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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 others such 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, Scenario 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. 28) approach for aluminium demand up to the year 2000 A.D. are fundamentally the scenario approach. Substitution and inter-substitution of Aluminiun 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.19) 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 variations, on a basic method - the most sophisticated version of which was developed by the ISF 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.9). 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...
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 correlated with it. At lower value of GNP, below $4000, per capita consumption seems to be proportional to per capita 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 formation (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).

![Figure 1: Relationship of per capita consumption and fixed capital formation and manufacturing, 1978. Data source: Refs. 8, 16, 17](image1.png)

![Figure 2: Relationship of per capita consumption and fixed capital formation and manufacturing, 1978. Data source: Refs. 8, 16, 17](image2.png)
LONG-TERM TENDENCIES OF PRICES

Real prices for aluminium have continued to drop until the early 1970s (after the oil crisis), when they started to rise (Fig. 4). Price rises were accentuated in 1974, with price increases of Bauxite, following the formation of the IBA. Also the price ratio of the engineering materials in comparison with aluminium started to fall, or at least the rate slowed down (see Fig. 5), especially for copper. The highest consumption growth rates have been seen during the period when real prices were falling and 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 swiftness 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 price 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 system 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 as shown in Fig. 6. There appears to be two groups of curves and Nigeria is in the first group, free-hand drawing provide the curve for forecasting demand 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

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.

CONCLUSION

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 a systems dynamic approach could provide a more realistic forecast especially when Nigeria establishes an aluminium smelter capacity. In any case, the present Nigerian aluminium consumption is distinctly higher than what is obtained by summing up import statistics from federal offices of statistics and extrapolating into the future.

REFERENCES

Aluminium Intensity Curves For Various Countries

FIG. 6

Gross Domestic Product PER Capita U.S.A Dollars (a)

Consumption per GDR at constant 1975 Prices/Grams per U.S. dollars

COUNTRIES
- Egypt
- Greece
- India
- Malaysia
- Philippines
- Portugal
- South Africa
- Thailand
- Venezuela

FIG. 7 Curves For The Nigerian Demand Forecast.
Simple Causal Relationships in Aluminium Consumption. FIG.8

1. I.S.I. PROJECTION '85: WORLD STEEL DEMAND, Brussel's, 1972
4. Metalwirtschaft, A.G., Metal Statistics, Frankfurt, 1979 and various years
8. UNIDO Sectional Studies Section. THE WORLD IRON AND STEEL INDUSTRY (Second study), UNIDO/ICIs.89, 20 Nov. 1978.
APPENDIX DATA FOR DEMAND FORECASTING IN NIGERIA

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Unwrought</th>
<th>Semis</th>
<th>Finished Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aluminium (100%)</td>
</tr>
<tr>
<td>1966</td>
<td>3.8</td>
<td>1247.3</td>
<td>4244.7</td>
</tr>
<tr>
<td>1968</td>
<td>46.9</td>
<td>4979.2</td>
<td>3947.5</td>
</tr>
<tr>
<td>1969</td>
<td>138.3</td>
<td>4553.3</td>
<td>564.1</td>
</tr>
<tr>
<td>1971</td>
<td>249.8</td>
<td>9879.5</td>
<td>1415.0</td>
</tr>
<tr>
<td>1972</td>
<td>110.3</td>
<td>7633.9</td>
<td>1529.9</td>
</tr>
<tr>
<td>1973</td>
<td>350.3</td>
<td>8354.9</td>
<td>1686.0</td>
</tr>
<tr>
<td>1975</td>
<td>3297.8</td>
<td>16315.5</td>
<td>3407.6</td>
</tr>
<tr>
<td>1976</td>
<td>5334.1</td>
<td>12126.9</td>
<td>5236.3</td>
</tr>
<tr>
<td>1977</td>
<td>3962.5</td>
<td>15123.7</td>
<td>7401.4</td>
</tr>
<tr>
<td>1978</td>
<td>1616.7</td>
<td>19168.9</td>
<td>9231.2</td>
</tr>
</tbody>
</table>

GROUP ISTC CODE COMMODITY

Unwrought 684 - 10 Aluminium and Aluminium Alloys, unwrought.

