for equipment group six.

Tables 5.5 to 5.8 give the present worths and distributions of the incentive cash allowances of the current policy with an assumed Iowa Type S_2 dispersion for all equipment. Table 5.14 gives the effects of the current policy, as percentage changes on the benefits that would result from the orthodox double declining balance procedure. This table indicates that users of equipment group one, under an assumed S_2 dispersion pattern, derive negative incremental benefits at 10%, 15%, and 20% discount factors. At the same discount factors and the same dispersion, users of equipment group six derive incremental cash benefits of 20.9%, 17.8%, and 15.5%, respectively from the current policy.

The present value of the cash allowances obtained under the Iowa Type S_2 dispersion are generally slightly lower than those from the Iowa Type R_2 dispersion. This at first seems to be a surprising result since the retirement frequency mode of the Iowa Type S_2 dispersion occurs earlier than for the R_2 dispersion. Closer examination at the retirement frequency contour of the two curves reveals that the Iowa Type R_2 dispersion has a higher proportion of retirements in the first half of the average service life than does the Iowa Type S_2 curve. This early advantage seems to have overshadowed the effect of the different modal positions, in the discounting process for present values.

Tables 5.9 to 5.12 give similar results obtained from an assumed Iowa Type L_2 dispersion. The incremental cash benefits under this dispersion pattern are given in Table 5.15. The results indicate that the users of equipment group one barely attain the break-even condition while the users of the longer-lived equipment again derive substantially higher incentive cash benefits. In general, the present values of the cash benefits obtained under the Iowa Type L_2 dispersion are slightly higher than with either the Iowa Type S_2 or R_2 dispersion. This results from the fact that the L_2 retirement frequency curve has both advantages of high early proportion of retirements and early modal year over either the S_2 or the R_2 curve.

B. Results from the Second Model

The first model yielded results which indicate that the current policy is substantially biased in favour of users of long-lived property. This second model investigates whether alternative capital allowance policies which are practical and are free of distortion of the optimal investment rules, can improve on the equity problem and at the same time grant to the total industry at least as much discounted cash benefits as does the current policy.

In Tables 5.16 to 5.19 the present values of the simulated annual cash allowances are presented for the alternative policies, assuming an Iowa Type R_2 dispersion pattern. In this particular case, only a 2% investment credit policy in conjunction with the orthodox double declining procedure has been considered and found to grant to total industry less than the benefits of the current plan. Hence, the 2% investment credit policy was not considered subsequently.

When the Iowa Type S_2 dispersion is assumed, the results are as presented in Tables 5.20 to 5.23, for the four different discount rates. Tables 5.26 to 5.27 present the results for an assumed Iowa Type L_2 dispersion.

Measures of the incentive content of the cash allowances are presented in Tables 5.28 to 5.39, for all the alternative practical asset allowance policies simulated in this study: the orthodox and modified double declining balance, the 3% investment credit, the three-year expensing, and the current procedure. These tables also give a column which gives the aggregate cash incentive measure for the total industry under each alternative policy. The results indicate that a policy of three-year expensing of capital expenditures will endow the greatest cash benefits to the users of all categories of equipment among all the alternative policies considered. But the inequity in the distribution of the cash benefits under the immediate expensing alternative is even more severe than with the current policy, for all the dispersion patterns and discount factors used in this study. With the Iowa Type L_2 dispersion pattern, for example, the policy of three-year expensing grants incremental cash benefits of 5.9% and 33.5% to the users of equipment group one (with an average service life of 7 years) and equipment group six (with an average service life of 17 years), respectively. Comparative values of incremental benefit under the current policy are 0.2% and 16% for equipment groups one and six, respectively. At 20% discount factor, see Table 5.38, the Iowa Type L_2 dispersion yields total industry incremental cash benefits of 2.4%, 4.2% and 6.4% under the current, modified double declining balance, and 3% investment credit policies respectively.

Both the modified double declining balance and the 3% investment credit policy each distribute the cash incentive benefits more equitably among the users of different equipment categories than is obtained with the current national policy. From Table 5.38, for example, the distribution bias (the difference in incremental benefits between users of the lowest-lived and highest-lived equipment) at a 20% discount factor is 16%, 5.6% and 1.7% for the current, modified double declining, and 3% investment credit procedures respectively.

