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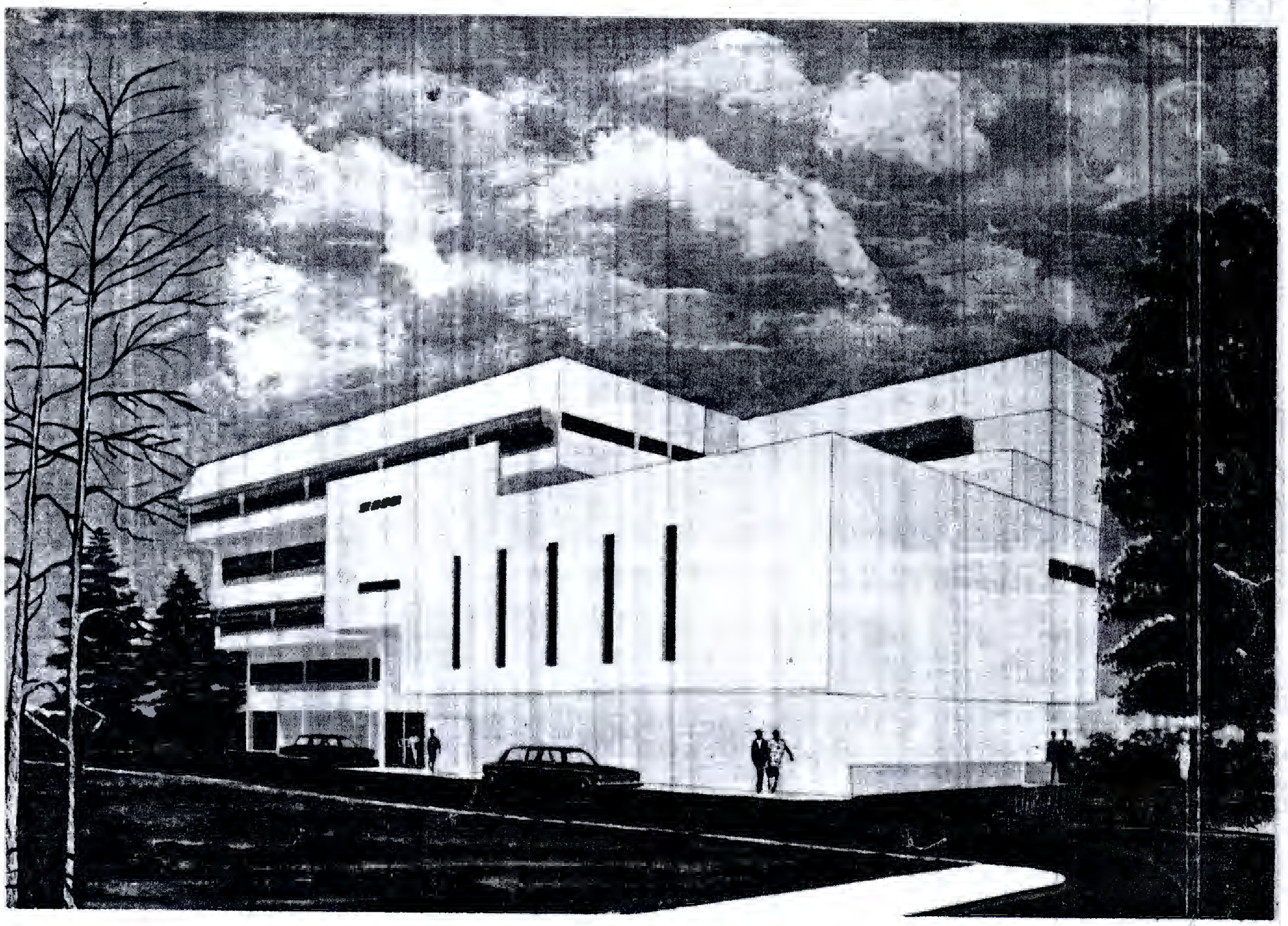

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Forecasting Nigerian aluminium demand

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ABSTRACT

In Nigeria today, Aluminium is beginning to find application not only for kitchen utensils but in construction, transportation and packaging. At this time when the plans for establishing a smelter capacity is being made, there is a need for an indepth study, despite the poor data, to determine the aluminium demand forecast which is invaluable for any practical capacity planning for such a very capital intensive industry. Various method used for medium and long-term forecasts in the ferrous and non-ferrous industry were examined as well as determining the main factors which influence aluminium consumption. Based on this a methodology was developed and used in making aluminium demand forecast for Nigeria for the year 1982 to 2,000. Direction for further work was also made.

INTRODUCTION

Numerous methods are used today to make medium and long-term projections in the ferrous and non-ferrous industries, and these can be classified into three broad categories, namely: qualitative, causal, and time series. There are of course otherssuch as the input-output, leading indicators, subjective probabilistic forecasting and decision analysis.

