Title of Thesis

An Analysis of Factors Influencing the Consumption of Aluminium in the UK.

Michael Stanley Turner

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Synopsis

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Consumption of aluminium and other selected materials in the UK is compared with that in other similarly developed economies between 1960-69. Reference has been made to relevant literature and the analysis has included statistical data relating to economic performance. Structure of the aluminium supply industry and the policy implemented by the main suppliers had a stimulative effect upon international consumption.
Growth in the aggregate consumption of aluminium was closely related to the value and growth rate in value of industrial output. Aggregate consumption of aluminium increased more rapidly than the value of output from manufacturing and construction industries. Specific consumption of aluminium tended to increase more at higher rates of increased value of manufactured output.

The transport equipment sector consumed the highest proportion of total aluminium consumption in the UK, but other sectors including electrical engineering, building and construction and packaging were also important. Analysis of end-use sectors showed, international trends towards increased specific aluminium consumption related to the value of output, but the strength of correlations varied from strong with respect to transport equipment to indefinite with the building sector.

Rate of increase in UK aluminium consumption was restrained by the slow rate of growth in sector output, compared with the other economies studied. The UK building and construction sector consumption contrasted with US and Japanese aluminium consumption and was notable for a reduction in specific consumption.

The UK and international specific consumption of plastics materials increased more rapidly than aluminium while the specific consumption of traditional non-ferrous metals decreased.

UK aluminium consumption behaviour is recognised as one symptom of a slow growth economy in which the cost benefit of technological innovation is difficult to realize. A conclusion is reached that, if the relative materials-related innovative performance observed between 1960-69 is allowed to continue, it will make UK manufactured products increasingly lesscompetitive.

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1. Introduction

Introduction

Published statistical data relating to the consumption of aluminium shows that the UK aggregate consumption in 1960 was high relative to other similarly developed economies, but that a low rate of growth in UK aluminium consumption occurred during the decade immediately following 1960.

Previous analyses (1) (2) (34) (47) have identified the need for effective use of materials and processes in order to achieve increased productivity and the contribution made by technological innovation toward improved economic efficiency and growth in industrial output. Progressive exploitation of newer materials and improved processes is recognised as an important aspect of technological innovation. It is postulated that response by industry toward achieving improved efficiency is partly reflected by the relative changes in the specific consumption of materials.

Literature relating directly to aluminium consumption is reviewed separately from that which relates to economic growth in the UK economy. Aspects discussed include the influence which the structure and policy of the aluminium industry have had upon consumption, the significance of derived demand for aluminium and the interaction of factors influencing growth in industrial output.

Attention is given to, the formulation of criteria relevant to the evaluation of differences in international materials consumption, the precautions which are necessary in order to ensure acceptable comparability of data and the need to acknowledge the limitations of the results obtained with respect to the explanation of behaviour.

 1.

Published statistical data for the period 1960-69 is analysed in order to investigate possible relationships between the level and rate of change of aggregate and disaggregate economic output and the demand for aluminium. Regression analysis is used to minimise the distorting influence of cyclic demand, to ascertain the degree of international correlation with the relationships investigated and to compare UK aluminium consumption with that of other countries. Production of different product forms and relative demand by selected industrial economic sectors is analysed with respect to the significance of the end-use profile of aluminium consumption.

Analysis is made of the detailed Aluminium Federation statistics for the UK to show the influence that particular industrial sectors have had upon consumption, but which is not possible when using the generalised international classification of end-use sectors adopted by OECD.

Comparative study is also made of steel, selected traditional non-ferrous metals and plastics materials consumption.

Explanations are presented concerning, factors which motivate technological innovation, need for capital investment in order to achieve innovation, difficulties inherent in attempting to justify capital investment in a slow growing economy and possible consequences of failure to achieve increased economic efficiency.

2. Review of Literature relating to Aluminium Consumption

2.1

Sources of Statistical Data relating to the Consumption of Primary and Secondary Aluminium.

A number of sources of statistical data covering the production and consumption of aluminium in developed Western economies are readily available, including publications by OECD(3), Metallgesllschaft(4), Organisation of European Aluminium Smelters (OEA)(5) and the European Aluminium Association (6). In general, these publications are primarily concerned with numerical data covering supply and consumption of metal and not with the detailed analysis of factors that govern demand and consumption. The OEA publication is a more specialised document that presents statistical data and discussion particularly relevant to the secondary metal industry and the consumption of aluminium in foundries. A certain amount of caution is necessary in making comparisons of absolute levels of consumption, since it is acknowledged that a standard international method of compiling aluminium statistics has not yet been adopted throughout the world or even in Europe. Limitations that arise in the analysis, comparison and interpretation of statistics are mainly due to the fact that all countries do not present equally comprehensive data and even the most comprehensive is restrictive for research purposes by the broad inhomogemeous groups in which the data is presented.

 2.2

Previous Analyses of Aluminium Consumption

Previous investigations by Rosenzweig (7) and Fisher (8) were concerned with the forecasting of demand for primary aluminium in the 1960's, in order to establish the increase in productive capacity required with specific reference to the USA market. The results of these analyses, based upon least squares and logarithmic regression analysis have limited significance in the present context for a number of reasons including, emphasis on the US market demand without reference to international comparisons, no reference is made to secondary metal consumption and the period which included World War II represents a period of gross distortion of demand pattern and level. These analyses represent an historical statistical forecasting exercise for primary aluminium completely divorced from total aluminium consumption, which includes a large proportion of secondary aluminium. However, both of these investigations questioned the economic causes of increase in demand, whilst Fisher alone admitted the distorting influence of World War II. Investigation of price demand elasticity resulted in Rosenzweig concluding that, "price factors seem to add nothing significant to the explanation of demand for aluminium and that the linkage between demand and level of GNP is the most important factor".

Fisher hypothesised about the effect of Oligopolistic competition (involving a few large firms) that existed among primary aluminium producers, suggesting a resultant rigidity in pricing, secrecy about real prices, and the establishment of conditions for long run profit maximisation. Fisher also recognised that aluminium consumption depends upon a derived demand.

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Consequently, any price elasticity would most probably be long term, significant over a three year period, whilst short-term price movement dictated by commercial expediency would not be significant in the long term.

Derived demand is a term used to describe the input provision of any non-primary industrial activity. For the purpose and aims of the present analysis, the consumption of primary and secondary aluminium is measured as the weight of aluminium input into end - use industries together with miscellaneous applications not discretely identified in the sources of statistical data, as opposed to the weight of aluminium absorbed by end-users in the form of final product. Adopting the terminology of Hirschman (26) Chenery and Watanabe (27), the derived demand for aluminium is generated through the backward linkage established by the absorption of aluminium in end-use manufacturing industry. Aluminium consumption conforming to the description of derived demand is, therefore, by implication directly affected by the behaviour of end-use industries, as well as indirectly by the end-use final product market. Conversely, the output utilisation (consumption) of primary and secondary aluminium is largely fed through forward linkages, defined as that delivered material that does not cater exclusively to final demand. Derived demand for aluminium forms part of a measure of the dependence of end-use manufacturing industries upon aluminium. Chenery and Watanabe have quantified the degree of interdependence of various industries by determining their respective backward and forward linkages from data contained in Input - Output tables, where backward linkage is defined as the ratio of inter-industry purchases to total production, and forward linkage as the ratio of inter-industry sales to total demand, and where both may be expressed as a percentage. Examples of high forward linkages are observed for inter mediate manufactured product forms, non-ferrous metals (81%), iron and steel (78%) and low forward linkages for final manufacturing industry, transport equipment (20%), shipbuilding (14%). In contrast, high backward linkages are observed for final manufacturing industry, transport equipment (60%), and low backward linkages for primary product industries, metal mining (21%).

Price elasticity of demand is a measure of the relationship between the change in the price of a product or material and the change in demand, thus a measureable degree of elasticity might indicate a progressive increase in demand for a product as the price decreased, where the greater the change in demand for a given change in price the higher the elasticity appertaining. Inelasticity in the price-demand relationship indicates that the level of demand is relatively insensitive to the level of price or change in the level of price within the limits observed in commercial practice. Long run or short run elasticity refers to the timescale required for the change in price to exert a real and total resultant effect upon demand. Long term regression analysis by Fisher failed to demonstrate a statistically significant price elasticity of demand. This was partly attributed the lack of data and the questioned agreement between published prices and those actually used in commercial contracts or transactions. Short run price elasticity of demand was found to be inelastic, but subject to the same reservations concerning significance as identified for long run price elasticity. A greater elasticity was forecast when the price of aluminium is falling with respect to alternative materials than when it is rising. Fisher strongly criticised Rosenzweig's analysis by questioning the wisdom of a procedure that adopted the non-selective input of available statistics in attempting to find significant correlations, and emphasised the need to assess the acceptability of data used in any analysis, quite independent of the correlation obtained, otherwise the economic meaning and usefulness of the results is nullified.

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Competition in the Aluminium Industry

M J Peck (9) in his contribution to the series of studies on competition and monopoly in America, produced a classical work devoted to the application of economic theory to the analysis of the primary aluminium industry, aimed at the understanding of market structure and behaviour. Peck's investigation was structured to include historical background, price elasticity of demand, pricing policy for ingot, price leadership in the industry and declared policy, the pricing of fabrications, pattern of output and inventory behaviour, distribution of production costs, vertical integration in the industry, the development of new markets, aluminium distributors, barriers to entry into the primary smelting industry. Recognition of the principles identified and the analytical observations made by Peck provide a valuable conceptual foundation for any present day analysis of aluminium consumption and are summarised as follows:

i) Increased aluminium consumption that occurs by the displacement of other materials usually requires modification of product and process involving capital expenditure, an investment decision, uncertainty and short term irreversibility. Hence, short run demand is relatively price inelastic. A price incentive is required to create new applications with demand relatively more elastic for new applications and less elastic for established ones. Price stability per se promotes increased aluminium consumption. Peck acknowledged, however, that neither the market survey conducted by Engle, Gregory and Moss' (10), or the statistical analysis Fisher, established a statistically significant price elasticity of demand.

ii) High price cross-elasticity of demand ensures a disclosed uniform price in an oligopolistic market if firms wish to maintain their share of the market, however, different firms have different views on the most desirable level of market price.

High price cross-elasticity of demand, in the context of the Peck analysis, describes observed market behaviour in which if a primary metal producer increases the price of aluminium independantly of other producers it will tend to experience a reduction in the share of the market that it supplies. This reduction in market share supplied occurs simply by end - user industries diverting their order for their aluminium input to alternative suppliers that maintain a lower price. The strength of this price cross-elasticity of demand is determined by the availability of supply from alternative producers. Primary metal production capacity has been shown by Spector (28), Fig 6, to be more than adequate between 1960 and 1970. Forecasts suggested that available primary metal production capacity would be excessive if all planned future capacity up to 1974 is commissioned.

The market for primary aluminium is described as Oligopolistic, because the demand for aluminium is measured at that stage of the product which is supplied mainly by a relatively small number of semi-finished product producers. Consequently, a decision by

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a small number of primary metal users to divert their source of supply would produce a pronounced alteration in the share of the market supplied by a given producer.

Alcoa, the free worlds largest producer of primary aluminium, is the price leader (the low price preference firm associated with the lowest cost of production). Thus the market price bears little relationship to current demand and the supply situation, but rather the price preferred by the lowest price preference firm. Publicised Alcoa policy establishes the objectives of maximising long term growth in consumption and profits at the expense of short term profits linked with a planned minimum rate of return on investment. However, Peck points out that the translation of overall price policy into administrative practice is complex and that any price policy is only the baseline for numerous exceptions. He further claims not to understands how the rate of return on investment required (stated as 10%) is determined or agreed upon.

iii) Aluminium product prices demonstrate either rigid prices linked to the primary metal price or flexible prices not linked to primary metal price depending upon whether the products are made predominantly by the primary producers. Extrusions are quoted as the important wrought product form having a flexible price and where primary producers have suffered a reduction in their share of the market due to their administrative inflexibility or reluctance to make price reductions. Castings are a further product form subject to flexible pricing.

2.3

iv) Short term fluctuations in demand for aluminium are a reflection of the change in demand for capital goods and consumer durables. But underlying the sharpness of the fluctuations in demand are the sudden movements in the level of inventories held by the purchasers of aluminium. This short term behaviour is discussed by O E A (5) and in "A Case Study of Inventory - Output Behaviour in the Aluminium Industry" (11). Buyers are postulated to aim at a constant ratio of inventories to sales, thus reduced sales lead to reduced inventories further associated with the effect of the level of short-term future confidence. Increased confidence in future sales potential of the final product leads to a rapid build up of materials inventories by intermediate and final product manufacturers.

v) All the international primary aluminium producers are actively engaged in aggressive marketing, development of new product outlets and technical service to customers. Thus acknowledging the principle established by E R Corey (12), which states that a new material that is to be integrated into existing products and processes requires a long learning period, products and materials are not simply accepted on their merits, but must be merchandised aggressively.

vi) Barriers to entry of new firms into primary aluminium productions is considered in the light of the classification published by J S Bain (13), namely, scale economies, capital requirements, product differentiation, absolute cost barriers (advantage gained

2.3

by existing firms having established old plants) and the level of profit motivating entry. Primary aluminium production and integrated production plant represent large barriers to entry due to the large minimum economic size of plant and the relatively low return achieved by current producers on capital invested.

vii) Primary producers have been active innovators in fields that directly affect the sale of primary aluminium, independent producers have contributed alloys, and fabricators have made important contributions in their own fields. Aspects of innovation have been investigated in detail by Peck (14).

2.4

Aluminium Marketing, Scale of Plant and Pricing of Aluminium

Brown and Butler (15) compared the performance of the copper industry with that of aluminium and revealed several important characteristics of the aluminium industry comprised of both production and marketing facets. Aluminium is a new metal, the first production of bauxite having occured in 1910, and which requires a very substantial capital investment at the conversion and reduction stages (16) in order to achieve material costs that are competitive. The effect of scale of investment and associated productive capacity on the cost per ton of output, assuming a 95% utilisation of capacity, is shown in Table 5.1.2. Associated with this degree of capital intensity is the sensitivity of the cost per unit of output to the level of demand, ie the total utilisation of available capacity that is used. This data is subject to further analysis in Tables, 5.1.3 and 5.1.4 Figs 1,2,3, as an extension of that provided in the UN publication, Pre-Investment Data for the Aluminium Industry (16), and demonstrates the following trends within the range of plant sizes investigated:

I) The maximum percentage returns on capital invested increases with increasing plant size.

II) The percentage return on capital invested increases linearly with percentage utilisation of capacity to a maximum at 100% utilisation.

III) At a given selling price, each plant size has a related break even level of percentage utilisation of capacity, which decreases with increasing plant size.

From this analysis it follows that a minimum economic size of plant may be postulated that will be capable of achieving a minimum acceptable return on capital to a given company, based upon assumptions about the given market price for aluminium, cost of capital, cost of energy and other variable costs, and plant depreciation accounting practice. Since the primary aim of any company is to achieve a return on capital invested that is acceptable to its shareholders, a minimum size of aluminium reduction plant in the region of 100,000 to 125,000 ton per annum appears most attractive, when adopting this criterion, involving a capital investment of the order of 72 million $ at early 1960 prices. This minimum economic size of plant establishes a high entry barrier to new or small firms (13), and partly explains why 80% of the western world's primary aluminium was produced by six companies in the 1960s. Table 5.15.1.

Alternative criteria, to that based upon percentage returns on invested capital, may be used to evaluate the optimum plant size, which include cash flow profile analysis and the way in which profiles are influenced by the forecast rate of increase in demand for primary aluminium, which in turn determines the time required to achieve a given level of plant utilisation. However, the maximum return on capital that a selected plant capacity is capable of achieving assumes further significance, because the larger the plant operated within the range investigated the lower the profitable, sel- . . .

ling price. Consequently, if a company decided to operate a plant of only 30,000 tons per annum capacity in competition with a second company operating a plant of 100,000 tons capacity, the second company would be in the position of the "low price preference firm" (price leader) and could conceivably, reduce the selling price until it became unprofitable to operate the smaller plant. Similar correlations are considered relevant to the selection of the optimum size of steel making (17) and plastic materials production (18) plant.

It is interesting to note that the capacicity of the three new smelters that recently came on stream in the UK each had an annual production capacity in the region of 100,000 tons per annum (19).

(1) Alcan plant at Lynemouth, Northumberland, 120,000 tons per annum in two stages.

(2) The British Aluminium Company at Invergordon, Ross and Cromerty 100,000 tons per annum.

(3) Anglesey Aluminium Metal Ltd (RTZ-BICC) at Anglesey, 100,000 tons per annum.

Patent rights to the Heroult extraction process also limited commercial control to a small number of companies in the early days. In Europe a succession of aluminium cartels retained control of the Heroult patents until 1939. The last of these cartels, the Alliance Aluminium Compagnie, established in 1931, regulated both the production and sales of aluminium. Similarly exclusive rights were held in the US by Alcoa (previously the

2.4

Pittsburgh Reduction Company) to the Hall patents, leading eventually to the Anti-trust proceedings against the company being initiated in 1937 and culminating in 1945 with the now celebrated decision, which set a precedent for judgements on US monopoly positions, that Alcoa was an illegal monopoly in the ingot production sector. By 1950, Alcoa's share of US aluminium production had been reduced to 50% by the introduction of Reynolds Metals Company (1941) and Kaiser (1947) who acquired US government World War II plants at low prices, as a deliberate result of government policy to establish vertically integrated firms which were regarded as vital for strategic purposes. Efforts were made to induce greater competition by offering to a new producer favourable amortization terms and a guaranteed market for the first five years of operation.

Rate of returns on capital achieved by Aluminium companies in the early and mid 1960s was between 4.9% and 5.9% (15) (20) offering no attraction to new investors.

Two key factors emerge, namely:

1) The linkage of primary aluminium production costs to the scale of plant and the cost of power used in extraction (21) Table 5.1.2. A comparison is made of the distribution of primary production costs for copper and aluminium. Table 5.1.5.2, showing that the structure of cost build-up is appreciably different. This difference is due to the nature of the ores used and the large quantities of electrical energy consumed in the reduction of aluminium.

11) Constraints imposed upon pricing policy, in part refered to by Bunce (22):

(a) Growth of consumption activated by a selling price that is sufficiently low, to encourage substitution of established materials such as, copper, iron and steel and to meet the competition of other new materials, eg. plastics materials.

(b) The need to encourage consumption by providing productive capacity in advance of demand, thus guaranteeing supply, but introducing cost penalties associated with excess capacity.

(c) High capital costs and exess capacity have led to the acceptance of orders at low prices, merely to make a contribution to the high fixed costs.

(d) Intervention of the Soviet bloc in 1958 in the form of aluminium offered at a price, $ 28-30 per ton, below the Alcan price, introduced competition to North American producers. UK anti-dumping legislation was not invoked against Soviet aluminium imports, but eventually led to the 'Gentleman's Agreement', between the major Western producers and the Soviet bloc countries. USSR, East Germany and Hungary agreed to limit export of ingot, scrap and semi-manufactures to Western Europe. The major Western companies, in return, purchased all ingot for export from these suppliers at an agreed price which was below the free world price, but was above the levels at which these countries would be able to sell their stocks to the West.

(e) The US strategic stockpile of aluminium, initiated in

 2.4

World War II, still remains and enables the US Government to exercise considerable influence upon the market price through its stockpile management policy. In 1965, 1.9 million tons of aluminium were held representing 63% of US consumption in that year. During October 1965, the US producers announced that they intended to increase the price of primary aluminium by 0.5 cent per lb (2%). The US Government objected and announced the proposed release of initially 200,000 tons and then 300,000 tons from the stockpile in 1966 to meet a short fall in supply. This expression of Government intention led to the producers withdrawing their price increase and only 70,000 tons were eventually released from the stockpile.

Price surveys, by OEA (5) reporting the primary producers list prices of virgin aluminium 99.5% for the period 1962 to 1970, is shown in Table, 5.1.5. Price of primary aluminium remained relatively stable within the period examined with no major short term movements in either direction. Pronounced international differences in price are not revealed by the published data and are unlikely to be the cause for difference in consumption behaviour. However, the price of primary aluminium in the UK, consistent with the USA, Germany and France, increased from the region of (22.5 - 24.5 ct/lb) to (27.5 - 29.0 ct/lb) during the period 1962 - 1970, using current market prices. Until 1970 the list price roughly reflected the actual market price, apart from the rebates granted to

2.4

customers buying on a large scale (5). Since the middle of 1970 a basic instability occured in the price of floating material and OEA changed its view of the accuracy with which the published list price reflected the development of prices during the period 1970 - 1974. The fluctuations in the price of virgin aluminium in the period post 1970 is attributable to a combination of shortage in aluminium availability, frozen prices, currency distortions due to currency revaluation and floating in the different countries.

EMH

2.5
Evaluation of Innovative Performance with respect to Aluminium

The OECD Science Policy Committee (34) investigated a number of economic sectors, including non-ferrous metals, with respect to innovative performance. It was recognised that technological progress might be less conspicuous in a traditional manufacturing sector, but that innovative and technological change in the non-ferrous metal sector are of major importance. Two factors were quoted:

(i) The considerable size of the non-ferrous metals (NFM) sector in the economy of many countries, 2.6% of total manufacturing in terms of sales and 1.8% in terms of added value in the UK in 1958, where aluminium represented approximately 19% of all NFM.

(ii) NFM sector assumes a strategic and critical role in the economic development of a country, as illustrated by the backward and forward linkage effects of various economic activities (27).

OECD underline that a nation increases its income either by intensifying the rate of exploitation of its resources, or by improving the manner of that exploitation in order to reduce costs. Further, that industrialised countries maintain large populations on declining natural resources by trading the products of advanced technology in exchange for essential raw materials. The capacity to create and use new technology is identified as the most important condition for increasing prosperity in a developed economy and gaps in technology represent international differences in this capacity.

OECD analysis was divided into three main sections concerned with; production, consumption and trade performance; production technology, current trends and differences in innovative performance; possible causes and the effects of differences in international performance. Differences in innovative performance are extremely relevant to the present investigation and the findings of the OECD report are, therefore, summarised. Product or process innovation was described as the resultant of interaction between particular economic and technological contexts and innovative capacity or ability inherent to the context. The significance of this statement on innovative performance provides a basis for the types of correlations explored with respect to aluminium. However, the problem occurs concerning how to quantify the economic significance of the data obtained on inventions and innovations. The relationship of innovated products to consumption is the source of their importance to sector growth. Any increase in consumption of a given material by an end-use sector can be due to:

(a) An increase in the output of the end-use sector generating a proportional increase in the material inputs.

(a) Substitution of one material by an alternative due to changes in relative prices.

(c) Innovations by the end-use sector that are more conducive to the use of a given material.

(d) Creation of new product forms for consumption by end-use

2.5

industries.

A formula designed to measure the index of product innovation is proposed, which attempts to quantify the increase in aluminium consumption that is directly attributed to product innovation as opposed to proportional increase, or that due to changes in relative price of alternative materials, or to autonomous innovation taking place in the end-use sectors

$$\phi = 100\left[1 + \frac{\Delta S_o - \left[\sum_{j=1}^{n} Q_j \Delta x_j \pm \frac{b}{100}\left(\frac{P_1}{P_2} - 1\right)\left(S_o + \sum_{j=1}^{n} Q_j \Delta X_j\right) \pm \sum_{j-1}^{n} f(\phi_j)\right]}{S_o}\right]$$

ϕ = Index of product innovation

S_o = Sales of aluminium in the base year.

ΔS_o = Increase of sales in aluminium at constant prices

Q_j = Input coefficient for a given sector j (j=1,2,3.....n)

Δx_j = Variation in output of the end use sectors at constant prices.

P_1 = Price index of aluminium in the year t, using year 0 as the base year.

P_2 = Price index of copper in the year t, assuming copper to be the chief material competitor of aluminium

$\sum_{j=1}^{n} f(\phi_j)$ = A term accounting for autonomous innovation in the end use sector.

Although the product innovation formula appears to provide a quantitative relationship expressing the dynamic reaction between the factors influencing aluminium consumption, no attempt is made to feed figures into the formula in order to arrive at an index of product innovation. This is not surprising since the formula requires knowledge of the relative price elasticities of demand between aluminium and competing materials, narrowly stated as copper by OECD. The formula ignores the time lag effect between appearance of differential price movements in alternative materials and any influence that they may have upon material consumption. Furthermore, the formula assumes that the influence of autonomous innovation in the end-use sector can be readily identified and quantified. Any quantitative analysis based upon this formula would be dependent upon so many assumptions and approximations that the conclusions reached would have extremely limited significance and be subject to considerable dispute concerning accuracy. Each input to the formula is clearly relevant but its relative quantitative effect must be impossible to evaluate accurately from currently available data on the end-use of aluminium.

Without dispute, innovation and the proportional increase in consumption have an important influence upon materials consumption and in particular aluminium consumption behaviour.

2.5

However, reference to a simple formula of the type proposed by OECD (34), which attempts to quantify product innovation, contributes an incomplete and uncertain quantitative evaluation of materials consumption behaviour. Uncertain due to the assumptions and approximations made and incomplete because the formula fails to take into account the range of relevant economic aspects involved.

A complete analysis must give adequate recognition to the economic aspects in order to reveal any principles involved in materials consumptions behaviour. Arbitrary distinction between product innovation and autonomous innovation in the end-use sector is unlikely to yield a useful relationship since in many instances these types of innovation must be interlinked. Furthermore, OECD make the point, when comparing the behaviour of different economies, that the new products have not necessarily been developed in the respective countries, but are likely to have occured by diffusion (35), which is promoted by the international nature of the aluminium industry. Diffusion aspects of innovation make the distinction between product and autonomous innovation even more indefinite than at the source.

LL

2.6
Research and Development Expenditure

Leadership of U.S.A. firms in the production of primary major metals is accompanied by a strong innovative performance, particularly in product technology (14) however, the growth of production and consumption is generally higher in both Europe and Japan, in spite of the absence of a spectacular innovative performance (34).

R and D resources, in terms of expenditure, Table 5.1.12.1, (34) (35) indicates some large international differences, in which the U.S.A. is clearly the leader and the UK appears to lag behind the European countries Germany and France, but the UK spends significantly more than Italy, Table 5.1.12.1, also reveals that research in the non-ferrous metals sector is financed predominantly from companies own funds, in many instances approaching 100%. Japan appears to spend a similar sum to that of the UK and does not, therefore, correlate well with the markedly different rates of increase in metals consumptions. Table 5.1.12.2 (34) indicates that in most countries emphasis is placed upon applied research and development as opposed to basic research. Quantitative assessment of R and D capability is difficult and attempts to draw comparisons based upon the number of patents and licenses issued leads to inconclusive results (34), partly because significant developments are frequently not patented and also because the number involved does not relate to their commercial value.

2.7
Tariff Barriers

In the non-ferrous metals sector there are internationally, no, or very low, tariffs on primary metal imports. In the UK no import tariff on primary aluminium is applied, since until the early, to mid 1970s, the UK was largely dependent upon imported primary aluminium. Even in those countries that had appreciable tariff barriers to imported aluminium, US (6.2%), EEC (9%), Japan (13%), these have been significantly reduced by the Kennedy Round objective of cutting tariffs by 50%.

With respect to semi-fabricated products, nearly all countries are protected by relatively high tariffs, but even these were reduced by the Kennedy Round ,Table 5.15.1(34). Differential tariff barriers are not regarded as significant in determining the international differences that occur in aluminium consumption behaviour.

LL

2.8
Secondary Aluminium Industry

Over 70% of secondary aluminium is consumed in the manufacture of castings, the remainder being used as a deoxidiser in steel making and hardener in the production of non-ferrous metals. Small quantities are used in forgings and powder products (36). A few foundry alloys are based upon primary metal specifications (2-3%), however, secondary metal may be replaced by primary metal in all alloys when a scrap shortage occurs. Castings provide an important outlet for secondary aluminium since for most wrought product applications it would fail to satisfy the compositional specifications with respect to impurity elements.

Bennett (36) and Doyle (37) have studied the price behaviour of secondary aluminium in the UK and the USA respectively, and actual price levels are reported by OEA (5) for a number of countries. The main price determining factors for secondary aluminium are reported as:

(a) The supply of scrap in relationship to the demand for foundry ingots.

(b) Virgin aluminium prices normally set the limit for scrap prices, unless virgin metal is in short supply, in which case the price of secondary metal can rise appreciably higher than primary metal.

(c) Availability of Eastern Bloc primary aluminium in the mid 1960's at prices levels of £20-32 per ton below North American prices had the effect of limiting secondary metal prices.

(d) Price behaviour for secondary aluminium in the USA was reported to be more similar to other non-ferrous metals, copper, zinc and lead than to primary aluminium.

UK secondary aluminium industry is composed of approximately 30 firms, varying considerably in size greater than 250t to less than 25t per week, range of output and nature of ownership, Table 5.1. 5.4. The principal primary producers have obtained varying interests in the large secondary smelters in the U.K:

(a) Alcan, Enfield Rolling Mills and John Dale Limited

(b) Alcoa, International Alloys Limited

(c) Reynolds Metal Co, British Aluminium Limited in association with Tube Investments

(d) Kaiser Aluminium Corporation, a selling agreement with BKL Alloys Limited

Integrated firms, Alcan, Alcoa, Reynolds and Kaiser utilise two types of secondary metal:

(i) Recycled scrap in their own fabricating operations.

(ii) Production of secondary ingots for foundry operations.

And through careful management of the demand for scrap metal can exercise a measure of control over the price of scrap metal and secondary metal.

BM

Economic Factors affecting the Production and Consumption of Pressure Die Castings

Bennett (38) has identified the main economic factors influencing the production and consumption of pressure die castings. Competition between alternative materials appears to be determined on a cost per unit of property basis and in the long-run, plastics, and to a lesser extent magnesium are the main competitors. Figures have been quoted for the growth in output of castings in the U S A compared with plastics in relationship to growth in manufacturing output, which suggest that substitution of plastics for castings, especially in respect of zinc die castings is taking place. It is recognised, however, that the real significance of the published data could only be assessed by the study of many complex factors.

Diecasting is a relatively new industry and is strongly forward linked to mass production industries in terms of product produced, e.g. cars, electrical appliances, office machinery and leisure goods. Die-casting businesses operate in a position which is competitive with respect to alternative materials and in relationship to large end-user industries. This position makes it difficult for the diecaster to maintain a product price that is acceptable to the end-user and ensure an acceptable returns on capital employed.

Growth of pressure die-castings in the U K between 1960-70 is shown to be less certain compared with other economies including Germany, France, Italy, U S A and Japan, and two important questions are raised;

i) Does the growth in die-cast component consumption depend upon the conditions imposed on the die-casting industry by the peculiar structure and growth pattern of British industry?

ii) Is the U K die-casting industry inefficient?

It is concluded that insufficient analysis has been carried out in order to provide an adequate explanation for the observed behaviour.

In spite of the linkages between the diecasting industry and mass production large scale consumer durable industries the die-casting process is not dependent upon large scale plants for cost competitive activity at the present stage of the technology in the U K. U K experience shows that small to medium sized firms are as efficient as larger plants. Most important die-casting foundries however, are subsidiaries of large foundry groups or general engineering groups and occasionally of financial holding companies. Technological improvements, automation and highly trained technicians, necessary for rapid expansion of the business may introduce levels of fixed cost more compatible with the larger scale operation.

The highly competitive environment in which die-casters operate, demands low cost production of appropriate quality in addition to an acceptable level of service to customers in terms of delivery. These objectives must be achieved along with adequate profitability and the need to cover the long-run cost of providing the specified quality and reliability. Die-casters claim that the intense level of competition in the UK forces low prices, unprofitable activity with adverse affects upon technological development.

Although Bennett (38) finds that small die-casting plants are as profitable as large plants, the fact that the UK industryis constituted by a large number of plants in relation to output compared with other countries, Table 5.1.5.5., especially Italy would appear to be a factor worthy of attention when investigating relative international performance.

Relative failure of the UK diecasting industry was considered with regard to the following possible causes:-

i) Higher cost per unit of property in the UK, in relation to competing materials.

ii) Lower technical efficiency, fewer shots per hour and higher rates of scrap.

iii) Intense competition in the UK, leading to lower profit margins and less resources available for development and expansion.

Factors i) ii) and iii) above are not regarded by Bennett as being totally responsible for the disappointing performance in the UK, however, factor iii) may be significant since UK industry appears to have under exploited the potential of the die-casting process and product. A further factor raised in the lower rate of capital form ation in the UK in the 1960s and the relative stagnation of the motor industry which absorbs 50% of aluminium diecastings.

HR

2.10
Competition of Materials

Intense competition is stated to exist between alternative materials in which traditional materials are observed to be defending their established markets against newer materials. Competition is actually taking place between firms that produce primary and secondary products in different materials, since in the main different firms are involved at this stage of production and materials are only integrated together by end-use manufacturing industry, except in the broadest sense of composite materials including coated semi-finished product forms.

Firms are normally concerned with stimulating the markets for their products in order to make full use of their available productive capacity and to increase their output, both in terms of total output and the market share supplied. These general aims are formulated from the influence of two main factors:-

i) Productive capacity that is under-utilised leads to high unit costs of production and non-profitable activity, especially when due to competition, or government action, the material price cannot be adjusted to compensate for rising unit costs.

ii) Failure to promote an expanding market raises the strong possibility of experiencing a contracting market which, even if confined to a reduced market share, as opposed to a reduction in the actual total production, provides a less secure commercial basis for investment in plant modernisation and expansion. Reduction in actual total production leads directly to the consequence of under-utilised productive capacity.

Under-utilised productive capacity was identified by Alexander (40) as a major cause of intense competition between rival materials in 1966 and is reinforced by analysis in section 2.4, which shows that a high level of plant utilisation is essential in order that the cost per unit of production, of aluminium in particular, should fall below the selling price. Lack of success in marketing relative to competitive materials, or an unfavourable economic climate, leading to lack of investment in plant modernisation and a expansion is concomitant with progressive decline in a firm's potential, or an industries potential, to meet competition in terms of material cost and quality. World and national trends in material consumption assume different significance dependent upon the stage of production. Productive capacity and production of primary materials is closely linked to world consumption and trade, In contrast, productive capacity and production of secondary semi-furnished products, both wrought and cast, are more closely linked with national consumption, or the behaviour of end-use industry and the level and pattern of demand in a given economy for end-products.