The effect of a higher discount factor is to reduce the present value of a given cash flow. This is reflected in the results of the simulation runs. While industrialists will tend to discount future cash receipts at the higher discount rates used in this study, the government will tend to discount the allowances (or disbursements) to industry at the lower discount rates. However, the relative merits of each policy are preserved at all the discount rates used. For example, the relative merits of the cash incentive benefits to the total industry of the 3% inventment credit policy over the current policy holds true for all the discount rates: 7.4% vs. 3.1% at a discount rate of 10%, 7.0% vs. 2.7% at a discount rate of 15%, 6.7% vs. 2.4% at 20% discount, and 6.6% vs. 2.3% at 25% discount, respectively. By a similar logical construction, the relative merits of the alternative policies in the equitable distribution of cash benefits are preserved at all the discount rates used.

Table 5.1. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	23,946,000	23,936,000
Two	23,266,000	23,421,000
Three	21,908,000	22,724,000
Four	20,616,000	22,108,000
Five	18,843,000	21,719,000
Six	17,778,000	21,576,000

Discount rate = 10 %
Dispersion pattern, Iowa Type R_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.2. Present values of end-of-year capital allowances (dollars) over the simulation period

Equipment group[a] \ Policy	Orthodox double declining balance	Current practice
One	16,125,000	16,132,000
Two	15,754,000	15,851,000
Three	14,974,000	15,429,000
Four	14,198,000	15,041,000
Five	13,092,000	14,636,000
Six	12,408,000	14,636,000

Discount rate = 15 %

Dispersion pattern, Iowa Type R_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.3. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	11,523,000	11,542,000
Two	11,308,000	11,383,000
Three	10,831,000	11,118,000
Four	10,335,000	10,861,000
Five	9,600,000	10,634,000
Six	9,133,000	10,547,000

Discount rate = 20 %

Dispersion pattern, Iowa Type R_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.4. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	8,653,000	8,678,000
Two	8,522,000	8,585,000
Three	8,212,000	8,413,000
Four	7,877,000	8,236,000
Five	7,361,000	8,056,000
Six	7,025,000	7,986,000

Discount rate = 25 %

Dispersion pattern, Iowa Type R_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.5. Present values of end-of-year capital allowances (dollars) over the simulation period

Equipment group[a] \ Policy	Orthodox double declining balance	Current practice
One	23,946,000	23,815,000
Two	23,266,000	23,408,000
Three	21,908,000	22,560,000
Four	20,616,000	22,066,000
Five	18,843,000	21,641,000
Six	17,778,000	21,501,000

Discount rate = 10 %

Dispersion pattern, Iowa Type S_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.6. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	16,125,000	16,082,000
Two	15,754,000	15,860,000
Three	14,976,000	15,337,000
Four	14,198,000	15,027,000
Five	13,092,000	14,720,000
Six	12,408,000	14,611,000

Discount rate = 15 %

Dispersion pattern, Iowa Type S_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.7. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	11,523,000	11,521,000
Two	11,308,000	11,396,000
Three	10,831,000	11,062,000
Four	10,335,000	10,860,000
Five	9,600,000	10,632,000
Six	9,133,000	10,545,000

Discount rate = 20 %

Dispersion pattern, Iowa Type S_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.8. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	8,653,000	8,669,000
Two	8,522,000	8,597,000
Three	8,212,000	8,376,000
Four	7,877,000	8,239,000
Five	7,361,000	8,065,000
Six	7,025,000	7,994,000

Discount rate = 25 %

Dispersion pattern, Iowa Type S_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.9. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	23,946,000	25,181,000
Two	23,266,000	24,572,000
Three	21,908,000	23,434,000
Four	20,616,000	22,189,000
Five	18,843,000	20,455,000
Six	17,778,000	19,462,000

Discount rate = 10 %

Dispersion pattern, Iowa Type L_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.10. Present values of end-of-year capital allowances (dollars) over the simulation period

Equipment group[a] \ Policy	Orthodox double declining balance	Current practice
One	16,125,000	16,768,000
Two	15,752,000	16,467,000
Three	14,974,000	15,871,000
Four	14,198,000	15,180,000
Five	13,092,000	14,134,000
Six	12,408,000	13,522,000