Qualitative methods are used when no quantitative data (or insufficient) for a very long term projection is available, or where historical data cannot be extrapolated sufficiently far into the future. A simplified classification (Refs. 3,9) is: Delphi technique, Trend extrapolation, Scenaria methodology, Dynamic system modelling and Cross impact modelling. Dore (Ref. 4) and the Aluminium Association forecasts are simply trend extrapolations. The U.S. Bureau of Mines contingency forecast (Ref. 12) and Woodward's (Ref. 20) approach for aluminium demand up to the year 2000 A.D. are fundamentally the scenario approach. Substitution and inter-substitution of Aluminium with other metals such as copper have been considered for the electrical industry by Rohatgi and Weiss (Ref. 12) and substitution forecast in input-output model by Ayres et al. (Ref. 2). Multi-level substitution could be performed instead, for instance, by dynamic modelling, as in Sharif et al. Ref. 13).

The causal method is quite a common approach for ferrous and non-ferrous metal demand forecasting. It expresses the relationship of the item being forecast (dependent variable) and a number of explanatory variable (independent variables), usually GDP population, and prices. Rohatgi et al. have reported various works using regression analysis. Some complicate the basic regression framework by including inter-substitutability between the non-ferrous metals under consideration, capacity utilization rate, and scrap prices, as in the forecasting and simulation model of the Aluminium/Copper industry by Synergy Inc. (Ref. 15) It is an econometric model.

Time series methods consist of establishing patterns and trends in a historical series of data and extrapolating them into the future. Although there appears to be numerous methods, most of them are based, with variation, on a basic method – the most sophisticated version of which was developed by the IISI for the projection of world steel demand up to 1985 (Ref. 1). Similar methods have been used by the EEC for its 1976 forecast (Ref. 5). Theoretical considerations and other time series approaches are presented in the OECD forecast (Ref. 11). Another method used by several developing countries is the assumption that their country will exactly follow the path of another country (Ref. 18), which is the underlying thought in Altenphol's paper (Ref. 1) in which he argues that there

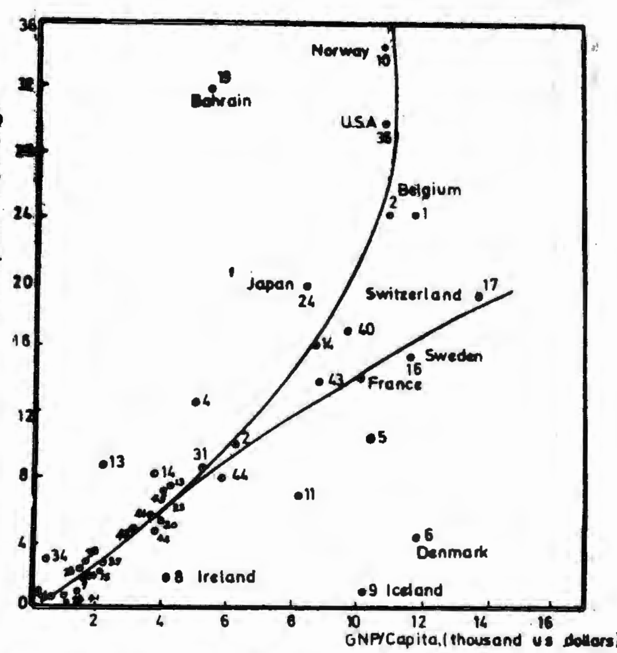


FIG:1 Relationship Of Per Capita Consumption And Income 1979.

is a 75 year lag between the developing countries and Western Europe.

From these papers one can see clearly that a straightforward application of any one methodology is inadequate, but a hybrid of these methods and also it will be essential to include cross sectional data from as many developing countries as possible. Unfortunately, the data for Nigeria is either not available, inadequate or conflicting. For this reason approaches similar to those above are used or indicate a possible methodology. However, before making the demand forecast we will first of all identify the major influences affecting aluminium consumption.