Alexander (40) has suggested that the outcome of competition between materials is dependent upon the relative cost per unit of property required in end-use, and that strength is the major consideration in a large proportion of applications. Further, that differences in material cost immediately following extraction are dependent upon the geology and chemistry of the different materials and upon the energy consumed. To these factors may be added the scale of production. Relative cost of materials tend to converge after extraction (production) due to common processing routes to final products. Pick (39) has analysed the added cost of production by alternative process routes and suggests that competition between alternative materials may be strongly influenced by process design and the relative compatibility between different materials and competitive processes. Traditional processes leading to wrought metal products are characterised by being multi-stage, producing low yields, being capital intensive and dependent upon large scale for cost competitiveness. Breakthrough in process development and the future pattern of materials consumption is dependent upon the recognition and possible exploitation of shorter process routes, typified by die-casting, injection moulding, powder methods, hydrostatic forming, direct continuous processing, optimum use of joining processes etc. which offer potential cost reductions due to increased productivity, particularly with respect to material yield.

Comparison of cost per unit of strength (40) (41) reveals that wrought steel is the most economic material in general engineering applications and that special design considerations, e.g. strength to weight ratio, or non-strength criteria typified by electrical conductivity, corrosion resistance, aesthetic qualities, space filling, etc., must be significant in order to justify the selection of alternative materials. Growth of plastics materials consumption may, therefore, be attributed to a combination of properties including corrosion resistance at normal temperatures, low density, insulative both electrically and thermally, easily shaped and readily coloured, as opposed to competitiveness in applications where cost per unit of strength is the main criterion of selection. Plastics materials, present special design problems when used in stressed applications, due to their tendency to creep at normal temperatures, notch sensitivity and brittle behaviour below their glass transition temperature and their limited capability above normal temperatures.

Comparison of alternative materials based upon generalized cost per unit of strength data is inevitably limited in accuracy when drawing conclusions about specific applications, since the difference in cost of satisfying a given end-use requirement in service resulting from different materials will be dependent upon detailed processing considerations. However, on a microscopic scale materials used in the largest quantities, steel, timber and concrete demonstrate highly competitive cost per unit of strength properties provided that design takes into account the individual limitations of these materials. However, the remarkable growth rate in the world consumption of plastics and aluminium in the last thirty years, confirms evidence for the importance of selection and design criteria in certain types of application that reveal the advantages of these newer materials. The high rate of growth in these newer materials is constituted by three distinct elements with respect to the competition of materials:-

i) Displacement of traditional or even newer materials from existing applications.

ii) Increased growth rate in the consumption of established product forms either due to, the improved performance achieved by the introduction of the newer material, or to increased economic prosperity.

iii) Creation of new product forms based upon the properties of the newer material, which are accepted into a changing product mix within the economy, made possible by increased national prosperity.

3. Review of Literature relating to Economic Growth and the UK Economy

3.1
EXPLANATION OF ECONOMIC PERFORMANCE

Evidence of a basic understanding of the economic events or behaviour in a complex economy as represented by the UK is provided when an event, in terms of direction and quantity, can be predicted from some law or hypothesis and not merely by a description. Application of facts or theories in isolation lead nowhere in economic analysis (29). However, it is unlikely that a real world economy moves in exact accordance with the simplified theories, expressed in economic text-books, that depend upon simple premises in order to facilitate the analysis of complex problems. Furthermore, hypothesis outside the limits of text book theory may prove necessary in order to explain economic events, but which do not have the support of a priori analysis and evaluation. Explanations involving value judgement, particularly with respect to the influence of controversial matters of economic policy, form an important part of appraisal, however, this aspect of analysis reveals variation between individuals and tends to change with time.

3.2
GROSS DOMESTIC INCOME

The UK domestic income can be summated in three different ways, income, output and expenditure. Gross domestic income, measures the sum of all income of UK residents earned in the production of goods and services during a stated period and may be sub-divided into income from employment and rent. Income such as pension and sickness benefits are excluded, because they are not earned from production. Gross domestic output (product) may be assessed from the value of output in the various economic sectors, presented in groups for the purpose of economic statistics (1966), agriculture, forestry and fishing (3.3%), mining and quarrying (2.2%), manufacturing (35.0%), construction (7.4%), services and distribution (54.0%). A problem arises when the prices at which stocks are valued vary during the period examined. Correction is obtained by making a special valuation adjustment, known as, the adjustment for stock appreciation. This adjustment, carried out by the Central Statistical Office, involves using the average price of stock during the period examined when determining the change in value between the beginning and the end of the period. Any difference in the change in value measured from that obtained by using terminal prices is called the adjustment for stock appreciation. GDP is identically equal to gross domestic income, but is measured in terms of the value of production by various firms and public enterprises in the country. A distinction is drawn between the output of intermediate products from one firm that represent the input to other, as opposed to output sold to final buyers, in order to avoid double counting. GDP may also be measured in terms of expenditure which should equal income and output, but because the statistical data is derived from different sources the actual totals differ by a quantity called the residual error which is sometimes quite high 0.5% in 1966. Expenditure estimate is the most frequently quoted version of GDP.

Types of National Expenditure

Four types of spending unit are identified, households, public authorities, firms and foreign residents. Household expenditure is known as consumers' expenditure or consumption. However, consumption is slightly misleading when applied to durable goods, the services of which are consumed over several years. Important differences exist in economic theory explaining consumption of durable and non-durable consumption. House purchase also forms a special case which is included under the broad heading of domestic capital formation or gross investment. Fixed investment includes additions to the assets of firms, that are not exhausted in current production. However, gross investment does not allow for the reduction in the value of fixed investment due to depreciation (wear, tear, obsolescence). Total final expenditure (TFE) must be corrected before arriving at GDP at factor cost, by subtracting the import content and the indirect tax content of the various expenditures. GDP differs from gross national product (GNP) in that it does not include interest, profit and dividends earned by UK residents from overseas productive activity and it does include the profits of foreign owned enterprises producing in the UK. The net property income from abroad is added to GDP in order to obtain GNP. The difference between GDP and GNP is small and tends to remain constant for the UK.

Importance of Technological Progress in Expanding Productive Capacity and its Contribution to Economic Growth

Eltis (47) stated that growth in the productive capacity of a developed economy is inevitable, due directly to continuous additions to technical knowledge as a result of research and development, thus allowing the production of a given output of goods with fewer workers, less capital or less of some other factor of production from year to year.

Gross Investment may be used to cover the depreciation of plant and increase productive capacity, where net investment is that investment in excess of depreciation. Rate of growth in national net product NNP is dependent upon the percentage of NNP used to make net additions to capital (S%) and the capital output ratio (C) so that:

$$\text{Rate of Growth NNP} = \frac{S}{C}$$

If the state of knowledge remained constant, the rate of increase of NNP for a given value of S would decline, due to an increase in C, however, a backlog of unexploited investment opportunities normally exists that prevents an increase in C. Care must be exercised in attempting to predict the effect of a given S in different economies, particularly with respect to the effect of different levels of unemployment, ie using the behaviour of the German economy in the 1950's with the UK in 1960's.

Eltis examines the natural rate of growth of the economy, which is linked to technical progress and population growth, assuming that demand ensures full employment, supply of finance is infinitely

3.3

elastic and that investment is pushed to the limit of profitable opportunity, in which entrepreneurs will push investment so that their expected profit rate from investment exceeds the interest rate by a margin sufficient to cover risk. In this hypothetical situation, technological progress is identified as the most important factor governing growth in the UK.

Fig 8 shows the effects, postulated by Robinson (48) of capital life on growth output with time, in which growth rate is said to be independent of capital life and that growth rate only changes during a period when capital life is being shortened (A-B). However, a refinement of this analysis suggests that technological progress may be increased with a higher share of investment, in which case shorter capital life gives rise to more rapid growth Fig. 9 It is also suggested that any increase in entrepreneurial efficiency or availability of finance (decrease in interest rate) would enable an economy to move to a higher line on the diagram.

Many factors are likely to affect embodied technical progress, (that which accompanies capital investment) including sociological factors, education, technical mindedness and willingness to accept change. R and D expenditure indicates the degree of willingness to invest in future profit and particularly uncertain future profit and this is governed by :

(a) Amount of competitive pressure.

(b) Size and security of the market.

(c) Structure of the industry, size, market shares, monopoly, oligopoly.

(d) Restrictive practices.

(e) Shortages of technically trained, or inadequately trained people.

Disembodied technical progress is likely to be reduced if workers believe that increased labour productivity is contrary to their interests, management is insufficiently skilled, or if a firm is ignorant of progress made by outsiders.

Labour productivity is 100% higher in the US than any other economy (47) which suggests that the possibility exists for duplicating US technology and thereby deriving considerable economic growth, however, this can only be achieved by considerable capital investment since capital per worker is two or three times higher in the US than the UK. Capital intensity is determined by entrepreneurs who decide upon the most profitable combination of labour and capital and other resources.

Further analysis by Eltis (47) leads to the concept of the warranted rate of economic growth which is linked to the capital output ratio determined by entrepreneurs to be the most profitable amount of capital to produce a unit of output (Cr) so that:

$$\text{Warranted Growth Rate} = Gw = \frac{S}{Cr}$$

Where the warranted rate of growth (Gw) can only exceed the natural rate of growth (Gn) when the life of capital is being reduced.

Only about half of the investment made in an economy is made directly for the purpose of making profit the other half is invested in houses and other structures. This observation led to the Keynesian policy of public works in the period of slump and that inability to absorb sufficient investment in profitable investment can at least in part be compensated by public investments (k), where profit motivated investment is equal to (s-k), and Gw need not be less than Gn and unemployment can be minimised.

UK Government has recognised the need to stimulate investment in industry by making available investment allowances and initial allowances against the payment of Corporation Tax before 1966, and cash grants made irrespective of Corporation Tax subsequent to 1966. These measures were intended to accelerate the rate of investment, increase capital intensity and reduce the life of capital. Eltis goes on to discuss the problems with matching supply and demand, the difficulty of forecasting disaggregated elements of growth, avoiding demand led inflation, making capital available at a reasonable level of interest and assessing the technical feasibility of projects; and attributed the limited economic growth achieved by the UK to a combination of the following factors:

1) Demand led inflation resulting in Government action which temporarily halted growth.

11) Restriction of growth to a critical level compatible with short-term trade equilibrium.

III) Absence of any effective mechanism to reduce domestic prices relative to foreign prices when necessitated by economic conditions.

IV) Tariffs applied to imported machinery.

V) Insufficient R and D activity in industry, especially machinery producing industries concentrated in small firms without adequate resources.

VI) No check on restrictive practices until 1956.

VII) Application of profit tax as opposed to pay-roll tax or added-value tax.

VIII) Investment incentives were not introduced until 1954.

Eltis has carried out a valuable analysis of the postulated contribution of technological progress toward economic growth and the way in which entrepreneurial activity may be affected by economic constraints and Government action. Unfortunately, the Eltis analysis of the natural and warranted rate of economic growth was not supported by data relating to economic performance, so that no guidance was given concerning the optimum level of investment or the opportunity for reduction in capital life in the UK. Furthermore, the analysis was focussed upon the productive capacity or supply side of the equation and had comparatively little to offer with respect to the management of demand.

However, the hypothetical analysis published by Eltis identifies technological progress and optimised investment as the two key factors in economic growth, together with the possible gearing effect of shorter capital life on technological progress.

3.3 3.3

It is, therefore, interesting to compare international performance with respect to the exploitation of a newer material like aluminium in order to ascertain whether the trends, at least in part, support the Eltis analysis.

3.4 3.4

Gross Domestic Product (GDP) and the Multiplier Hypothesis (29)

Two aspects of growth in GDP are important, firstly, the increase in TFE required in order to produce a given increase in GDP and secondly, the distribution of increased GDP between income recipients. The relationship between TFE and GDP differs markedly dependent upon the type of expenditure. Investment in stocks is likely to have a large import content producing a ratio TFE to GDP of say 2, compared with public authorities expenditure which has a high domestic output content producing a ratio of TFE to GDP of about 1·15.

NIBB (30) indicate that a rise in domestic income of £100 million leads to a rise in personal income of £84 million from employment and dividends, where £16 million is absorbed by the aggregate of Corporation Tax, selective employment tax and undistributed profits. Deduction of personal income tax at an estimated average rate of 29% leaves a personal disposable income of £59 million. Assuming that the marginal propensity to consume is 0.9, then the addition to consumers' expenditure on all goods and services at market prices is £53. A further deduction is necessary to correct for indirect taxation and the proportion of consumers' expenditure taken by imports, 17% plus 19% totalling 36% (3). This leaves a rise of about £34 million in consumers' expenditure on domestic goods and services at factor cost; from a primary rise in GDP of £100 million.

At the end of the first round of the income-flow, GDP is higher than its original level by its initial increase of £100 million plus a secondary increase of £34 million. Assuming that the secondary increase is subject to the same divisions of income consumption, taxes etc, it will lead to a tertiary increase of 34% of £34 million giving rise to the postulated series:

$$£100 \quad 1 + 0.34 + (0.34)^2 + (0.34)^3 \text{ ---- } (0.34)^n \quad \text{million}$$

$$£100 + 34 + 11.1 + 3.8 + 1.3 + 0.4 + 0.1 = £151 \quad \text{million}$$

The successive spending of income, therefore, is likely to raise an initial increase in GDP of £100 million into an eventual increase of about £151 million over an uncertain period indicating a multiplier estimated at 1.5 from data in the national accounts. The multiplier hypothesis shows a close relationship with a simpler concept, where national income Y is divided into consumption and investment I and the multiplier is expressed as the reciprocal of the marginal propensity to save:

$$\frac{\Delta Y}{\Delta I} = \frac{1}{1 - \text{Marginal propensity to consume}} = \frac{1}{\text{Marginal propensity to save}}$$

This simple explanation is inadequate, because there are additional leakages to the system other than personal savings.

$$\text{So, } \frac{\Delta Y \text{ (final)}}{\Delta Y \text{ (initial)}} = \frac{1}{1 - \text{marginal propensity to respend domestic output}} = \frac{1}{\text{Marginal propensity to leak}}$$

$$= \frac{1}{1 - 0.34} = 1.51$$

Where marginal propensity to leak is the marginal propensity for domestic output not to be respent upon itself.

3.4 3.4

Thus in the real world situation there are far more opportunities for not respending income. Any multiplier is dependent upon the assistance of sufficient spare capacity for it to work itself out and may be affected by a wide variety of factors in a real economy.

3.5 3.5

Aggregate Demand

Consumer expenditure accounts for nearly 50% of TFE and is the largest single element in aggregate demand. Keynes (31) proposed that the marginal propensity to consume (MPC) is positive, fractional and reasonably stable over the short run, where:

$$MPC = \frac{\text{Additional Consumption}}{\text{Additional Income}}$$

Analysis (29) demonstrates that between 1950-66, in the UK, the MPC was unstable ranging from (0.6 to 1.2) and exceeded unity for nearly half this period. This analysis suggests that further refinement of the principle is necessary, including reference to the influence of the availability of credit to finance purchases of durable consumer goods, which account for 7-8% of total consumers' expenditure of which approximately half is financed by borrowing.

Public consumption or expenditure includes spending by both central and local government and depends upon the policies of the government of the day and not macro-economic principles. Drastic changes can occur as a result of re-assessments of the size of the public sector in relation to the economy as a whole.

Fixed investment expenditure may be divided into investment in dwellings (both by local authorities and privates) and other investment. The latter is likely to be determined by factors including, the expected rate of return, expected costs, long run forecasts about demand, and assessment of risk and uncertainty. Explanation of investment in aggregative terms from macro-economic theory is difficult and relies upon correlation with the rate of change of sales or profits.

Expenditure on stocks, stockbuilding, is the addition to final expenditure caused by a change in stock levels. Work in progress is a fairly constant proportion of production, however, raw material and final product stocks vary according to the forecast level of further activity. The stock-adjustment principle states that the level of stock investment is inversely proportional to the stock-output ratio.

Fluctuations in Economic Activity and Increased Productivity

Regular cycles in the level of output, or GDP, over a period of years, say between 7 - 10 years, have not been evident in the UK since 1945, however, the rate of change from year to year reveals sequences of slow and fast increases. Kennedy (29) shows that a succession of slow and fast increases in GDP have been accompanied by a corresponding movement in productivity, when productivity is quantified by the ratio GDP per employee. This correlation between the rates of increase in productivity, as defined, and GDP is attributed to increase in employment hours per employee during boom periods, labour hoarding during recession, and more efficient combinations of capital and labour when high levels of plant capacity utilisation are achieved.

3.6 3.6

The definition of productivity used by Kennedy (29) is more simple than that adopted by Kendrick and Creamer(2) which considered the cost of all inputs in relationship to output. When evaluating the possible impact of materials selection and utilisation on productivity the wider definition would seem a more relevant and significant criterion of performance, although precise measurement and explanation of change become less certain.

3.7 3.7

Control of Aggregate Demand in the UK

Theoretical models explaining the mechanisms of control over aggregate demand must take into account the inter-relation of consumption and investment behaviour (multiplier hypothesis), exports, government expenditure, and the actions of the government in retarding or stimulating the level of consumers expenditure. During the period 1956-1967 different categories of economic activity have revealed varying percentages of total final expenditures (TFE), eg consumers expenditure between 0.8 and 2.9%, fixed investment between -0.1 and 2.3%, stockbuilding between -0.9 and 1.1% , exports between 0.3 and 1.0% and public expenditure between -0.3 and 0.4%. Balance of payment considerations have also been important in determining government policy toward the control of consumer behaviour.

Government control over aggregate demand is aided by the publication of a national income forecast three times a year, by the National Institute of Economic Research (NIER) which covers a forward period of twelve to eighteen months. The forecast is based upon the maximum use of direct information from business firms and government departments together with simple macro-economic relationships, which provide a reasonable basis for short term forecasting of domestic activity, but provides less certainty about exports due to world production and trade effects together with currency revaluations.

Comparison is made between the forecast data of economic activity with the aims of government policy, in order to identify the need for stimulation or retardation of the elements of demand and investment expenditure, by the usual instruments of taxation, credit restrictions, government spending, investment grants and tax concessions. Main emphasis has been given in the past to fiscal changes, since it is possible to calculate with reasonable certainty the initial effects upon disposable income, consumption and GDP. The effects of monetary changes are not so well understood and this explains why more emphasis is given to fiscal measures when government wishes to alter demand.

Explanations are sought about the irregular and slow rate of economic growth achieved in the UK in the period 1960-1969, and why government policy using forecasting and stabilisation instruments has not been more successful. An economist, Kennedy (29) has questioned the accuracy and value of short term forecasts by NIER, and the basic understanding of the economic control instruments used, and reaches the conclusion that the UK economic performance has been very close to what the government intended. In particular this diagnosis blames the competing demands of the balance of payments and the ballot box in determining short term cyclic expansion and deflation motivated policies. Gibson (29) identified the official UK policy goals cited since 1945 as, full employment, price stability, economic growth, fixed exchange rates and a satisfactory balance of payments position, added to this list are free health, welfare and education services, and effective defence. Gibson continues, by asking whether these goals are mutually compatible within the Uk economy given the range of acceptable economic controls, since economic policy since 1950 must be judged a failure. The pound has been devalued, regular balance of payments problems, price instability common, and economic growth uncertain and low by international standards. Full employment is the goal most nearly and consistently achieved. It is further suggested that, such a wide spectrum of goals requires more, well understood, instruments of economic control than are currently used. Alternatively it may be more realistic to pursue a more limited number of goals.

Monetary and fiscal policy are recognised as important in determining the level of economic activity. Reduction in economic activity may be achieved by restricting the growth of the money supply listed with higher interest rates, however, this action is likely to reduce investment and restrict future and economic growth potential. Alternatively, consumption may be reduced by increasing taxation, especially on consumer goods, and reduced government expenditure, without the same direct effect upon investment. Political considerations may encourage governments to use reduced taxation and increased government spending in order to stimulate the economy, thereby satisfying the electorate, and adopt monetary control in order to restrain the economy. This combination of expansionary fiscal and restrictive monetary policies, broadly pursued over a period of years, would tend to increase interest rates and limit investment as observed in the UK.

3.8 3.8

The Growth of Productive Potential and Increased Productivity

When ample reserves exist of unused resources the change in domestic output can be determined by the behaviour of aggregate demand. The rate of expansion of GDP, under these conditions, can be governed by the rate of increase of total demand. Economics of growth, however, is concerned with the rate of growth that may be sustained at full employment and at some margin of unused resources. This introduces the need for a growth in productive potential and increased productivity, which permit a given rate of growth in GDP without an increase in productive resources. Furthermore, increased productivity maximises the rate of growth in GDP associated with the injection of a given increased level of resources, capital, materials, energy and manpower.

Analysis by Maddison (32), Table 5.1.13, reveals the contrast in performance achieved by the UK, between 1950-60, and eleven other industrial countries. UK performance, irrespective of the parameter used, reveals a slower rate of growth than any other country in the sample, this is only slightly offset by the increase in the pressure of demand in other countries during the period, whilst remaining unaltered in the UK. Economists divide the factors influencing economic growth into those primarily affecting supply and those affecting demand, but acknowledge that growth processes arise out of mutual interaction of both the supply and the demand side of the equation.

Supply factors identified include the availability, mobility and quality of labour and the rate of increase in the nations invested stock of capital, both in quantity and quality. Estimates of the UK capital stock have shown a progressive increase (33), 3.4% per annum between 1957 and 1965, however, capital stock is extremely difficult to measure in terms that provide a reliable basis for comparison. This difficulty arises because the figures in the national accounts are based upon data for tax purposes and not upon rates of deterioration or scrapping of plant. Quality of the capital stock is even more important and even more difficult to measure, and is related to its age-structure. Each new generation of plant and machines is of higher quality (greater productive potential and efficiency) than previous ones, due to technological and scientific progress. A high rate of gross investment, even for replacement purposes, will reduce the age of the capital stock and increase its quality (32).

Demand factors identified include, the change in the pressure of demand, average level of the pressure of demand and the degree of fluctuation. Transition to a high pressure of demand tends to stimulate investment, raise labour productivity, and encourage the search for more efficient methods of production. Fluctuations in the pressure of demand tend to retard capital formation, because it reduces industrial confidence.

Kennedy (29) suggests that insufficient is yet known about the causes of economic growth in order to establish the conditions under which an increase of a selected order may be consistently maintained in the UK, and that several decades of economic experimentation may be necessary before such understanding is achieved.

R H

Definitions and Concepts relating to Gross Domestic Product

Gross domestic product in real terms can be considered as the sum of the real products of all the various goods and service industries in the economy. To avoid double counting of intermediate products sold from one industry to another, it is necessary to measure the real product (output) of each industry by the value added to the product by that industry at constant market prices and then summate the separate added values to obtain the gross value, or more precisely gross added value.

Added value, therefore, is the difference between output and input value at constant market prices. This procedure is referred to as the "double deflation method", because it emphasises the need to estimate two series of data at constant market prices for each industry. However, it is common to estimate movements in added value using the output index alone, due to lack of information about the value of input for every industry, and this is referred to as the "single indicator method". Many countries mainly use the single indicator method, including the UK (except for agriculture), whereas others including France, Japan, Italy and the US broadly use the double deflation method, even though the accuracy and adequacy of the data used is often questionable. Germany is reported to use a mixed method approximating to the single indicator method. A detailed survey (23) shows a wide variety of methods used, which involve fundamental differences in approach, to measure growth of real product and which are subject to different types of error:

(a) Single indicator method neglects differences that may occur in the rate of change of input and output values.

(b) Double deflation method is affected by errors in the evaluation of input and output data which possibly leads to cumulative error in the computation of added value.

3.10
Comparability of GDP Data between Countries

A generally agreed procedure for computing the value of GDP in different countries does not exist, mainly as a result of differences in the data available and uncertainties about the choice of appropriate units of output. Many of the factors in the aggregate cannot be accurately identified in units of value, or monitored in a consistent way over time. This introduces doubts about comparability between countries of the measured growth rates in GDP and micro-economic sectors. However, analysis by Hill (23) shows that, for the entire economy, it makes little difference over a wide range of industries, whether double deflation or the single indicator method is adopted, since errors appear to be self-cancelling on aggregation. In contrast, the method used for determining added value for individual industries can have a considerable effect on measured growth rate. Although Hill's results are not conclusive by his own admission, they reinforce the general conclusion that differences in growth rates observed between different countries and particularly given economic sectors in different countries need to be interpreted with a great deal of caution.

3.11
<u>Growth Rate Patterns</u>

Two important observations may be made with respect to the comparison of disaggregated growth rate within an economy and when making international comparisons:

(a) The growth rate of a given economic sector can show pronounced differences when compared internationally, and

(b) The growth rates of different economic sectors within a given economy can show wide differences, typically between (-5 to 15% per annum) for the UK.

For many developed countries the differences in growth rate in micro-economic sectors in a given economy are greater than the differences that occur when comparing a given sector internationally. The existence of pronounced contrasts in micro-economic trends in a given economy emphasise the need to examine these in detail, particularly those sectors that consume significant quantities of aluminium or any other

3.11
3.12

material whose consumption is being studied. Since any cumulative trend represented by a correlation between gross consumption and GDP, or even value of manufactured output and construction, is likely to be constituted by a wide spectrum of micro-economic correlations dependent upon the end-use distribution of a given material in a given economy. This supports the view that the correlation of material consumption on a macro-economic scale, irrespective of its strength, presents a false impression of homogeneous behaviour and represents the type of correlation which Hill (23) indicated, as a generalisation, should be interpreted with considerable caution.

3.12

Correlation between Micro-Economic Growth, Rates and GDP

Pronounced differences are observed in the strength of the international correlation between micro-economic sector growth and GDP, Table 5.1.14. Many sectors show no appreciable correlation with GDP, because their rate of change occurs irrespective of what else is happening in the economy, but tend to behave similarly internationally. However, other sectors show remarkably high degree of correlation betwean growth rate and GDP.

To suggest that strong or weak international correlations in this context may be interpreted as evidence for similar micro economic behaviour in all developed countries would be an over simplification. Important isolated differences between economies may be important when studying materials consumption and certainly the micro-economic constitution of any given countries added value and the inputs producing a progressive rate of change in the level of added value achieved in a twelve month period will be unique for a given economy.

Whenever a straight line regression line representing the correlation between a postulated dependent variable and the rate of increase in GDP, or added value of output in a given sector, does not pass through or close to the origin, the ratio of the respective growth rates may be changing. A negative constant implies a faster growth rate in the dependent variable than in the index of added value.

Growth of Output by Industry

T P Hill (23) computed the annual percentage rates of growth of different major industrial and commercial sectors of the UK economy and others, Tables, 5.1.15, 5.1.16. This shows that over either long periods 1950-1965 or over short periods 1960-1965, the growth rates for individual industries have differed widely. In the UK, the long period annual growth rates ranged from the extremes -2.35% for road transport to 15.48% for air transport, and the short period annual growth rates ranged from, -3.23% for road transport, to 15.03% for air transport, compared with respective average growth rates of industrial output of 6.07% and 7.51% per annum respectively. Cable (29) suggests that a satisfactory explanation of the causes underlying a particular industry's growth rate in a given country requires detailed study and the application of econometric techniques, however, an attempt was made to identify the more significant and obvious factors determining the growth rate of industrial output between 1955-1965, namely:

(i) Effect of rising incomes on the composition of final demand, as illustrated by the slow growth trend in food, drink and tobacco and the high growth rate in the vehicles sector of the engineering and allied industries.

(ii) Protection of the domestic market by import controls.

(iii) Purchase tax, hire purchase regulations and other types of government action.

(iv) High rates of growth may be associated with low total levels of activity.

(v) Technical developments, especially relevant to synthetic resins; GPO telecommunications network and railway modernisation have made a major contribution to a very rapid expansion in the electronics section of the electrical engineering industries; man-made fibres.

(vi) Displacement of traditional materials, e.g. leather and steel by alternative recently developed materials.

(vii) Consumption of a given material may decline because the end-use industrial sectors in which it finds predominant application are in decline, notably coal, railways, shipbuilding and defence.

(viii) Process innovation leading to a reduction in real prices.

(ix) Change in relative prices of products and international competition in the form of imports.

(x) Structural changes in the economy over a period due to the range of growth rates in output between different industries.

Government Policy and Industrial Efficiency

Since the mid 1960s there has been increased emphasis given by government to policies which directly seek to improve the efficiency or productivity as part of the effort to secure more rapid economic growth. The measures identified by Cable (29) centre on three inter-related aspects, namely, structural reorganisation, technical advance and planning at the micro-economic level. A principal aim was to overcome the limitations of industries with outdated structures, mainly those with large numbers of small units. Three industries that have received individual attention are textiles, aircraft and shipbuilding which, although using appreciable quantities of aluminium do not represent major end-use micro-economic sectors of this material.

The Industrial Reorganisation Corporation (IRC) was established in 1966 to identify areas of industrial activity that would benefit from rationalisation in the private sector and initiate and finance mergers which might not otherwise occur. Provided with an initial capital of £150 million, the initial aims of the IRC were to give particular attention to prospects for stimulating exports and technical advance. Compulsory purchasing powers, support of non-viable schemes, or a permanent financial interest in the newly created enterprises was not intended. IRC was concerned with the Leyland-BMC, and GEC-AEI mergers, although the real extent of

3.14

its initiating and catalytic role is difficult to judge externally.

The Industrial Expansion Bill, 1968, was intended in past to reinforce (IRC) projects and provided a maximum £150 million assistance for schemes which would improve efficiency, create, expand or sustain productive capacity, or promote and support technical improvements where these would benefit the economy of the UK, and where these developments would otherwise not take place.

Since 1964 a large number of Economic Development Committees (EDC's) have been set up, covering at least two-thirds of industry by employment, to provide more continuous co-operation as an industry-by-industry basis. EDC's report on progress towards achievement of plan targets and take action on matters likely to prevent their attainment. Further activities include regular demand and supply forecasts, investigate export performance, sales opportunities and import trends, manpower problems, standardisation, stockholding procedures, factors affecting investment, R and D, and the effects of taxation and devaluation. Some exchange of information between industries occurs and in some cases arrangements for co-operation, e.g. between the chemical and engineering industry EDC's.

The government is the principal source of funds for R and D work in the UK, approximately 2.5% of GDP is devoted to R and D, 55% from government sources although private industry was the largest sector carrying out the work. However, government funds were provided to finance defence projects which have limited general benefit to the economy. Technological innovation in the UK was the topic of a symposium (35) and R and D activity in the non-ferrous metals sector has been investigated by OECD (34) and MJ Peck (9).

4 Methodology

4.1
Methodology

Comparability of Data

The findings of this investigation are dependent upon the analysis, synthesis and evaluation of published statistical data relating to the consumption of aluminium in various product forms, in various end-use sectors together with economic performance in macro and micro economic detail. As detailed previously, a number developed economies have been included in the exercise. Table 5.2.2 Macro analysis of a selection of other materials, plastic materials, steel copper, zinc, tin and lead has also been included in order to reinforce the comparative analysis of aluminium consumption in different economies.

Many sources of statistical information have been used in compiling the tables of data for analysis and evaluation and this diversity of sources raises the question concerning the degree of comparability that may be claimed between international data and between different materials. Reference has previously been made, 3.9,(23) to the comparability of data relating to GDP and similar or more serious doubts may be expressed about the absolute accuracy of data relating to materials consumption.

It was considered important to take cognizance of the limited absolute accuracy of data when evaluating the differences in international behaviour and when comparing the consumption of different materials. Although the data selected is associated with varying degrees of uncertainty and variances from absolute performance, which cannot be quantified, it is reasonable to suppose that the compilation of data for OECD, UN and Metallgesellschaft and other bodies is carried out in a consistent manner, which means that changes in behaviour and performance are likely to be reflected accurately

4.2
Selection and Manipulation of Data for Synthesis, Analysis and Evaluation of Performance

Investigation of consumption behaviour of materials in relationship to economic activity is inevitably dependent upon historical data compiled by world wide statistical organisations, government bodies and trade associations and no significant attempt can realistically be made to add to this data by empirical observations or personal surveys. However, little attempt is made publicly to synthesise, analyse and evaluate the data that is collected with respect to materials consumption. Undoubtedly, analysis is performed by government departments and by companies behind closed doors in order to reveal the significance of any trends with respect to decision and policy making. When attempting to interpret the available data it was recognised that the trends derived may be highly sensitive to the type and range of data selected and the manner in which it is manipulated.

In order to avoid deliberate or inadvertent distortion of the trends and relationships studied, a number of elementary precautions have been taken when the available data permitted, including: (i) Confining data to domestic consumption in a given economy, by compensating for the trade balance.

(ii) Comparing the results that emerge from different types of consumption data i.e.primary and secondary aluminium compared with end-use statistics.

4.2

(iii) Comparing aggregated and disaggregated consumption behaviour.

(iv) Using the widest international sample of countries, but with developed economies. (Availability of statistical data restricted the number of countries that could be included in the end-use analysis of aluminium and in the analysis of product form statistics.)

(v) Adopting statistical regression methods to minimise distortion due to cyclic and irregular variations in consumption and to measure the accuracy of time series trends and the strength of correlations.

(vi) Evaluating the effect of changing the population of the data used in order to determine whether the trends are sensitive to the countries included in the sample.

Time series analysis of consumption was applied to:

I) Primary plus secondary aluminium consumption plus the trade balance in semi-manufactured product forms.

II) Aggregate end-use consumption of primary and secondary aluminium in domestic markets.

III) Production statistics for rolled, extruded, wire and cast aluminium product forms.

IV) Disaggregated end-use consumption of aluminium in domestic markets.

V) Aggregate consumption of other materials in domestic markets.

4.2
VI) Gross domestic product (GDP)

Correlation regression analysis was applied to:

1) Value of GDP and aggregate aluminium consumption with time.

II) Value of output in selected end-use sectors and disaggregated aluminium consumption.

III) Rate of change in GDP and the rate of change in aggregate aluminium consumption.

IV) Rate of change in the value of end-use sectors output and the rateof change in disaggregated aluminium consumption.

V) Rate of change in the value of end-use sectors output and the rate of change in the specific consumption of aluminium.

VI) Value of GDP and the aggregate consumption of other materials with time.

VII) Rate of change in GDP and the rate of change in the aggregate consumption of other materials.

Analysis of aluminium consumption was extended to study the profile, or proportional constitution of end-use consumption in order to identify the relative importance of different end-use sectors at a given time and to reveal significant changes over a period of time. Comparison was then made with the profile of end-use consumption of plastics materials and steel.

An analysis of UK aluminium consumption would be incomplete without an attempt to evaluate relative international performances and this is dependent upon the identification and definition of relevant criteria for the purpose of comparison. Certain criteria of performance emerge directly from the time series analysis, namely gross consumption, disaggregated consumption in end-use sectors and the rate of change in consumption over a period of time. An additional criterion considered extremely interesting and relevant in comparative analysis is that of specific consumption, both at aggregate and disaggregate consumption levels. Specific consumption has been computed from the ratio of the weight of aluminium consumption to the value of output at constant market prices.

Specific consumption provides an index of diffusion or absorption of aluminium by a given market, with respect to the value of output in that market, and is used for international comparison by measuring the value of output in a given market or sector in terms of United States dollars at Constant market prices.