Discount rate = 15 %

Dispersion pattern, Iowa Type L_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.11. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	11,523,000	11,879,000
Two	11,308,000	11,724,000
Three	10,831,000	11,395,000
Four	10,335,000	10,991,000
Five	9,600,000	10,325,000
Six	9,133,000	9,921,000

Discount rate = 20 %
Dispersion pattern, Iowa Type L_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.12. Present values of end-of-year capital allowances (dollars) over the simulation period

Policy / Equipment group[a]	Orthodox double declining balance	Current practice
One	8,653,000	8,862,000
Two	8,522,000	8,779,000
Three	8,212,000	8,589,000
Four	7,877,000	8,340,000
Five	7,361,000	7,894,000
Six	7,025,000	7,612,000

Discount rate = 25 %

Dispersion pattern, Iowa Type L_2

[a]Groups one, two, three, four, five, and six have average service lives equal to 7, 8, 10, 12, 15, and 17 years, respectively.

Table 5.13. Effects of the current policy on the present worth of capital allowances, as percentage changes over the standard minima[a]

Discount factor / Equipment group	10 %	15 %	20 %	25 %
One	-0.1	0.1	0.2	0.3
Two	0.7	0.6	0.7	0.7
Three	3.7	3.0	2.6	2.4
Four	7.2	5.9	5.1	4.6
Five	15.3	12.6	10.8	9.4
Six	21.4	18.0	15.5	13.7

Simulation of equipment retirement based on the Iowa Type R_2 dispersion

[a]The standard minimum is the simulated cash benefits resulting from an orthodox double declining balance procedure.

Table 5.14. Effects of the current policy on the present worth of capital allowances, as percentage changes over the standard minima[a]

Discount factor / Equipment group	10 %	15 %	20 %	25 %
One	-0.5	-0.3	-0.1	0.2
Two	0.6	0.9	0.8	0.9
Three	2.9	2.4	2.1	1.9
Four	7.0	5.8	5.0	4.6
Five	14.8	12.4	10.8	9.6
Six	20.9	17.8	15.5	13.8

Simulation of equipment retirement based on the Iowa Type S_2 dispersion

[a]The standard minimum is the simulated cash benefits resulting from an orthodox double declining balance procedure.

Table 5.15. Effects of the current policy on the present worth of capital allowances, as percentage changes over the standard minima [a]

Discount factor / Equipment group	10 %	15 %	20 %	25 %
One	0.1	0.1	0.2	0.3
Two	0.9	0.8	0.8	0.8
Three	4.1	3.3	2.9	2.6
Four	7.9	6.6	5.6	5.0
Five	15.6	13.1	11.2	9.9
Six	21.9	18.6	16.2	14.5

Simulation of equipment retirement based on the Iowa Type L_2 dispersion.

[a]The standard minimum is the simulated cash benefits resulting from an orthodox double declining balance procedure.

Table 5.16. Effects of the current policy on the present worth of capital allowances, as percentage changes over the standard minima[a].

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	23.946	23.266	21.908	20.616	18.843	17.778
Current procedure	23.936	23.421	22.724	22.108	21.719	21.576
Modified double declining balance	25.186	24.563	23.384	22.072	20.381	19.323
2 % investment credit	25.049	24.370	23.012	21.720	19.947	18.882
3 % investment credit	25.605	24.926	23.568	22.276	20.503	19.438
Three year write-off	26.593	26.590	26.598	26.576	26.581	26.587

Discount rate = 10 %
Dispersion pattern, Iowa Type R_2

[a]The values in the table are in millions of dollars.

Table 5.17. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Equipment group / Policy	One	Two	Three	Four	Five	Six
Orthodox double declining balance	16.125	15.754	14.974	14.198	13.092	12.408
Current procedure	16.132	15.851	15.429	15.041	14.747	14.636
Modified double declining balance	16.767	16.459	15.840	15.108	14.075	13.402
2 % investment credit	16.837	16.466	15.686	14.911	13.804	13.120
3 % investment credit	17.197	16.826	16.046	15.270	14.163	13.479
Three year write-off	17.430	17.429	17.432	17.423	17.425	17.428

Discount rate = 15 %
Dispersion pattern, Iowa Type R_2

[a]The values in the table are in millions of dollars.