MAIN FACTORS INFLUENCING THE CONSUMPTION OF ALUMINIUM

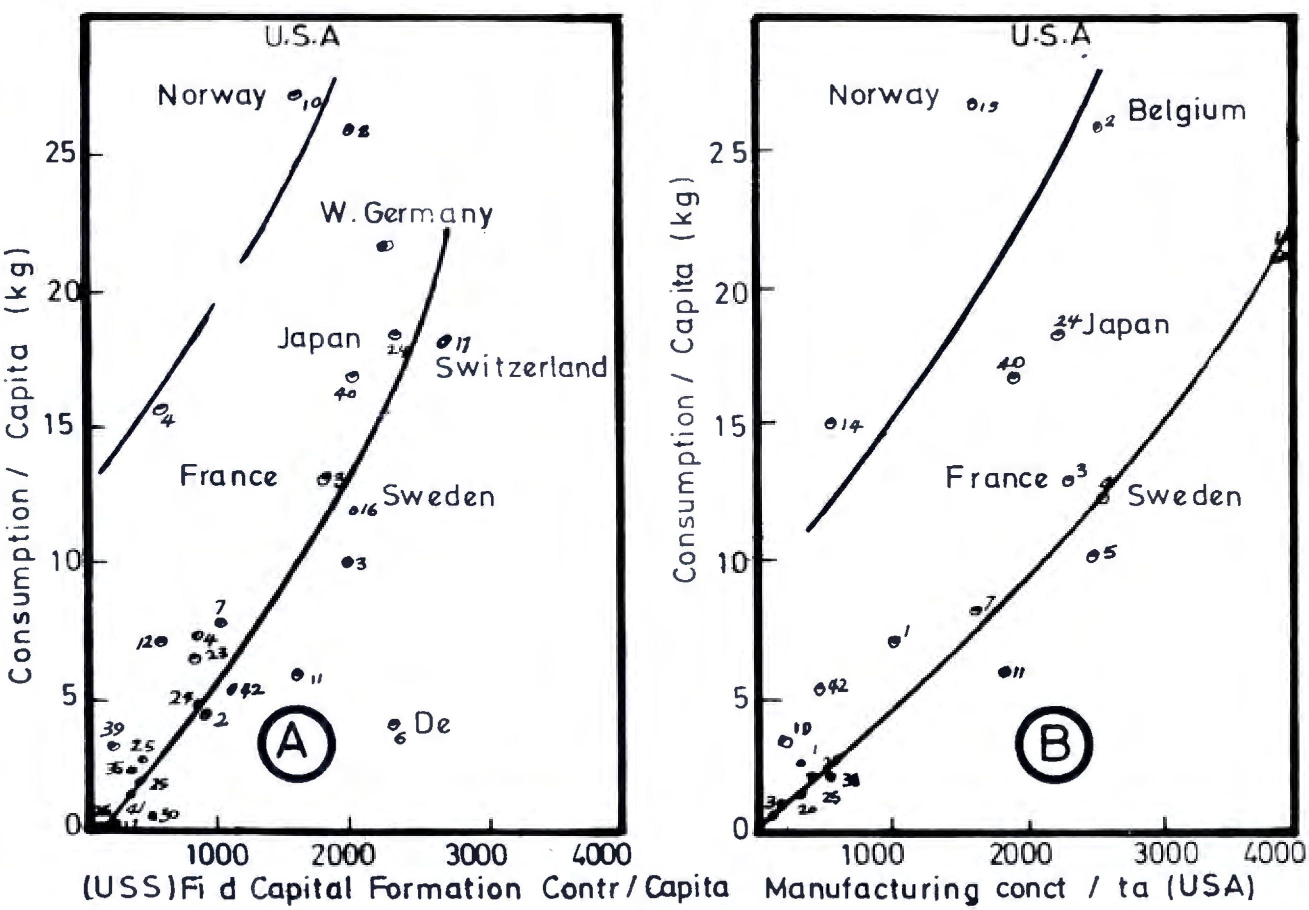
LEVEL OF ECONOMIC DEVELOPMENT

If economic development is characterised by the gross national product per capita, consumption is seen (Fig. 1) to be correclated with it. At lower value of GNP, below $4000, per capita consumption seems to be proportional to per capital GNP, with a gradient of 1.5 kg per thousand dollars. Above that, it tends to increase exponentially (in the U.S.A., Norway and Japan), or decrease (in France, Sweden, Switzerland, etc.). Also there is considerable dispersion around the lines indicating that there are other factors. The countries that are very far off from the lines are mainly countries with small populations; for example, Ireland, Iceland, Bahrain, etc.

When per capita is plotted against contribution from fixed capital formation or manufacturing to GDP, the dispersion is slightly reduced, especially for fixed capital formatoin (Fig. 2a & b). There again seems to be two groups: the U.S.A. and France-groups.