Semis 694 - 21 Bars, Rods, Angle Shapes, Sections, and Aluminium Wire

694 - 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).
Total Aluminium Apparent Consumption for Nigeria, 1966 - 78 (Tonnes)
(Source: Statistische Zusammenstellungen)

<table>
<thead>
<tr>
<th>Year</th>
<th>Adjusted</th>
<th>Finished Product</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>5764</td>
<td>5620</td>
<td>11,384</td>
</tr>
<tr>
<td>1967</td>
<td>5111</td>
<td>(5620)</td>
<td>10,731</td>
</tr>
<tr>
<td>1968</td>
<td>3582</td>
<td>4315</td>
<td>7897</td>
</tr>
<tr>
<td>1969</td>
<td>5510</td>
<td>907</td>
<td>6417</td>
</tr>
<tr>
<td>1970</td>
<td>7566</td>
<td>(1000)</td>
<td>8566</td>
</tr>
<tr>
<td>1971</td>
<td>10298</td>
<td>2645</td>
<td>12,943</td>
</tr>
<tr>
<td>1972</td>
<td>9203</td>
<td>2770</td>
<td>11,973</td>
</tr>
<tr>
<td>1973</td>
<td>10280</td>
<td>2551</td>
<td>13,241</td>
</tr>
<tr>
<td>1974</td>
<td>13339</td>
<td>(3000)</td>
<td>16,339</td>
</tr>
<tr>
<td>1975</td>
<td>35251</td>
<td>5408</td>
<td>41,669</td>
</tr>
<tr>
<td>1976</td>
<td>22716</td>
<td>9113.4</td>
<td>31,829</td>
</tr>
<tr>
<td>1977</td>
<td>31461</td>
<td>12347</td>
<td>43,808</td>
</tr>
<tr>
<td>1978</td>
<td>26546</td>
<td>14231</td>
<td>40,777</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>694 - 10 Unwrought</td>
<td>1396</td>
<td>3042</td>
</tr>
<tr>
<td>694 - 21 Bars</td>
<td>1087</td>
<td>2949</td>
</tr>
<tr>
<td>694 - 22 Foils, Sheets</td>
<td>1843</td>
<td>2454</td>
</tr>
<tr>
<td>694 - 29 Foils, Powder</td>
<td>2547</td>
<td>4315</td>
</tr>
<tr>
<td>699 - 21 Doors and Windows</td>
<td>3197</td>
<td>3681</td>
</tr>
<tr>
<td>699 - 23 Other structural</td>
<td>4801</td>
<td>4220</td>
</tr>
<tr>
<td>699 - 13 Containers</td>
<td>6266</td>
<td>6604</td>
</tr>
<tr>
<td>692 - 22 Cans</td>
<td>3988</td>
<td>4204</td>
</tr>
<tr>
<td>697 - 23 Holloware</td>
<td>2308</td>
<td>4076</td>
</tr>
</tbody>
</table>

Assumed Growth Rates (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP High</th>
<th>Low</th>
<th>FCF High</th>
<th>Low</th>
<th>Manufacturing High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986-1990</td>
<td>8.0</td>
<td>5.5</td>
<td>5.5</td>
<td>4.5</td>
<td>18.0</td>
<td>10.0</td>
</tr>
<tr>
<td>1991-1995</td>
<td>7.5</td>
<td>5.0</td>
<td>4.0</td>
<td>3.0</td>
<td>15.0</td>
<td>10.0</td>
</tr>
<tr>
<td>1996-2000</td>
<td>7.0</td>
<td>4.5</td>
<td>3.5</td>
<td>2.5</td>
<td>10.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2001-2005</td>
<td>6.5</td>
<td>4.0</td>
<td>3.0</td>
<td>2.0</td>
<td>10.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Population: \( y = 40.85 e^{0.0295t} \) (R^2 = 0.999)

Base 1980 billion dollars @ 1975 prices

GDP : 68.624
FCF : 22.612
Manufacturing : 8.859

Multiple Regression:

\( y = 1.313 e^{0.000869x} \) (R^2 = 0.753)

\( FCF = 0.4156 e^{0.00325x} \) (R^2 = 0.950)

\( Production = 0.762 + 1.5x \) (R^2 = 0.918)

\( y = 0.918 (\text{GDP/Cap}) + 15.790 (\text{Price}) - 337.545 (\text{Pop}) + 13655.83 \) (R^2 = 0.84796)

\( (R^2 = 0.00985) \) (R^2 = 0.00184)