Table 5.18. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	11.523	11.308	10.831	10.335	9.600	9.133
Current practice	11.542	11.383	11.118	10.861	10.634	10.547
Modified double declining balance	11.877	11.718	11.377	10.946	10.276	9.821
2 % investment credit	12.016	11.801	11.324	10.828	10.093	9.627
3 % investment credit	12.266	12.051	11.574	11.078	10.343	9.876
Three year write-off	12.202	12.201	12.203	12.199	12.200	12.201

Discount rate = 20 %
Dispersion pattern, Iowa Type R_2

[a]The values in the table are in millions of dollars

Table 5.19. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Equipment group / Policy	One	Two	Three	Four	Five	Six
Orthodox double declining balance	8.653	8.522	8.212	7.877	7.361	7.025
Current practice	8.678	8.585	8.413	8.236	8.056	7.986
Modified double declining balance	8.861	8.775	8.579	8.312	7.853	7.529
2 % investment credit	9.015	8.884	8.574	8.239	7.723	7.387
3 % investment credit	9.199	9.067	8.758	8.422	7.906	7.571
Three year write-off	9.025	9.025	9.026	9.024	9.024	9.024

Discount rate = 25 %
Dispersion pattern, Iowa Type R_2

[a]The values in this table are in millions of dollars.

Table 5.20. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	23.946	23.266	21.908	20.616	18.843	17.778
Current policy	23.815	23.408	22.560	22.066	21.641	21.501
Modified double declining balance	25.088	24.512	23.266	22.020	20.278	19.229
3 % investment credit	25.605	24.926	23.568	22.276	20.503	19.438
Three year write-off	26.576	26.580	26.576	26.576	26.576	26.576

Discount rate = 10 %
Dispersion pattern, Iowa Type S_2

[a]The values in the table are in millions of dollars.

Table 5.21. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	16.125	15.754	14.974	14.198	13.092	12.408
Current practice	16.082	15.860	15.337	15.027	14.720	14.611
Modified double declining balance	16.724	16.439	15.779	15.086	14.037	13.374
3 % investment credit	17.197	16.824	16.046	15.270	14.163	13.479
Three year write-off	17.423	17.425	17.423	17.423	17.423	17.423

Discount rate = 15 %
Dispersion pattern, Iowa Type S_2

[a]The values in the table are in millions of dollars.

Table 5.22. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Equipment group / Policy	One	Two	Three	Four	Five	Six
Orthodox double declining balance	11.523	11.308	10.831	10.335	9.600	9.133
Current practice	11.521	11.396	11.062	10.860	10.632	10.545
Modified double declining balance	11.857	11.711	11.344	10.938	10.269	9.823
3 % investment credit	12.266	12.051	11.574	11.078	10.343	9.876
Three year write-off	12.199	12.199	12.199	12.199	12.199	12.199

Discount rate = 20 %
Dispersion pattern, Iowa Type S_2

[a]The values in the table are in millions of dollars.

Table 5.23. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Equipment group / Policy	One	Two	Three	Four	Five	Six
Orthodox double declining balance	8.653	8.522	8.212	7.877	7.361	7.025
Current practice	8.669	8.597	8.376	8.239	8.065	7.994
Modified double declining balance	8.851	8.773	8.559	8.311	7.860	7.545
3 % investment credit	9.199	9.067	8.758	8.422	7.906	7.571
Three year write-off	9.024	9.023	9.023	9.025	9.024	9.024

Discount rate = 25 %
Dispersion pattern, Iowa Type S_2

[a]The values in the table are in millions of dollars.

Table 5.24. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	23.946	23.266	21.908	20.616	18.843	17.778
Current practice	23.963	23.475	22.813	22.256	21.780	21.667
Modified double declining balance	25.181	24.572	23.434	22.189	20.445	19.462
3 % investment credit	25.605	24.926	23.562	22.276	20.503	19.438
Three year write-off	26.576	26.587	26.580	26.576	26.576	26.576

Discount rate = 10 %
Dispersion pattern, Iowa Type L_2

[a]The values in the table are in millions of dollars.