Acquisition of accurate data relating to the value of output in selected and relevant end-use economic sectors tends to present problems with respect to availability, accuracy and comparability. In spite of the limitations associated with data, which tend to be an extrapolation of the limitations outlined with respect to the measurement of GDP and material consumption, an attempt has been made to present a micro-economic analysis based upon the specific consumption of aluminium.

Macro-economic specific consumption of aluminium has been based upon the value of GDP measured in US $, at constant market prices (or the value of manufacturing and construction) 1963. Micro-economic specific consumption of aluminium in the transport equipment and building and construction sectors has been based

based upon the value of output determined from tables giving the structure of industrial production published by OECD(44) and the OECD National Accounts Statistics.

Values of output in the transport equipment sector were obtained from the following form of computation:

Value of Transport Equipment Output (at constant market prices 1963)

$$= \left[\begin{array}{l}\text{GDP}\\ \text{(at constant market prices)}\end{array}\right] \left[\begin{array}{l}\text{Proportion of Total GDP}\\ \text{represented by}\\ \text{Industrial Production}\end{array}\right] \left[\begin{array}{l}\text{Proportion of Total}\\ \text{Production}\\ \text{represented by}\\ \text{Transport Equipment}\end{array}\right]$$

Value of output in the building and construction sector were obtained from the following form of computation:

Value of Building and Construction (at constant market prices 1963)

$$= \left[\begin{array}{l}\text{GDP}\\ \text{(at constant market}\\ \text{prices)}\end{array}\right] \times \left[\begin{array}{l}\text{Proportion of Total GDP represented}\\ \text{by Building and Construction}\end{array}\right]$$

Micro-economic specific consumption of aluminium in electrical apparatus, equipment and machinery was based upon the OECD Engineering Series Statistics (43) which record the value of output in that sector at current market prices. A deflation factor was, therefore, applied in order to obtain an approximate value of output in the electrical sector at constant market prices, using the following conversion:

$$\begin{array}{l}\text{Value of Electrical}\\ \text{Products Output}\\ \text{(at constant market}\\ \text{prices 1963)}\end{array} = \left[\begin{array}{l}\text{Value of Output}\\ \text{(at current market}\\ \text{prices)}\end{array}\right] \times \left[\frac{\text{GDP (at constant market prices 1963}}{\text{GDP (at current market prices).}}\right]$$

Micro-economic specific consumption of aluminium in packaging could not be determined so precisely as the previously mentioned sectors, because values of output of packaging could not be obtained on an international scale, although estimates are available for the UK, following two statistical reports by Rowena Mills for Pira(46).

4.2

Packaging represents an important end-use sector for aluminium and for this reason an index of specific consumption of aluminium in this sector was determined based upon the ratio, weight of aluminium used in packaging divided by the value of GDP at constant market prices.

4.3 Time Series Analysis of Aluminium Consumption and GDP

Aluminium consumption and GDP time series data, 1960-69, relating to free world economies at a similar stage of development, formed the basis of the statistical information used in the present analysis of comparative performance with special reference to the U.K. Comparative study based upon terminal year data is acknowledged to be subject to distortion associated with cyclic and irregular variation in economic performance. Caution is essential in synthesis and analysis to avoid the use of terminal year data that is inconsistent with time series trends in behaviour and the consequential computation of misleading growth rates.

Distortion of trends in behaviour associated with cyclic and irregular variation in statistical data was minimised by the use of logarithmic regression analysis of time series aluminium consumption and GDP data in the present investigation. Logarithmic regression was justified by the exponential growth behaviour associated with the consumption of commodities and economic wealth, leading directly to the relevance of compound rates of growth when quantifying the rate of change in economic activity.

Regression analysis was performed, using a standard programme in a Hewlett Packard Model (9830A)computer, based upon the least square method of fitting a straight line to the series of data. Least squares analysis provided the straight line trend representing the observed data, so that the sum of the squares of the 'y' deviations were at a minimum. This type of logarithmic time series regression analysis was applied to series of data relating to the consumption of aluminium and other materials and to GDP for a number of developed economies, giving rise to equations of the form:

$\log y = \log a + n \log x$ (r^2= - - -, coefficient of determination)

where:

y = consumption or GDP after a period n years

a = consumption or GDP in the base year (in most cases 1960)

$x = (1 + r)$

r = rate of growth per annum.

based upon the exponential growth rate formula :

$$y = a(1 + r)^n$$

These regression equations enabled the calculation of regressed consumption at a given year within the time limits investigated, and may be used for extrapolation exercises.

The coefficient of determination (r^2) was computed in order to quantify the reduction in total error achieved by fitting the regression line. At the same time (r^2) measures the closeness of fit of the regression line to the statistical data analysed. For example, when (r^2= 0.80), 80% of the data fits the regression equation, and when r^2= 1.0, all the data is on the regression line. Thus, a value of (r^2) less than 1 indicates the degree of cyclic and irregular variation in the data analysed, together with the relevance or appropriateness of the form of straight line regression adopted.

Time series data must also be critically reviewed with respect to the presence of pronounced political or economic distorting effects. Previous analyses (7) (8) have been criticised, or have acknowledged their limited general significance, due to the distorting influence of World War II. The period 1960-69 was selected for analysis for a combination of reasons, including:

1) Availability of statistics, particularly with respect to the end-use consumption of aluminium.

II) Apparent poor performance of the UK with respect to aluminium consumption.

III) Apparent absence of extreme political and economic factors producing distorted trends in international behaviour.

IV) A period between terminal years that should have a moderating effect upon cyclic and irregular consumption behaviour, thus reducing the reliance upon regression analysis for minimising errors when quantifying trends in behaviour.

In spite of selecting a comparatively stable political and economic period for comparative analysis, it is relevant to note that macro-economic behaviour is a function of a particular aggregate of a wide range of dynamic economic, political and economic factors. The detailed aggregate of factors is likely to be peculiar to a given country at a given time and are unlikely to be repeated in the future either by the given, or any other, economy. Nevertheless, a period of stability is more favourable to the analysis of behaviour, with the aim of revealing principles relating to the effect of identifiable factors, than a period associated with a major distorting influence which may mask or reduce to insignificance factors that would otherwise be extremely important.

When evaluating the significance and formulating interpretations of time series regression trends, it is important to distinguish between two different types of objective:

1) Determination of trend behaviour for the purpose of predicting future consumption by extrapolation of the trend.

II) Determination of trend behaviour for the purpose of eliminating cyclic and irregular distortion of terminal year data and to improve the accuracy with which the rate of change in performance may be calculated within the time period for which data is available.

Since the present investigation is primarily concerned with objectives of the type (II) above, the sensitivity of the type of relationships studies to the absolute accuracy of data used is less pronounced than type (1).

T.P.Hill(23) has discussed the value of fitting an exponential trend by least squares analysis to time series data compared with using terminal year data and concluded that the amount of effort involved could not be justified by the improvement in accuracy or confidence in results obtained. This observation was reinforced by reference to the contrasts in procedure used by different countries when compiling economic statistics. However, regression analysis has been adopted, whenever the availability of data permitted, in order to improve the accuracy of trends and growth rates determined, using the premise that if a readily applied mathematical technique for improving and defining the limits of accuracy of trends is available, then it should be used to advantage.

4.4 Corrlation Regression Analysis

The variables considered in the correlation regression analysis, have been itemised in section 4.2. Analysis was performed using the input data derived mainly from the results of the time series regression analysis and was based upon the least squares method of fitting a straight line to the series of data. This gave rise to a series of results having the standard straight line form:

$y = a + bx$ (r^2 = - - , coefficient of determination)

where:

y = dependent variable (aluminium consumption, or rate of change etc)

a = intercept when $x = 0$

b = slope of the straight line

x = independent variable (economic index, or rate of change etc).

As indicated when the time series regression was described, the value of (r^2) the coefficient of determination provides a measure of the closeness of fit of the regression line to the distribution of observations. Further, because of the related nature of data subjected to the analysis and the direction of dependency, (r^2) is used as an approximation of the degree of covariability between the inputs examined. However, simply revealing a close fit between input data and a regression line does not establish cause and effect, this can only be achieved by substantive reasoning based upon technological and economic principles.

JB

5. Basic Data

Productive Capacity x 1000 tons per annum	Investment x 1 million US $	Investment $ per ton annual capacity
20	19.6	980
30	26.6	890
60	47.0	.780
100	72.0	720

Reference UN 1966 Pre-Investment Data for the Aluminium Industry

Reported Capital Investment Cost

$ in Plant for every $1.00 Sales

Aluminium 3.00

Steel 1.00 - 1.50

Chemicals 1.00 - 1.5

Copper 1.00

Reference Roan Selection Trust Limited

Table 5.1.1

Investment Cost in Aluminium Extraction Plants

(Hypothetical US Plants)

Annual Capacity Tons	20,000	30,000	60,000	100,000
Item		Production Costs $ per ton Output		
Alumina	150	150	150	150
Fluorides	25	25	25	25
Carbon	25	25	25	25
Operating and Maintenance	18	18	18	18
Power	61	61	61	61
Labour	54	51	45	42
Misc and General Expenses	50	48	40	38
Capital Depreciation	72	66	58	53
Interest on Fixed Capital	53	48	41	38
TOTAL:	508	492	463	450

Assumptions:
(1) Plants using Soderberg anode system
(2) Operating 3 shifts at 95% rated capacity
(3) Depreciation: (a) Equipment 12.5 years
(b) Buildings 20 year
(4) Interest on Fixed Investment at 5% per annum

Table 5.1.2

Average Production Costs of Aluminium Ingots

(Hypothetical US Plants)

	Plant Capacity tons per annum 20,000		30,000		60,000		100,000	
Total Fixed Cost(1) at 100% Utilisation	3.33 mill $ per annum		4.62 mill $ per annum		7.93 mill $ per annum		12.25 m $ per annum	
Variable Cost $ per ton	333		330		324		321	
% Utilisation of Productive Capacity	Fixed Cost $ per ton	Total Cost $ per ton	Fixed Cost $ per ton	Total Cost $ per ton	Fixed Cost $ per ton	Total Cost $ per ton	Fixed Cost $ per ton	Total Cost $ per ton
95	175	508	162	492	139	463	129	450
85	196	529	182	512	155	479	144	465
75	222	555	205	535	176	500	164	485
65	256	589	237	567	203	527	189	510
55	303	636	280	610	240	564	223	544

(1) Fixed Cost defined as the summuation of:

Misc and General Expenses + Capital Depreciation + Interest on Fixed Capital

Table 5.1.3

Analysis of Primary Aluminium Production Costs

	Plant Capacity tons per annum											
	20,000			30,000			60,000			100,000		
% Utilisation of Productive Capacity	1 $ ton^{-1}	2 $ x 10^3	3 %	1 $ ton^{-1}	2 $ x 10^3	3 %	1 $ ton^{-1}	2 $ x 10^3	3 %	1 $ ton^{-1}	2 $ x 10^3	3 %
95	52	985	5.02	68	1940	7.3	97	5550	11.8	110	10450	14.5
85	31	528	2.7	48	1220	4.58	81	4130	8.8	95	8100	11.3
75	5	75	0.38	25	560	2.1	60	2700	5.74	75	5630	7.83
65	-29	-377	-1.92	-7	-137	-0.52	33	1285	2.74	50	3250	4.5
55	-76	-838	-4.27	-50	-825	-3.1	-4	-132	-0.28	16	880	1.2

Columns 1 (Selling Price - Total Cost of Production) $ per ton

2 (Selling Price - Total cost of Product) x Wt of Al Sold) $ x 10^3 per annum

3 (% Return on Capital Investment in Plant per annum)

Assumption Total Production is equal to Total Sales

Table 5.1.4

Difference between Selling Price and Production Costs

(Assuming Selling Price $560 per ton = 25 US Cents per Lb)

Mid Year	Germany ct/lb	France ct/lb	Italy ct/lb	UK ct/lb	USA ct/lb
1962	24.55	22.35	26.15	22.50	24.00
1963	23.40	22.35	25.40	22.50	22.50
1964	24.50	22.95	25.40	24.00	23.00
1965	24.50	24.10	25.40	24.50	24.00
1966	25.05	24.10	25.40	24.50	24.50
1967	25.05	24.50	25.40	24.50	25.00
1968	24.50	24.50	25.05	25.50	26.00
1969	25.50	26.50	26.50	26.50	27.00
1970	28.50[1]	27.50	28.10	28.00	29.00

1 Currency modification

Table 5.1.5

List Prices of Virgin Aluminium 99.5%

Company	Country of Origin	Production. 1965 x 1000 tons
Alcoa	US	875
Alcan	Canada	661
Reynolds	US	672
Kaiser	US	568
Pechiney	France	272
Alusuisse	Switzerland	224

Six Major Western World Primary Aluminium Producers

Table 5.1.5.1

BM

Stage	Share of Primary Production Costs %	
	Aluminium	Copper
Extraction	10	40
Beneficiation	20	10
Reduction	60	10
Refining	-	5
Overheads (1)	10	35
	100	100

Comparison of Cost Distribution on the Primary Productions of Aluminium and Copper

Table 5.1.5.2.

EM

Description of Product Form	USA		EEC		UK		Japan	
	Pre KR %	Post KR %	Pre KR %	Post KR %	Pre KR %	Post KR %	Pre KR %	Post KR %
Primary Aluminium	6.2	3.1	9	9	0	0	13	9
Wrought plates, sheets and strip.	8.4	4.2	15	12	12.5	8	25	18
Fabricated Products	n.a	n.a	15	7.5	20	10	20	10

KR = Kennedy Round

<u>Tariff Rates on Imported Aluminium</u>

Table 5.1 5.3
BM

Size tons per week	% Estimated Share of Output	Nature of Origin	% Estimated Share of Output	Control	% Estimated Share of Output
>250	40	MM	28	Independant	20
100-250	30	NF	14	Subsidiary of Primary Producer	50
50-100	10	ALB	8		
				Subsidiary of User	5
25-50	6	ALG	50		
<25	12			Other Subsidiary	25

MM, Established Metal Merchant
NF, Established Non-ferrous Manufacturer
ALB, Aluminium Smelter of British Origin
ALG, Aluminium Smelter of German Origin

Structure of the Secondary Aluminium Industry in the U.K.

Table 5.1.5.4

BM

Country	No of Plants	1969 Output X 1000 Metric tons	Average Output per plant X 1000 Metric tons
UK	350	49.3	0.141
Germany	230	90	0.391
France	150	43.8	0.242
Italy	40	86.0	2.144
USA	950	466.0	0.490
Japan	400	136.3	0.34

Number of Die Casting Plants (Approximate).

Table 5.1.5.5
BM

Country	GDP at Constant Market Prices (1963) X1000 Million US $									
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Germany	85.0	90.0	93.0	97.0	103.0	109.0	112.0	111.0	119.0	129.0
Belg - Lux	12.0	12.7	13.3	13.9	14.9	15.4	15.9	16.4	16.9	18.1
France	70.5	74.5	79.0	83.7	89.5	93.6	97.8	103.0	106.7	116.7
Italy	41.2	44.8	47.6	50.0	51.2	52.8	56.8	60.0	63.4	67.5
Netherlands	13.1	13.5	14.1	14.5	15.9	16.6	17.2	18.2	19.4	20.5
UK	78.5	80.8	81.5	84.8	89.3	91.6	93.3	95.0	98.0	101.0
Norway	4.93	5.27	5.51	5.80	6.10	6.45	7.73	7.15	7.4	7.6
Austria	6.85	7.1	7.25	7.52	8.2	8.9	9.4	9.7	10.0	10.3
USA	528	539	574	596	628	668	712	732	766	792.5
Japan	50.2	63.0	67.6	70.3	81.0	88.9	96.4	109	126.2	128.1
Sweden	14.8	15.0	15.3	15.4	15.4	16.0	16.55	16.9	19.2	21.7

Table 5.1.6

GDP at Constant Market Prices (1963)

(X1000 Million US $)

MP

Country	GDP Factor Cost 1963 Prices	Agriculture Forestry & Fishing	Mining & Quarrying	Manuf Industry	Elec, Gas & Water	Total Industry	Construction	Industry and Construction	Other Activities
Germany	100	5.5	2.9	40.1	1.9	44.9	7.5	52.4	42.1
Austria	100	11.1	na	38.7	2.8	41.5	9.6	51.1	37.8
Belgium	100	8.3	2.8	28.9	1.8	33.5	6.8	40.3	51.7
Canada	100	7.3	4.3	24.2	3.2	31.7	5.4	37.1	55.6
USA	100	3.9	2.3	27.5	2.4	32.2	5.0	37.2	58.9
France	100	9.9	1.7	35.0	1.6	38.3	8.0	46.3	43.8
Italy	100	15.2	0.9	25.5	2.5	28.9	7.8	36.7	48.1
Japan	100	14.8	1.6	29.2	-	30.8	5.5	36.3	48.9
Luxemburg	100	7.1	na	na	na	na	na	53.8	39.1
Norway	100	10.9	1.0	26.3	2.7	30.0	8.0	38.0	51.1
Netherlands	100	11.2	na	na	na	na	na	40.3	48.5
UK	100	3.6	2.9	34.4	2.8	40.1	6.4	46.5	49.9
Sweden	100	7.1	1.2	26.8	2.7	30.7	8.5	39.2	53.7

Table 5.1.7

Structure of Gross Domestic Product at Factor Cost at 1963 Prices 1960

OECD National Accounts Statistics

MP

Country	GDP Factor Cost 1963 Prices	Agriculture Forestry & Fishing	Mining & Quarrying	Manuf Industry	Elec, Gas & Water	Total Industry	Construction	Industry and Construction	Other Activities
Germany	100	4.8	2.0	41.4	2.1	45.5	7.2	52.7	42.5
Austria	100	9.5	na	38.4	3.4	41.8	9.7	51.5	39.0
Belgium	100	6.0	1.6	32.7	2.9	37.2	6.1	43.3	50.7
Canada	100	5.8	4.6	27.1	3.9	35.6	5.6	41.2	53.0
USA	100	2.9	2.0	29.6	2.6	34.2	3.8	38.0	59.1
France	100	7.6	1.0	37.1	2.0	40.1	9.6	49.7	42.7
Italy	100	12.4	0.8	29.8	2.9	33.5	6.9	40.4	47.2
Japan	100	10.5	0.7	29.8	-	30.5	7.4	37.9	51.6
Luxemburg	100	6.9	na	na	na	na	na	52.8	40.3
Norway	100	7.1	1.1	26.5	3.2	30.8	7.4	38.2	54.7
Netherlands	100	8.5	na	na	na	na	na	44.0	47.5
UK	100	3.5	2.0	35.1	3.4	40.5	6.8	47.3	49.2
Sweden	100	5.4	1.1	30.3	3.4	34.8	9.2	44.0	50.6

Table 5.1.8

Structure of Gross Domestic Product at Factor Cost at 1963 Prices 1969

OECD National Accounts Statistics

MP

	ISIC DIVISIONS AND GROUPS												
	21 - 29 Mining & Quarrying	31 - 39 Total Manuf Industry	37 Basic Metal Industries Total	371 Ferrous Metals	372 Non-Ferrous Metals	381-384 Metal Product Industries Total	382 Non Elec M/C	384 Transp Equip	31 Food Beverage Tobacco	321, 322 324 Textiles Clothing Footwear	351 - 354 Chemicals Petrol Coal Prod	Other Manuf Ind	4101 4102 Elec & Gas
Germany	6.1	89.3	7.6	6.4	6.5	32.9	10.3	7.1	11.6	8.2	11.6	17.4	4.6
Austria	2.7	90.4	10.5	8.2	7.6	24.1	8.7	3.4	11.9	12.1	14.1	17.7	6.9
Belgium	7.9	86.1	12.7	-	-	26.9	5.9	5.8	10.2	14.3	8.3	13.7	6.0
Canada	12.8	78.7	6.7	4.7	4.9	22.8	3.6	7.6	11.4	6.8	7.1	23.9	8.5
USA	7.1	86.9	6.3	4.8	4.3	31.1	8.6	10.4	10.4	6.4	10.9	21.8	6.0
France	9.5	81.6	13.1	10.4	9.4	18.7	-	7.5	-	15.6	16.7	17.5	8.9
Italy	2.3	90.1	5.9	4.6	6.4	29.2	8.2	7.4	12.2	17.3	8.4	17.1	7.6
Japan	2.6	93.2	8.6	6.1	6.9	33.2	10.2	7.5	11.0	9.4	12.2	18.8	4.2
Luxemburg	6.0	90.1	55.3	-	-	9.9	-	-	5.9	-	11.1	7.9	3.9
Norway	3.1	87.4	8.3	-	-	23.9	3.8	9.8	13.8	8.0	9.2	24.2	9.5
Netherlands	4.5	88.6	3.9	-	-	32.0	-	-	14.3	10.9	11.3	16.2	6.9
UK	6.4	85.8	6.9	5.3	4.9	35.8	-	11.0	9.7	9.5	8.1	15.8	7.8
Sweden	5.0	95.0	8.7	-	-	37.5	-	-	9.0	7.5	7.7	24.6	-

Manufacturing Industries

Source OECD Industrial Production Historical Statistics

Table 5.1.9

Structure of Industrial Production in 1960 (Total Industrial Production 100)

ISIC 2, 3, 4101 and 4102

MP

	ISIC DIVISIONS AND GROUPS												
	21 - 29 Mining & Quarrying	31 - 39 Total Manuf Industry	37 Basic Metal Industries Total	371 Ferrous Metals	372 Non-Ferrous Metals	381-384 Metal Product Industries Total	382 Non Elec M/C	384 Transp Equip	31 Food Beverage Tobacco	321, 322 324 Textiles Clothing Footwear	351 - 354 Chemicals Petrol Coal Prod	Other Manuf Ind	4101 4102 Elec & Gas
Germany	4.4	90.5	7.8	6.5	1.3	30.8	8.9	6.8	11.1	7.4	15.6	17.8	5.1
Austria	1.7	90.5	9.7	7.6	2.1	23.9	8.3	2.6	11.3	11.4	16.0	18.2	7.8
Belgium	5.0	88.1	14.2	-	-	26.1	6.6	5.6	10.3	12.9	9.9	14.8	6.9
Canada	12.9	77.5	6.8	4.9	1.9	25.3	3.9	9.6	10.2	6.2	7.2	21.8	9.6
USA	6.2	87.1	5.7	4.3	1.4	32.9	9.2	11.0	9.0	6.0	11.8	21.7	6.7
France	8.1	86.5	11.9	9.4	2.5	20.0	-	7.2	-	12.5	20.1	17.8	9.6
Italy	2.2	90.0	8.0	6.4	1.6	26.8	7.8	7.1	10.9	13.8	11.4	19.1	7.8
Japan	1.4	94.9	9.5	6.9	2.6	41.7	11.4	11.0	8.2	6.6	12.9	16.0	3.7
Luxemburg	4.6	91.6	56.8	-	-	7.5	-	-	6.3	-	14.4	6.6	3.8
Norway	3.4	86.2	10.5	-	-	23.4	3.6	9.5	12.0	5.6	10.3	24.4	10.4
Netherlands	5.1	85.5	4.3	-	-	29.2	-	-	12.4	7.7	16.3	15.6	9.4
UK	4.6	87.1	6.4	4.9	1.5	36.5	-	10.4	9.4	9.1	9.4	16.3	8.3
Sweden	5.0	95.0	8.8	-	-	38.2	-	-	8.2	5.5	10.4	23.9	-

Manufacturing Industries

Table 5.1.10

Structure of Industrial Production in 1969 (Total Industrial Production 100)

ISIC 2, 3 4101 and 4102

Country Currency Unit	GDP and Capital Formation	Gross Fixed Capital Formation at Constant Market Prices (1963) National Currency									
		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
UK	GDP	27828	28575	28988	30151	31850	32561	33259	33958	35179	35812
x 10^6 £	Manufacturing	1106	1305	1196	1058	1198	1316	1347	1306	1358	1528
	Construction	74	87	74	99	129	138	122	139	142	134
	M/c + Eq	1613	1833	1802	1880	2117	2265	2432	2536	2525	2575
USA	GDP	528.4			596.3			712.3	731.9	768.4	789.4
X1000 x 10^6 $	Manufacturing	14.5			15.7			27.0	28.5	28.4	31.4
	M/c + Eq	23.1			24.7			36.3	37.1	35.7	38.7
France	GDP	346.1			411.4			484.5	508.5	533.9	575.3
X1000 x 10^6 Fr	Manufacturing	19.6			28.1			33.8	35.0	35.7	41.1
	M/c + Eq	23.5			33.3			41.4	44.1	47.7	54.5
Germany	GDP	338.6			384.8			446.4	445.3	476.9	515.8
X1000 x 10^6 DM	M/c + Eq	28.7			34.2			39.5	36.4	39.7	48.9
Italy	GDP	25677			31140			35066	37482	39843	42082
X1000 x 10^6 Li-re	M/c + Eq	1551			2376			1884	2204	2453	2702
Netherlands	GDP	47090			52231			61820	65210	69830	74750
x 10^6 Guilder	M/c + Eq	3280			4138			5520	5730	6360	6420
Norway	GDP	35803			41531			48060	50778	52822	55481
x 10^6 Kroner	Manufacturing	2253			2883			3655	4047	3913	3920
* Sweden	GDP	68.7	72.3	75.2	114.5	122.0	126.9	130.4	134.6	140.2	147.2
X1000 x 10^6 Kro-ner	M/c + Eq	3.5	4.1	4.5	6.4	6.7	7.3	7.7	7.9	8.2	8.7
Japan	Manufacturing	NA									NA
	M/c + Eq	NA									NA

* Upto 1963 constant market prices 1959
1963 and beyond constant market prices 1968

Table 5.1.11

Gross Fixed Capital Formation at Constant Market Prices (1963)

Country	Item	Capital Formation as a % of GDP (at constant market prices)									
		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
UK	Manufacturing	3.98	4.57	4.12	3.5	3.75	4.04	4.04	3.84	3.85	4.27
	Construction	0.27	0.30	0.26	0.33	0.40	0.42	0.37	0.41	0.40	0.37
	M/c + Eq	5.80	6.42	6.21	6.23	6.64	6.95	7.30	7.45	7.18	7.20
USA	Manufacturing	2.74			2.64			3.79	3.90	3.70	3.98
	M/c + Eq	6.79			4.14			5.10	5.07	4.65	4.90
France	Manufacturing	5.67			6.83			6.97	6.88	6.68	7.14
	M/c + Eq	6.80			8.1			8.54	8.64	8.84	9.5
Germany	M/c + Eq	8.47			8.88			8.86	8.17	8.29	9.5
Italy	M/c + Eq	6.03			7.62			5.37	5.87	6.15	6.42
Netherlands	M/c + Eq	6.97			7.95			8.91	8.82	9.1	8.57
Norway	Manufacturing	6.28			6.94			7.40	7.95	7.40	7.07
Sweden	M/c + Eq	5.1	5.66	5.99	5.58	5.5	5.76	5.91	5.87	5.85	5.5
Japan	Manufacturing	NA									NA
	M/c + Eq	NA									NA

Table 5.1.12

Capital Formation as a Percentage of GDP (at constant market prices)

Country	R & D Expenditure X1000 US $	% Total R & D Expenditure From Companies Own Funds
U S A	85,000	93.3
AUSTRIA	407	n.a.
NORWAY	1,522	88.0[1]
U K	12,113	87.8
BELGIUM	6,050	100.0
FRANCE	20,325	67.1
GERMANY	34,500	96.0
ITALY	2,321	n.a.
JAPAN	17,471	99.3

R & D Expenditure based upon replies to an OECD check list and the International Statistical Year on Research and Development OECD DAS/SPR/66 14

% R & D Expenditure from companies own funds 1964 - 65

1. Entire metals sector.

<u>Table 5. 1. 12.1</u>
<u>Research and Development Capacity in the Non-Ferrous Metal Sector</u>

HR

<table>
<tr><th></th><th colspan="3">% TOTAL R & D ACTIVITIES</th></tr>
<tr><th>Country</th><th>Basic Research</th><th>Applied Research</th><th>Development</th></tr>
<tr><td>U S A</td><td>3.8</td><td>43.6</td><td>52.6</td></tr>
<tr><td>NORWAY</td><td>4.1</td><td>27.6</td><td>68.3</td></tr>
<tr><td>U K</td><td>3.0</td><td>48.0</td><td>49.0</td></tr>
<tr><td>FRANCE</td><td colspan="2">39.0</td><td>61.0</td></tr>
<tr><td>ITALY</td><td>-</td><td>72.2</td><td>22.8</td></tr>
<tr><td>BELGIUM</td><td>-</td><td>1.9</td><td>98.1</td></tr>
<tr><td>JAPAN'</td><td>11.0</td><td>31.0</td><td>58.0</td></tr>
</table>

Japan' 1965

<u>Orientation of R and D Activities in Non-Ferrous Metals 1963-64</u>
<u>Table 5. 1. 12. 2</u>

HR

Country	GDP	GDP per capita	GDP per man	GDP per man hour
Belgium	2.9	2.3	2.5	2.5
Denmark	3.3	2.6	2.3	2.9
France	4.4	3.5	3.8	3.9
Germany	7.6	6.5	5.3	6.0
Italy	5.9	5.3	4.1	4.1
Netherlands	4.9	3.6	3.7	3.7
Norway	3.5	2.6	3.2	3.9
Sweden	3.3	2.6	2.7	3.5
Switzerland	5.1	3.7	3.8	4.2
U K	2.6	2.2	1.9	2.0
Canada	3.9	1.2	2.0	2.5
U S A	3.2	1.6	2.1	2.4
Average	4.2	3.1	3.2	3.5

Table 5.1.13

Annual Average Percentage Rates of Growth 1950 - 60

EMH

Sector	Coefficient of determination r^2
Electricity and Gas	0.84
Distribution	0.78
Chemicals, Petrol, Rubber	0.70
Electrical Equipment	0.70
Printing and Publishing	0.64
Textiles	0.61
Rail transport	0.57
Metal Products, Machinery	0.53
Construction	0.49
Road transport	0.02
Air transport	0.02
Miscellaneous	0.02
Transport Equipment	0.07
Agriculture, Forestry and Fishing	0.17

Table 5.1.14
International Correlation between the Rate of
Micro - Economice Sector and GNP Growth.
T. P. Hill (23)

EMH

Industry	Belgium 1953 to 1965	France 1958 to 1966	FR Germany 1950 to 1965	Italy 1957 to 1966	Netherlands 1958 to 1965	Norway 1950 to 1965	Sweden 1950 to 1965	UK 1950 to 1965	Canada 1950 to 1965	USA 1950 to 1965
Agriculture, Forestry and Fishing	0.62	2.92	2.41	2.40	2.50	0.32	0.14	2.58	2.00	1.35
Mining and Quarrying	- 2.63	1.72	2.19	4.46	3.44	5.28	5.06	- 0.60	8.50	2.21
Food, Drink and Tobacco	2.45	2.93	7.28	6.29	5.25	2.56	4.19	2.59	4.62	2.47
Textiles	3.61	2.72	6.25	6.69	4.17	0.14	-	- 0.68	5.00	2.55
Wood and Furniture	7.75	4.99	6.09	5.53	7.10	4.73	3.87	2.40	4.43	2.33
Paper, Printing and Publishing	4.15	5.68		5.13	6.78	4.64		4.08	3.87	3.49
Leather	1.30	-	-	8.36	2.96	3.07	-	- 1.28	2.11	0.78
Rubber	8.80	5.16	-	10.89	9.25	1.96		3.33	4.22	4.88
Chemicals		8.69	-	13.49	11.35	8.44	6.13	5.74	8.31	6.64
Petroleum	10.56	9.29	-					7.20	7.78	3.44
Non Metallic Materials	5.29	7.14	8.89	7.18	8.41	6.04		3.77	6.81	3.13
Basic Metals	5.18	5.57	6.29	9.00	10.67	8.29	6.83	2.91	5.76	1.55
Metal products	7.31	5.00	10.89	7.25	10.26	6.25	-	2.14	5.60	3.94
Machinery		5.20			8.32		-	2.99		4.60
Electrical Equipment		7.28	11.74		12.35	9.06	-	5.78	7.68	7.44
Transport Equipment	-	5.94	-	10.24	3.46	3.70	-	4.42	5.56	5.57
Miscellaneous Manufacturing	5.25	5.15	-	2.95	2.11	7.18	-	4.84	8.56	4.52
Construction	3.86	7.06	7.49	3.32	5.91	1.61	3.64	3.16	5.97	2.57
Rail Transport	0.38	3.92	2.18	5.40	6.71	1.84	-	- 0.77	2.84	0.91
Road Transport	5.97		7.45			4.56	-	- 2.35	- 1.79	2.92
Water Transport	5.00	4.47	7.81		4.13	7.69	-	-	4.23	1.45
Air Transport	12.14		-			15.30	-	15.48	15.93	12.65
Storage	-	-	-	-	-	6.11	-	4.02	6.09	2.22
Communications	5.97	7.51	7.17	6.18	6.12	3.83	-	3.78	6.08	7.02
Agriculture	0.62	2.92	2.41	2.40	2.50	0.32	0.14	2.58	2.00	1.35
Industry	4.61	5.76	8.26	6.87	7.23	4.36	5.01	3.13	6.07	3.87
Distribution, Transport and Communication	3.98	5.18	6.41	5.59	7.19	5.65	3.26	2.50	4.84	3.73
Other Services	3.66	4.31	5.67	4.20	2.68	3.83	3.74	2.12	4.34	3.96
Goods	4.06	5.29	7.53	5.59	6.48	3.40	4.29	3.10	5.33	3.60
Services	3.79	4.66	6.04	4.69	4.98	5.05	3.48	2.31	4.55	3.86
Gross Domestic Products	3.92	5.03	6.93	5.17	5.79	4.25	3.90	2.69	4.90	3.74

Table 5.1.15

Long Period Growth Rates of Real Product by Industry of Origin

Average Annual Percentages Rates of Growth T P Hill (23)