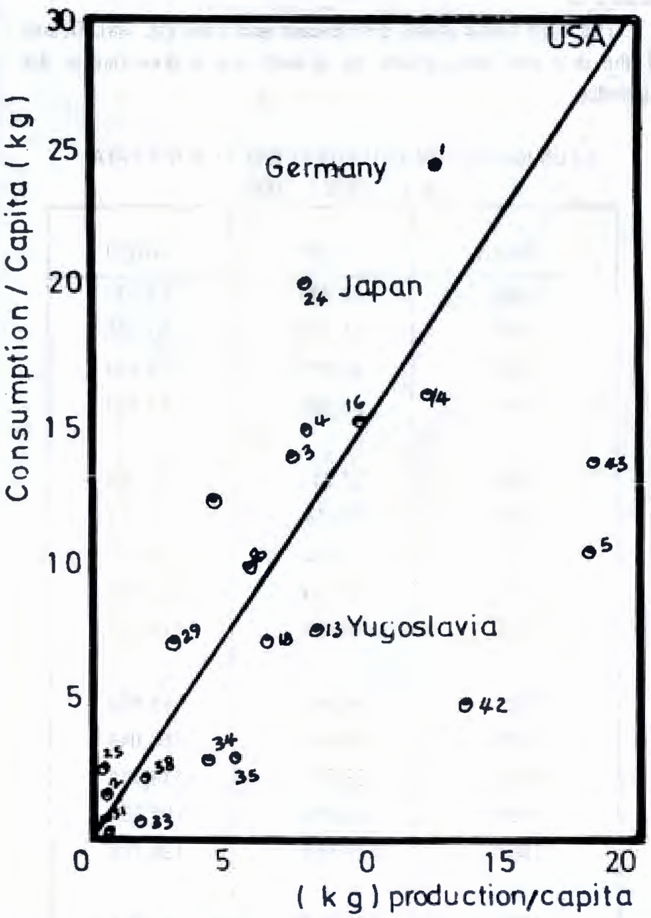
AVAILABILITY OF ALUMINIUM

In most forecasting studies in the metals industry, this factor has been neglected, and where it is considered it is incorporated in an indirect way, such as supply/demand imbalance, or in qualitative assessment. From Fig. 3 it is clear that per capita consumption is positively correlated to production per capita. Consumption per capita increases at a rate of about 1.5 kg for every kg increase in production for 1978 data. Furthermore, it appears that non-producing countries have lower consumption per capita than exporting countries, or where it is readily available - for example, in Belgium. In other words, the per capita consumption tends to increase when aluminium is easily available. This 'ease' is punctuated in countries where there are imports and foreign exchange controls, such as in Nigeria. Another observation that can be made, although not distinct, is that for countries of about the same production per capita, the consumption per capita tends to be higher according to the age of the industry (i.e. time of first smelter capacity) - for example, W. Germany (1897); Japan (1933); U.S.A. (1888); Yugoslavia (1954).

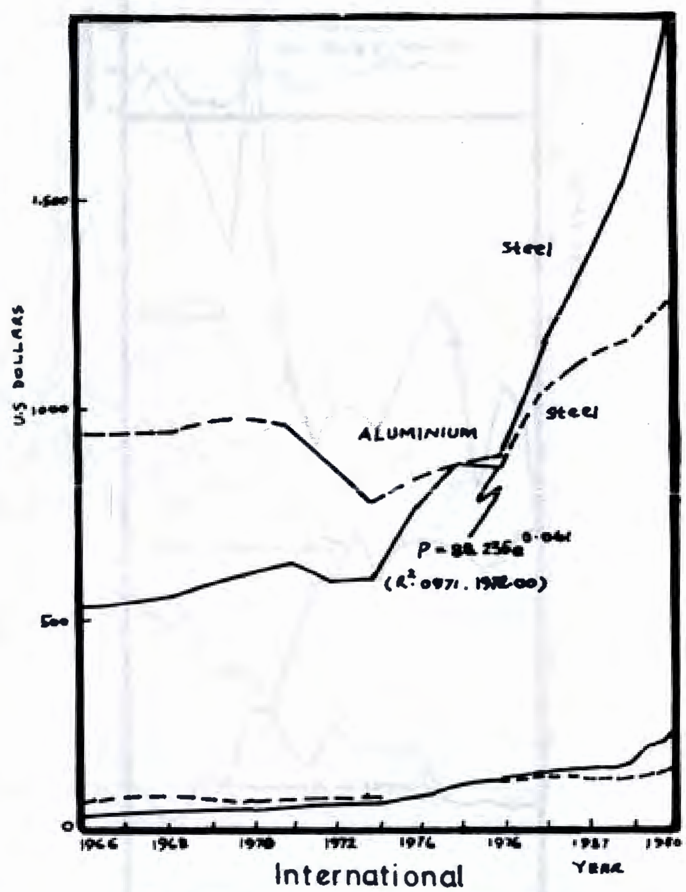


Relationship of per capita cosumption and fixed capital formation and manufacturing, 1978. Data source: Refs. 8,16,17

FIG. 2



Relationship of per capita cosumption with production/ capita, 1975.
Date sources. Ref. 8, 16, 17. FIG. 3



International
Bauxite And Alumminium Prices

FIG: 4

LONG-TERM TENDENCIES OF PRICES

Real prices for aluminium have continued to drop until the early 1970's (after the oil crisis), when it then started to rise (Fig. 4). Price rises were accentuated in 1974 with price increaes of Bauxite, following the formation of the IBA [2] Also the price ratio of the engineering materials in competition with Aluminium started to fall, or at least the rise slowed down (see Fig. 5), especially for Copper. The highest consumption growth rates have been seen during the period when real prices were fallingand the price ratios were to the advantage of Aluminium.

POPULATION GROWTH

In the early stages of economic development, the per capita consumption will tend to rise in line with the level of economic development, but will tend to stabilize, and the absolute magnitude of demand is then determined by the growth of the population.