Table 5.25. Comparison of present worth of capital allowanccs[a] resulting from alternative policies, over the simulation period

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	16.125	15.754	14.974	14.198	13.092	12.408
Current practice	16.144	15.882	15.478	15.131	14.801	14.716
Modified double declining balance	16.768	16.467	15.871	15.180	14.134	13.522
3 % investment credit	17.197	16.826	16.046	15.270	14.163	13.479
Three-year write-off	17.423	17.428	17.425	17.423	17.423	17.423

Discount rate = 15 %
Dispersion rate, Iowa Type L_2

[a]The values in the table are in millions of dollars.

Table 5.26. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Equipment group / Policy	One	Two	Three	Four	Five	Six
Orthodox double declining balance	11.523	11.308	10.831	10.335	9.600	9.133
Current practice	11.546	11.401	11.142	10.916	10.679	10.613
Modified double declining balance	11.879	11.724	11.395	10.991	10.325	9.921
3 % investment credit	12.266	12.051	11.574	11.078	10.343	9.876
3 year write-off	12.199	12.201	12.199	12.199	12.199	12.199

Discount rate = 20 %
Dispersion pattern, Iowa Type L_2

[a]The values in the table are in millions of dollars.

Table 5.27. Comparison of present worth of capital allowances[a] resulting from alternative policies, over the simulation period

Policy \ Equipment group	One	Two	Three	Four	Five	Six
Orthodox double declining balance	8.653	8.522	8.212	7.877	7.361	7.025
Current practice	8.677	8.595	8.423	8.268	8.092	8.041
Modified double declining balance	8.862	8.779	8.589	8.340	7.894	7.612
3 % investment credit	9.199	9.067	8.758	8.422	7.906	7.571
Three year write-off	9.024	9.025	9.024	9.024	9.024	9.024

Discount rate = 25 %
Dispersion pattern, Iowa Type L_2

[a]The values in the table are in millions of dollars.

Table 5.28. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	-0.1	5.2	6.9	11.1
Two	0.7	5.6	4.7	14.3
Three	3.7	6.7	7.6	21.4
Four	7.2	7.0	8.1	28.9
Five	15.3	8.2	8.8	41.0
Six	21.4	8.7	9.3	49.6
Aggregate industry	3.4	6.0	7.4	18.5

Discount rate = 10 %
Dispersion pattern, Iowa Type R_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.29. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.1	4.0	6.6	8.0
Two	0.6	4.5	6.8	10.6
Three	3.0	5.8	7.2	16.4
Four	5.9	6.4	7.6	22.7
Five	12.6	7.5	8.2	33.1
Six	18.0	8.0	8.6	40.4
Aggregate industry	2.9	5.0	7.0	14.2

Discount rate = 15 %
Dispersion pattern, Iowa Type R_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.30. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.2	4.0	6.4	5.9
Two	0.7	3.6	6.6	7.9
Three	2.6	5.0	6.9	12.7
Four	5.1	5.9	7.2	18.0
Five	10.8	7.0	7.7	27.0
Six	15.5	7.5	8.1	33.6
Aggregate industry	2.6	4.2	6.7	11.0

Discount rate = 20 %
Dispersion pattern, Iowa Type R_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.31. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.3	2.4	6.3	4.3
Two	0.7	3.0	6.4	5.9
Three	2.4	4.5	6.6	9.9
Four	4.6	5.5	6.9	14.6
Five	9.4	6.7	7.4	22.6
Six	13.7	7.1	7.7	28.5
Aggregate industry	2.4	3.6	6.6	8.7

Discount rate = 25 %
Dispersion pattern, Iowa Type R_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.32. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	-0.5	4.8	6.9	11.0
Two	·0.6	5.4	7.1	14.2
Three	2.9	6.2	7.6	21.3
Four	7.0	6.8	8.1	28.9
Five	14.8	7.6	8.8	41.0
Six	20.9	8.2	9.3	49.5
Aggregate industry	2.9	5.6	7.4	12.2