Industry	Belgium	France	FR Germany	Italy	Netherlands	Norway	Sweden	UK	Canada	USA
Agriculture, Forestry and Fishing	- 1.03	1.77	0.84	2.75	0.54	0.18	0.54	3.05	2.15	1.51
Mining and Quarrying	- 0.34	1.01	0.32	0.92	2.71	7.39	6.05	- 0.45	6.20	2.44
Food, Drink and Tobacco	3.27	3.05	5.26	8.58	4.94	4.61	4.51	2.55	5.18	2.54
Textiles	3.24	1.34	3.91	4.06	2.08	0.18	-	- 0.38	9.69	5.65
Wood and Furniture	11.01	4.45)	4.90	4.20	5.92	6.79)	6.55	2.32	7.12	4.98
Paper, Printing and Publishing	6.11	4.88)		3.12	5.64	5.61)		3.48	4.16	5.08
Leather	4.68	-	-	14.17	1.63	- 1.80	-	0.31	5.64	2.25
Rubber	10.34	3.63	-	12.64	6.05	2.86)		2.77	7.60	6.76
Chemicals		9.25	- }	13.71 }	9.88 }	11.72 }		5.86	8.47	7.55
Petroleum	10.44	10.20	-				11.95	3.97	5.55	4.27
Non Metallic Materials	4.65	8.90	5.67	5.52	7.52	3.87)		5.64	7.24	4.67
Basic Metals	7.40	3.77	1.94	9.14	7.84	6.48	9.53	2.05	7.02	5.45
Metal Products		4.78)	7.04 }		8.33 }	6.85 }		2.62 }	10.64	6.01
Machinery		5.11)		5.11	6.96)			4.36)		8.10
Electrical Equipment	10.01	8.46	7.12)		8.46	8.77 }	9.45	5.00	11.54	9.15
Transport Equipment		5.36	-	9.57	1.70	5.05)		2.21	13.11	8.48
Miscellaneous Manufacturing	5.92	4.88	-	0.65	2.69	12.16	-	5.92	9.49	4.72
Construction	5.40	8.83	5.26	2.88	6.06	2.97	3.99	4.36	6.63	1.75
Rail Transport	0.32)	3.85	0.56)		6.43	2.21	-	- 2.28	6.00	4.44
Road Transport	6.22)		2.86)	5.41 }		5.32	-	- 3.23	1.35	4.30
Water Transport	4.79)	4.75			2.02	8.45	-	-	7.81	1.52
Air Transport	3.65)		-			17.68	-	15.03	12.36	12.89
Storage	-	-	-	-	-	5.15	-	5.23	2.14	3.56
Communications	7.17	8.36	5.49	8.55	6.42	3.98	-	5.20	5.24	7.43
Agriculture	- 1.03	1.77	0.84	2.75	0.54	0.18	0.54	3.05	2.15	1.51
Industry	6.45	5.94	5.74	5.94	6.21	5.51	7.51	3.23	7.51	5.14
Distribution, Transport and Communication	4.63	5.70	4.54	5.69	7.10	6.41	4.16	2.75	5.52	5.17
Other Services	4.55	4.46	5.02	3.88	2.75	4.39	4.46	2.85	4.03	4.76
Goods	5.45	5.21	5.28	5.06	5.34	4.40	6.63	3.34	6.62	4.77
Services	4.59	4.96	4.77	4.52	4.99	5.78	4.30	2.80	4.64	4.94
Gross Domestic Product	4.99	5.11	5.09	4.81	5.18	5.05	5.52	2.99	5.45	4.86

Table 5.1.16

Short Period Growth Rates of Real Product by Industry of Origin 1960-1965

Average Annual Percentages Rates of Growth T P Hill (23)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
German F R	168.9	172.6	177.8	208.8	219.9	234.4	243.9	252.9	257.4	262.7	309.3
Belg Lux											
France	235.2	279.2	294.5	298.4	316.0	340.5	363.5	361.2	365.7	371.7	381.1
Italy	83.6	83.4	80.9	91.4	115.0	124.1	127.8	127.7	142.3	143.6	146.7
Netherlands	-	-	-	-	-	-	19.5	32.1	47.2	69.3	75.0
EEC	487.7	535.2	553.2	598.6	650.9	699.0	754.7	773.9	812.6	847.3	912.1
UK	29.4	32.8	34.6	31.1	32.2	36.2	37.1	39.0	38.2	33.8	39.6
Norway	170.7	175.2	208.9	225.3	261.0	275.6	330.3	361.0	462.8	501.6	526.9
Austria	68.0	67.7	74.1	76.5	77.7	78.7	78.9	78.7	85.9	89.7	90.0
Sweden	16.0	15.6	16.0	17.1	32.3	29.6	28.7	33.4	56.8	66.8	66.2
Europe	865.2	933.7	1009.1	1090.2	1202.2	1278.2	1441.3	1553.0	1745.5	1863.0	2019.5
India	18.2	18.4	35.2	55.2	56.2	63.7	83.6	96.4	120.1	132.5	161.1
Japan	133.2	153.7	171.5	223.9	265.8	293.9	337.3	382.1	481.9	568.8	732.8
USA	1827.5	1727.3	1921.4	2097.9	2316.0	2498.8	2692.9	2965.8	2952.9	3441.0	3607.1
Canada	691.3	601.6	626.3	652.5	764.4	753.4	807.3	873.9	888.3	996.2	972.3
America	2537.0	2347.4	2569.4	2776.8	3124.8	3305.3	3575.7	3925.1	3960.0	4582.8	4747.0
Australia	11.8	13.4	16.4	41.9	80.0	87.8	92.0	92.8	97.4	126.4	204.5
Western Countries	3617.6	3523.2	3864.9	4252.8	4799.9	5098.4	5595.4	6152.8	6580.9	7459.9	8069.7

TABLE 5.2.1

Production of Primary Aluminium

(x 1000 metric tons)

R H

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany F R	428.7	412.1	426.4	442.5	535.6	558.5	595.5	587.2	748.6	878.1	881.0
Belg-Lux	66.3	70.9	70.3	91.9	115.0	117.8	151.9	134.7	154.5	168.5	177.4
France	240.2	245.1	277.5	288.5	308.8	310.4	357.6	374.8	386.5	456.3	490.8
Italy	143.0	154.0	167.0	188.0	178.0	195.0	252.0	281.0	323.0	382.0	420.0
Netherlands	20.0	17.6	19.5	25.5	22.7	20.3	24.6	28.0	37.2	53.5	61.4
UK	481.0	407.2	421.5	469.4	534.9	528.7	538.5	530.8	578.7	596.2	602.9
Norway	20.3	21.9	26.2	17.4	21.6	21.0	29.2	42.7	54.4	72.2	77.4
Austria	40.0	40.9	41.5	42.2	46.8	45.8	50.8	55.4	65.6	76.6	82.2
Sweden	40.6	38.1	44.9	55.5	59.2	54.2	70.6	66.4	78.9	95.4	100.0
Japan	200.0	255.1	255.7	310.1	366.2	406.0	507.4	694.6	847.2	1100.3	1229.0
USA	1942.6	2236.1	2622.7	2941.3	3183.1	3626.1	4106.9	3940.7	4532.4	4664.2	4356.1
Western Countries	4057.1	4366.6	4921.7	5469.6	6051.1	6701.4	7684.2	7727.2	8939.8	9785.0	9849.1
Total World	5157.1	5616.6	6221.7	6819.6	7531.1	8351.4	9459.2	9727.2	11139.8	12185.0	12349.1

TABLE 5.2.2.

Total Consumption of Primary and Secondary Aluminium

x 1000 metric tons

R H

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Germany	383	384	393	410	500	516	535	507	672	796
Belg-Lux	30.2	30.4	26.7	37.5	46.5	36.3	52.2	49.6	57.8	62.0
France	224	227	244	258	281	268	319	316	350	440
Italy	144	150	165	198	174	186	243	273	296	352
Netherlands	39.2	27.8	28.3	38.3	44.7	35.7	43.8	49.0	57.2	68.5
UK	410	375	385	435	512	490	497	485	553	583
Norway	20.7	23.2	29.2	22.0	26.7	20.0	31.0	42.0	36.0	48.5
Austria	22.6	27.6	26.5	25.8	28.8	31.3	30.0	33.8	40.4	45.7
Sweden	47.8	45.2	51.3	60.0	66.7	59.0	71.8	75.0	97.5	105
Japan	186	245	238	288	349	383	506	650	800	1050
US	1950	2250	2660	2900	3150	3610	4130	3780	4300	4570

TABLE 5.2.3.

Consumption of Primary and Secondary Aluminium (+ Import-Export Semi-manufactures)

(x 1000 metric tons) (European Aluminium Statistics)

R H

	1950	1955	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany	1.8	4.8	7.2	7.1	7.2	7.4	8.9	9.1	9.3	8.8	11.6	13.7	13.7
Belg-Lux	0.9	1.8	3.2	3.2	2.8	3.9	4.8	3.7	5.3	5.0	5.8	6.2	6.6
France	1.6	2.9	4.9	4.9	5.2	5.4	5.8	5.5	6.5	6.4	7.0	8.8	8.8
Italy	1.3	1.7	2.9	3.0	3.3	3.9	3.4	3.6	4.7	5.2	5.6	6.6	7.5
Netherlands	0.9	1.7	3.4	2.4	2.4	3.2	3.7	2.9	3.5	3.9	4.5	5.3	5.5
EEC	1.5	3.0	4.9					5.8	6.6	6.6	7.9	9.4	9.7
UK	4.6	6.8	7.8	7.1	7.2	8.1	9.5	9.0	9.1	8.8	10.0	10.5	11.1
Norway		7.2	5.76	6.46	8.0	5.97	7.23	5.4	8.22	11.1	9.2	12.6	11.3
Austria		4.7	3.2	3.9	3.7	3.6	4.0	4.3	4.1	4.6	5.5	6.2	7.8
Sweden	2.3	4.9	6.4	6.0	6.8	7.9	8.7	7.6	9.3	9.5	12.3	13.1	14.8
Japan		0.5	2.0	2.6	2.5	3.0	3.6	3.9	5.1	6.5	7.9	10.3	
USA	6.8	11.4	10.8	12.3	14.2	15.4	16.4	18.6	21.0	19.0	21.4	22.4	20.9
Canada	4.0	5.1	5.1	6.0	7.2	8.6	9.1	9.6	11.3	12.6	12.9	14.2	13.8

TABLE 5.2.4.

Per Capita Consumption of Aluminium (Domestic Market) (kg per capita)

Apparent Consumption of Primary + Secondary Metal + (Imports-Exports of Semi Fabricated Products)

R H

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Germany	361	352	356	366	500	474	484	448	575	682
Belg-Lux	12.14	17.16	16.74	20.99	31.85	33.95	46.14	31.0	40.79	47.12
France	218	222	240	261	266	266	306	308	316	373
Italy	137	147	159	179	160	172	225	250	277	329
Netherlands	30	34	33	40	51.5	55	46	53	65	80
U.K.	351	312	313	350	394	403	403	402	440	463
Austria	52.5	55.2	33.5	33.3	39.0	36.0	40.2	38.6	46.3	57.1
Japan	na	na	na	293	338	354	482	608	770	999
U. S.	na	2087	2431	2680	2989	3437	3832	3760	4234	4450

Consumption of Primary & Secondary Aluminium (& Import-Export Semi-Manufactures)

x 1000 Metric tons (Metallgesellschaft End-Use Statistics - OECD Statistics)

Table 5.2.5.

(BM)

Country	1950	1955	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany F.R	29.0	81.5	131.0	130.2	129.1	138.6	166.0	185.9	175.0	149.9	189.0	229.5	241.6
							8.4	9.7	10.0	11.2	12.1	11.7	12.0
Belg/Lux		1.5	1.6	1.9	2.5	2.3		2.2			2.6	3.3	3.4
France			70.8	71.4	81.8	88.4	89.0	92.0	109.0	105.4	106.8	128.1	141.3
Italy		36.0	56.0	60.0	65.0	75.0	67.0	75.0	98.0	117.0	130.0	144.0	162.0
Netherlands		2.0	3.5	3.0	5.5	6.0	7.5	8.5	9.0	8.0	8.0	9.3	8.2
U.K.	58.4	91.7	105.3	94.7	97.3	108.1	123.2	120.6	117.4	115.3	127.2	139.1	135.2
Norway (Al+Mg)		0.8	2.0					4.8			5.0	5.0	5.0
Austria		5.2	4.7	5.0	5.4	4.7	5.2	5.4	5.8	5.5	6.3	8.5	11.3
												20.5	21.0
Sweden	4.6	6.6	8.4	10.2	10.2	11.2	13.8	16.4	16.5	17.5	18.5	16.1	16.5
Japan	7.4	15.8	61.8	77.3	77.8	90.8	109.9	117.9	143.8	180.9	233.4	282.9	335.5
U.S.A.	246.3	372.3	351.3	345.5	528.8	547.5	568.7	639.1	743.9	696.1	720.4	770.2	683.7

Upper Data DEA)
Lower Data EAS) Pronounced discrepancy between data from different sources.

Total Production of Aluminium Castings

x1000 metric tons

Table 5.2.6

(BM)

136

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR	135.7	137.7	144.9	158.8	188.6	202.9	196.7	185.5	231.9	271.3	258.5
Belg-Lux	2.8	1.9	2.8	3.6	3.5	3.2	2.5	*1.5	2.2	*2.5	*2.0
France	44.0	43.2	46.9	49.6	50.3	50.2	59.6	62.5	73.6	88.5	87.4
Italy	42.0	45.0	56.0	65.0	58.0	61.0	85.0	102.0	102.0	125.0	154.0
Netherlands	6.0	5.6	5.5	6.0	1.1	1.1	1.5	2.0	2.2	5.5	7.0
EEC	230.5	233.4	256.1	283.0	301.5	318.4	345.3	353.5	411.9	495.8	508.9
UK	111.4	119.0	131.8	149.0	171.6	178.8	183.6	178.6	188.0	209.5	201.4
	17.2	11.7	9.2	10.0	10.5	11.5	15.9	14.3	16.1	15.1	19.5
Norway	2.3	2.1	2.1	2.4	2.6	3.2	3.1	3.4	3.4	4.1	4.2
Austria											
Sweden	2.7	4.5	5.5	5.9	8.0	10.0	11.0	13.0	16.8	19.0	20.0
Europe	379.5	387.4	424.1	473.5	526.9	556.6	601.5	605.9	686.2	802.8	814.7
Japan	49.5	69.5	71.5	90.8	104.4	117.9	140.5	178.1	226.6	281.1	319.0
USA	401.4	445.0	533.4	601.0	648.2	774.3	832.8	821.5	935.3	958.0	868.0
Canada	8.3	8.7	10.4	13.6	17.5	21.4	27.7	31.2	32.0	32.3	31.8
America	412.7	458.2	548.3	619.1	670.7	801.8	880.2	873.9	988.3	1011.3	922.3
Australia	4.5	4.8	5.0	*5.0	*7.5	*8.0	*10.0	*10.0	*10.0	*12.0	*15.0
Western Countries	856.4	931.9	1061.9	1203.4	1324.5	1504.3	1659.5	1695.9	1943.1	2139.2	2104.0

Aluminium Recovered from Scrap
(X1000 metric tons)

Lower Figs.: UK Actual Scrap used by Manufacturers

* Estimate

Table 5.2.6.1

HR

Country/Product	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR Total	29.0	131.0	130.2	129.1	138.6	166.0	185.9	175.0	149.9	189.0	229.5	241.6
Pressure Die Castings		31.0	30.5	32.0	35.0	45.0	55.0	56.0	52.0	70.0	92.0	97.1
rem Processes		100.0									137.5	
PD as % Total C		23.6	23.5	24.8	25.2	27.0	29.6	32.0	34.9	37.1	40.0	
France Total		70.8	71.4	81.8	88.4	89.0	92.0	109.0	105.4	106.8	128.1	141.3
Pressure Die Castings		12.0	11.5	15.0	17.0	16.0	22.0	30.0	30.1	33.0	42.0	(48.4)
rem Processes		58.8									86.1	
PD as % Total C		16.9	16.1	18.4	19.3	18.0	23.9	27.5	28.6	31.0	32.8	
Italy Total		56.0	60.0	65.0	75.0	67.0	75.0	98.0	117.0	130.0	144.0	162.0
Pressure Die Castings		12.0	20.5	26.0	33.0	30.5	42.0	60.0	70.0	78.0	97.0	(102.0)
rem Processes		44.0									47.0	
PD as % Total C		21.4	34.2	40.0	44.0	45.5	56.0	61.2	60.0	60.0	67.3	
UK Total	58.4	105.3	94.7	97.3	108.1	123.2	120.6	117.4	115.3	127.2	139.1	135.2
Pressure Die		27.4	23.2	25.4	30.7	40.9	42.0	41.2	41.3	47.4	49.3	43.8
Gravity Die		56.3	51.6	52.9	58.3	63.8	60.7	58.6	58.0	62.9	71.6	73.0
Sand		21.5	20.0	19.0	19.1	18.5	17.9	17.6	16.1	16.9	18.2	18.4
PD as % Total C		26.1	22.0	26.1	27.4	33.2	34.8	35.0	35.9	37.3	35.6	32.5
Japan Total	7.4	61.8	77.3	77.8	90.8	109.9	117.9	143.8	180.9	233.4	282.9	335.5
Pressure Die		26.9	35.7	36.7	46.6	53.1	58.6	70.2	85.6	111.4	136.3	157.7
rem Processes		34.9	41.6	41.1	44.2	56.8	59.3	73.6	95.3	122.0	146.6	177.8
PD as % Total C		43.5	46.1	47.2	51.3	48.3	49.6	48.8	47.3	47.6	48.2	47.1
USA Total	246.3	351.3	345.5	528.8	547.5	568.7	639.1	743.9	696.1	720.4	770.2	683.7
Pressure Die		174.9	170.5	281.7	301.8	311.8	364.5	420.0	397.8	444.0	466.1	425.4
Gravity Die		117.0	118.2	148.7	150.9	147.1	150.1	183.6	173.5	174.5	196.9	146.3)
Sand		58.8	56.5	94.0	92.0	104.7	121.8	132.4	113.7	96.3	100.2	90.5)
PD as % Total C		49.8	49.3	53.3	55.2	54.8	57.0	56.6	57.0	61.7	60.5	62.3

Cast Product Statistics - Disaggregated

X1000 metric tons

Table 5.2.7

HR

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR	2.46	2.41	2.36	2.5	2.96	3.1	2.9	2.5	3.1	3.8	3.9
Belg-Lux						1.0	1.0	1.1	1.2	1.2	1.2
France	1.55	1.55	1.74	1.85	1.84	1.9	2.2	2.1	2.1	2.5	2.8
Italy	1.13	1.2	1.3	1.48	1.3	1.48	1.8	2.2	2.3	2.7	3.0
Netherlands	0.3	0.26	0.47	0.5	0.62	0.7	0.7	0.6	0.6	0.7	0.6
UK	2.0	1.79	1.82	2.02	2.28	2.2	2.1	2.1	2.3	2.5	2.4
Norway											
Austria	0.67	0.71	0.76	0.65	0.72	0.7	0.8	0.7	0.9	1.1	1.7
Sweden	1.1	1.3	1.3	1.48	1.8	1.9	2.1	2.3	2.3	2.6	2.6
Japan	0.67	0.82	0.82	0.95	1.13	1.2	1.5	1.8	2.3	2.7	3.2
USA	1.95	1.88	2.85	2.9	2.95	3.3	3.7	3.5	3.8	3.8	3.3

Total Consumption kg Per Capita of Aluminium Castings

Consumption = Production

Table 5.2.8

HR

Country	1950	1955	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR	59.8	154.9	245.0	234.1	245.8	255.0	316.1	319.0	365.6	380.9	474.9	563.8	554.3
Belg-Lux	8.1	26.7	60.0	69.8	78.2	93.2	115.1	125.8	163.5	132.6	144.7	167.0	164.8
France	34.0	74.2	136.2	140.0	159.6	176.7	189.3	189.4	225.8	243.0	252.4	302.6	319.0
Italy	30.8	53.0	83.0	90.0	97.0	107.0	105.0	112.5	144.0	151.0	183.7	229.3	246.5
Netherlands	4.0	7.0	11.0	15.0	17.0	20.0	22.0	22.0	24.0	26.0	32.0	48.5	57.0
UK	168.7	226.8	265.7	250.5	255.0	272.8	290.1	303.9	315.2	316.5	336.6 350.6	344.8 358.2	321.2 340.0
Norway		13.0	16.5	17.0	16.0	15.6	17.8	19.2	26.0	34.0	38.9	55.4	68.9
Austria		26.1	30.0	30.5	31.9	30.7	32.0	30.3	33.9	36.6	44.4	55.9	57.8
Sweden	11.1	41.2	32.6	32.3	38.3	43.0	50.6	44.7	50.7	51.7	61.9	80.3	78.6
Japan	33.1	58.0	134.2	176.0	177.0	224.0	259.0	245.8	345.0	415.0	467.0 529.3	626.7 701.1	689.5 776.9
USA	777.2	1266.3	1383.0	1517.3	1728.8	1931.0	2193.1	2576.1	2929.1	2880.6	3252.3	3471.2	3355.5

Upper Data OEA

Lower Data EAS

Total Production of Semi-Fabricated Aluminium Products
X1000 metric tons

Table 5.2.9

HR

UK	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Wrought P	269.3	250.5	255.0	272.8	290.1	302.9	315.2	316.5	336.6	344.8	327.9
Sheet	122.6	107.1	92.7	103.4	107.9	102.4	98.7	97.6	107.0	106.7	92.9
Strip in Coil	40.0	43.9	64.3	58.0	52.5	56.9	63.6	59.0	61.3	65.5	61.5
Circles & Blanks	22.2	20.7	19.5	21.5	23.8	23.3	22.7	22.1	24.1	22.8	23.9
Total Flat Prod	184.8	171.7	176.5	182.9	184.2	.82.6	185.0	178.7	192.3	195.0	178.3
Forging Bar	0.29	0.24	0.21	0.29	0.27	0.25	0.24	0.24	0.30	0.47	0.42
Rod, wire drawing	0.81	1.48	1.72	1.28	1.48	1.42	4.54	7.17	7.09	8.42	6.17
Other bar	13.07	12.19	10.45	12.09	12.93	13.05	13.14	12.50	12.25	13.93	12.34
Sections	35.5	33.3	32.6	34.7	42.5	45.4	47.6	50.4	59.7	68.2	69.7
Tubes	12.8	10.7	11.2	13.4	14.2	15.9	16.0	14.4	16.5	18.6	17.4
Wire	19.5	18.9	21.3	27.3	33.8	45.2	48.7	52.7	48.5	40.2	43.6
Forgings	4.2	4.2	3.5	3.9	4.3	4.3	3.9	4.0	3.9	4.0	3.7
Foil	27.7	26.0	26.0	27.9	30.2	31.4	31.6	31.8	34.1	35.1	35.0

Table 5.2.10

Wrought Product Statistics

UK
X1000 metric tons (Despatches of Fabricated Al and Al alloys)

EMH

Italy	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Wrought Products	83.0	90.0	97.0	107.0	105.0	112.5	144.0	151.0	183.7	229.3	246.5
Rolled	49.0	51.8	54.5	70.0	73.0	77.5	92.0	99.0	118.5	143.0	150.5
Foil	7.0	9.2	10.5	12.0	9.5	12.0	16.0	16.0	17.5	19.5	22.6
Extruded	14.5	16.0	18.0	28.0	26.0	28.8	42.0	43.0	51.0	69.0	73.0
Tubes	4.5	5.0	5.0								
Wire	8.0	8.0	9.0	9.0	6.0	5.7	10.0	9.0	13.5	16.5	22.0
Forgings	na	na	na	na	0.4	0.5	2.0	4.0	0.7	0.8	1.0
Sweden	Production of Aluminium and Aluminium Products										
Total Wrought Products	32.6	32.3	38.3	43.0	50.6	44.7	50.7	51.7	61.9	80.3	78.6
Sheets	18.8	19.1	21.1	23.1	29.3	29.2	32.3	27.7	36.3		
Foil	1.4	1.5	2.0	2.0	2.8	3.4	4.3	5.8	5.6		
Tubes	0.8	1.0	1.4	1.3	1.5	2.1	2.4	2.6	2.5		
Rods	2.4	2.6	3.7	3.5	5.2	5.8	5.2	6.9	8.2		
Wire	12.2	9.6	12.0	15.1	14.6	8.6	12.7	13.2	12.6		

Table 5.2.10

Wrought Products Statistics

X 1000 metric tons - consumption at the first stage of processing

U S A	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
												3228.6
Total Wrought Products	777.2	1383.0	1517.3	1728.8	1931.0	2193.1	2576.1	2929.1	2880.6	3252.3	3471.2	3355.5
Sheet and Plate		629.7	677.4	776.0	905.0	1031.4	1183.3	1332.1	1300.9	1544.3	1690.5	1673.1
Foil		112.9	122.7	134.9	146.2	161.8	179.5	196.0	203.9	230.8	254.0	255.4
Forging & Impact		22.7	25.6	36.0	38.1	40.1	43.7	63.1	74.9	78.3	71.0	54.6
Rolled rod, bar * and structural shapes (* includes continuous cast)		42.1	45.7	62.0	55.2	66.6	72.4	68.9	64.9	59.0	65.4	62.7
Wire, bare		25.1	23.9	24.8	26.1	28.6	37.5	46.8	44.4	45.5	43.0	42.4
ACSR & Al cable		83.1	105.6	114.8	123.5	140.3	194.7	230.3	229.6	223.2	215.5	226.6
Wire & Cable Insulated		27.4	31.1	34.9	40.5	46.8	58.7	75.0	79.3	97.0	113.6	118.0
Total Wire		135.6	160.6	174.5	190.1	215.7	290.9	352.1	353.3	365.7	372.1	
Extruded Shape		386.0	423.9	471.5	522.8	591.1	699.7	779.8	696.4	758.3	812.8	746.5
Drawn Tube		27.4	29.0	35.6	29.7	30.3	37.4	45.2	40.4	42.0	40.3	38.2
Welded Tube		11.7	16.1	18.5	23.6	35.1	42.5	41.4	39.8	48.5	46.1	42.0
Japan												
										462.0	626.7	689.5
Total Semis Produced	33.1	134.2	176.0	177.0	224.0	259.0	245.8	345.0	415.0	529.3	701.1	776.9
Total Wrought Produced		61.8									344	
Sheet Products		25.0	35.3	38.1	42.3	50.95	51.19	60.04	80.18	102.29	138.27	157.14
Electric Wire		14.06	17.97	14.08	20.92	17.26	23.53	41.32	50.38	61.41	73.3	87.36
Forgings		0.53	0.59	0.43	0.61	0.70	0.76	1.10	1.34	0.97	1.19	1.46

Table 5.2.10
Wrought Product Statistics
Shipments of Wrought Aluminium

Product Description Export and Import	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Sheet, Strip, Disc & Circles										
Exported	36.7	42.3	48.1	43.9	33.6	30.6	33.9	24.1	24.1	22.6
Imported	9.9	16.8	17.6	18.9	17.2	16.4	17.3	19.4	25.1	29.3
Foil										
Exported	7.3	6.2	6.6	6.8	7.5	7.3	7.3	6.8	9.0	8.7
Imported	1.9	1.8	2.3	2.4	3.3	2.7	3.5	4.3	4.9	6.1
Wire, Rods **Tube Sections**										
Exported	5.0	5.2	5.0	6.0	6.5	10.3	6.2	6.0	5.5	8.3
Imported	1.9	2.9	3.2	3.9	6.0	4.9	7.5	6.5	7.5	11.0
Holloware Domestic										
Exported	1.8	1.5	1.3	1.2	1.3	2.2	1.9	2.0	2.0	2.2
Imported	0.3	0.5	0.2	0.4	0.6	0.4	0.5	1.0	1.0	0.1

UK Export and Import of Aluminium Product Forms

X1000 Metric tons.

Table 5.2.11

BN

	£		
Fixed Capital			
Plant	200,000		
Buildings	50,000		
	250,000		
Fixed Costs			
Overheads	20,000		
Depreciation	12,000		
	32,000		
	£ 1 Shift	£ Beginning of 3rd Shift	£ 3 Shifts
Variable Cost	22,600		66,330
Fixed + Variable Cost (excluding Material)	54,600		98,300
Material Cost	455,000	910,000	1,365,000
Material + Processing	509,600	1,008,000	1,463,000
Output lb	2,448,000	4,896,000	7,344,000

Material Cost = 18.6 p per lb
(Estimating 68% extrusion yield and casting yield 96%)

Costs Incurred by the Extrusion of Aluminium

R Chadwick (50)

Table 5.2.12

BM

Sector	Germany		Belg-Lux		France		Italy		Netherlands		UK		Japan		US	
	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969
Transport	27	26	9.6	6.7	31.0	32.7	41.7	36.6	8.3	8.2	31.6	31.8	19.7	22.0	23.6	21.7
Mech Eng	12.3	9.7	7.2	2.8	9.2	7.1	7.0	7.3	8.7	8.2	7.6	6.7	8.8	6.0	6.9	6.6
Elec Eng	16.9	15.1	5.2	5.0	14.2	16.6	7.7	8.5	10.0	10.6	10.1	13.1	8.8	14.3	12.1	14.0
Building	6.8	15.0	25.8	25.6	7.0	8.8	10.3	14.0	16.7	27.7	9.0	7.9	7.8	24.6	25.6	23.3
Ch, Food, Adg	3.5	2.8	11.5	2.8	2.0	1.9	1.1	1.8	1.0	1.3	1.6	2.7	2.8	2.4	1.0	0.8
Packaging	9.6	9.5	7.7	11.5	10.0	10.2	9.9	9.1	16.7	20.1	8.4	7.9	2.3	1.8	7.7	12.2
D.O. App	4.4	2.5	13.4	2.7	9.6	7.2	8.1	14.6	21.7	17.6	10.2	9.8	33.1	10.4	11.6	8.7
Powder	1.2	1.1	-	0.51	3.2	0.9	0.7	0.8	1.7	1.9	1.7	1.7	0.8	0.6	1.1	2.8
Iron & Steel	5 3	5.0			4.8	5.2	2.0	2.3	1.7	2 5	4.8	4.3	3.8	4.2		
Met Industry	5.8	5.1	5.6	1.3	2.0	4.5					4.3	1.7	4.8	7.1		1.8
							11.6	5.0	13 7	1.9					6.5	
Misc	7.3	8.3	13.7	40.4	7.5	5.1					10 5	12.5	7.7	6.3		6.1
Total Al Consumed x 1000 Metric tons	361	683	12	47	218	373	137	329	30	80	351	463	293	999	2087	4233

PERCENTAGE OF TOTAL APPARENT CONSUMPTION BY MANUFACTURING INDUSTRY. LESS EXPORT OF SEMIS.