TECHNOLOGICAL PROGRESS AND SUBSTITUTION

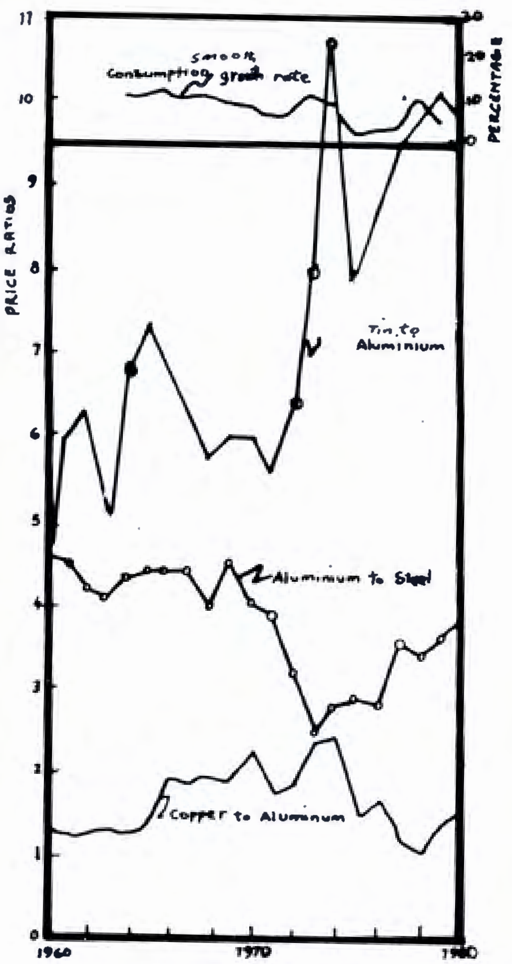
The effects of technological progress on Aluminium consumption is difficult to determine numerically. Essentially, it affects aluminium consumption in two ways: by creating new, technically better, and functionally cheaper products, and by improving the technologies in the production process. The swifteness of the development of aluminium usage over the relatively short period of its introduction is partly because of extensive research and development in industry and laboratories. The effect of technological progress could be incorporated indirectly through substitution and inter-substitution with competing materials, such as copper, tin, steel and plastics.

FORECASTING DEMAND FOR NIGERIA

The consumption, population, and GDP prices data for the Nigerian study is presented in Appendix. Consumption data was obtained from summing up and comparing import/export data from various sources for each individual year. Three approaches are considered viz: multiple regression, the intensity method and systems dynamics.

For the multiple regression approach consumption per capita was regressed with GDP per capita and international prices. In the intensity method, intensity curves for over 30 countries were drawn [3] as shown in Fig. 6. There appears to be two groups of curves and Nigeria is in the first groups, free-hand drawing provide the curve for forecasting damand in Nigeria. Similarly, intensity-like curve for per capita contribution of fixed capital formation to GDP per capita, and the curves, are shown in Fig. 7; this time more developing countries were included.

So far the effects of production substitution has not been incorporated. A ready method of incorporating all these could be by dynamic modelling. Although there have been some investigations on substitution and inter-substitution using System Dynamics, there does not appear to be any integrating of all these factors. It is for this reason that a simple solution is indicated. However, because of



Price Ratio Of Engineering Materials (1980) In Competition With Aluminium.

FIG. 5

the difficulty of obtaining data in the Nigerian case, numerical solution is not performed. The causal diagram is shown in Fig. 8. DYNAMO could be used in the programming.

In trying to use Fig. 7 with fixed gross capital function data or for manufacturing the discrepancy with the GDP/ capita is very significant. For example, for 1981 the aluminium intensity is as follows:

GDP/Capita	–	0.64 gram/US dollar
Fixed capital function	–	1.1 gram/US dollar
Manufacturing	–	0.29 gram/US dollar

A prima facie reason for this large difference could be because of the difficulty in obtaining consistent data.

CONSLUSION

The GDP/capita data appears to give an average of the two extremes provided by fixed capital formation data and manufacturing data. It would appear however that a systems approach via system dynamic approach could provide a more realistic forecast especially when Nigeria establishes an aluminium smelter capacity. In any case, the present Nigerian alumium consumption is distinctly higher than what is obtained by summing up import statistics from federal offices of statistics and extrapolating into the future.

RESULTS

The table below shows the forecast read from Fig. 7(a). Details of the data and assumptions for growth rate is presented in the appendix.

ALUMINIUM DEMAND FORECAST FOR NIGERIA (M.T.) 1982 – 2000

YEAR	LOW	HIGH
1982	52,333	52,333
1983	54,729	54,729
1984	58,929	58,929
1985	63,666	63,333
1986	67,947	70,665
1987	72,78-	79,312
1988	77,78-	86,492
1989	84,132	100,959
1990	90,728	118,253
1991	94,495	145,942
1992	101,650	160,044
1993	106,920	173,745
1994	118,151	183,536
1995	129,958	196,199
1996	139,933	206,858
1997	150,390	218,066
1998	162,637	229,757
1999	183,459	241,953
2000	119,690	261,519