Discount rate = 10 %
Dispersion pattern, Iowa Type S_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.33. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	-0.3	3.7	6.6	8.0
Two	0.9	4.3	6.8	10.6
Three	2.4	5.4	7.2	16.4
Four	5.8	6.3	7.6	22.7
Five	12.4	7.2	8.2	33.0
Six	17.8	7.8	8.6	40.4
Aggregate industry	2.5	4.7	7.0	14.2

Discount rate = 15 %
Dispersion pattern, Iowa Type S_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.34. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	-0.1	2.9	6.4	5.9
Two	0.8	3.6	6.6	7.9
Three	2.1	4.7	6.9	12.6
Four	5.0	5.8	7.2	18.0
Five	10.8	7.0	7.7	27.0
Six	15.5	7.6	8.1	33.6
Aggregate industry	2.4	4.0	6.7	11.0

Discount rate = 20 %
Dispersion pattern, Iowa Type S_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.35. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.2	2.3	6.3	4.3
Two	0.9	2.9	6.4	5.9
Three	1.9	4.2	6.6	9.9
Four	4.6	5.5	6.9	14.6
Five	9.6	6.8	7.4	22.6
Six	13.8	7.4	7.7	28.5
Aggregate industry	2.3	3.5	6.6	8.7

Discount rate = 25 %
Dispersion pattern, Iowa Type S_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.36. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.1	5.2	6.9	11.0
Two	0.9	5.6	7.1	14.3
Three	4.1	7.0	7.6	21.3
Four	7.9	7.6	8.1	28.9
Five	15.6	8.5	8.8	41.0
Six	21.9	9.5	9.3	49.5
Aggregate industry	3.1	6.0	7.4	17.4

Discount rate = 10 %
Dispersion pattern, Iowa Type L_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.37. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.1	4.0	6.6	8.0
Two	0.8	4.5	6.8	10.6
Three	3.3	6.0	7.2	16.4
Four	6.6	6.9	7.6	22.7
Five	13.1	8.0	8.2	33.1
Six	18.6	9.0	8.6	40.4
Aggregate industry	2.7	5.0	7.0	13.5

Discount rate = 15 %
Dispersion pattern, Iowa Type L_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.38. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.2	3.0	6.4	5.9
Two	0.8	3.7	6.6	7.9
Three	2.9	5.2	6.8	12.6
Four	5.6	6.3	7.2	18.0
Five	11.2	7.6	7.7	27.1
Six	16.2	8.6	8.1	33.6
Aggregate industry	2.4	4.2	6.7	10.5

Discount rate = 20 %
Dispersion pattern, Iowa Type L_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

Table 5.39. Effects of alternative policies on the present worth of capital allowances, as percentage changes over the standard minima[a]

Policy / Equipment group	Current practice	Modified double declining balance	3 % investment credit	Three year write-off
One	0.3	2.4	6.3	4.3
Two	0.8	3.0	6.4	5.9
Three	2.6	4.6	6.6	9.9
Four	5.0	5.9	6.9	14.6
Five	9.9	7.2	7.4	22.6
Six	14.5	8.3	7.8	28.5
Aggregate industry	2.3	3.6	6.6	8.3

Discount rate = 25 %
Dispersion pattern, Iowa Type L_2

[a]The standard minimum is the period simulated cash benefit resulting from an orthodox double declining balance procedure.

VI. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions which are drawn from the results of the simulation models of this study on the incentive merits of the current asset allowance policy in Nigeria. Recommendations are also made for improvements to the policy and for further research.

A. Conclusions

The current asset allowance policy in Nigeria which allows an initial first year total allowance of 32.5% of first cost, conveys a mental impression of a very generous incentive scheme. The results of this study indicate that it is a generous provision, alright, but its generosity seems to be confined to one segment of the Nigerian industry. For those industries employing short-lived equipment (with average service life equal to or less than 7 years)[1], the current policy does not grant sufficient allowances to the investors to compensate for the year to year loss in productive capacity of equipment. At the same time, users of the longer-lived equipment, presumably the big business organizations who have more access to the large and durable capital assets, derive substantial capital allowances from the current policy. This inequity in the distribution of the cash incentive endowment among the users of the different categories of equipment prevails under all the discount rates and retirement dispersion patterns used in this study.

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[1]The average annual budget proportion for users of euqipment with an average service life equal to or less than 8 years is 64% (see Section IV-A above.