Germany	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	
Transportation		97.7	98.2	98.9	108.0	131.1	141.8	135.6	113.9	145.2	178.0	184.7	
Mech Eng		44.2	42.5	40.9	42.5	51.9	58.1	55.4	45.7	56.9	66.0	65.8	
Elec Eng		60.9	63.1	70.0	63.4	76.7	72.6	77.5	75.8	89.7	102.7	105.1	
Building & Constr		24.4	25.2	26.6	28.1	41.3	47.5	55.4	58.6	80.8	101.6	112.8	
Chem, Food & Ag		12.8	10.7	11.4	12.9	15.1	16.5	15.0	12.5	15.6	19.4	22.0	
Packaging		34.6	34.5	38.3	39.2	41.8	42.7	47.2	43.0	53.5	65.1	69.1	
Dom & Office App		15.8	13.8	13.6	13.7	16.0	17.0	16.1	15.4	15.7	17.2	17.8	
Powder Cons Ind		4.4	4.2	3.2	3.7	4.8	5.2	5.9	5.0	6.2	7.2	8.5	
Iron & Steel		19.1	18.7	19.0	18.6	22.6	22.4	21.7	23.4	29.7	33.8	34.5	
Metal Ind (add)		20.8	19.2	19.4	18.8	23.5	20.6	18.6	18.0	29.4	35.1	29.1	
Misc		26.3	22.2	14.9	17.4	24.7	29.6	35.9	36.0	52.7	55.4	52.6	
Total App		361.0	352.3	356.2	366.3	499.5	474.0	484.3	447.9	575.4	682.5	702.0	
Export		34.9	38.3	43.6	51.0	56.5	54.7	77.4	95.7	115.8	142.3	128.4	
Total		395.9	390.6	399.8	417.3	506.0	528.7	561.7	543.6	691.2	824.8	830.4	

CONSUMPTION OF ALUMINIUM BY END USES

x 1000 Metric Tons

Table 5.3 2

(BM)

Belgium - Luxemburg	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Transportation	1.16	1.56	1.68	2.17	2.46	2.42	2.22	1.90	2.95	3.17	2.89
Mech Eng	0.87	0.68	1.59	1.85	2.05	1.60	1.08	0.50	1.25	1.33	1.42
Elect Eng	0.63	-	0.81	0.91	0.98	1.15	2.53	2.03	2.09	2.37	5.00
Build Const	3.14	3.61	4.49	5.46	6.06	8.75	12.43	11.87	11.71	12.12	16.14
Chem Food Ag	1.39	0.63	0.76	0.67	1.17	0.77	1.25	1.33	1.32	1.34	1.14
Packaging	0.94	1.35	2.05	3.42	4.10	3.23	4.32	3.79	5.35	5.43	4.99
Domestic & Office	1.63	2.00	1.69	2.16	2.55	1.69	1.85	1.61	2.01	1.27	1.55
Powder Cons Ind	-	0.08	0.05	0.06	0.60	0.16	0.19	0.16	0.18	0.20	0.27
Destructive Uses	0.05	0.02	0.01	0.03	0.03	0.04	0.04	0.04	0.14	0.24	0.27
Metal Industry	0.68	0.82	1.01	0.29	1.77	0.44	0.48	0.41	0.32	0.62	0.62
Miscellaneous	1.66	2.77	2.59	3.98	10.62	13.71	19.79	7.42	13.48	19.04	14.45
Total Apparent Cons	12.14	17.16	16.74	20.99	31.85	33.95	46.14	31.10	40.79	47.12	48.73
Export	45.54	50.31	60.18	68.32	81.40	92.72	125.29	102.57	122.01	129.25	132.96
Total	57.68	67.47	76.92	89.31	113.25	126.67	171.43	133.67	162.80	176.37	181.69

Table 5.3.3

Consumption of Aluminium by End Uses

X1000 Metric Tons

MP

France	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Transportation	67.31	70.71	80.04	95.43	86.12	93.13	114.70	102.56	99.73	122.00
Mech Eng	20.02	22.43	22.18	23.37	22.25	23.10	25.40	25.14	23.78	26.40
Elect Eng	31.00	27.02	28.17	28.99	33.04	30.40	35.86	44.19	49.27	61.80
Build and Const	15.30	16.40	16.92	17.98	21.76	23.71	25.44	28.72	29.07	32.80
Chem Food Ag	4.34	4.40	5.87	5.67	4.96	5.43	5.93	7.62	7.44	7.10
Packaging	21.80	22.61	24.83	24.32	27.01	26.49	26.50	27.23	30.32	37.80
Domestic and Office	20.84	23.44	24.93	28.74	30.54	24.73	27.35	20.76	22.81	26.90
Powder Cons Ind	6.86	7.60	6.79	7.87	7.90	7.59	7.93	2.26	2.47	3.00
Iron and Steel	10.36	9.28	10.04	9.22	9.52	10.77	11.03	18.37	20.31	19.50
Metal Industry	4.35	4.70	5.59	5.82	7.02	6.82	8.28)	30.86	8.46	16.60
Miscellaneous	16.24	13.05	14.92	13.90	16.05	14.31	17.35)		22.56	19.10
Total Apparent Cons	218.39	221.63	240.27	261.31	266.18	266.49	305.73	307.70	316.21	373.00
Export	21.68	25.05	35.18	36.01	41.65	40.74	57.08	65.24	63.59	85.50
Total	240.07	246.68	275.45	297.32	307.82	307.22	362.85	372.94	379.80	458.50

Metal shot for Metal Industry transferred under Iron and Steel Industry

Table 5.3.4

Consumption of Aluminium by End Uses

X1000 Metric Tons

MP

Italy	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Transportation	57.0	62.6	67.5	77.0	68.0	75.0	102.0	114.0	128.0	120.0	140.0
Mech Eng	9.5	10.0	11.0	14.0	13.0	14.0	17.0	20.0	21.0	24.0	25.0
Elec Eng	10.5	10.7	12.0	12.5	10.0	11.0	16.0	17.0	20.0	28.0	34.0
Build and Const	14.0	15.8	17.5	22.0	20.0	20.0	24.0	26.0	30.0	46.0	53.0
Chem, Food, Ag	1.5	1.6	2.0	2.5	2.3	2.5	3.5	4.0	5.0	6.0	7.0
Packaging	13.5	14.8	16.0	18.0	15.0	16.5	22.5	23.0	25.0	30.0	35.0
Domestic and Office	11.0	11.0	11.5	14.0	13.0	13.0	14.0	18.0	21.0	48.0	52.0
Powder Cons Ind	1.0	1.0	1.2	1.2	1.0	1.0	1.2	1.5	2.0	2.5	3.0
Iron and Steel	2.7	2.9	3.1	3.8	4.0	5.0	6.2	6.9	8.0	7.5	9.5
Metal Industry) Miscellaneous)	15.9	16.1	17.2	14.3	13.7	13.5	18.2	19.7	16.8	16.7	16.4
Total Apparent Cons	136.6	146.5	159.0	179.3	160.0	171.5	224.6	250.1	276.8	328.7	374.9
Exports	6.4	8.0	8.0	8.7	18.0	23.5	27.4	30.9	46.2	53.3	45.1
Total	143.0	154.5	167.0	188.0	178.0	195.0	252.0	281.0	323.0	382.0	420.0

Table 5.3.5

Consumption of Aluminium by End Uses

X1000 Metric Tons

MP

Netherlands	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Transportation	2.5	3.0	3.0	4.0	5.5	5.5	5.0	5.0	5.0	6.5
Mech Eng	2.6	3.5	4.0	4.5	6.0	6.5	4.5	4.5	5.0	6.5
Elec Eng	3.0	3.5	3.0	4.5	6.0	6.5	4.5	4.5	7.0	8.5
Build and Const	5.0	6.2	5.6	7.5	9.5	10.0	11.0	14.5	19.0	22.0
Chem, Food, Ag	0.3	0.3	0.3	0.5	0.7	0.7	0.7	0.5	0.6	1.0
Packaging	5.0	5.9	6.2	7.0	9.0	9.5	9.7	11.5	13.2	16.0
Domestic and Office	6.5	6.5	6.5	7.0	8.0	8.5	8.5	10.0	12.5	14.0
Powder Cons Ind	0.5	0.5	0.5	0.6	0.8	0.85	0.6	0.5	0.7	1.5
Iron and Steel	0.5	0.2	0.2	0.8	1.0	1.1	1.1	1.1	1.2	2.0
Metal Industry) Miscellaneous)	4.1	4.4	3.7	3.6	5.0	5.5	0.6	0.4	0.4	1.5
Total Apparent Cons	30.0	34.0	33.0	40.0	51.5	54.7	46.2	52.5	64.6	79.5
Exports	6.2	7.4	8.1	8.9	10.5	12.6	14.1	15.2	22.7	31.3
Total	36.2	41.4	41.1	48.9	62.0	67.3	60.3	67.7	87.3	110.8

Table 5.3.6

Consumption of Aluminium by End Uses

X1000 Metric Tons

MP

U K	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Transportation		111.37	94.47	96.65	112.56	125.81	121.05	123.25	124.41	135.34	147.40	134.00
Mech Eng		26.65	23.04	23.57	26.62	27.37	26.56	27.28	25.40	30.73	30.73	28.30
Elec Eng		35.27	33.77	34.48	43.13	51.70	59.29	59.67	62.65	64.22	60.49	64.60
Building & Cont		31.53	31.57	27.81	29.22	35.12	36.69	35.06	34.48	36.35	36.68	36.00
Chem Food Ag		5.5	5.52	5.60	7.53	7.99	9.07	8.03	8.70	10.38	12.43	15.30
Packaging		29.24	26.26	24.39	27.35	27.35	29.54	31.15	30.93	36.73	36.24	35.10
Dom & Office App		37.01	33.56	36.73	42.56	42.41	41.46	39.33	39.99	47.68	45.40	43.40
Powder Cons Ind		6.09	5.25	5.19	4.97	5.93	6.92	7.86	6.15	7.62	8.01	10.30
Iron & Steel		16.94	13.08	12.96	12.38	14.65	15.22	15.63	14.01	15.87	19.68	21.70
Metal Ind (add)		14.79	12.00	11.58	9.76	9.07	9.00	7.51	8.11	8.06	7.92	7.50
Misc		37.05	33.65	34.09	36.56	46.15	47.93	48.16	46.94	49.80	57.56	58.80
Total App Cons		351.43	312.17	313.04	349.51	393.54	402.73	402.93	401.78	439.49	462.53	455.00
Exports		47.04	53.53	61.35	55.73	47.12	47.46	50.72	42.39	43 82	42.36	36.60
Total		398.47	365.69	374.40	405.24	440.66	450.19	453.65	44.17	483.31	504.89	491.60

Consumption of Aluminium by End-Uses
x1000 metric tons

Table 5.3.7

HR

Austria	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Transporation		5.94	4.66	3.59	3.04	2.86	2.99	2.69	2.97	3.46	5.23	
Mech Eng		5.93	5.88	0.95	1.08	1.39	2.04	2.65	2.61	3.28	4.49	
Elect Eng		9.46	8.32	6.02	5.9	6.08	5.61	6.40	6.64	6.81	9.69	
Build & Cons		20.49	24.42	2.38	3.25	4.08	5.23	5.83	6.59	6.84	8.78	
Chem Food Ag		1.20	1.32	0.77	0.94	1.15	1.59	1.54	1.90	2.34	2.73	
Packaging		4.21	3.92	7.11	8.35	8.35	6.08	6.46	6.70	7.40	8.45	
Dom & Off		2.45	3.46	1.14	1.54	1.75	1.82	1.63	1.92	2.09	2.67	
Powder Cons Ind		0.91	0.93	2.48	2.04	2.09	1.90	1.72	0.91	0.89	1.55	
Iron & Steel		1.70	2.01	1.87	1.82	2.84	2.80	2.41	2.17	2.49	2.85	
Metal Ind		0.19	9.27	0.71	0.98	0.84	0.77	0.99	1.78	2.74	2.55	
Misc			0.01	6.47	4.39	7.64	5.17	7.85	4.35	7.92	8.12	
Total App Cons		52.48	55.20	33.48	33.34	39.08	36.01	40.17	38.55	46.25	57.12	
Exports		3.79	3.89	12.19	50.34	51.64	54.07	64.10	53.20	56.67	66.54	
Total		56.27	59.09	45.68	83.68	90.71	90.08	104.27	91.75	102.92	123.66	

<u>Consumption of Aluminium by End Uses</u>
x 1000 metric tons

Table 5.3.8

HR

Japan	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Transport					57.57	75.12	86.11	104.71	132.57	177.93	219.79	256.66
Mech Eng					25.76	29.62	26.66	32.42	41.97	49.95	60.32	71.70
Elec Eng					25.85	21.91	44.63	62.14	87.09	103.68	143.34	155.82
Build Const					22.73	35.36	44.96	69.70	103.20	156.88	246.59	297.86
Chem Food Ag					8.15	10.15	8.79	12.99	16.70	18.61	24.73	32.98
Packaging					6.67	7.82	8.79	11.52	12.74	14.53	17.72	20.26
Dom & Off					97.20	95.44	69.47	87.86	99.79	100.64	104.49	102.72
Powder Cons Ind					2.38	2.69	0.89	1.01	1.92	5.10	5.68	5.56
Iron & Steel					10.96	12.41	12.65	20.68	27.11	35.57	41.88	49.51
Metal Ind					14.08	15.76	20.30	33.50	33.49	52.38	71.01	80.54
Misc					22.57	31.13	30.85	46.05	51.06	53.66	63.46	66.84
Total App Cons					292.91	337.56	354.08	481.97	607.63	768.92	998.98	1140.45
Exports					29.71	37.56	27.40	40.52	22.20	37.43	46.45	52.75
Total					322.62	375.12	381.48	522.49	629.83	806.35	1045.43	1193.20

Table 5.3.9
Consumption of Aluminium by End Uses
X 1000 metric tons

KR

USA	1950	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Transport			492.0	598.3	676.8	712.8	848.2	924.0	846.9	947.6	956.2	
Mech Eng			144.0	180.6	201.4	219.5	247.7	278.0	252.2	292.6	295.3	
Elec Eng			253.0	291.2	306.6	362.0	468.6	563.4	552.5	570.6	623.2	
Build Const			534.0	636.4	706.3	777.9	842.2	877.7	846.4	989.7	1037.8	
Chem Food Ag			20.0	16.3	18.2	19.0	24.9	30.4	27.7	28.1	35.8	
Packaging			159.0	171.9	225.0	260.4	297.6	335.7	393.7	465.4	541.4	
Dom & Off			242.0	236.3	247.2	287.6	327.9	340.2	307.5	361.5	386.9	
Powder Cons Ind			23.0	19.5	20.0	20.9	26.8	49.9	105.7	124.3	125.2	
Destructive Uses			84.0	68.5	74.8	86.2	91.6	91.6	87.5	90.7	98.9	
Metal Ind			136.0	45.8	51.3	56.7	63.5	72.1	73.5	78.5	78.5	
Misc				166.1	153.1	185.9	191.6	268.7	266.5	284.6	271.2	
Total App Cons			2087.0	2430.9	2679.7	2988.7	3436.6	3831.7	3760.1	4233.6	4450.1	
Export Semi			148.0	187.7	212.9	264.1	260.2	265.2	297.8	293.3	456.9	
Foil												
Cable												
Powder												
Total			2235.0	2618.6	2892.6	3252.8	3696.8	4096.9	4057.9	4526.9	4907.0	

Table 5.3.10
Consumption of Aluminium by End Uses
X 1000 metric tons

ANNUAL ANALYSIS: Tonnages of Wrought and Cast End-Uses Combined

Application	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1. DEFENCE a) Aircraft (inc. civil aircraft)	14,765	13,632	16,092	14,687	15,185	18,842	18,827	17,690	18.784	20,023
b) Admiralty i) Marine	2,034	2,438	2,360	2,211	2,604	2,782	2,206	2,424	2,647)	2,571
ii) Non-Marine	103	105	196	108	110	81	212	149	204)	
c) Service Vehicles	1,052	1,308	1,305	1,113	1,110	1,193	990	863	1,419	1,230
d) Other	5,190	4,491	5,502	5,155	5,479	5,053	5,002	3,849	5,536	5,456
2. DIRECT EXPORTS	36,167	37,632	37,053	45,209	41,552	40,337	49,683	55,595	48,259	39,997
3. TRANSPORT a) Road (mechanically driven)	104,055	97,343	88,827	92,478	89,809	90,373	78,759	62,464	59,601	72,071
b) Rail	2,429	2,165	3,178	2,678	2,766	3,728	3,067	3,959	4,013	5,045
c) Marine	2,248	2,623	2,927	2,620	2,453	2,114	2,852	3,816	2,409	3,784
d) Freight	4,639									
e) Other	13,752	13,595	7,570	5,417	5,104	4,711	3,872	3,760	3,903	4,896
4. MINING & COLLIERY EQUIPMENT	609	598	623	681	831	863	716	771	989	1,155
5. ELECTRICAL PLANT & EQUIPMENT	57,012	60,854	59,733	56,394	56,256	48,739	40,748	32,406	31,472	32,679
6. BUILDING & CONSTRUCTION	35,836	35,536	33,758	34,371	35,899	34,339	28,596	27,151	30,851	30,805
7. CHEMICAL & FOOD PLANT AND EQUIPMENT	12,229	10,218	8,566	7,906	8,929	7,860	7,407	5,508	5,433	5,416
8. PACKAGING MATERIALS	49,618	46,730	41,553	41,487	39,121	34,761	32,667	31,731	34,096	40,743
9. ENGINEERING & a) Textile Machinery	4,946	4,327	3,576	4,684	4,168	3,962	3,278	2,452	3,037	4,959
INDUSTRIAL b) Machine Tools	2,975	2,057	1,985	2,162	2,583	2,789	2,709	2,671	2,480	2,943
MACHINERY c) Atomic Energy	581	1,402	1,353	834	308	352	534	551	742	652
d) Other	20,832	18,503	17,464	18,490	18,251	18,974	16,013	16,751	15,751	16,523
10. DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	35,017	35,912	29,650	29,498	30,821	32,109	32,294	27,464	24,743	27,980
11. HOLLOWARE	9,664	11,012	9,714	9,217	9,981	9,635	9,599	8,691	8,291	8,443
12. MISCELLANEOUS (End-Uses identified but not classifiable under Grouping 1-11)	8,208	8,351	8,402	7,777	9,327	9,399	10,110	11,991	12,428	15,318
13. UNIDENTIFIED END-USES										
a) Sales to Stockists and Merchants	38,590	32,183	27,439	29,265	28,896	28.362	20,608	18,692	18,134	18,739
b) Other	5,385	4,980	5,775	5, 162	5,368	5,383	4,228	5,378	4,574	7,230
	467,936	448,005	414,601	419,604	416,911	406,741	374,977	346,777	339,522	368,658

(BM) U.K. CONSUMPTION OF ALUMINIUM (1960-69) Table 5.4.1

ANNUAL ANALYSIS: Percentages for Wrought and Cast End-Uses Combined

Application	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
1. DEFENCE a) Aircraft (inc. civil aircraft)	3.16	3.04	3.88	3.50	3.64	4.63	5.02	5.10	5.53	5.43
i) Marine	0.43	0.55	0.57	0.53	0.63	0.68	0.59	0.70	0.78)	
b) Admiralty										0.70
ii) Non-Marine	0.02	0.02	0.05	0.03	0.03	0.02	0.06	0.04	0.06)	
c) Service Vehicles	0.23	0.29	0.32	0.27	0.27	0.29	0.26	0.25	0.42	0.33
d) Other	1.11	1.00	1.33	1.23	1.31	1.24	1.33	1.11	1.63	1.48
2. DIRECT EXPORTS	7.75	8.40	8.94	10.77	9.97	9.92	13.26	16.03	14.21	10.85
3. TRANSPORT a) Road (Mechanically driven)	22.24	21.73	21.42	22.04	21.54	22.22	21.00	18.01	17.55	19.55
b) Rail	0.52	0.48	0.77	0.64	0.66	0.92	0.82	1.14	1.18	1.38
c) Marine	0.48	0.59	0.71	0.62	0.59	0.52	0.76	1.10	0.71	1.03
d) Freight	0.99									
e) Other	2.94	3.03	1.85	1.29	1.23	1.16	1.03	1.08	1.15	1.33
4. MINING & COLLIERY EQUIPMENT	0.13	0.13	0.15	0.16	0.20	0.21	0.19	0.22	0.29	0.31
5. ELECTRICAL PLANT & EQUIPMENT	12.18	13.59	14.41	13.44	13.49	11.98	10.87	9.35	9.27	8.86
6. BUILDING & CONSTRUCTION	7.66	7.93	8.14	8.19	8.61	8.44	7.63	7.83	9.09	8.36
7. CHEMICAL & FOOD PLANT AND EQUIPMENT	2.61	2.28	2 07	1.88	2.14	1.93	1.98	1.59	1.60	1.47
8. PACKAGING MATERIALS	10.60	10.43	10.02	9.89	9.38	8.55	8.71	9.15	10.04	11.05
9. ENGINEERING & INDUSTRIAL MACHINERY a) Textile Machinery	1.06	0.97	0.86	1.12	1.00	0.97	0.87	0.71	0.90	1.34
b) Machine Tools	0.64	0 46	0.48	0.51	0.62	0.69	0.72	0.77	0.73	0.80
c) Atomic Energy	0.12	0.31	0.33	0.20	0.07	0.09	0.14	0.16	0.22	0.13
d) Other	4 45	4 13	4.21	4.41	4.38	4.67	4 27	4 83	4.54	4.48
10. DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	7.48	8.02	7.13	7.03	7.39	7.90	8.61	7.92	7.29	7.59
11. HOLLOWARE	2.07	2.46	2.34	2.20	2.39	2.37	2.56	2.51	2.44	2.29
12. MISCELLANEOUS (End-Uses identified but not classifiable under Grouping 1-11)	1.75	1.87	2.03	1.85	2.24	2.31	2.69	3 46	3.66	4.15
13. UNIDENTIFIED END-USES a) Sales to Stockists and Merchants	8.25	7.18	6.62	6.97	6.93	6.97	5.50	5.39	5.36	5.08
b) Other	1.15	1.11	1.39	1.23	1.29	1 32	1.13	1.55	1.35	1.96
	100.00	100.00	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00

U.K. CONSUMPTION OF ALUMINIUM (1960-69)

Table 5.4.2

(BM)

ANNUAL ANALYSIS: Tonnages of Wrought End-Uses

	Application	1969 Tons	1968 Tons	1967 Tons	1966 Tons	1965 Tons	1964 Tons	1963 Tons	1962 Tons	1961 Tons	1960 Tons
1.	DEFENCE a) Aircraft (inc. civil aircraft)	13,698	12,583	14,819	13,158	13,307	16,839	16,883	15,469	16,389	17,791
	b) Admiralty i) Marine	1,622	1,929	1,867	1,628	2,045	2,226	1,694	1,904	2,055	1,928
	ii) Non-Marine	31	26	82	48	67	41	177	99	144	
	c) Service Vehicles	229	477	388	137	142	212	143	55	333	236
	d) Other	4,519	3,824	4,847	4,434	4,580	4,118	4,214	3,091	4,661	4,536
2.	DIRECT EXPORTS	35,934	37,371	36,768	44,620	41,078	39,961	49,361	55,396	48,026	39,990
3.	TRANSPORT a) Road (mechanically driven)	32,447	33,947	30,524	31,231	29,879	29,075	26,899	20,234	20,546	26,126
	b) Rail	861	685	939	743	919	1,818	1,417	2,248	2,119	2,748
	c) Marine	1,380	1,735	2,126	1,732	1,508	1,243	1,952	2,892	1,486	2,558
	d) Freight Containers	4,456									
	e) Other	13,064	12,919	6,879	4,619	4,338	3,888	3,206	3,049	2,857	4,126
4.	MINING & COLLIERY EQUIPMENT	289	256	271	261	279	207	179	263	391	331
5.	ELECTRICAL PLANT & EQUIPMENT	39,171	43,058	42,807	41,112	38,853	31,807	26,597	18,384	17,577	19,377
6.	BUILDING & CONSTRUCTION	33,530	32,554	31,420	31,996	33,407	31,847	25,606	24,772	28,143	28,011
7.	CHEMICAL & FOOD PLANT AND EQUIPMENT	9,999	8,363	7,177	6,550	7,360	6,052	5,371	4,830	4,638	4,578
8.	PACKAGING MATERIALS	49,581	46,700	41,529	41,464	39,091	34,737	32,593	31,714	34,082	40,735
9.	ENGINEERING & INDUSTRIAL MACHINERY a) Textile Machinery	3,127	2,529	2,127	2,892	2,435	2,037	1,658	1,025	1,627	3,395
	b) Machine Tools	216	160	330	231	186	138	123	96	232	455
	c) Atomic Energy	397	1,212	1,236	389	218	141	290	246	586	436
	d) Other	12,918	11,849	12,079	13,494	12,814	13,186	11,740	12,560	10,964	11,079
10.	DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	16,275	18,540	15,558	16,153	17,091	17,913	19,098	15,466	13,776	15,475
11.	HOLLOWARE	9,132	10,460	9,181	8,648	9,363	9,071	8,959	8,037	7,724	7,955
12.	MISCELLANEOUS (End-Uses identified but not classifiable under Grouping 1 - 11)	4,984	5,144	5,620	4,807	5,863	5,860	5,960	5,459	5,716	7,318
13.	UNIDENTIFIED END-USES a) Sales to Stockists and Merchants	38,566	32,157	27,416	29,234	28,869	28,333	20,594	18,672	18,082	18,727
	b) Other	4,581	4,365	5,086	4,423	4,531	4,756	3,846	5,017	4,163	7,089
		331,007	322,843	301,076	304,004	298,228	285,506	268,560	250,998	246,317	265,000

UK Consumption of Aluminium (1960 - 69)

Table 5.4.3.

HR

ANNUAL ANALYSIS: Tonnages of Cast End-Uses

	Application	1969 Tons	1968 Tons	1967 Tons	1966 Tons	1965 Tons	1964 Tons	1963 Tons	1962 Tons	1961 Tons	1960 Tons
1.	DEFENCE a) Aircraft (inc. civil aircraft)	1,067	1,049	1,273	1,529	1,878	2,003	1,944	2,221	2,395	2,232
	b) Admiralty i) Marine	412	509	493	583	559	556	512	520	592	643
	b) Admiralty ii) Non-Marine	72	79	114	60	43	40	35	50	60	
	c) Service Vehicles	823	831	917	976	968	981	847	808	1,036	994
	d) Other	671	667	655	721	899	935	788	758	875	920
2.	DIRECT EXPORTS	233	261	285	589	474	376	322	199	233	7
3.	TRANSPORT a) Road (mechanically driven	71,608	63,396	58,303	61,247	59,930	61,298	51,860	42,230	39,055	45,945
	b) Rail	1,568	1,480	2,239	1,935	1,847	1,910	1,650	1,711	1,694	2,297
	c) Marine	868	888	801	888	945	871	900	924	923	1,226
	d) Freight Containers	183									
	e) Others	688	676	691	798	766	823	666	711	1,046	770
4.	MINING & COLLIERY EQUIPMENT	320	342	352	420	552	656	537	508	598	824
5.	ELECTRICAL PLANT & EQUIPMENT	17,841	17,806	16,926	15,282	17,403	16,932	14,151	14,022	13,895	13,302
6.	BUILDING & CONSTRUCTION	2,306	2,982	2,338	2,375	2,492	2,492	2,990	2,379	2,708	2,794
7.	CHEMICAL & FOOD PLANT & EQUIPMENT	2,230	1,855	1,389	1,356	1,569	2,808	2,036	678	795	838
8.	PACKAGING MATERIALS	37	30	24	23	30	24	74	17	14	3
9.	ENGINEERING & INDUSTRIAL MACHINERY a) Textile Machinery	1,819	1,798	1,449	1,792	1,733	1,925	1,620	1,427	1,410	1,564
	b) Machine Tools	2,759	1,897	1,655	1,931	2,397	2,651	2,586	2,575	2,248	2,458
	c) Atomic Energy	184	190	117	445	90	211	244	305	156	216
	d) Other	7,914	6,654	5,385	4,996	5,437	5,788	4,273	4,171	4,463	5,444
10.	DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	18,742	17,372	14,092	13,345	13,730	14,196	13,196	11,998	10,967	12,505
11.	HOLLOWARE	532	552	533	569	613	564	640	654	567	488
12.	MISCELLANEOUS (End-Uses identified but not classifiable under Groupings 1 - 11)	3,224	3,207	2,782	2,970	3,464	3,539	4,150	6,532	6,712	8,000
13.	UNIDENTIFIED END-USES a) Sales to Stockists and Merchants	24	26	23	31	27	29	14	20	102	12
	b) Other	804	615	689	739	837	627	382	361	411	141
		136,929	125,162	113,525	115,600	118,683	121,235	106,417	95,779	93,205	103,658

UK Consumption of Aluminium (1960 - 69)

Table 5.4.4

HR

ANNUAL ANALYSIS: Tonnages of Wrought (Drawn/Extruded/Forged products) End-Uses

	Application	1969 Tons	1968 Tons	1967 Tons	1966 Tons	1965 Tons	1964 Tons	1963 Tons	1962 Tons	1961 Tons	1960 Tons
1.	DEFENCE a) Aircraft (inc. civil aircraft)	6,205	5,465	6,826	6,633	6,641	6,814	6,184	6,220	7,936	8,109
	b) Admiralty i) Marine	534	567	553	701	687	574	439	526	472	465
	b) Admiralty ii) Non-Marine	8	14	6	11	18	36	39	19	21	
	c) Service Vehicles	66	366	247	66	70	83	82	23	298	111
	d) Other	3,868	3,321	4,191	3,477	3,606	3,437	3,444	2,486	3,281	2,645
2.	DIRECT EXPORTS	13,641	10,914	11,341	9,745	10,064	6,228	5,381	6,679	5,711	5,921
3.	TRANSPORT a) Road (mechanically driven)	10,527	9,767	9,295	9,201	8,981	8,865	8,092	6,954	7,073	9,157
	b) Rail	573	462	484	445	549	1,012	859	1,286	1,085	1,335
	c) Marine	1,005	1,200	1,077	925	799	652	887	1,342	650	1,403
	d) Freight Containers	2,334									
	e) Other	3,263	4,178	1,208	691	614	505	426	423	338	354
4.	MINING & COLLIERY EQUIPMENT	58	93	67	70	58	37	50	37	168	74
5.	ELECTRICAL PLANT & EQUIPMENT	35,770	39,953	40,302	38,261	36,188	28,462	23,129	15,571	15,028	15,392
6.	BUILDING & CONSTRUCTION	21,694	20,903	17,762	18,154	18,288	17,667	13,426	12,262	13,997	14,333
7.	CHEMICAL & FOOD PLANT AND EQUIPMENT	3,047	2,006	1,862	1,466	1,909	1,341	1,316	1,124	999	940
8.	PACKAGING MATERIALS	468	148	176	170	143	32	60	121	205	95
9.	ENGINEERING & INDUSTRIAL MACHINERY a) Textile Machinery	3,052	2,435	1,855	2,785	2,288	1,914	1,447	845	902	2,585
	b) Machine Tools	168	144	184	208	155	114	112	61	201	409
	c) Atomic Energy	133	294	259	112	128	85	189	92	245	176
	d) Other	6,116	5,543	5,592	6,362	6,014	6,179	5,289	5,500	4,944	5,769
10.	DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	8,497	8,134	7,187	8,029	7,730	7,258	6,716	5,821	4,326	4,703
11.	HOLLOWARE	76	135	86	61	46	70	121	107	39	58
12.	MISCELLANEOUS (End-Uses identified but not classifiable under Groupings 1 - 11)	2,223	2,646	2,485	1,856	2,632	2,701	3,032	2,531	2,569	2,468
13.	UNIDENTIFIED END-USES a) Sales to Stockists and Merchants	13,430	12,622	10,406	10,605	9,175	8,388	6,052	5,168	5,191	4,980
	b) Other	2,330	2,240	1,709	1,894	1,687	1,739	1,787	2,025	1,607	1,576
		139,086	133,550	125,160	121,928	118,470	104,193	88,559	77,223	77,286	83,058

UK Consumption of Aluminium 1960 - 69

Table 5,4,5

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ANNUAL ANALYSIS: Percentages for Wrought End-Uses

	Application	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
1.	DEFENCE a) Aircraft (inc. civil aircraft)	4.14	3.90	4.92	4.33	4.46	5.90	6.25	6.16	6.65	6.71
	b) Admiralty i) Marine	0.49	0.60	0.62	0.54	0.69	0.78	0.64	0.76	0.83	0.72
	b) Admiralty ii) Non-Marine	0.01	0.01	0.03	0.02	0.02	0.01	0.06	0.04	0.06	
	c) Service Vehicles	0.07	0.15	0.13	0.05	0.05	0.07	0.05	0.02	0.14	0.09
	d) Other	1.36	1.18	1.61	1.46	1.54	1.44	1.61	1.23	1.89	1.71
2.	DIRECT EXPORTS	10.86	11.57	12.21	14.68	13.77	14.00	18.38	22.07	19.50	15.09
3.	TRANSPORT a) Road (mechanically driven)	9.80	10.52	10.14	10.27	10.02	10.18	10.02	8.06	8.34	9.86
	b) Rail	0.26	0.21	0.31	0.24	0.31	0.64	0.53	0.90	0.86	1.04
	c) Marine	0.42	0.54	0.71	0.57	0.50	0.44	0.73	1.15	0.60	0.97
	d) Freight Containers	1.35									
	e) Other	3.95	4.00	2.28	1.52	1.45	1.36	1.19	1.21	1.16	1.56
4.	MINING & COLLIERY EQUIPMENT	0.09	0.08	0.09	0.09	0.09	0.07	0.07	0.11	0.16	0.13
5.	ELECTRICAL PLANT & EQUIPMENT	11.83	13.34	14.22	13.52	13.03	11.14	9.90	7.32	7.14	7.31
6.	BUILDING & CONSTRUCTION	10.13	10.08	10.44	10.52	11.20	11.16	9.53	9.87	11.43	10.57
7.	CHEMICAL & FOOD PLANT AND EQUIPMENT	3.02	2.59	2.38	2.15	2.47	2.12	2.00	1.92	1.88	1.73
8.	PACKAGING MATERIALS	14.98	14.47	13.79	13.64	13.11	12.17	12.14	12.64	13.84	15.37
9.	ENGINEERING & INDUSTRIAL MACHINERY a) Textile Machinery	0.94	0.78	0.71	0.95	0.82	0.71	0.62	0.41	0.66	1.28
	b) Machine Tools	0.06	0.05	0.11	0.08	0.06	0.05	0.04	0.04	0.09	0.17
	c) Atomic Energy	0.12	0.38	0.41	0.13	0.07	0.05	0.11	0.10	0.24	0.16
	d) Other	3.90	3.67	4.01	4.44	4.30	4.62	4.37	5.01	4.45	4.18
10.	DOMESTIC, OFFICE AND MEDICAL (other than Holloware)	4.92	5.74	5.17	5.31	5.73	6.27	7.11	6.16	5.59	5.84
11.	HOLLOWARE	2.76	3.24	3.05	2.84	3.14	3.18	3.33	3.20	3.14	3.00
12.	MISCELLANEOUS (End-Uses identified but not classifiable under Groupings 1 - 11)	1.51	1.59	1.86	1.58	1.97	2.05	2.22	2.18	2.32	2.76
13.	UNIDENTIFIED END-USES a) Sales to Stockists and Merchants	11.65	9.96	9.11	9.62	9.68	9.92	7.67	7.44	7.34	7.07
	b) Other	1.38	1.35	1.69	1.45	1.52	1.67	1.43	2.00	1.69	2.68
		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

UK Consumption of Aluminium (1960 - 69)

Table 5.4.6

HR

ANNUAL ANALYSIS: Percentages for Cast End-Uses

Application		1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
1	DEFENCE (a) Aircraft (incl civil aircraft)	0.78	0.84	1.12	1.32	1.58	1.65	1.83	2.32	2.56	2.15
	(b) Admiralty (i) Marine	0.30	0.41	0.43	0.51	0.47	0.46	0.48	0.54	0.64	0.62
	(ii) Non-Marine	0.05	0.06	0.10	0.05	0.04	0.03	0.03	0.05	0.06	
	(c) Service Vehicles	0.60	0.66	0.81	0.84	0.82	0.81	0.80	0.84	1.17	0.96
	(d) Other	0.49	0.53	0.58	0.62	0.76	0.77	0.74	0.79	0.94	0.89
2	DIRECT EXPORTS	0.17	0.21	0.25	0.51	0.40	0.31	0.30	0.21	0.25	0.01
3	TRANSPORT (a) Road (mechanically driven)	52.30	50.65	51.36	52.98	50.50	50.56	48.73	44.09	41.90	44.32
	(b) Rail	1.15	1.18	1.97	1.67	1.56	1.58	1.55	1.79	2.03	2.22
	(c) Marine	0.63	0.71	0.71	0.77	0.80	0.72	0.85	0.97	0.99	1.18
	(d) Freight Containers	0.13									
	(e) Other	0.50	0.54	0.61	0.69	0.64	0.68	0.63	0.74	1.12	0.74
4	MINING AND COLLIERY EQUIPMENT	0.23	0.27	0.31	0.36	0.46	0.54	0.50	0.53	0.64	0.79
5	ELECTRICAL PLANT AND EQUIPMENT	13.03	14.23	14.91	13.22	14.66	13.96	13.30	14.64	14.91	12.83
6	BUILDING AND CONSTRUCTION	1.68	2.38	2.06	2.06	2.10	2.06	2.81	2.48	2.91	2.70
7	CHEMICAL AND FOOD PLANT AND EQUIPMENT	1.63	1.48	1.22	1.17	1.32	1.49	1.91	0.71	0.85	0.81
8	PACKAGING MATERIALS	0.03	0.03	0.02	0.02	0.02	0.02	0.07	0.02	0.02	0.01
9	ENGINEERING AND INDUSTRIAL MACHINERY (a) Textile Machinery	1.33	1.44	1.28	1.55	1.46	1.59	1.52	1.49	1.51	1.51
	(b) Machine Tools	2.02	1.52	1.46	1.68	2.02	2.19	2.43	2.59	2.41	2.40
	(c) Atomic Energy	0.13	0.15	0.10	0.39	0.08	0.17	0.23	0.32	0.17	0.21
	(d) Other	5.78	5.32	4.74	4.32	4.58	4.77	4.02	4.35	4.79	5.25
10	DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	13.69	13.88	12.41	11.54	11.57	11.71	12.40	12.53	11.77	12.06
11	HOLLOWARE	0.39	0.44	0.47	0.49	0.52	0.47	0.60	0.68	0.61	0.47
12	MISCELLANEOUS (End-Uses identified but not classifiable under Groupings 1-11)	2.35	2.56	2.45	2.57	2.92	2.92	3.90	6.82	7.20	7.72
13	UNIDENTIFIED END-USES (a) Sales to Stockists and Merchants	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.02	0.11	0.01
	(b) Other	0.59	0.49	0.61	0.64	0.70	0.52	0.36	0.38	0.44	0.14
		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 5.4.7
UK Consumption of Aluminium 1960-69

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ANNUAL ANALYSIS: Percentage for Wrought (Drawn-Extruded-Forged Products) End-Uses