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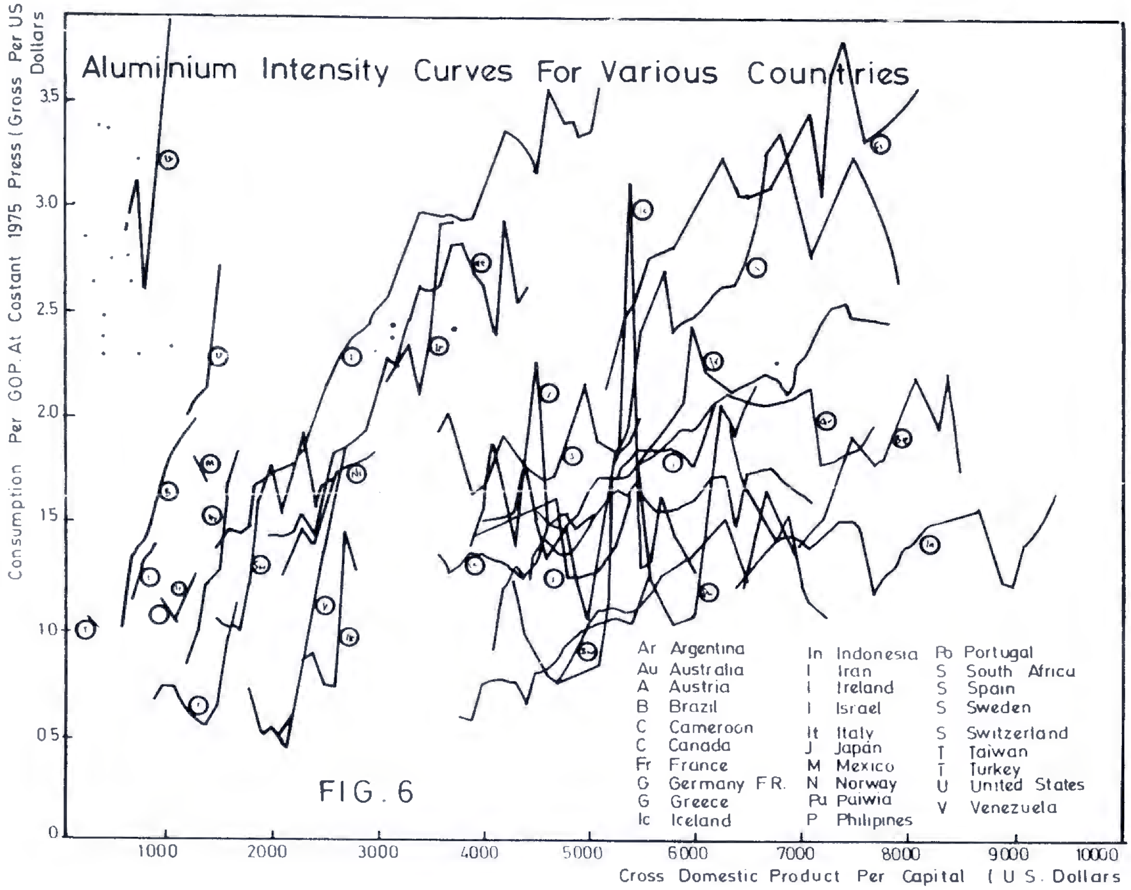