The three-year write-off, the 3% investment credit, the modified double declining balance, and the current policy are generally more incentive, in that order, than the orthodox DDB.[1]

An inequity exists in the distribution of cash benefits among the users of the different categories of equipment under the present policy. This inequity is improved under the modified double declining balance method, and even more under the 3% investment credit procedure, each of which would introduce less bias to the investment decision rules than would the current policy.

A capital allowance policy which takes into consideration the service life of each equipment category will improve the cash incentive bias of the present policy. In particular, the 3% investment credit in conjunction with the orthodox double declining balance procedure has proved to be the most equitable and, in addition, it grants to the total Nigerian industry at least as much aggregate cash benefits as does the current policy, and would be a recommended substitute for the current policy.

The modified double declining balance procedure would conform more readily with the current accounting practice in Nigeria. While not as good as the 3% investment credit procedure on either score of equity of incentiveness, it is better than the current policy on both scores. For accounting simplicity the modified double declining balance procedure would be a recommended substitute for the current policy.

The dispersion pattern has an effect on the incentive content of the capital allowance policies studied in this research. But the effects

[1]DDB represents double declining balance.

are of a relatively small magnitude in comparison to those resulting from the average service life parameter. More diverse dispersion patterns would probably exert more influence on the absolute magnitudes of these values while most likely maintaining their relative merits as shown by these results.

This study had the objective of establishing equity in the distribution of benefits among the different industrial sectors. If the governmental objective is different, in favor of differential sectoral stimulation, the methodology presented here can be modified to suit the purpose.

B. Recommendations

Based on the results of this study, it is recommended that:

1. A capital allowance policy which reflects the longevity of durable assets be adopted as a means of ensuring capital recovery patterns that are not short of the value erosion requirements, for all sectors of the economy.
2. Further research be carried out to establish the realized life characteristics of Nigerian industrial equipment. The availability of such data will be of benefit not only for national policy making, but also to the individual firms in bringing their profit and loss statements and their equipment economy studies closer to reality.
3. Either the modified double declining balance procedure (for ease of adoption) or better the 3% investment credit in conjunction with the orthodox double declining balance procedure is a recommended substitute to the current policy on equity grounds.

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IX. APPENDIX: RETIREMENT RATIO LIFE ANALYSIS

The method of least squares curve fitting for the retirement ratio curve is as follows:

let, y = actual retirement ratio from raw data

x = age, in years

w = weighting factor = number of exposures

u = assumed retirement ratio function

where,

$$u = \begin{cases} a + bx \text{ if straight line function is assumed} \\ a + bx + cx^2 \text{ if quadratic function is assumed} \\ a + bx + cx^2 + dx^3 \text{ if cubic function is assumed} \end{cases}$$

where a, b, c, and d are independent constants.

The method of least squares minimizes the sum of the squares of the differences, D, between the series of the observed data, (6) and the series of values of (u) computed by assumed retirement rate function. That is,

$$\text{minimize} \qquad \Sigma D^2 = \Sigma(y-u)^2 \qquad (9.1)$$

for an unweighted retirement ratio curve fitting;

or,

$$\text{minimize} \qquad \Sigma wD^2 = \Sigma w(y-u)^2 \qquad (9.2)$$

for a weighted retirement ratio fit.

A necessary condition for a minimum is that the partial derivatives of (2.2) and (2.1) with respect to the independent constants be each set equal to zero. From these partial derivatives, one is able to set up the normal equations from which the constants can be determined simultaneously:

$$\Sigma wy = a\Sigma w + b\Sigma wx + c\Sigma wx^2 + d\Sigma wx^3 \qquad (2.3)$$

$$\Sigma wxy = a\Sigma wx + b\Sigma wx^2 + c\Sigma wx^3 + d\Sigma wx^4 \qquad (2.4)$$

first degree

$$\Sigma wx^2y = a\Sigma wx^2 + b\Sigma wx^3 + c\Sigma wx^4 + d\Sigma wx^5 \qquad (2.5)$$

second degree

$$\Sigma wx^3y = a\Sigma wx^3 + b\Sigma wx^4 + c\Sigma wx^5 + d\Sigma wx^6 \qquad (2.6)$$

third degree fit