Application		1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
1	DEFENCE (a) Aircraft (incl civil aircraft)	4.46	4.09	5.45	5.44	5.61	6.54	6.98	8.05	10.27	9.76
	(b) Admiralty (i) Marine	0.38	0.43	0.44	0.57	0.58	0.55	0.50	0.68	0.61	0.56
	(ii) Non-Marine	0.01	0.01	-	0.01	0.02	0.03	0.04	0.02	0.03	
	(c) Service Vehicles	0.05	0.27	0.20	0.05	0.06	0.08	0.09	0.03	0.39	0.13
	(d) Other	2.78	2.49	3.35	2.85	3.04	3.30	3.89	3.22	4.25	3.18
2	DIRECT EXPORTS	9.81	8.17	9.06	7.99	8.50	5.98	6.08	8.65	7.39	7.13
3	TRANSPORT (a) Road (mechanically driven)	7.57	7.31	7.43	7.55	7.58	8.50	9.14	9.00	9.15	11.03
	(b) Rail	0.41	0.35	0.39	0.37	0.46	0.97	0.97	1.67	1.40	1.61
	(c) Marine	0.72	0.90	0.86	0.76	0.67	0.63	1.00	1.74	0.84	1.69
	(d) Freight Containers	1.68									
	(e) Other	2.35	3.13	0.97	0.57	0.52	0.48	0.48	0.55	0.44	0.43
4	MINING AND COLLIERY EQUIPMENT	0.04	0.07	0.05	0.06	0.05	0.03	0.06	0.05	0.22	0.09
5	ELECTRICAL PLANT AND EQUIPMENT	25.72	29.92	32.20	31.38	30.55	27.32	26.12	20.16	19.44	18.53
6	BUILDING AND CONSTRUCTION	15.60	15.65	14.19	14.89	15.44	16.96	15.16	15.88	18.11	17.26
7	CHEMICAL AND FOOD PLANT AND EQUIPMENT	2.19	1.50	1.49	1.20	1.61	1.29	1.49	1.46	1.29	1.13
8	PACKAGING MATERIALS	0.34	0.11	0.14	0.14	0.12	0.03	0.07	0.16	0.26	0.11
9	ENGINEERING AND INDUSTRIAL MACHINERY (a) Textile Machinery	2.19	1.82	1.48	2.28	1.93	1.84	1.63	1.09	1.16	3.11
	(b) Machine Tools	0.12	0.11	0.15	0.17	0.13	0.11	0,13	0.08	0.26	0,49
	(c) Atomic Energy	0.09	0.22	0.21	0.09	0.11	0.08	0.21	0.12	0.32	0.21
	(d) Other	4.40	4.15	4.47	5.22	5.08	5.93	5.97	7.12	6.40	6.95
10	DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	6.11	6.09	5.74	6.59	6.52	6.97	7.58	7.54	5.60	5.66
11	HOLLOWARE	0.05	0.10	0.07	0.05	0.04	0.07	0.14	0.14	0.05	0.07
12	MISCELLANEOUS (End-Uses identified but not classifiable under Groupings 1-11)	1.60	1.98	1.99	1.52	2.22	2.59	3.42	3.28	3.32	2.97
13	UNIDENTIFIED END-USES (a) Sales to Stockist and Merchants	9.66	9.45	8.31	8.70	7.74	8.05	6.83	6.69	6.72	6.00
	(b) Other	1.67	1.68	1.36	1.55	1.42	1.67	2.02	2.62	2.08	1.90
		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Table 5.4.8
UK Consumption of Aluminium 1960-69

FR

ANNUAL ANALYSIS: Percentage for Wrought (Rolled Products) End-Uses

Application		1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
1	DEFENCE (a) Aircraft (incl civil aircraft)	3.90	3.76	4.54	3.58	3.71	5.53	5.94	5.32	5.00	5.32
	(b) Admiralty (i) Marine	0.57	0.72	0.75	0.51	0.75	0.91	0.70	0.79	0.94	0.80
	(ii) Non-Marine	0.01	0.01	0.04	0.02	0.03	-	0.08	0.05	0.07	
	(c) Service Vehicles	0.08	0.06	0.08	0.04	0.04	0.07	0.03	0.02	0.02	0.07
	(d) Other	0.34	0.26	0.37	0.53	0.54	0.38	0.43	0.35	0.82	1.04
2	DIRECT EXPORTS	11.62	13.98	14.45	19.15	17.25	18.61	24.43	28.04	25.03	18.73
3	TRANSPORT (a) Road (mechanically driven)	11.42	12.77	12.07	12.10	11.63	11.15	10.44	7.64	7.97	9.33
	(b) Rail	0.15	0.12	0.26	0.16	0.21	0.44	0.31	0.55	0.61	0.78
	(c) Marine	0.20	0.28	0.60	0.44	0.39	0.33	0.59	0.89	0.50	0.63
	(d) Freight Containers	1.11									
	(e) Other	5.11	4.62	3.22	2.16	2.07	1.87	1.55	1.51	1.49	2.07
4	MINING AND COLLIERY EQUIPMENT	0.12	0.08	0.12	0.11	0.12	0.09	0.07	0.13	0.13	0.14
5	ELECTRICAL PLANT AND EQUIPMENT	1.77	1.64	1.42	1.57	1.48	1.85	1.93	1.62	1.51	2.19
6	BUILDING AND CONSTRUCTION	6.17	6.15	7.76	7.60	8.41	7.82	6.77	7.20	8.37	7.52
7	CHEMICAL AND FOOD PLANT AND EQUIPMENT	3.62	3.36	3.02	2.79	3.03	2.60	2.25	2.13	2.15	2.00
8	PACKAGING MATERIALS	25.59	24.59	23.51	22.68	21.67	19.14	18.07	18.18	20.04	22.33
9	ENGINEERING AND INDUSTRIAL MACHINERY (a) Textile Machinery	0.04	0.05	0.16	0.06	0.08	0.07	0.12	0.10	0.43	0.44
	(b) Machine Tools	0.02	0.01	0.08	0.01	0.02	0.01	0.01	0.02	0.02	0.03
	(c) Atomic Energy	0.14	0.48	0.55	0.15	0.05	0.03	0.06	0.09	0.20	0.14
	(d) Other	3.54	3.33	3.69	3.92	3.78	3.86	3.58	4.08	3.56	2.92
10	DOMESTIC, OFFICE AND MEDICAL EQUIPMENT (other than Holloware)	4.05	5.50	4.76	4.46	5.21	5.88	6.88	5.55	5.59	5.92
11	HOLLOWARE	4.72	5.45	5.17	4.72	5.19	4.96	4.91	4.56	4.55	4.34
12	MISCELLANEOUS (End-Uses identified but not classifiable under Groupings 1-11)	1.44	1.33	1.78	1.62	1.80	1.74	1.63	1.69	1.86	2.67
13	UNIDENTIFIED END-USES (a) Sales to Stockists and Merchants	13.10	10.33	9.67	10.23	10.96	11.00	8.08	7.77	7.63	7.56
	(b) Other	1.17	1.12	1.92	1.39	1.58	1.66	1.14	1.72	1.51	3.03
		100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Table 5.4.9
UK Consumption of Aluminium 1960-1969

KR

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Germany	800	828	993	1080	1375	1485	1640	1820	2350	2930
Belg-Lux	79.5	97.8	138	151.0	217	243	252	248	268	305
France	331	na	455	518	605	678	835	935	1070	1360
Italy	248	336	417	515	563	615	765	930	1020	1250
Netherlands	104.5	94.2	123	126.5	178	203.0	207.0	280 .0	341	313
U.K.	493	508	540	617	750	815	850	955	1065	1200
Norway	33.2	36.1	42.6	48.3	58.3	71.2	67.8	84.0	1025	121
Austria	60.5	78.0	82.8	91.0	111.0	121	138	153	188	228
Sweden	82.5	90.0	109.0	131.5	160	191.5	207	249	327	373
Japan	na	700	na	1015	1315	1385	1680	2340	2930	3360
U.S.A.	1940	2870	2930	3620	4000	4800	5620	5680	6680	7870

Dervived from The Chemical Industry OECD Reports (in which kg per cap are quoted)

ESTIMATED CONSUMPTION OF PLASTIC MATERIALS

x 1000 Metric Tons. (Production + Imports - Exports).

TABLE 5.5.1

(BM)

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR	516.2	561.9	500.6	493.5	561.1	536.3	458.7	501.2	608.8	655.7	697.5
Belg-Lux	92.0	95.0	90.0	85.0	100.0	115.0	117.0	98.0	120.0	112.2	109.5
France	236.8	243.6	243.7	250.3	291.7	287.3	291.3	271.3	292.9	334.8	330.7
Italy	185.0	202.0	214.0	228.0	202.0	192.0	195.0	222.0	226.0	238.0	274.0
Netherlands	31.7	30.1	21.6	25.6	32.3	32.4	26.9	29.4	34.3	38.4	39.1
U.K.	560.3	528.8	526.1	558.0	632.9	650.1	592.5	514.3	539.2	546.8	546.5
Norway	8.0	9.0	11.0	6.1	8.0	10.2	15.0	13.5	13.8	15.0	13.0
Austria	28.1	33.0	30.0	30.5	33.0	30.7	26.7	27.7	31.3	34.7	42.6
Sweden	92.1	93.2	91.0	96.0	96.6	95.3	83.6	85.7	85.0	88.2	82.5
Europe	1930.9	2003.5	1928.8	1970.9	2172.9	2166.9	2025.6	1985.3	2183.8	2328.4	2406.3
Japan	304.0	372.9	301.0	352.1	475.5	427.5	482.5	616.0	695.2	806.9	820.6
U.S.A.	1224.8	1327.1	1451.2	1582.4	1655.9	1818.6	2140.9	1755.9	1705.8	1943.4	1842.1
Canada	106.7	128.6	137.5	159.9	189.6	209.0	247.7	205.1	232.2	221.7	229.0
Western Countries	3844.2	4117.3	4130.8	4397.3	4863.9	5012.8	5233.9	4865.3	5179.1	5697.2	5700.4
Total World	4755.8	5069.1	5155.9	5438.3	5918.9	6127.4	6411.2	6112.7	6469.2	7050.2	7180.4

CONSUMPTION OF REFINED COPPER

X1000 Metric tons

Table 5.5.2

(BM)

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR	296.7	306.0	291.0	280.4	320.5	330.0	310.2	302.7	361.5	398.4	395.7
Belg-Lux	105.9	115.9	122.4	124.0	132.9	124.8	112.3	119.3	122.4	151.5	136.8
France	172.1	188.7	185.8	180.8	203.6	185.7	197.1	202.5	202.3	239.0	220.2
Italy	85.0	90.0	106.0	110.0	108.0	116.0	125.0	141.0	155.0	167.0	178.0
Netherlands	26.0	30.6	31.1	31.5	31.7	30.9	32.7	30.3	38.4	34.3	37.2
UK	275.9	258.7	246.3	265.2	291.9	282.1	272.6	258.5	280.7	288.9	277.8
Norway	14.0	15.0	12.0	14.8	17.0	19.0	20.0	18.0	20.0	23.0	24.0
Austria	12.7	14.0	14.4	14.7	17.1	16.8	17.6	13.0	17.5	19.4	22.7
Sweden	30.8	27.1	28.9	27.8	28.4	34.0	31.2	30.3	35.6	38.1	36.0
Japan	189.3	234.3	242.8	304.7	364.3	329.5	388.7	461.8	522.7	599.9	635.3
USA	790.4	838.0	929.3	996.2	1088.5	1221.3	1272.6	1116.9	1205.1	1241.3	1054.4
Western Countries	2441.1	2579.2	2708.5	2909.0	3213.4	3301.2	3413.0	3390.4	3717.6	4007.3	3863.8
Total World	3072.1	3237.1	3384.8	3627.5	3937.5	4053.9	4234.3	4271.8	4652.2	4989.4	4903.5

Consumption of Zinc

X1000 metric tons

Table 5.5.3

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany	14.5	14.0	13.1	12.5	13.7	13.0	12.1	11.8	12.3	14.4	15.1
Belg-Lux	2.8	2.5	3.2	3.5	3.4	2.5	2.7	2.5	2.8	3.3	3.1
France	11.4	10.2	11.4	11.2	11.2	10.3	10.5	10.2	9.5	10.7	10.5
Italy	5.1	5.5	5.5	6.0	5.7	6.4	6.0	5.7	6.6	6.8	7.2
Netherlands	3.2	3.5	3.8	4.0	3.5	3.4	3.1	4.5	4.2	4.9	5.5
UK	23.2	22.0	22.8	22.1	21.4	21.0	20.0	19.5	19.5	19.7	18.6
Norway	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5
Austria	0.9	0.7	0.7	0.8	0.6	0.6	0.6	0.5	0.5	0.6	0.6
Sweden	0.8	0.7	0.7	0.6	0.7	0.9	0.7	0.6	0.6	0.4	0.4
Japan	14.6	15.1	14.0	16.1	18.2	17.0	19.1	21.1	23.1	26.0	25.3
USA	52.4	51.1	55.5	56.1	59.5	59.5	61.2	58.8	59.8	58.7	53.9
Western Countries	159.7	158.8	163.3	166.9	172.3	169.5	171.0	168.0	171.6	180.2	175.1
Total World	200.8	201.5	213.1	218.2	223.7	223.4	224.9	222.6	230.8	239.9	234.7

Consumption of Tin

X1000 metric tons

Table 5.5.4

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Germany FR	239.5	236.1	243.9	245.7	259.7	272.9	258.0	259.4	288.2	314.7	308.9
Belg-Lux	55.2	52.6	52.2	47.6	50.3	50.5	48.6	53.6	62.1	70.5	62.7
France	161.4	160.7	156.3	170.1	172.1	144.6	168.6	164.2	179.3	198.5	192.5
Italy	78.0	86.0	91.0	92.0	89.0	92.0	105.0	123.0	133.0	146.0	168.0
Netherlands	51.0	54.6	51.1	45.6	50.4	53.0	51.0	50.9	53.7	49.3	49.4
UK	286.5	275.7	276.3	283.5	307.8	312.1	293.4	276.3	276.8	275.3	261.7
Norway	9.0	10.0	11.0	11.5	10.0	10.0	13.0	13.6	12.0	12.0	12.5
Austria	21.1	18.9	21.4	20.1	20.6	21.4	20.6	21.0	24.4	23.9	30.4
Sweden	43.8	44.2	49.1	51.2	54.9	52.5	55.4	52.9	55.7	54.9	48.8
Japan	99.6	125.7	117.7	130.3	164.2	147.3	147.9	163.3	180.7	192.2	210.5
USA	646.6	640.8	689.6	718.3	727.9	735.5	821.8	770.2	817.7	842.0	826.0
Western Countries	2046.9	2113.2	2185.2	2312.8	2405.9	2440.5	2549.0	2511.3	2681.8	2819.2	2813.7
Total World	2633.4	2706.3	2810.2	2944.9	3112.6	3178.7	3349.2	3331.5	3597.0	3789.8	3805.5

Consumption of Refined Lead

Table 5.5.5

HR

Country	Product	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Netherlands	HS	211	197	223	229	260	267	307	305	331	381
	LS	690	707	675	719	854	789	792	847	876	909
	WR	203	196	177	169	194	178	189	188	247	241
	HRS	155	153	161	170	241	213	214	206	230	268
	U&P	653	541	501	448	540	551	575	543	603	732
	Sheets L3 mm	453	573	590	686	844	862	971	872	1038	1211
	T BP	185	155	207	190	203	177	219	222	254	256
		2550	2522	2534	2611	3156	3037	3268	3182	3599	3998
UK	HS	2450	2242	1876	2026	2488	2555	2184	2203	2207	2414
	LS	3252	2866	2612	2693	3342	3324	2891	2819	2846	3070
	WR	1572	1352	1356	1474	1701	1732	1615	1667	1878	1943
	HRS	1716	1408	1413	1572	1820	1783	1651	1532	1753	1863
	U&P	2510	2440	1960	2393	2916	2309	2777	2577	3036	3485
	Sheets L3 mm	3197	2296	2713	3063	3666	3319	3218	3120	3603	3846
	T BP	720	651	704	775	810	812	851	864	927	1010
		15417	13255	12634	13996	16743	16334	15187	14782	16250	17631
Austria	HS	63	51	51	47	62	80	81	63	70	72
	LS	353	415	373	272	313	401	389	322	385	421
	WR	153	160	149	159	195	201	199	195	225	238
	HRS	95	104	55	65	95	91	80	89	101	119
	U&P	209	224	184	200	220	245	263	225	266	341
	Sheets L3 mm	191	183	167	172	216	212	242	216	259	313
	T BP	12	12	17	16	18	14	19	19	23	24
		1075	1149	996	931	1119	1244	1273	1129	1329	1528
Japan	HS	65	63	1233	1239	1713	1773	2342	3356	3862	5091
	LS	5206	7034	5619	5940	6888	7015	7683	9694	10589	11664
	WR	1335	1548	1568	1879	2121	2300	2517	3525	3746	4346
	HRS	835	1085	1127	1161	1363	1078	1141	3425	3664	4015
	U&P	3229	4243	3519	3573	4481	4854	5988	8815	8130	10118
	Sheets L3 mm	5997	5278	5347	6912	9659	8869	11468	14057	14891	18974
	T BP	377	427	379	484	437	527	595	649	621	740
		14979	19615	18792	21188	26662	26416	31734	43521	45503	54948
US	HS	4897	4373	4508	5238	6075	5977	6928	6492	7000	NA
	LS	10800	10440	10915	11908	13356	15185	15066	14457	15809	
	WR	4230	4411	4593	4902	5253	5757	5843	5313	6077	
	HRS	4338	4387	4159	4089	4643	4874	5039	4464	4674	
	U&P	6867	6208	6502	7546	9240	10933	10792	10055	11090	
	Sheets L3 mm	26297	25456	27376	30859	34651	38218	39230	37009	42852	
	T BP	10995	10797	10328	9550	10748	1062	10607	11286	12064	
		68424	66072	68381	73312	83966	82006	93505	89076	99566	

Table 5.5.6
Apparent Home Consumption of Steel Products (X1000 tons)

EMH
7.4.75.

Country	Product	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Germany	Heavy Sect	1562	1707	1616	1570	1874	1880	1716	1566	1822	2252
	Light Sect	5235	4993	4611	4372	5413	5024	4766	4133	5278	6399
	Wire Rods	2201	2094	2099	2251	2780	2868	2814	2846	3212	3501
	HR Strip	2504	2274	2502	2434	3079	3024	3369	3890	4764	5099
	Univ & Plates	3408	3307	3476	3027	3919	3658	3449	3296	4598	5269
	Sheets L3 mm	3573	3290	3582	4018	4660	4547	4533	4182	5398	6084
	T&BP	502	476	575	556	570	535	580	577	608	655
		19085	18141	18761	18228	22295	21535	21227	20490	25680	29259
Belg - Lux	HS	181	217	237	221	257	229	231	214	249	315
	LS	593	707	680	677	673	674	699	717	710	1045
	WR	658	669	695	710	816	811	843	866	935	952
	HRS	335	332	360	374	437	410	429	427	452	547
	U&P	298	388	402	377	432	393	443	400	408	578
	Sheets L3 mm	287	284	276	327	387	366	508	502	600	758
	T&BP	61	62	73	77	82	59	69	81	81	99
		2413	2659	2723	2763	3084	2942	3222	3207	3435	4294
France	HS	705	803	892	784	921	938	979	1038	1015	1262
	LS	2252	2326	2498	2427	2893	2793	2776	2941	2881	3332
	WR	1022	963	892	973	1048	1022	1034	1083	1054	1304
	HRS	966	938	952	1000	1136	1045	1111	1017	1037	1263
	U&P	1504	1814	1649	1707	2049	1951	2088	2411	2479	3233
	Sheets L3 mm	2038	1956	2173	2442	2607	2419	2836	2831	3005	3994
	T&BP	302	289	312	359	357	341	389	407	409	421
		8789	9089	9368	9692	11011	10509	11213	11728	11880	14809
Italy	HS										
	LS	2163	2632	3086	3410	3026	2926	3251	4011	4451	4696
	WR	489	512	513	556	487	475	502	553	546	607
	HRS	430	484	538	632	583	727	769	765	850	946
	U&P	842	1072	1486	1283	1100	1100	1397	1569	1586	1826
	Sheets L3 mm	1249	1283	1602	2056	1784	1865	2109	2425	2496	2975
	T&BP	188	242	239	307	251	310	319	340	338	405
		5361	6225	7464	8244	7231	7403	8347	9663	10267	11455

Table 5.5.6.

Apparent Home Consumption of Certain Steel Products (X1000 tons)

EMH
8.4.75.

Industry	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Coal Mining	608.0	549.9	459.0	489.4	509.4	477.4	477.8	480.8	465.3	443.3
Iron & Steel	763.1	665.5	549.1	557.5	735.1	901.8	1069.3	1141.1	1387.6	1488.3
Misc Machinery	681.3	670.9	592.3	684.3	777.1	785.0	754.4	722.9	734.2	818.2
Industrial Plant and Steelwork	1806.8	1783.9	1446.9	1611.3	1904.9	1993.3	1935.5	1823.8	1773.0	1760.9
Electrical Machinery	387.8	334.6	335.8	391.8	400.2	396.6	381.7	342.9	349.8	343.2
Shipbuilding	708.6	742.0	640.0	580.4	774.9	669.8	656.4	584.6	596.8	670.6
Motors	2476.7	1567.1	1857.5	2190.2	2368.2	2375.8	2277.2 x	2002.3 x	2202.3	2343.9
Bolts, Nuts, Wire, Wire Man'f	1577.2	1353.6	1288.5	1411.2	1561.6	1553	1426	1344	1440.5	1475.7
Drop Forgings	659.2	576.2	538.1	635.5	764.6	799.2	762.2	709.9	754.1	863.4
Cans and Boxes	565.0	520.0	589.7	642.6	657.2	710.0	756.8	749.9	810.7	866.7
Construction	954.3	942.9	869.1	923.7	1063.7	1089.4	937.9	934.6	989.2	1004.3
Transport	537.2	618.4	313.6	379.5	332.3	381.2	319.6	290.1	291.4	318.6
Total Consumers	15,788	13,876	12,839	14,323	16,190	16,628	16,206	15,591	16,571	17,491

x Not strictly comparable with previous years

Table 5.5.7.

UK Steel Consumption in Selected Economic Sectors (X1000 tons)

EMH
8.4.75.

6. Results

Country	Regression Equation $\log y = \log a + n \log x$	r^2	Regressed GDP x 1000 Mill US $ 1960	1969	Growth Rate per Annum %
Germany	$\log y = 1.9331 + 0.0186.\ n$	0.977	85.72	126.2	4.3
Belg-Lux	$\log y = 1.862 + 0.0189.\ n$	0.989	12.2	18.04	4.4
France	$\log y = 1.8509 + 0.0234.\ n$	0.995	70.94	115.2	5.5.
Italy	$\log y = 1.6238 + 0.0222\ n$	0.989	42.06	66.67	5.2
Netherlands	$\log y = 1.1080 + 0.0221\ n$	0.991	12.82	20.28	5.2
U.K.	$\log y = 1.8937 + 0.0124.n$	0.987	78.29	101.3	2.9
Norway	$\log y = 0.7001 + 0.0224\ n$	0.921	5.01	7.97	5.3
Austria	$\log y = 0.8279 + 0.0218\ n$	0.975	6.73	10.56	5.2
Sweden	$\log y = 1.1475 + 0.0156\ n$	0.784	14.05	20.89	3.6
Japan	$\log y = 1.7284 + 0.0440\ n$	0.984	53.51	133.2	10.7
U.S.A.	$\log y = 2\ 7172 + 0.0209\ n$	0.993	521.4	803.5	4.9

$y = a\ (1 + r)^n$

$\log y. = bga + n \log\ (1 + r)$

where y = GDP after period n years

a = GDP at the beginning of the period

r = compound rate of growth in consumption

$x = (1 + r)$

<u>Time Series Logarithmic Regression (1960-1969 Inclusive)</u>

<u>GDP x 1000million US $ at Constant Market Prices 1963</u>

<u>Table 6.1.1</u>.

(BM)

Country	Value of Manufacturing and Construction x1000 Million US $		% Growth per Annum
	1960	1969	
Germany	40.7	61.3	4.7
Belg-Lux	4.35	7.0	5.4
France	29.7	53.8	6.8
Italy	14.0	24.3	6.3
Netherlands	na	na	na
U.K.	32.1	43.2	3.4
Norway	1.72	2.71	5.2
Austria	3.26	5.1	5.1
Sweden	4.95	8.22	5.8
Japan	18.6	49.5	11.5
U.S.A.	170	269	5.2

Date Source, OECD National Accounts Statistics

<u>Time Series Logarithmic Regressed Values of Manufacturing and Construction</u>

(x 1000 million US $ at constant market prices 1963)
Table 6.1.2.

(BM)

Country	Value of Transport Equipment x 1000 Million US $		% Growth per Annum
	1960	1969	
Germany	2.73	3.93	4.1
Belg-Lux	0.24	0.41	6.1
France	2.03	3.33	5.6
Italy	0.9	1.59	6.5
Netherlands	na	na	na
U.K.	3.45	4.26	2.3
Japan	1.24	4.45	15.3
U.S.A.	17.4	30.2	6.3

TIME SERIES LOGARITHMIC REGRESSED VALUES OF TRANSPORT EQUIPMENT

(x 1000 million US $ at constant market prices 1963)

Table 6.1.3.

(BM)

Country	Value of Electrical M/C, Apparatus and Appliances x 1000 million US $		% Growth per Annum
	1960	1967	
Germany	4.3	5.05	2.3
Belg-Lux	0.32	0.49	6.3
France	2.1	2.94	4.9
Italy	1.16	1.30	1.6
Netherlands	0.73	0.97	4.1
U.K.	3.48	4.93	5.1
Japan (1)	5.5	8.8	9.8
U.S.A. (2) (3)	24.7	38.3	7.6

(1) 1963 not 1960
(2) 1961 not 1960
(3) 1966 not 1967

DATA SOURCE, OECD Engineering Series Statistics.

Estimated Values of Electrical Machinery, Apparatus and Appliances.

x 1000 Million US $ at constant market prices

Table 6.1.4

(BM)

Country	Value of Building and Construction x 1000 million US $ 1960	1969	% Growth per Annum
Germany	6.4	9.1	4.0
Belg - Lux	0.83	1.1	3.1
France	5.68	11.1	7.7
Italy	3.27	4.6	3.9
Netherlands	NA	NA	NA
U K	5.0	6.88	3.6
Japan	2.95	9.85	14.3
U S A	26.1	30.6	1.7

Data Source OECD National Accounts Statistics

Table 6.1.5
Time Series Logarithmic Regression Values of Building and Construction
(x 1000 million US $ at constant market prices 1963)

KR

Country	Regression Equation logy = loga + n log	r^2	Regressed Consumption x 1000 metric tons per annum 1960	1969	Growth Rate %
Germany	logy = 2.5455 + 0.0332 n	0.881	351.2	698.4	7.9
Belg-Lux	logy = 1.4404 + 0.0390 n	0.843	25.57	61.84	9.4
France	logy = 2.3271 + 0.0289 n	0.991	212.3	386.8	6.9
Italy	logy = 2.1303 + 0.0421 n	0.922	135	323	10.2
Netherlands	logy = 1.4661 + 0.0342 n	0.702	29.3	59.4	8.1
U K	logy = 2.5825 + 0.195 n	0.824	382.3	572.4	4.6
Norway	logy = 1.2998 + 0.0350 n	0.641	19.95	41.2	8.4
Asutria	logy = 1.3583 + 0.0283 n	0.866	22.82	41.03	6.8
Sweden	logy = 1.6409 + 0.0389 n	0.915	43.74	97.95	9.3
Japan	logy = 2.2430 + 0.0807 n	0.974	175.0	932.2	20.4
U S A	logy = 3.3277 + 0.0399 n	0.947	2126	4859	9.6
Western World	logy = 3.6073 + 0.0429 n	0.994	4049	9824	10.4
Total World	logy = 3.7107 + 0.0417 n	0.997	5137	12180	10.1

$y = a\ (1 + r)^n$

$\log y = \log a + n \log (1 + r)$

where y = consumption after period years

a = consumption at the beginning of the period, 1960

r = compound rate of growth in consumption

x = (1 + r)

Table 6.1.6
Time Series Logarithmic Regression (1960-69 Inclusive)
Primary and Secondary Aluminium (+ Imports - Exports Secondary Products)
x 1000 metric tons
KR

Country	Regression Equation logy = loga + n log x	r^2	Regressed Consumption x 1000 metric tons 1960	 1969	Growth Rate per annum %
Germany	logy = 2.5209 + 0.0292 n	0.814	331.8	607.8	6.9
Belg-Lux	logy = 1.1522 + 0.0626 n	0.855	14.2	51.93	15.5
France	logy = 2.3308 + 0.0238 n	0.952	214.2	350.5	5.6
Italy	logy = 2.1091 + 0.0404 n	0.906	128.5	296.8	9.7
Netherlands	logy = 1.4764 + 0.0427 n	0.893	29.95	72.52	10.4
U K	logy = 2.5017 + 0.0174 n	0.816	317.5	455.0	4.1
Austria	logy = 1.6185 + 0.0019 n	None			
Japan	logy = 2.1536 + 0.0910 n	0.973	142.4	939.1	23.3
U S A	logy = 3.3054 + 0.0407 n	0.966	2020	4693	9.8

Table 6.1.7
Time Series Logarithmic Regression (1960-1969 Inclusive)
Aluminium Consumption based upon OECD End-Use Statistics
x 1000 metric tons.

KR

Country	Regression Equation logy = loga + n log	r^2	Regressed Production x 1000 metric tons 1960	1969	Growth Rate Per Annum %
Germany	logy = 2.0938 + 0.0243 n	0.750	124.1	205.2	5.8
France	logy = 1.8478 + 0.0265 n	0.940	70.44	122.1	6.3
Italy	logy = 1.7143 + 0.0468 n	0.924	51.8	136.6	11.4
Netherlands	logy = 0.5838 + 0.0497 n	0.757	3.84	10.74	12.1
U K	logy = 1.9903 + 0.0149 n	0.741	97.79	133.0	3.5
Austria	logy = 0.6388 + 0.0227 n	0.716	4.35	6.97	5.4
Sweden	logy = 0.9462 + 0.0427 n	0.958	8.83	21.4	10.4
Japan	logy = 1.7667 + 0.0713 n	0.974	58.4	256.2	17.9
U S A	logy = 2.4764 + 0.0522 n	0.628	299.5	883.3	12.8

$y = a(1 + r)^n$

$\log y = \log a + n \log(1 + r)$

where y = production after period   years
a = production at the beginning of the period, 1960
r = compound rate of growth in consumption
x = (1 + r)

Table 6.1.8
Time Series Logarithmic Regression (1960-1969 Inclusive)
Production of Aluminium Castings x 1000 metric tons

Country	Regression Equation logy = loga + n logx	r^2	Regressed Production x1000 metric tons 1960	 1969	Growth Rate per Annum %
Germany	logy = 1.4362 + 0.0517.n	0.920	27.30	79.79	12.7
France	logy = 1.0329 + 0.0636.n	0.956	10.78	40.29	15.8
Italy	logy = 1.1762 + 0.0927.n	0.964	15.01	102.5	23.8
UK	logy = 1.3916 + 0.0359.n	0.845	24.63	51.80	8.6
Japan	logy = 1.4337 + 0.0740.n	0.985	27.14	125.9	18.6
USA	logy = 2.2820 + 0.0484.n	0.879	191.4	52.2	11.8

<u>Time Series Logarithmic Regression (1960 - 1969 inclusive)</u>

<u>Production of Aluminium Pressure Die Castings X1000 metric tons</u>

<u>Table 6.1.9</u>

HR

Country	Regression Equations logy = loga + n. logx	r^2	Regressed Production X1000 metric tons		Growth Rate per Annum
			1960	1969	%
Germany	logy = 2.3268 + 0.0414.n	0.924	212.2	499.2	10.0
Belg-Lux	logy = 1.8359 + 0.0466.n	0.878	68.5	179.9	11.4
France	logy = 2.1232 + 0.0372.n	0.979	132.8	286.5	8.9
Italy	logy = 1.8873 + 0.0456.n	0.930	77.1	198.3	11.1
Netherlands	logy = 1.0894 + 0.0561.n	0.917	12.3	39.3	13.8
UK	logy = 2.3967 + 0.0157.n	0.925	249.3	345.3	3.7
Norway	logy = 1.1044 + 0.0581.n	0.821	12.7	42.3	14.3
Austria	logy = 1.4342 + 0.0241.n	0.676	27.2	44.7	5.7
Sweden	logy = 1.4987 + 0.0383.n	0.902	31.5	69.6	9.2
Japan	logy = 2.1294 + 0.0690.n	0.970	134.7	561.5	17.2
USA	logy = 3.1494 + 0.0463.n	0.979	141.0	368.4	11.3

Time Series Logarithmic (1960 - 69 inclusive)

Aluminium Total Wrought Products Production (X1000 metric tons)

Table 6.1.10

HR

Country	Product	Regression Equations logy = loga + n. logx	r^2	Regressed Production X100 metric tons 1960	1969	Growth Rate per Annum %
UK	Flat	logy = 2.2469 + 0.0036.n	0.445	176.6	190.4	0.8
	Extruded	logy = 1.4843 + 0.0346.n	0.902	30.5	62.56	8.2
	Wire	logy = 1.2885 + 0.0518.n	0.796	19.4	56.7	12.7
	Foil	logy = 1.4130 + 0.0143.n	0.883	25.88	34.79	3.4
Italy	Flat	logy = 1.6643 + 0.0507.n	0.977	46.16	131.6	12.4
	Extruded	logy = 1.2450 + 0.0586.n	0.940	17.58	59.16	14.5
	Wire	logy = 0.8314 + 0.0275.n	0.350	6.80	12.00	6.5
	Foil	logy = 0.8903 + 0.0445.n	0.895	7.78	19.5	10.8
USA	Flat	logy = 2.7678 + 0.0542.n	0.958	585.9	1798	13.3
	Extruded	logy = 2.4508 + 0.0619.n	0.658	282.3	1018	11.3
	Wire	logy = 2.1454 + 0.0540.n	0.942	139.7	427.0	13.2
	Foil	logy = 2.0521 + 0.0388.n	0.997	112.7	252.4	9.3
Japan	Flat	logy = 1.4131 + 0.0727.n	0.956	25.89	116.1	18.2
	Extruded	logy = NA		NA	NA	NA
	Wire	logy = 1.0640 + 0.0847.n	0.889	11.6	66.8	21.5
	Foil	logy = NA		NA	NA	NA

Time Series Logarithmic Regression

Aluminium Wrought Products Production (X1000 metric tons)