FIG. 6

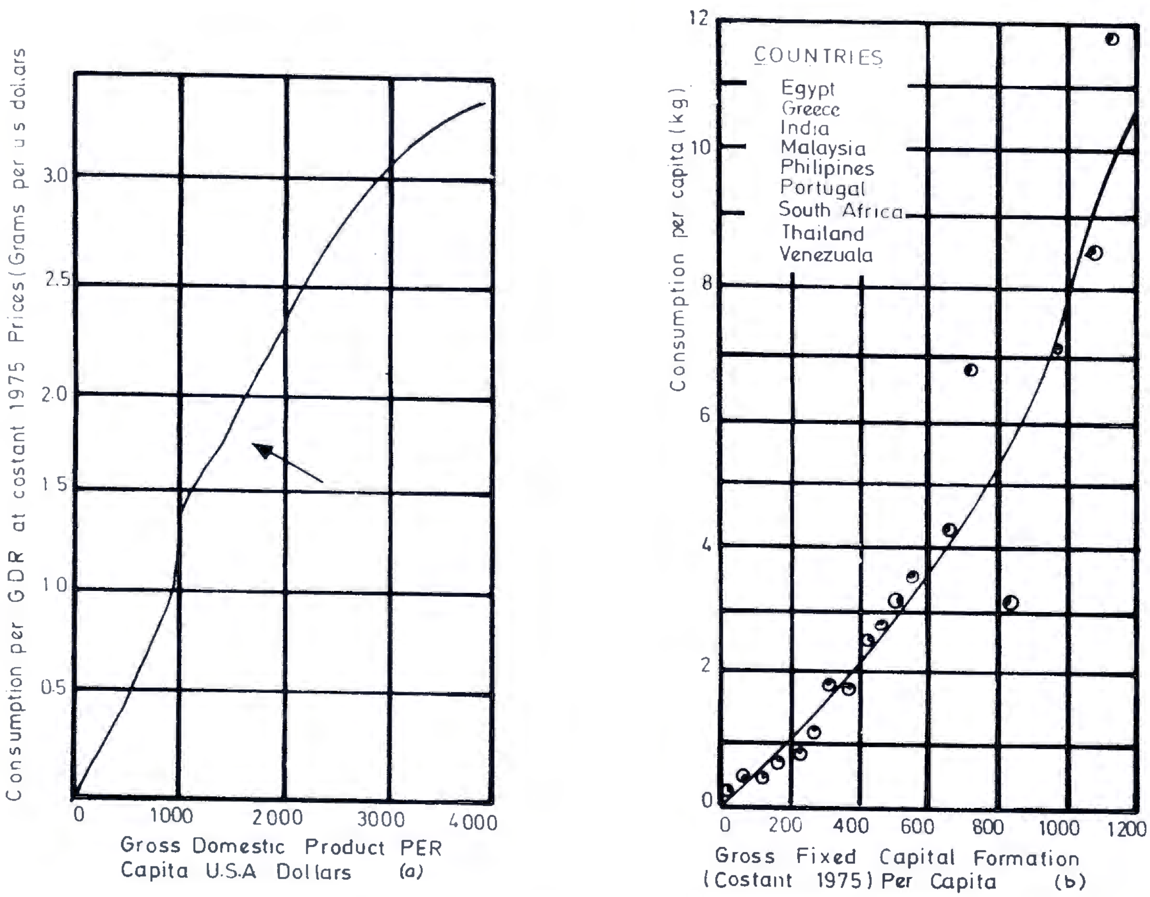
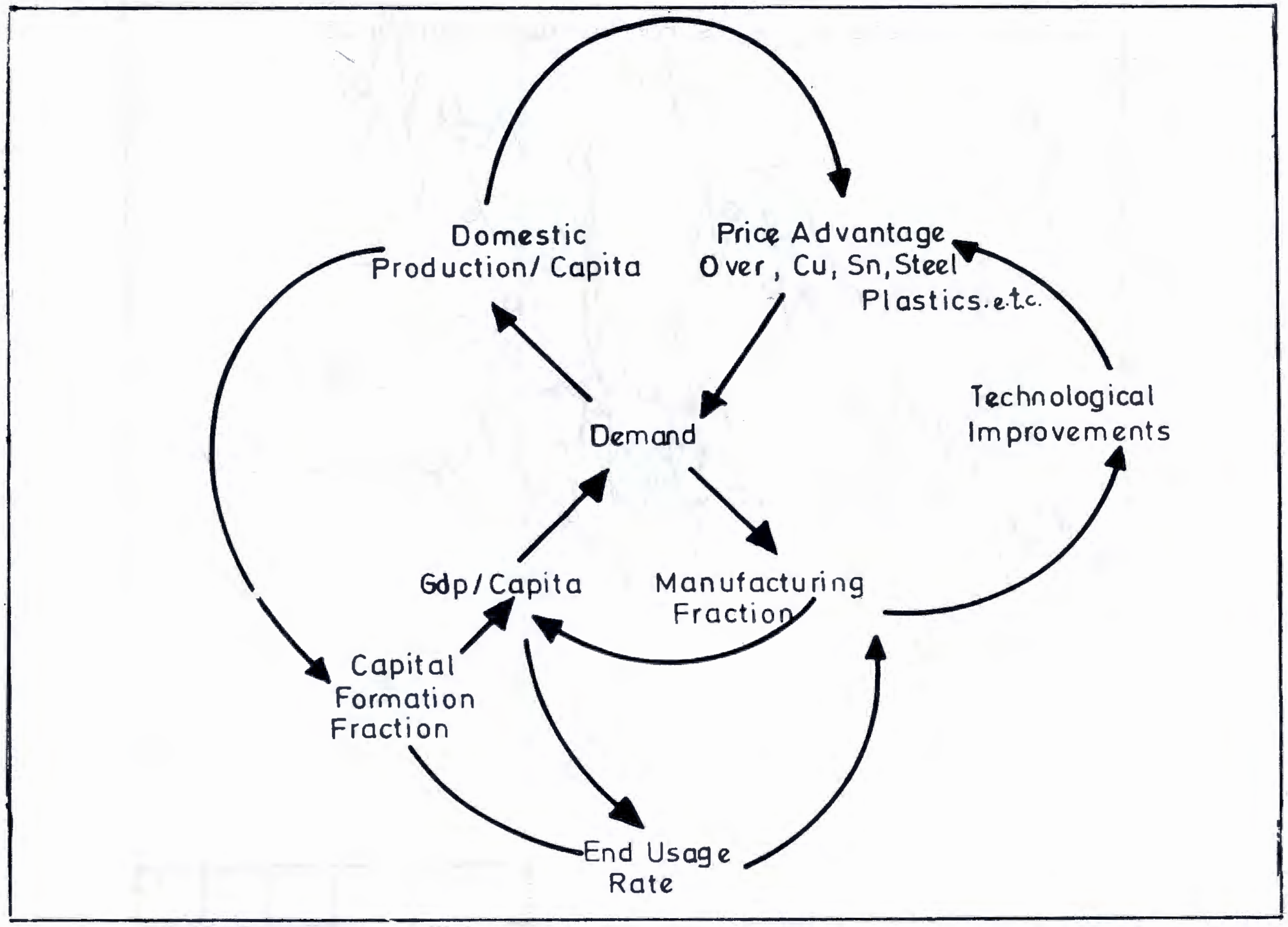


FIG:7 Curves For The Nigerian Demand Forecast.