Flat, Extruded, Wire and Foil Products

Table 6.1.11

HR

Country	Val Manuf & Constr X1000 million US $			Flat Products Production X1000 metric tons			Extruded Products Prod X1000 metric tons			Wire Products Production X1000 metric tons		
	1960	1969	% Growth per Annum	1960	1969	% Growth per Annum	1960	1969	% Growth per Annum	1960	1969	% Growth per Annum
UK	32.1	43.2	3.4	176.6	190.4	0.8	30.5	62.56	8.2	19.4	56.7	12.7
Italy	14.0	24.3	6.3	46.16	131.6	12.4	17.58	59.16	14.5	6.8	12.0	6.5
USA	17.0	26.9	5.2	585.9	17.98	13.3	282.3	10.18	11.3	139.7	427.0	13.2
Japan	18.6	49.5	11.5	25.89	116.1	18.2	NA	NA	NA	11.6	66.8	21.5

	Flat Products Specific Production metric tons per million US $			Extruded Products Specific Production metric tons per million US $			Wire Products Specific Production metric tons per million US $		
	1960	1969	% Growth per Annum	1960	1969	% Growth per Annum	1960	1969	% Growth per Annum
UK	5.49	4.42	2.6	0.95	1.48	4.8	0.61	1.31	9.3
Italy	3.3	5.41	6.1	1.26	2.43	8.2	0.49	0.494	0.2
USA	3.44	6.68	8.1	1.66	3.79	6.1	0.82	1.59	8.0
Japan	1.39	2.34	6.7	NA	NA	NA	0.62	1.35	10.0

	Foil Production X1000 metric tons			Foil Specific Production metric tons per million US $		
	1960	1969	% Growth per Annum	1960	1969	% Growth per Annum
UK	25.88	34.79	3.4	0.81	0.804	0
Italy	7.78	19.5	10.8	0.56	0.80	4.5
USA	112.7	252.4	9.3	0.663	0.937	4.1
Japan	NA	NA	NA			

HR Aluminium Wrought Products Production Table 6.1.11.1

Country	Regression Equations logy = log a + n logx	r^2	Regressed Consumption x 1000 metric tons 1960	1969	Growth Rate per Annum %
Germany	logy = 1.9744 + 0.0253.n	0.752	94.3	159.2	6.0
Belg-Lux	logy = 0.1511 + 0.0373.n	0.730	1.42	3.07	9.0
France	logy = 1.8480 + 0.0253.n	0.830	70.47	119.1	6.0
Italy	logy = 1.7419 + 0.0402.n	0.900	55.2	127	9.7
Netherlands	logy = 0.4521 + 0.0405.n	0.782	2.83	6.56	9.7
U.K.	logy = 1.9954 + 0.0172.n	0.749	98.95	141.3	4.0
Japan	logy = 1.4690 + 0.0958.n	0.993	29.44	214.3	24.7
U.S.A.	logy = 2.7093 + 0.0344.n	0.879	512.1	104.4	8.2

<u>Time Series Logarithmic Regression (1960-69 Inclusive)</u>

<u>Aluminium Consumption in Transport Applications x 1000 Metric Tons</u>

<u>TABLE 6.1.12</u>

(BM)

Country	Regression Equations logy = log a + n logx	r^2	Regressed Consumption x 1000 metric tons 1960	1967	Growth Rate per Annum %
Germany	logy = 1.7750 + 0.0213.n	0.834	59.6	84.0	5.1
Belg-Lux*	logy = 0.7721 + 0.0722.n	0.928	0.59	1.89	18.0
France	logy = 1.3955 + 0.0348.n	0.780	24.9	43.6	8.3
Italy	logy = 0.9582 + 0.0415.n	0.735	9.1	17.7	10.0
Netherlands	logy = 0.4889 + 0.0430.n	0.694	3.1	6.2	10.4
U.K.	logy = 1.5304 + 0.0354.n	0.854	33.9	60.0	8.5
Japan 1	logy = 0.9287 + 0.1383.n	0.948	22.1	78.8	37.5
U.S.A. [2,3]	logy = 2.3631 + 0.0524.n	0.936	260.4	476.2	12 8

* Belg-Lux Consumption Regressed at x10 to avoid (T) values in equation.
1 1963 not 1960 (1960 data not available)
2 1961 not 1960 (" " ")
3 1966 not 1967 (1967 " ")

TIME SERIES LOGARITHMIC REGRESSION (1960-69INCLUSIVE)

ALUMINIUM CONSUMPTION IN ELECTRICAL ENGINEERING PRODUCTS X 1000 METRIC TONS

TABLE 6.1.13

(BM)

Country	Regression Equations logy = loga + n.logx	r^2	Regressed Consumption X1000 Metric Tons 1960	1969	Growth Rate per Annum %
Germany	logy = 1.3169 + 0.0714.n	0.958	20.74	91.03	17.9
Belg-Lux	logy = 0.5161 + 0.0738.n	0.928	3.28	15.15	18.5
France	logy = 1.1769 + 0.0379.n	0.988	15.03	32.96	9.1
Italy	logy = 1.0862 + 0.0459.n	0.475	12.2	31.56	11.1
Netherlands	logy = 0.6703 + 0.0714.n	0.967	4.68	20.56	17.9
U.K.	logy = 1.3823 + 0.0098.n	0.552	29.85	37.16	2.4
Japan	logy = 0.8372 + 0.170.n	0.996	6.87	233.1	47.9
U.S.A.	logy = 2.7359 + 0.0323.n	0.928	544.4	1064	7.8

TIME SERIES LOGARITHMIC REGRESSION (1960-69 INCLUSIVE)

ALUMINIUM CONSUMPTION IN BUILDING AND CONSTRUCTION X 1000 METRIC TONS

TABLE 6.1.14

(BM)

Country	Regression Equations logy = loga + n log x	r^2	Regressed Consumption x1000 Metric Tons 1960	 1969	Growth Rate per Annum %
Germany	logy = 1.5180 + 0.0261.n	0.859	32.96	56.61	6.2
Belg-Lux*	logy = 0.8409 + 0.1186.n	0.533	0.693	8.11	31.4
France	logy = 1.3333 + 0.0203.n	0.817	21.54	32.79	4.8
Italy	logy = 1.1149 + 0.0325.n	0.863	13.03	27.02	8.4
Netherlands	NA				
U.K.	logy = 1.4018 + 0.0157.n	0.682	25.23	34.89	3.7
Japan	logy = 0.6114 + 0.0704.n	0.991	4.09	17.60	17.6
U.S.A.	logy = 2.1317 + 0.0670.n	0.994	135.4	543.0	16.7

* BELG-LUX ALUMINIUM CONSUMPTION (PACKAGING) XID TO AVOID T IN REGRESSION

TIME SERIES LOGARITHMIC REGRESSION (1960-69 INCLUSIVE)

ALUMINIUM CONSUMPTION IN PACKAGING X1000 METRIC TONS

TABLE 6.1.15

(BM)

Country	GDP		% Annual Growth Rate	Manufacture and Construction Value		% Annual Growth Rate	Al-Consumption P+S+(I-E)		% Annual Growth Rate	Al-Consumption EUS - E		% Annual Growth Rate
	1960	1969		1960	1969		1960	1969		1960	1969	
Germany	85.7	126.2	4.3	40.7	61.3	4.7	351.0	698.0	7.9	331.8	607.8	6.9
Belgium - Luxembourg	12.2	18.04	4.4	4.35	7.0	5.4	27.6	61.8	9.4	14.2	51.93	15.5
France	70.9	115.2	5.5	29.7	53.8	6.8	212.0	387.0	6.9	214.0	350.5	5.6
Italy	42.06	66.67	5.2	14.0	24.3	6.3	135.0	323.0	10.2	128.5	296.8	9.7
Netherlands	12.85	20.28	5.2	NA	NA	NA	29.3	59.4	8.1	29.95	72.52	10.4
UK	78.29	101.3	2.9	32.1	43.2	3.4	382.3	572.4	4.6	317.5	455.0	4.1
Norway	5.01	7.97	5.3	1.72	2.71	5.2	20.0	41.2	8.4	NA	NA	NA
Austria	6.73	10.6	5.2	3.26	5.1	5.1	22.82	41.0	6.8	Discontinous		
Sweden	14.05	20.89	3.9	4.95	8.22	5.8	43.74	97.95	9.3	NA	NA	NA
Japan	55.3	133.2	10.7	18.6	49.5	11.5	175.0	932.0	20.4	142.4	939.1	23.3
USA	521.4	803.5	4.9	170.0	269.0	5.2	2126.0	4859.0	9.6	2020.0	4693.0	9.8

Units
GDP and, Value of Manufacturing and Construction, X1000 Million US $ at Constant Market Prices 1963
Weight of Aluminium Consumption, X1000 Metric Tons

Table 6.2.1

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Alternative Statistical Data Bases for Estimating Total Domestic Aluminium Consumption

P+S+(I-E) = Primary and Secondary Metal + (Imported - Exported Semi-Finished Products)

EUS - E = Metal Consumption based upon End-Use Statistics - Exported Semi-Finished Products

Country	Specific Aggregate Aluminium Consumption P+S+(I - E)		% Annual Growth Rate	Specific Aggregate Aluminium Consumption EUS - Exp		% Annual Growth Rate
	1960	1969		1960	1969	
Germany	8.63	11.39	3.2	8.13	9.9	2.2
Belgium - Luxembourg	6.35	8.83	4.0	3.26	7.4	10.1
France	7.14	7.18	0.1	7.2	6.52	-0.8
Italy	9.63	13.3	3.9	9.2	12.4	3.4
Netherlands	NA	NA	NA	NA	NA	NA
UK	11.9	13.2	1.2	9.9	10.5	0.7
Norway	11.6	15.3	3.2	NA	NA	NA
Austria	7.0	8.05	1.7	NA	NA	NA
Sweden	8.8	11.9	3.5	NA	NA	NA
Japan	9.4	18.8	8.9	7.63	19.0	11.8
USA	12.5	18.0	4.4	11.9	17.4	4.6

Units of Aluminium Specific Consumption

Metric Tons of Aluminium per Million US $ at Constant Market Prices (1963)

$$\text{Aluminium Aggregate Specific Consumption} = \frac{\text{Wt of Aluminium Consumed}}{\text{Value of Manufacturing and Construction}}$$

Table 6.2.2

Aluminium Aggregate Specific Consumption

Country	Total Aluminium Castings 1960	Total Aluminium Castings 1969	% Annual Growth Rate	Aluminium Castings Specific Production 1960	Aluminium Castings Specific Production 1969	% Annual Growth Rate	Aluminium Pressure Die Castings 1960	Aluminium Pressure Die Castings 1969	% Annual Growth Rate	% Annual Growth Rate Specific Production Pressure Die Castings
Germany	124.1	205.2	5.8	3.05	3.34	1.1	27.3	79.8	12.7	8.0
France	70.44	122.0	6.3	2.37	2.27	-0.5	10.8	40.3	15.8	9.0
Italy	51.8	136.6	11.4	3.7	5.6	5.1	15.0	102.5	23.8	17.5
Netherlands	3.84	10.74	12.1	NA	NA	NA	NA	NA	NA	NA
UK	97.8	133.0	3.5	3.05	3.08	0.1	24.6	51.8	8.6	5.2
Austria	4.4	7.0	5.4	1.35	1.37	0.3	NA	NA	NA	NA
Sweden	8.83	21.4	10.4	1.79	2.6	4.6	NA	NA	NA	NA
Japan	58.4	256.2	17.9	3.14	5.17	6.4	27.1	125.9	18.6	7.1
USA	299.5	883.3	12.8	1.77	3.28	7.6	191.4	522.0	11.8	6.6

Assumption Production = Consumption

Units

Consumption, X1000 Metric Tons

Specific Consumption, Metric Tons per Million US $ at Constant Market Prices, 1963

Table 6.2.3

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Aluminium Castings Production

Aluminium Castings Specific Production

MP

Country	Castings % Total Aluminium Consumption		Castings Production X1000 Metric Tons	
	1960	1969	1960	1969
Germany	35.4	29.4	124.1	205.2
France	33.2	31.6	70.4	122.1
Italy	38.4	42.2	51.8	136.6
UK	25.6	23.2	97.8	133.0
Japan	33.4	27.5	58.4	256.2
USA	14.2	18.2	299.5	883.3

Table 6.2.3.1

Aluminium Castings Production - % Total Aluminium Consumption

MP

End-Use Industry and Description of Data	Germany	France	UK	USA
Transport				
% Total Castings Production	57.0	73.0	56.0	43.6
Wt x 1000 Metric Tons	131.0	93.5	77.8	336.0
Value of Transport Equipment x 1000 Million $	4.0	3.38	4.25	29.8
Specific Consumption Castings	34.3	27.7	18.3	11.25
Specific Consumption Total Aluminium	44.5	36.0	34.6	32.0
Specific Consumption Wrought Aluminium	10.2	8.3	16.3	20.75
Electrical Engineering				
% Total Castings Production	11.0	6.0	13.0	8.0
Wt x 1000 Metric Tons	25.3	7.68	18.1	61.5
Value of Electrical Engineering x 1000 Million $	5.05	2.94	4.93	38.3
Specific Consumption Castings	5.02	2.61	3.67	1.61
Specific Consumption Total Aluminium	15.0	15.05	12.75	14.2
Specific Consumption Wrought Aluminium	9.98	12.44	9.08	12.6
Building and Construction				
% Total Castings Production	4.0	1.5	2.5	5.0
Wt x 1000 Metric Tons	9.2	1.82	3.5	38.5
Value of Construction x 1000 Million $	9.3	11.2	6.9	30.2
Specific Consumption Castings	0.99	0.16	0.51	1.27
Specific Consumption Total Aluminium	10.9	2.94	5.3	34.4
Specific Consumption Wrought Aluminium	9.01	1.78	4.79	33.13

Table 6.2.3.2

Analysis of End-Uses of Cast Product Forms

Proportion of total cast product production used in specific end-use sectors based upon statistical data published by OEA in 1967 for 1966.

Country	Wrought Products 1960	Al Production 1969	% Annual Growth Rate	Wrought Al Sp 1960	Products Prod 1969	% Annual Growth Rate
Germany	212.2	499.2	10.0	5.2	8.14	5.3
Belg-Lux	68.5	179.9	11.4	15.75	25.7	6.0
France	132.8	286.5	8.9	4.47	5.32	2.1
Italy	77.1	198.3	11.1	5.5	8.16	4.8
Netherlands	12.3	39.3	13.8	NA	NA	NA
UK	249.3	345.3	3.7	7.76	7.98	0.3
Norway	12.7	42.3	14.3	7.38	15.6	9.1
Austria	27.2	44.7	5.7	8.35	8.76	0.6
Sweden	31.5	69.6	9.2	6.36	8.47	3.4
Japan	134.7	561.5	17.2	7.23	11.32	5.7
USA	141.0	368.4	11.3	8.3	13.7	6.1

Basic Data from Time Series Logarithmic Regression Analysis
Input Data for Correlation Regression Analysis
Aluminium Wrought Products Production
Aluminium Wrought Products Specific Production

Units
Production, X1000 metric tons
Specific Production, metric tons per million US $ at Constant Market Prices, 1963.

Table 6.2.4

HR

Country	Al Consumption in Transport Eq 1960	1969	% Annual Growth Rate	Al Sp Con in Transport Eq 1960	1969	% Annual Growth Rate
Germany	94.3	159.2	6.0	34.5	40.5	1.9
Belg-Lux	1.42	3.07	9.0	5.9	7.5	2.9
France	70.47	119.1	6.0	34.75	35.8	0.4
Italy	55.2	12.7	9.7	61.4	80.0	3.2
Netherlands	2.83	6.56	9.7	NA	NA	NA
UK	98.95	141.3	4.0	28.6	33.2	1.7
Japan	29.44	214.3	24.7	23.75	48.2	9.4
USA	512.1	1044	8.2	29.4	34.6	1.9

Basic Data from Time Series Logarithmic Regression Analysis
Input Data for Correlation Regression Analysis
Aluminium Consumption in Transport Equipment
Aluminium Specific Consumption in Transport Equipment

Units
Consumption, X1000 metric tons
Specific Consumption, metric tons per million US $ at constant market prices, 1963.

Table 6.2.5

HR

Country	Al Consumption in Electrical Apps 1960	Al Consumption in Electrical Apps 1967	% Annual Growth Rate	Al Sp Con in Electrical Apps 1960	Al Sp Con in Electrical Apps 1967	% Annual Growth Rate
Germany	59.6	84.0	5.1	13.85	16.62	2.8
Belg-Lux	0.59	1.89	18.0	1.85	3.86	11.7
France	24.9	43.6	8.3	11.85	14.78	3.4
Italy	9.1	17.7	10.0	7.85	13.6	8.4
Netherlands	3.1	6.2	10.4	4.24	6.4	6.3
UK	33.9	60.0	8.5	9.75	12.15	3.4
Japan	22.1	78.8	37.5	4.02	8.96	27.7
USA	260.4	476.2	12.8	10.5	12.4	4.2

1. 1963 not 1960 (data not available for 1960)
2. 1961 not 1960 (" " " " " "))
3. 1966 not 1967 (" " " " " ")

Basic Data from Time Series Logarithmic Regression Analysis
Input Data for Correlation Regression Analysis
Aluminium Consumption in Electrical Applications (Appliances, Equipment and Machinery)
Aluminium Specific Consumption in Electrical Applications

Units
Consumption, X1000 metric tons
Specific Consumption, metric tons per million US $ at constant market prices, 1963

Table 6.2.6.

HR

Country	Al Consumption in Build & Const 1960	Al Consumption in Build & Const 1969	% Annual Growth Rate	Al Sp Cons in Build & Const 1960	Al Sp Cons in Build & Const 1969	% Annual Growth Rate
Germany	20.74	91.03	17.9	3.25	10.0	13.9
Belg-Lux	3.28	15.15	18.5	3.95	13.78	15.4
France	15.03	32.96	9.1	2.64	2.97	1.4
Italy	12.2	31.56	11.1	3.73	6.86	7.2
Netherlands	4.68	20.56	17.9	NA	NA	NA
UK	29.85	37.16	2.4	5.98	5.4	-1.2
Japan	6.87	233.1	47.9	2.33	23.7	33.6
USA	544.4	1064	7.8	20.8	34.8	6.1

Basic Data from Time Series Logarithmic Regression Analysis
Input Data for Correlation Regression Analysis
Aluminium Consumption in Building and Construction
Aluminium Specific Consumption in Building and Construction

Units
Consumption, X1000 metric tons
Specific Consumption, metric tons per million US $ at constant market prices, 1963.

Table 6.2.7

HR

Country	Al Consumption in Packaging 1960	Al Consumption in Packaging 1969	% Annual Growth Rate	Al Sp Cons in Packaging 1960	Al Sp Cons in Packaging 1969	% Annual Growth Rate
Germany	32.96	56.61	6.2	0.385	0.450	1.9
Belg-Lux	0.693	8.11	31.4	0.057	0.45	27.0
France	21.54	32.79	4.8	0.304	0.285	-0.7
Italy	13.03	27.02	8.4	0.311	0.406	3.2
Netherlands	NA	NA	NA	NA	NA	NA
UK	25.23	34.89	3.7	0.322	0.347	0.8
Japan	4.09	17.60	17.6	0.074	0.132	6.9
USA	135.4	543.0	16.7	0.260	0.674	12.8

Basic Data from Time Series Logarithmic Regression Analysis
Input Data for Correlation Regression Analysis
Aluminium Consumption in Packaging
Aluminium Specific Consumption in Packaging

Units
Consumption, X1000 metric tons
Specific Consumption, metric tons per million US $ at constant market prices, 1963.

Table 6.2.8

HR

End-Use	Regression Equation logy = loga + n log x	r^2	Regressed Consumption X1000 Metric Tons		Growth Rate Per Annum	% Total Aluminium Consumption	
			1960	1969	%	1960	1969
Total Domestic	logy = 2.5017 + 0.0174n	0.816	317.5	455.0	4.1	100.0	100.0
Aircraft	logy = 1.2991 - 0.0169n	0.77	19.91	14.03	-4.0	6.28	3.08
Road Vehicles	logy = 1.8091 + 0.0236n	0.766	64.43	105.2	5.5	20.3	23.2
Railways	logy = 0.6559 - 0.0334n	0.801	4.53	2.27	-8.0	1.43	0.5
Other Transport	logy = 0.5031 + 0.0595n	0.724	3.18	10.93	14.7	1.0	2.4
Domestic, Office and Medical Equipment	logy = 0.4268 + 0.0124n	0.578	2.67	3.45	2.9	0.84	0.76
Miscellaneous	logy = 1.1257 - 0.0289n	0.839	13.36	7.34	-6.9	4.2	1.61
Unidentified	logy = 1.2432 + 0.0355n	0.878	17.51	36.56	8.5	5.52	8.03
Electrical	logy = 1.5304 + 0.0354n	0.854	33.9	60.0'	8.5	10.67	13.2
Building and Construction	logy = 1.3823 + 0.0098n	0.552	29.85	37.16	2.4	9.4	8.15
Packaging	logy = 1.4018 + 0.0157n	0.682	25.23	34.89	3.7	7.95	7.68
Total Transport	logy = 1.9954 + 0.0172n	0.749	98.95	141.3	4.0	31.2	31.1

' 1967

Table 6.3.1

Aluminium Consumption in the UK - Disaggregated

Wrought and Cast Products End-Use Consumption

Time Series Logarithmic Regression 1960-1969 Inclusive

X1000 Metric Tons

MP

Sector of Economy	Annual Rate of Growth %	Annual Rate of Growth Value of Sector %	Specified Aluminium Consumption in Sector		Annual Rate of Growth of Specified Consumption %	% Total Aluminium Consumption	
			1960	1969		1960	1969
Total Manufacture and Construction	4.6[1]	3.4	11.9	13.2	1.2	100.0	100.0
Transport Equipment	4.0	2.3	28.6	33.2	1.7	31.2	31.1
Electrical Engineering	8.5	5.1	9.75	12.15[2]	3.4	10.67	13.2
Building and Construction	2.4	3.6	5.98	5.4	-1.2	9.4	8.15
Packaging	3.7	2.9[3]	0.322	0.347	0.8	7.95	7.68

1 Based upon Primary and Secondary Aluminium (+ Imports - Exports Semi-Finished Products)

2 1967

3 Annual Rate of Growth GDP

Table 6.3.2

Analysis of End-Use Aluminium Consumption Trends in the UK

MP

End-Use Industry	% of Cast Product		% of Wrought Product		% of Total	
	1960	1969	1960	1969	1960	1969
Transport						
Aircraft (Civil and Military)	2.15	0.79	6.71	4.14	5.43	3.16
Road (Mech Driven)	44.32	52.3	9.86	9.80	19.55	22.24
Rail	2.22	1.15	1.04	0.26	1.38	0.52
Marine	1.18	0.63	0.97	0.42	1.03	0.48
Others	0.74	0.50	1.56	3.95	1.33	2.94
Electrical Plant and Equipment	12.83	13.03	7.31	11.83	8.86	12.18
Building and Construction	2.70	1.68	10.57	10.13	8.36	7.66
Chemical and Food Plant and Equipment	0.81	1.63	1.73	3.02	1.47	2.61
Packaging Material	0.01	0.03	15.37	14.98	11.05	10.60
Engineering and Industry M/C						
Textile M/C	1.51	1.33	1.28	0.94	1.34	1.06
M/C Tools	2.40	2.02	0.17	0.06	0.80	0.64
Other M/C	5.25	5.78	4.18	3.90	4.48	4.45
Domestic, Office and Medical	12.06	13.69	5.84	4.92	7.59	7.48
Holloware	0.47	0.39	3.00	2.76	2.29	2.07
Miscellaneous	7.72	2.35	2.76	1.51	4.15	1.75
Exports	0.01	0.17	15.09	10.86	10.85	7.73
Unidentified	0.15	0.61	9.7	13.0	7.0	9.4

Table 6.3.3

Analysis of End-Use Consumption of Aluminium by Industry in the UK

Percentages of Total Consumption (Aluminium Federation Statistics)

(Percentages include Exports in the Consumption Total)

End-Use Industry	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
<u>Transport</u>										
Aircraft (Civil and Military)	20.02	17.78	17.69	18.83	18.84	15.19	14.69	16.09	13.63	14.77
Road (Mech Driven)	72.07	59.60	62.46	78.76	90.37	89.81	92.48	83.83	97.34	104.06
Rail	5.05	4.01	3.96	3.07	3.73	2.77	2.68	3.18	2.17	2.43
Marine	3.78	2.41	3.82	2.85	2.11	2.45	2.62	2.93	2.62	2.25
Others	4.90	3.90	3.76	3.87	4.71	5.10	5.42	7.57	13.60	13.75
Electrical Plant and Equipment	32.68	31.47	32.41	40.75	48.74	56.26	56.39	59.73	60.86	57.01
Building and Construction	30.81	30.85	27.15	28.60	34.34	35.90	34.37	33.76	35.54	35.84
Chemical and Food Plant and Equipment	5.42	5.43	5.51	7.41	7.86	8.93	7.91	8.57	10.23	12.23
Packaging Material	40.74	34.10	31.73	32.67	34.76	39.12	41.49	41.55	46.73	49.62
<u>Engineering and Industry M/C</u>										
Textile M/C	4.96	3.04	2.45	3.28	3.96	4.17	4.68	3.58	4.33	4.95
M/C Tools	2.94	2.48	2.67	2.71	2.79	2.58	2.16	1.99	2.06	2.98
Other M/C	16.52	15.43	16.75	16.01	18.97	18.25	18.49	17.46	18.50	20.83
Domestic, Office and Medical	27.98	24.74	27.46	32.29	32.11	30.82	29.50	29.65	35.91	35.02
Holloware	8.44	8.29	8.69	9.60	9.64	9.98	9.22	9.71	11.01	9.66
Miscellaneous	15.32	12.43	11.99	10.11	9.40	9.33	7.78	8.40	8.35	8.21
Unidentified	25.9	22.7	24.0	24.8	33.7	34.0	34.4	33.2	37.0	43.9

<u>Table 6.3.4</u>

<u>Analysis of End-Use Consumption of Aluminium by Industry in the UK</u>

<u>Wrought and Cast End-Uses Combined (Aluminium Federation Statistics)</u>

<u>X1000 Tons</u>

End Use Industry	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	% Compound Growth
Transport											
Aircraft(Civil & Military)	2.23	2.40	2.22	1.94	2.00	1.88	1.53	1.27	1.05	1.07	- 7.6
Road (Mech Driven)	45.95	39.06	42.23	51.86	61.50	59.93	61.25	58.30	63.40	71.61	+ 4.6
Rail	2.30	1.89	1.71	1.65	1.91	1.85	1.94	2.24	1.48	1.57	- 4.0
Marine	1.23	0.92	0.92	0.90	0.87	0.95	0.89	0.80	0.89	0.87	- 3.5
Others	0.77	1.05	0.71	0.67	0.82	0.77	0.80	0.69	0.68	0.69	- 1.1
Elec Plant & Equip	13.30	13.90	14.02	14.15	16.93	17.40	15.28	16.93	17.81	17.84	+ 3.0
Build & Constr	2.79	2.71	2.38	2.99	2.49	2.49	2.38	2.34	2.98	2.31	Cyclic
Chem Food Plant & Equip	0.84	0.80	0.68	2.04	1.81	1.57	1.36	1.39	1.86	2.23	+ 10.3
Packaging Mat	0.008	0.014	0.017	0.074	0.024	0.030	0.023	0.024	0.030	0.037	+ 16.6
Eng & Ind M/c											
Textile M/c	1.56	1.41	1.43	1.62	1.93	1.73	1.79	1.45	1.80	1.82	+ 1.6
M/c Tools	2.49	2.25	2.58	2.59	2.65	2.40	1.93	1.66	1.90	2.76	+ 1.0
Other M/c	5.44	4.46	4.17	4.27	5.79	5.44	5.00	5.39	6.65	7.91	+ 3.8
Domestic Office & Medical	12.51	10.97	12.0	13.2	14.2	13.73	13.35	14.09	17.37	18.74	+ 4.1
Holloware	0.49	0.57	0.65	0.64	0 56	0.61	0.57	0.53	0.55	0.53	Negligable
Miscellaneous	8.00	6.71	6.53	4.15	3.54	3.46	2.97	2.78	3.21	3.22	- 9.5

Table 6.3.5

Analysis of End-Use Consumption of Aluminium by Industry in the UK

Cast Product Form consumption (Aluminium Federation Statistics)
x 1,000 tons.

KR

End-Use Industry	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	% Compound Growth per annum
Transport											
Aircraft (Civil + Military)	17.79	16.39	15.47	16.88	16.84	13.31	13.16	14.82	12.58	13.70	- 2.8
Road (Mech Driven)	26.13	20.55	20.23	26.90	29.08	29.88	31.23	30.52	33.95	32.45	+ 1.4
Rail	2.75	2.12	2.25	1.42	1.82	0.92	0.74	0.94	0.69	0.86	- 8.8
Marine	2.56	1.49	2.89	1.95	1.24	1.51	1.73	2.13	1.74	1.38	- 3.4
Others	4.13	2.86	3.05	3.21	3.89	4.34	4.62	6.88	12.92	13.06	+ 24.8
Elec Plant & Equip	19.35	17.58	18.38	26.60	31.81	38.85	41.11	42.81	43.06	39.17	+ 8.7
Building & Construction	28.01	28.14	24.77	25.61	31.85	33.41	32.00	31.42	32.55	33.53	+ 4.2
Chem Food Plant & Equip	4.58	4.64	4.83	5.37	6.05	7.36	6.55	7.18	8.36	10.00	+ 12.5
Packaging Mat	40.74	34.08	31.71	32.59	34.74	39.09	41.46	41.53	46.70	49.58	+ 1.6
Eng & Ind M/c											
Textile M/c	3.40	1.63	1.03	1.66	2.04	2.44	2.89	2.13	2.53	3.13	+ 1.6
M/c Tools	0.46	0.23	0.10	0.12	0.14	0.19	0.23	0.33	0.16	0.22	- 9.3
Other M/c	11.08	10.96	12.58	11.74	13.19	12.81	13.49	12.08	11.85	12.92	+ 0.6
Domestic Office & Medical	15.48	13.78	15.47	19.10	17.91	17.09	16.15	15.56	18.54	16.28	+ 6.1
Holloware	7.96	7.72	8.04	8.96	9.07	9.37	8.65	9.18	10.46	9.13	+ 2.8
Miscellaneous	7.32	5.72	5.46	5.96	5.86	5.86	4.81	5.62	5.14	4.98	- 1.0

Table 6.3.6

Analysis of End Use Consumption of Aluminium by Industry in the UK

Wrought Product Form Consumption (Aluminium Federation Statistics) x 1,000 tons

KR

End Use Applications	Wrought and Cast	Wrought Only	Cast Only
Transport: Mechanically Propelled			
Military Vehicles	0.6	0.7	0.2
Other Vehicles (and semi-trainers)	25.0	11.0	56.0
Non-Mechanically Propelled:			
Caravans	3.2	4.5	-
Other	0.7	0.25	
Shipbuilding: Civil (incl Hovercraft)	0.4	0.45	0.4
Admiralty	0.23	0.35	0.06
Rail: Aircraft and Aerospace Construction	2.2	3.0	0.5
Containers: Air, Land and Sea	0.5	0.7	0.04
Funiculars, Cog Railways, Ski-Lifts etc.	-	-	-
Combustion Engines (included in transport)	0.02	.02	0.04
General Engineering			
Industrial M/c and Acc: Textile	0.45	0.30	0.7
Other	4.0	4.3	1.4 - 5.03
Other (incl M/c Tools, Handling, Eg, Precision)	2.5	1.6	4.8
Electrical Eng:			
Power Transmission and Distribution	2.0	1.5	3.0
Telephones, Communications and Electronics	0.45	0.5	0.3
Domestic and Ind Equip	1.9	1.0	3.7
All Other	1.0	1.0	1.1
Building and Construction. Roofing	1.8	2.4	0.4
Doors, Windows, Curtain Walling	4.6	6.4	0.04
Prefab Build and Glasshouses	0.8	1.2	-
Public Works	0.25	0.35	0.05
General Building, Structures, Scaffolding Equipment and Decorating	2.4	3.0	0.8
Industrial Refrigeration etc Chem, Food and Agricultural Plant and Equipment	1.5	1.1	2.5
Packaging			
Foil Stock	9.0	12.5	-
All Packaging (incl Impact Ext)	4.25	6.2	0.1
Domestic and Office Equipment			
Holloware incl mugs and plates	2.2	3.0	0.5
Kitchen and Camping Utensils	0.04	0.02	0.1
Domestic M/C and Appliances (non elect and elec)	2.75	2.5	4.0
All Other (incl Radio, TV, Lighting, Office)	5.8	3.7	10.5

Table 6.3.7
Disaggregated Aluminium Consumption in the UK (available for 1973 only)
% Total Consumption

Country	Regression Equation logy = loga + n log x	r^2	Regressed Consumption x 1000 metric tons 1960	1969	Growth Rate per annum %
Germany	logy = 2.8709 + 0.0615 n	0.98	742.9	2655	15.2
Belg-Lux	logy = 1.9828 + 0.0625 n	0.893	96.12	351.0	15.4
France	logy = 2.5177 + 0.0659 n	0.996	329.4	1291	16.3
Italy	logy = 2.4479 + 0.0727 n	0.984	280.5	1265	18.2
Netherlands	logy = 1.9932 + 0.0598 n	0.899	98.45	340.2	14.8
U K	logy = 2.6700 + 0.0450 n	0.984	467.7	1188	10.9
Norway	logy = 1.5069 + 0.0620 n	0.985	32.13	116.1	15.3
Austria	logy = 1.7886 + 0.0605 n	0.993	61.64	215.1	14.9
Sweden	logy = 1.8962 + 0.0744 n	0.994	78.74	368.2	18.7
Japan	logy = 2.7469 + 0.0866 n	0.987	558.4	3360	22.1
U S A	logy = 3.3516 + 0.0614 n	0.971	2247	8021	15.2

Table 6.4.1

Time Series Logarithmic Regression (1960-1969 Inclusive)

Estimated Consumption of Plastics Materials x 1000 metric tons

KR

Country	Regression Equation $\log y = \log a + n \log x$	r^2	Regressed Consumption x 1000 metric tons 1960	 1969	Growth Rate per annum %
Germany	$\log y = 2.7006 + 0.0065\,n$	0.178	501.9	573.7	1.5
Belg-Lux	$\log y = 1.9489 + 0.0130\,n$	0.546	88.9	116.5	3.0
France	$\log y = 2.3720 + 0.0142\,n$	0.790	235.5	315.9	3.3
Italy	$\log y = 2.2879 + 0.0074\,n$	0.360	194.0	226.2	1.7
Netherlands	$\log y = 1.4247 + 0.0114\,n$	0.238	26.59	33.67	2.7
U K	$\log y = 2.7506 + 0.0000\,n$	No Correlation	563	563	0
Norway	$\log y = 0.8724 + 0.0332\,n$	0.560	7.45	14.84	7.9
Austria	$\log y = 1.4761 + 0.0017\,n$	0.021	29.93	31.02	0.4
Sweden	$\log y = 1.9783 - 0.0049\,n$	0.416	95.13	86.0	-1.1
Japan	$\log y = 2.4529 + 0.0462\,n$	0.893	283.7	739.6	11.3
U S A	$\log y = 3.1215 + 0.0207\,n$	0.712	1323	2032	4.9
West World	$\log y = 3.5949 + 0.0172\,n$	0.897	3934	5615	4.0
Total World	$\log y = 3.6856 + 0.0174\,n$	0.939	4849	6961	4.1