Simple Causal Relationships in Aluminium Consumption. FIG.8

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APPENDIX DATA FOR DEMAND FORECASTING IN NIGERIA

(a) Aluminium Imports in Nigeria, 1966–1978 (metric tonnes)

Year	Unwrought	Semis	Finished Products		
			Aluminium (100%)	Part Aluminium	Total
1966	3.8	1247.3	4244.7	1375.6	6871.4
1968	46.9	4979.2	3947.5	367.0	9340.6
1969	138.3	4553.3	564.1	342,8	5598.5
1971	249.8	9879.5	1415.0	1230.2	12,774.5
1972	110.3	7633.9	1529.9	(1240.0)	10514.1
1973	350.3	8354.9	1688.0	1263.3	11,656.5
1975	3297.8	16315.5	3407.6	(2000.0)	10,336.9
1976	5334.1	12126.9	5236.3	3877.1	26,574.4
1977	3962.5	15123.7	7401.4	4945.5	31,433.1
1978	1616.7	19168.9	9231.2	(5000.0)	35,016.8

GROUP	ISTC CODE	COMMODITY
Unwrough	684 – 10	Aluminium and Aluminium Alloys, unwrought.
Semis	684 – 21	Bars, Rods, Angle Shapes, Sections, and Aluminium Wire
	684 – 22	Plates, Sheets, and Aluminium Strips
	684 – 29	Aluminium Foil, Aluminium Powders and Flakes, Tubes, Pipes, etc.
Finished Products: (all Aluminium)	691 – 21	Aluminium Doors and Window Frames.
	691 – 29	Other Aluminium Structural Parts and Constructions.
	692 – 13	Tanks Vats and Reservoirs of Aluminium for storage or manufacturing used for transport of goods.
	697 – 23	Domestic Utensils of Aluminium.
(partly Aluminium)	723 – 10	Insulated Wire and Cable (3% 1966–70, 5% 1971–72).
	732	Road Motor Vehicles (0.4% 1966 –70, 0.8% 1971–78).

(b) Total Aluminium Apparent Consumption for Nigeria, 1966 – 78 (Tonnes)
(Source: Statische Zusammenstellungen)

Year	Adjusted	Finished Product[1]	Total
1966	5764	5620	11,384
1967	5111	(5620)	10,731
1968	3582	4315	7897
1969	5510	907	6417
1970	7566	(1000)	8566
1971	10298	2645	12,943
1972	9203	2770	11,973
1973	10290	2951	13,241
1974	13339	(3000)	16,339
1975	35261	5408	40,669
1976	22716	9113.4	31,829
1977	31461	12347	43,808
1978	26546	14231	40,777

Import Costs (c.i.f.) Aluminium (100% content) (U.S.$/Tonne)

Commodity		1975–1976	1977-1978
684 – 10	Unwrought	1396	3042
684 – 21	Bars	1087	2849
684 – 22	Plates, Sheets	1843	2454
684 – 29	Foils, Powder	2547	4315
691 – 21	Doors and Windows	3197	3681
691 – 29	Other structural	4801	4220
692 – 13	Containers	6266	6064
692 – 22	Cans	3988	4204
697 – 23	Holloware	2308	4076

(c) Assumed Growth Rates (%)

Year	GDP		FCF		Manufacturing	
	High	Low	High	Low	High	Low
1986–1990	8.0	5.5	5.5	4.5	18.0	10.0
1991–1995	7.5	5.0	4.0	3.0	15.0	10.0
1996–2000	7.0	4.5	3.5	2.5	10.0	8.0
2001–2005	6.5	4.0	3.0	2.0	10.0	6.0

POPULATION: $y = 40.85\,e^{0.0295\,t}$ (0.999)

Base 1980 billion dollars @ 1975 prices

GDP : 68.624

FCF : 22.612

Manufacturing : 8.859

Manufacturing : $y = 1.313\,e^{0.000869\,x}$ ($R^2 = 0.753$)

FCF : $y = 0.4156\,e^{0.00325\,x}$ ($R^2 = 950$)

Production : $y = 0.762 + 1.5\,x$ ($R^2 = 918$)

Multiple Regression :

$$y = 0.918\,(GDP/Cap) + 15.790\,(Price) - 337.545\,(Pop) + 13655.93$$

($R^2 = 84796$) ($R^2 = 0.00985$) ($R^2 = 0.00184$)

FOOTNOTES

International Iron and Steel Institute

International Bauxite Assocation

From Tabe (a)