Table 6.4.2

Time Series Logarithmic Regression (1960-1969 Inclusive)

Estimated Consumption of Copper x 1000 metric tons

KR

Country	Regression Equation logy = loga + n log x	r^2	Regressed Consumption x 1000 metric tons 1960	 1969	Growth Rate Per Annum %
Germany	logy = 2.4510 + 0.0114 n	0.564	282.5	358.1	2.7
Belg-Lux	logy = 2.0515 + 0.0082 n	0.347	112.6	133.5	1.9
France	logy = 2.2422 + 0.0106 n	0.674	174.7	217.7	2.4
Italy	logy = 1.9250 + 0.0317 n	0.967	84.14	162.2	7.6
Netherlands	logy = 1.4520 + 0.0106 n	0.565	28.31	35.3	2.4
U K	logy = 2.4189 + 0.0034 n	0.186	262.3	281.4	0.8
Norway	logy = 1.1172 + 0.0251 n	0.777	13.1	22.03	5.9
Austria	logy = 1.1273 + 0.0144 n	0.478	13.41	18.05	3.4
Sweden	logy = 1.4376 + 0.0121 n	0.562	27.39	35.18	2.8
Japan	logy = 2.2939 + 0.0549 n	0.96	196.7	613.7	13.4
U S A	logy = 2.9246 = 0.0221 n	0.816	840.7	1328	5.2
West World	logy = 3.3933 + 0.0228 n	0.971	2474	3965	5.4
Total World	logy = 3.4899 + 0.0225 n	0.985	3089	4928	5.3

Table 6.4.3

Time Series Logarithmic Regression (1960-1969 Inclusive)

Estimated Consumption of Zinc x 1000 metric tons

KR

Country	Regression Equation logy = loga + n log x	r^2	Regressed Consumption x 1000 metric tons 1960	1969	Growth Rate Per Annum %
Germany	logy = 2.3648 + 0.0115 n	0.792	231.6	293.8	2.7
Belg-Lux	logy = 1.6898 + 0.0094 n	0.297	48.96	59.46	2.2
France	logy = 2.1911 + 0.0071 n	0.338	155.2	179.7	1.6
Italy	logy = 1.8803 + 0.0280 n	0.881	75.91	135.5	6.7
Netherlands	logy = 1.7083 + 0.0000 n	-	51.1	51.1	0
U K	logy = 2.4590 - 0.0006 n	-	287.7	284.4	- 0.1
Norway	logy = 0.9804 + 0.0144 n	0.550	9.56	12.89	3.4
Austria	logy = 1.2934 + 0.0077 n	0.500	19.65	23.05	1.8
Sweden	logy = 1.6600 + 0.0111 n	0.744	45.71	57.53	2.6
Japan	logy = 2.0362 + 0.0273 n	0.872	108.6	191.3	6.5
U S A	logy = 2.8089 + 0.0134 n	0.922	644	849.6	3.1
West World	logy = 3.3136 + 0.0146 n	0.974	2059	2787	3.4
Total World	logy = 3.4175 + 0.0172 n	0.985	2615	3734	4.0

Table 6.4.4

Time Series Logarithmic Regression (1960 - 1969 Inclusive)

Estimated Consumption of Lead x 1 000 metric tons

KR

Country	Regression Equation logy = loga + n log x	r^2	Regressed Consumption x 1000 metric tons 1960	 1969	Growth Rate Per Annum %
Germany	logy = 1.1369 - 0.0043 n	- 0.166	13.71	12.53	- 1.0
Belg-Lux	logy = 0.4624 - 0.0001 n	-	2.9	2.9	0
France	logy = 1.0496 - 0.0050 n	0.337	11.21	10.0	- 1.2
Italy	logy = 0.7222 + 0.0109 n	0.715	5.27	6.61	2.5
Netherlands	logy = 0.5153 + 0.0136 n	0.400	3.28	4.34	3.1
U K	logy = 1.3643 - 0.0090 n	0.904	23.14	19.21	- 2.1
Norway	logy = $\bar{1}$.3423 + 0.0360 n	0.806	0.22	0.464	8.6
Austria	logy = $\bar{1}$.9071 - 0.0225 n	0.691	0.807	0.507	- 5.2
Sweden	logy = $\bar{1}$.9048 - 0.0194 n	0.388	0.803	0.537	- 4.6
Japan	logy = 1.1309 + 0.0280 n	0.908	13.52	24.15	6.7
U S A	logy = 1.7255 + 0.0070 n	0.660	53.15	61.49	1.6
West World	logy = 2.2037 + 0.0048 n	0.780	159.9	176.6	1.1
Total World	logy = 2.3077 + 0.0075 n	0.884	203.1	237.4	1.7

Table 6.4.5

Time Series Logarithmic Regression (1960 - 1969 Inclusive)

Estimated Consumption of Tin x 1000 metric tons

KB

Country	Regression Equation logy = loga + n log X	r^2	Regressed Consumption x 1000 tons 1960	1969	Growth Rate Per Annum %
Germany	logy = 4.2422 + 0.0188 n	0.709	17470	25770	4.4
Belg-Lux	logy = 3.4000 + 0.0201 n	0.724	2512	3810	4.7
France	logy = 3.9330 + 0.0213 n	0.896	8570	13320	5.1
Italy	logy = 3.7633 + 0.0308 n	0.874	5798	10970	7.4
Netherlands	logy = 3.3797 + 0.0219 n	0.900	2397	3774	5.2
U K	logy = 4.1307 + 0.0090 n	0.327	13510	16290	2.1
Austria	logy = 2.9975 + 0.0154 n	0.555	994.2	1368	3.6
Sweden					
Japan	logy = 4.1731 + 0.0605 n	0.964	14890	52200	14.9
U S A	logy = 4.8106 + 0.0227 n	0.911	64660	103500	5.4

Table 6.4.6

Time Series Logarithmic Regression (1960 - 1969 Inclusive)

Estimated Consumption of Steel x 1000 tons

KR

County	Plastics Materials Consumption 1960	1969	% Annual Growth rate	Plastics Materials Spec Cons 1960	1969	% Annual Growth rate
Germany	742.9	2655	15.2	18.3	43.2	10.5
Bel-Lux	96.12	331.0	15.4	22.1	56.1	10.0
France	329.4	1291	16.3	11.1	24.0	9.5
Italy	280.5	1265	18.2	20.0	52.1	11.9
Neterlands	98.45	340.2	14.8	NA	NA	NA
UK	467.7	1188	10.9	14.55	27.5	7.5
Norway	32.13	116.1	15.3	18.65	42.8	10.1
Austria	61.46	215.1	14.9	18.85	42.1	9.8
Sweden	78.74	368.2	18.7	15.9	44.8	12.9
Japan	558.4	3360	22.1	30.0	68.0	10.6
USA	2247	8021	15.2	13.22	29.8	10.0

Table 6.5.1.

Basic Data From Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Plastics Materials Consumption

Plastics Materials Specific Consumption

Units
Consumption, XI000 metric tons
Specific Consumption, metric tons per million US $ at constant Market Prices, 1968.

EMH

Country	Refined Copper Consumption 1960	1969	% Annual Growth Rate	Refined Copper Specs Cons 1960	1969	% Annual Growth Rate
Germany	501.9	573.7	1.5	12.3	9.35	-3.5
Belg-Lux	88.9	116.5	3.0	20.4	16.65	-2.4
France	235.5	315.9	3.3	7.93	5.88	-3.5
Italy	194.0	226.2	1.7	13.85	9.3	-4.6
Netherlands	26.59	33.67	2.7	NA	NA	NA
UK	563	563	0	17.55	13.0	-3.4
Norway	7.45	14.84	7.9	4.33	5.47	-2.7
Austria	29.93	31.02	0.4	9.17	6.08	-4.7
Sweden	95.13	86.0	-1.1	19.2	10.45	-6.9
Japan	283.7	739.6	11.3	15.2	14.92	-0.2
USA	1323	2032	4.9	7.77	7.55	-0.3

Table 6.5.2.

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Refined Copper Consumption

Refined Copper Specific Consumption

Units
Comsumption XI000 metric tons
Specific consumption, metric tons per million $, at constant market prices, 1963.

EMH

Country	Zinc Consumption 1960	1969	% Annual Growth Rate	Zinc Spec Cons 1960	1969	% Annual Growth Rate
Germany	282.5	358.1	2.7	6.97	5.83	- 2.0
Belg-Lux	112.6	133.5	1.9	25.8	19.1	- 3.5
France	174.7	217.7	2.4	5.88	4.04	- 4.4
Italy	84.14	162.2	7.6	6.0	6.68	1.3
Netherlands	28.3	35.3	2.4	NA	NA	NA
UK	262.3	281.4	0.8	8.16	6.51	- 2.6
Norway	13.1	22.03	5.9	7.62	8.12	0.5
Austria	13.4	18.05	3.4	4.11	3.54	- 1.7
Sweden	27.39	35.2	2.8	5.54	4.29	- 3.0
Japan	196.7	613.7	13.4	10.58	12.38	1.9
USA	840.7	1328	5.2	4.95	4.93	0

Table 6.5.3.

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Zinc Consumption

Zinc Specific Consumption

Units
Consumption, XI000 metric tons
Specific Consumption, metric tons per million US $ at constant market prices, 1963.

Country	Lead Consumption 1960	1969	% Annual Growth Rate	Lead Spec Cons 1960	1969	% Annual Growth Rate
Germany	231.6	293.8	2.7	5.69	4.79	- 2.0
Belg-Lux	48.96	59.46	2.2	11.26	8.49	- 3.2
France	155.2	179.7	1.6	5.23	3.34	- 5.2
Italy	75.91	135.5	6.7	5.42	5.58	0.4
Netherlands	51.1	51.1	0	NA	NA	NA
UK	287.7	284.4	- 0.1	8.93	6.58	- 3.5
Norway	9.6	12.89	3.4	5.58	4.76	- 1.8
Austria	19.65	23.05	1.8	6.03	4.52	- 3.3
Sweden	45.71	57.53	2.6	9.23	7.0	- 3.2
Japan	108.6	191.3	6.5	5.84	3.86	- 5.0
USA	644	849.6	3.1	3.79	3.16	- 2.1

Table 6.5.4.

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Lead Consumption

Lead Specific Consumption

Units
Consumption, X1000 metric tons
Specific Consumption, metric tons per million US $ at constant market prices, 1963.

EMH

Country	Tin Consumption		% Annual Growth Rate	Tin Specific Consumption		% Annual Growth Rate
	1960	1969		1960	1969	
Germany	13.7	12.5	-1.0	0.337	0.204	- 5.7
Belg - Lux	2.9	2.9	-	0.667	0.414	- 5.4
France	11.2	10.0	-1.2	0.377	0.186	- 8.0
Italy	5.27	6.62	2.5	0.376	0.272	- 3.8
Netherlands	3.28	4.34	3.1	NA	NA	NA
UK	23.14	19.21	-2.1	0.721	0.445	- 5.5
Norway	0.22	0.46	8.6	0.128	0.17	3.4
Austria	0.81	0.51	-5.2	0.248	0.1	-10.3
Sweden	0.80	0.54	-4.6	0.162	0.066	-10.4
Japan	13.52	24.15	6.7	0.727	0.488	- 4.8
USA	53.15	61.49	1.6	0.313	0.229	- 3.6

Units
Consumption, X1000 Metric Tons
Specific Consumption, Metric Tons per Million US $ at Constant Market Prices, 1963

Table 6.5.5

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Tin Consumption

Tin Specific Consumption

MP

	Steel Consumption		% Annual Growth Rate	Steel Specific Consumption		% Annual Growth Rate
	1960	1969		1960	1969	
Germany	17470	25770	4.4	428	420	-0.3
Belg - Lux	2512	3810	4.7	577	544	-0.7
France	8570	13320	5.1	289	248	-1.7
Italy	5798	10970	7.4	413	450	1.1
Netherlands	2397	3774	5.2	NA	NA	NA
UK	13510	16290	2.1	421	377	-1.3
Austria	9942	1368	3.6	308	268	-1.5
Japan	14890	52200	14.9	800	1055	3.4
USA	64660	103500	5.4	380	385	0.2

Units
Consumption, X1000 Tons
Specific Consumption, Tons per Million US $ at Constant Market Prices, 1963

Table 6.5.6

Basic Data from Time Series Logarithmic Regression Analysis

Input Data for Correlation Regression Analysis

Steel Consumption

Steel Specific Consumption

MP

Specific Consumption Metric Tons per Million US $	Germany		France		Italy		UK		Japan		USA	
	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969	1960	1969
Aluminium	8.63	11.39	7.14	7.18	9.63	13.3	11.9	13.2	9.4	18.8	12.5	18.0
Steel[1]	428.00	420.00	289.00	248.00	413.00	450.00	421.00	377.00	800.00	1055.00	380.00	385.00
Plastics	18.3	43.2	11.1	24.0	20.0	52.1	14.55	27.5	30.0	68.0	13.22	29.8
Copper	12.3	9.35	7.93	5.88	13.85	9.3	17.55	13.0	15.2	14.92	7.77	7.55
Zinc	6.96	5.83	5.88	4.04	6.0	6.68	8.16	6.51	10.58	12.38	4.95	4.92
Lead	5.69	4.79	5.23	3.34	5.42	5.58	8.93	6.58	5.84	3.86	3.79	3.16
Tin	0.337	0.204	0.377	0.186	0.376	0.272	0.721	0.445	0.727	0.488	0.313	0.229

1 Tons per Million US $

Table 6.5.7

Specific Consumption of Aluminium, Steel, Plastics, Copper, Zinc, Lead, Tin

$$\text{Macro-Specific Consumption} = \frac{\text{Metric Tons of Material Consumed}}{\text{Value of Manufacturing and Construction Million US \$ at Constant Market Prices (1963)}}$$

MP

Material Sector	Specific Consumption 1960	Specific Consumption 1969	Change in Sp Cons % per annum	Change in Val of Prod % per annum	% Total of a Given Materials Cons 1960	% Total of a Given Materials Cons 1969
Aluminium						
Manufacture-Construction 1	11.9	13.2	1.2	-	-	-
Manufacture-Construction 2	9.9	10.5	0.7	3.4	-	-
Transport Equipment	28.6	33.2	1.7	2.3	3[illegible].6	31.8
Electrical Engineering	9.75	12.15	3.4	5.1	10.1	13.1
Construction	5.98	5.4	- 1.2	3.6	9.0	7.9
Packaging[3]	0.322	0.347	0.8	2.9	8.4	7.9
Steel						
Manufacture-Construction	421.00	377.00	- 1.3	3.4	-	-
Transport Equipment	1238.00	1020.00	- 2.0	2.3	27.8	24.6
Electrical Engineering	197.5	145.8	- 3.5	5.1	4.5	4.1
Construction	190.0	148.0	- 2.5	2.9	6.2[4]	6.0[5]
Packaging	-	-	-	-	3.57	5.0
Plastics						
Manufacture-Construction	14.55	27.5	7.5	3.4	-	-
Transport Equipment	12.4	13.2	0.8	2.3	8.7	5.0
Electrical Engineering	23.8	26.6	1.4	5.1	17.2	12.4
Construction	11.5	40.6	17.6	2.9	11.8	25.0
Packaging	-	-	-	-	17.0	21.0
Copper	17.55	13.0	- 3.4	3.4	-	-
Zinc	8.16	6.51	- 2.6	3.4	-	-
Lead	8.93	6.51	- 3.5	3.4	-	-
Tin	0.721	0.445	- 5.5	3.4	-	-

1. Primary and Secondary Aluminium Statistics Correct for Export-Import Balance
2. End-Use Statistics
3. Specific Consumption based upon the Value of GDP
4. 26.0% including industrial construction in 1960
5. 24.4% including industrial construction in 1969

Table 6.5.8

Profile of Materials Specific Consumption in the UK

Countries	Year	Correlation Regression Equation	r^2
All countries Table 6.1.6	1960	$y = - 17.07 + 4.113\ x$	0.997
excluding US	1960	$y = - 19.34 + 4.176\ x$	0.931
All countries Table 6.6.6	1969	$y = - 56.33 + 6.105\ x$	0.995
excluding US	1969	$y = - 38.25 + 5.797\ x$	0.890

Table 6.6.1

Correlation Regression Analysis

Aluminium Consumption (x1000 metric tons) with Value of Gross Domestic Product (x1000 million US $ at constant market prices 1963)

where Aluminium Consumption = Primary + Secondary Aluminium + (Imports-Exports secondary products)

EMH

Countries	Year	Correlation Regression Equation	r^2
All countries Table 6.1.6.	1960	$y = -53.00 + 12.604x$	0.991
excluding US	1960	$y = -2.300 + 9.306x$	0.923
All countries Table 6.1.6.	1969	$y = -153.41 + 18.215x$	0.981
excluding US	1969	$y = -5.640 + 12.165x$	0.780

Table 6.6.2.

Aluminium Consumption (x1000 metric tons) with Value of Manufacturing and Construction

x1000 million US $ at constant market prices 1963

where y = Aluminium consumption x1000 metric tons

x = Value of GDP or Manufacturing and Construction

x1000 million US $ at Constant Market Prices (1963)

EMH

Countries	Year	Correlation Regression Equation	r^2
All countries Table 6.1.7	1960	$y = - 90.87 + 12.294x$	0.995
excluding US	1960	$y = - 14.40 + 8.855x$	0.943
All countries Table 6.1.7	1969	$y = - 262.50 + 18.169x$	0.978
excluding US	1969	$y = 25.21 + 10.661x$	0.519

Table 6.6.3

Correlation Regression Analysis

Aluminium Consumption (x1000 metric tons) with Value of Manufacturing and Construction x1000 million US $ at constant market prices 1963

where Aluminium Consumption = Total estimated end use consumption excluding secondary products.

where y = Aluminium consumption x1000 metric tons

x = Value of Manufacturing and Construction x1000 million US $ at Constant Market Prices (1963)

EMH

	Definition of Criteria	Regression Equation	r^2
1	Growth Rates, Al Consumption (P+S+(I-E) with GDP	$y = -0.470 + 1.857x$	0.825
2	Growth Rates, Al Consumption (P+S+(I-E) with Val M+C	$y = -1.512 + 1.816x$	0.848
3	Growth Rates, AI Consumption (EUS) with GDP	$y = -1.438 + 2.246x$	0.695
4	Growth Rates, AI Consumption (EUS) with Val M+C	$y = -2.3614 + 2.112x$	0.670
5	Growth Rates, Sp AI Consumption (P+S+(I-E)with Val M+C	$y = -1.448 + 0.818x$	0.554
6	Growth Rates, Sp AI Consumption (EUS) with Val M+C	$y = -2.342 + 1.118x$	0.376

Table 6.6.4

Correlation Regression Analysis

% Compound Annual Rates of Growth, Aluminium Consumption with Economic Indices.

FMH

Product	Year	Correlation Regression Equation $y = a + b\,x$	r^2
All castings	1960	$y = 23.33 + 1.6873\ x$	0.956
All castings	1969	$y = 12.46 + 3.2430\ x$	0.974
Pressure Die Castings	1960	$y = -10.14 + 1.1676\ x$	0.974
Pressure Die Castings	1969	$y = -7.90 + 1.9351\ x$	0.939

Table 6.6.5

Correlation Regression Analysis

Production Aluminium Castings (x1000 metric tons) with Value of Manufacturing and Construction

x1000 million $ at constant market prices 1963.

where y = Production of Aluminium Castings, x1000 metric tons

x = Value of Manufacturing and Construction,

x1000 million US $ at Constant Market Prices

EMH

Criteria Correlated	Correlation Regression Equations	r^2
Production Aluminium Castings with Value of Manufacture and Construction		
All Countries in Table 6.1.9	$y = -0.5635 + 1.5965x$	0.650
All Countries in Table 6.1.9, excl Italy	$y = -0.8374 + 1.5991x$	0.668
Specific Production Aluminium Castings with Value of Manufacture and Construction		
All Countries in Table 6.2.3	$y = -1.4374 + 0.6604x$	0.243
All Countries in Table 6.2.3, excl Italy	$y = -0.8374 + 0.5991x$	0.220
Production of Aluminium Pressure Die castings with Value of Manufacture and Construction		
All Countries in Table 6.2.3	$y = 8.0374 + 1.1366x$	0.346
All Countries in Table 6.2.3, excl Italy	$y = 6.3731 + 1.1241x$	0.870

Table 6.6.6
Correlation Regression Analysis
% Compound Annual Rates of Growth, Cast Aluminium Production with Economic Indices

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.2.4	1960	$y = -5.5425 + 2.7045\ x$	0.995
	1969	$y = -55.4546 + 4.6067\ x$	0.993

Aluminium Wrought Products Production (x 1000 metric tons) with
Value of Manufacturing and Construction (x 1000 million US $ at constant market prices 1963)

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.2.4	1960	$y = -28.6271 + 8.2731\ x$	0.985
	1969	$y = -128.3005 + 13.7262\ x$	0.976

Table 6.6.7
Correlation Regression Analysis
Aluminium Wrought Products Production (x 1000 metric tons) with
Value of Gross Domestic Product (x 1000 million US $ at constant market prices 1963)

Criteria Correlated	Correlation Regression Equation	r^2
Total Wrought Products Production with Value of Gross Domestic Product	$y = 3.3984 + 1.3777\ x$	0.506
Total Wrought Products Production with Value of Manufacture and Construction	$y = 2.5780 + 1.2966\ x$	0.524
Total Flat Products Production with Value of Manufacture and Construction	$y = -0.5123 + 1.7708\ x$	0.698
Total Extruded Products Production with Value of Manufacture and Construction	$y = 0.7628 + 2.1283\ x$	0.978
Total Wire Production with Value of Manufacture and Construction	$y = 5.4241 + 1.2198\ x$	0.475
Total Foil Production with Value of Manufacture and Construction	$y = 5.1935 + 2.6229\ x$	0.964
Specific Wrought Aluminium Production with Value of Manufacture and Construction		
All Products	$y = 2.5780 + 0.2966\ x$	0.054
Flat Products	$y = -0.5123 + 0.7708\ x$	0.305
Extruded Products	$y = 0.7628 + 1.1283\ x$	0.927
Wire	$y = 5.4241 + 0.2198\ x$	0.029
Foil	$y = -5.1935 + 1.6229\ x$	0.910

Table 6.6.8
Correlation Regression Analysis

% Compound Annual Rates of Growth

Wrought Products Production with Value of Gross Domestic Product
Wrought Products Production with Value of Manufacturing and Construction

KR

Countries	Year	Correlation Regression Equations	r^2
All countries Table 6.2.5	1960	$y = 7.0228 + 29.0357\ x$	0.995
excl U S A	1960	$y = 6.4924 + 29.3506\ x$	0.863
excl Belg-Lux	1960	$y = 10.3936 + 28.7603\ x$	0.995
excl Belg-Lux and Italy	1960	$y = 4.1351 + 29.2210\ x$	0.998
All countries Table 6.2.5	1969	$y = 16.8244 + 36.8961\ x$	0.749
excl Belg-Lux	1969	$y = 35.6926 + 33.3001\ x$	0.993
excl U S A	1969	$y = 16.8244 + 36.8961\ x$	0.749
excl Italy	1969	$y = 14.3734 + 34.2364\ x$	0.995
excl Italy and Belg-Lux	1969	$y = 23.1943 + 33.8299\ x$	0.996

Table 6.6.9
Correlation Regression Analysis
Aluminium Consumption (x 1000 metric tons) in Transport Equipment with
Value of Transport Equipment (x 1000 million US $ at Constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equation	r^2
Total Aluminium Consumed in Transport Equipment with the Value of Transport Equipment		
All Countries in Table 6.2.5	$y = -1.2862 + 1.6581\ x$	0.973
All Countries in Table 6.2.5 excl Japan	$y = 1.0063 + 1.1929\ x$	0.813
All Countries in Table 6.2.5 excl U S A	$y = -1.1043 + 1.6548\ x$	0.976
Specific Aluminium Consumption in Transport Equipment with Value of Transport Equipment		
All Countries in Table 6.2.5	$y = -1.2862 + 0.6581\ x$	0.850

Table 6.6.10
Correlation Regression Analysis

% Compound Annual Rates of Growth
Aluminium Consumption in Transport Equipment with Value of Transport Equipment

KR

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.2.6	1960	$y = -4.2774 + 10.5914\ x$	0.973
excl Belg Lux Netherlands	1960	$y = -4.5968 + 10.6105\ x$	0.969
excl Belg-Lux U S A	1960	$y = 12.1803 + 5.3627\ x$	0.241
All Countries Table 6.2.6	1967	$y = -1.1127 + 12.3812\ x$	0.991
excl Belg-Lux	1967	$y = 0.9466 + 12.3063\ x$	0.990
excl Belg-Lux Netherlands USA	1967	$y = 19.4252 + 8.1222\ x$	0.710

Table 6.6.11
Correlation Regression Analysis
Aluminium Consumption (x 1000 metric tons) in Electrical Engineering Applications with
Value of Electrical Engineering Products (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Aluminium Consumed in Electrical Engineering with Value of Electrical Engineering Products		
All Countries in Table 6.2.6	$y = -2.1861 + 3.0717x$	0.648
All Countries in Table 6.2.6 excl Italy, Belg, Lux Netherlands	$y = -9.4824 + 4.0273x$	0.763
Specific Aluminium Consumption in Electrical Engineering Products with Value of Electrical Engineering Products.		
All Countries in Table 6.2.6	$y = -2.0661 + 2.0247x$	0.428
All Countries in Table 6.2.6 excl Italy, Belg Lux, Netherlands	$y = -9.3808 + 2.9766$	0.614

Table 6.6.12
Correlation Regression Analysis
% Compound Annual Rates of Growth
Aluminium Consumption in Electrical Engineering with Value of Electrical Engineering Products

KR

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.2.7	1960	y = - 74.7440 + 23.0057 x	0.964
excl U S A	1960	y = 0.2020 + 3.5955 x	0.592
All Countries Table 6.2.7	1969	y = - 184.2259 + 38.1616 x	0.904
excl U S A	1969	y = - 5.3000 + 11.0898 x	0.253
excl Japan & USA	1969	y = 14.7308 + 4.0941 x	0.305

Table 6.6.13
Correlation Regression Analysis
Aluminium Consumption (x 1000 metric tons) in Building and Construction with
Value of Building and Construction (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Aluminium Consumed in Building and Construction All Countries in Table 6.2.7	$y = 0.5179 + 2.9001\ x$	0.691
All Countries in Table 6.2.7 excl Japan	$y = 11.7325 - 0.1498\ x$	0.002
Specific Aluminium Consumption in Building and Construction with Value of Building and Construction All Countries in Table 6.2.7.	$y = 0.5179 + 1.9001\ x$	0.490
All Countries in Table 6.2.7 excl U S A	$y = -\ 0.5435 + 2.0099\ x$	0.482
All countries in Table 6.2.7 excl Japan	$y = 11.7325 - 1.1498\ x$	0.121
All Countries in Table 6.2.7 excl Japan and USA	$y = 15.7941 - 1.8955\ x$	0.226

Table 6.6.14
Correlation Regression Analysis
% Compound Annual Rates of Growth
Aluminium Consumption in Building and Construction with Value of Building and Construction

Countries	Year	Correlation Regression Equation	r^2
All Countries Table 6.2.8	1960	$y = 1.1484 + 0.2597\,x$	0.980
excl Japan and Belg-Lux	1960	$y = 5.8322 + 0.2493\,x$	0.995
All Countries Table 6.2.8	1969	$y = -35.9803 + 0.7125\,x$	0.986
excl Japan and Belg Lux	1969	$y = -35.4945 + 0.7188\,x$	0.998

Table 6.6.15
Correlation Regression Analysis
Aluminium Consumption (x 1000 metric tons) in Packaging with
Value of Gross Domestic Product (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Aluminium Consumed in Packaging with Gross Domestic Product		
All Countries in Table 6.2.8	$y = 7.5443 + 0.9496\ x$	0.056
All Countries in Table 6.2.8 excl Belg-Lux	$y = 0.6178 + 1.6028\ x$	0.494
All Countries in Table 6.2.8 excl Belg-Lux and Japan	$y = -\ 0.4575 + 1.8459\ x$	0.134
All Countries in Table 6.2.8 excl Belg-Lux Japan and USA	$y = 1.2891 + 1.0024\ x$	0.333

Table 6.6.16
Correlation Regression Analysis
% Compound Annual Rates of Growth
Aluminium Consumption in Packaging with Gross Domestic Product

KR

Countries	Year	Correlation Regression Equations	r^2
All countries Table 6.4.1	1960	$y = 75.9106 + 12.9477\ x$	0.972
	1969	$y = 204.0071 + 29.8625\ x$	0.921

Table 6.7.1

Correlation Regression Analysis

Total Plastics Material Consumption (X 1000 metric tons) with

Value of Manufacturing and Construction (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Plastics Material consumed with Value of Manufacturing and Construction All countries Table 6.5.1	$y = 9.0871 + 1.2069\ x$	0.809
Specific Plastics Materials consumption with Value of Manufacturing and Construction All Countries Table 6.5.1	$y = 9.0025 + 0.2151\ x$	0.105

Table 6.7.2

% Compound Annual Rates of Growth

Total Plastics Material Consumption with Value of Manufacturing and Construction

KR

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.4.2	1960	$y = 90.2810 + 7.5762\ x$	0.933
	1969	$y = 80.3407 + 7.4320\ x$	0.951

Table 6.7.3

% Compound Annual Rates of Growth

Total Refined Copper Consumption with Value of Manufacturing and Construction

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Refined Copper consumed with Value of Manufacturing and Construction All countries Table 6.5.2	$y = -4.2469 + 1.2688x$	0.510
Specific Refined Copper consumption with Value of Manufacturing and Construction All countries Table 6.5.2	$y = -4.3297 + 0.2777x$	0.047

Table 6.7.4

% Compound Annual Rates of Growth

Total Refined Copper Consumption with Value of Manufacturing and Construction

KR

Countries	Year	Correlation Regression Equations	r^2
All countries Table 6.4.3	1960	$y = 47.9082 + 4.7857\ x$	0.966
	1969	$y = 64.5441 + 4.8164\ x$	0.914

Table 6.7.5

Correlation Regression Analysis

Total Zinc Consumption (x 1000 metric tons) with

Value of Manufacturing and Construction (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Zinc consumed with Value of Manufacturing and Construction All Countries Table 6.5.3	$y = -4.2238 + 1.4822\,x$	0.741
Specific Zinc Consumption with Value of Manufacturing and Construction All Countries Table 6.5.3	$y = -4.2238 + 0.4822\,x$	0.233

Table 6.7.6

% Compound Annual Rates of Growth

Total Zinc Consumption with Value of Manufacturing and Construction

KR

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.4.4	1960	$y = 44.8266 + 3.6905\,x$	0.935
	1969	$y = 48.5989 + 3.0550\,x$	0.964

Table 6.7.7
Correlation Regression Analysis

Total Lead Consumption (x 1000 metric tons) with

Value of Manufacturing and Construction (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Lead consumed with Value of Manufacturing and Construction All Countries Table 6.5.4	$y = -1.0571 + 0.6914\,x$	0.501
Specific Lead consumption with Value of Manufacturing and Construction All Countries Table 6.5.4	$y = -1.0571 - 0.3086\,x$	0.167

Table 6.7.8
% Compound Annual Rates of Growth

Total Lead consumption with Value of Manufacturing and Construction

KR

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.5.4	1960	$y = 2.6520 + 0.3074\ x$	0.924
	1969	$y = 1.9782 + 0.2263\ x$	0.926

Table 6.7.9

Correlation Regression Analysis

Total Tin consumption (x 1000 metric tons) with

Value of Manufacturing and Construction (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Total Tin consumed with Value of Manufacturing and Construction All Countries Table 6.5.5	$y = -5.3070 + 0.9827x$	0.225
Specific Tin consumption with Value of Manufacturing and Construction All Countries Table 6.5.5	$y = -5.3070 - 0.0173x$	0.000

Table 6.7.10

% Compound Annual Rates of Growth

Total Tin consumption with Value of Manufacturing and Construction

KR

Countries	Year	Correlation Regression Equations	r^2
All Countries Table 6.4.6	1960	$y = 1508.35 + 327.03\ x$	0.979
	1969	$y = 4351.67 + 374.93\ x$	0.873

Table 6.7.11

Correlation Regression Analysis

Steel Consumption (x 1000 tons with

Value of Manufacturing and Construction (x 1000 million US $ at constant market prices 1963)

KR

Criteria Correlated	Correlation Regression Equations	r^2
Steel consumed with Value of Manufacturing and Construction All Countries Table 6.5.6	$y = -3.4890 + 1.5602\ x$	0.933
Specific Steel consumption with Value of Manufacturing and Construction All countries Table 6.5.6	$y = -3.4890 + 0.5602\ x$	0.642

Table 6.7.12

% Compound Annual Rates of Growth

Steel Consumption with Value of Manufacturing and Construction

KR

7. Description of Results
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 7.1.1.

Time Series Logarithmic Regression
Analysis of Economic Output Data

GDP

Table 6.1.1, shows the results of time series logarithmic regression analysis of GDP at constant market prices expressed in units of 1000mUS $ at constant market prices. This reveals a range of economic activity, both in terms of total output and rate of change in the level of output. UK is notable because in 1960 the level of output was high by international standards, exceeded marginally by Germany, but demonstrated the lowest rate of economic growth (2.9% per annum), within the sample examined. By 1969, Germany, France and Japan had established clear leads ahead of the UK in terms of GDP and Japan exhibited an exceptionally high rate of growth (10.7% per annum). Overall economic rate of growth in eight of the eleven countries in the sample was in the range (4.3 to 5.5% per annum) so that differences in economic performance are possibly related to the size of the economy and the structure of economic activity. The US represents an exceptionally high level of economic activity, approximately, eight times higher than the UK in 1969. Apart from Sweden, all countries exhibit relatively consistant growth performance with their respective logarithmic regression equation, as indicated by high (r^2) values.

7.1.2.
7.1.3.

7.1.2

Value of Manufacturing and Construction

Table 6.1.2, shows the values of manufacturing and construction (M & C) derived from the time series logarithmic regression analysis of GDP and the structure of economic activity published by OECD. In general, the rate of increase in manufacturing and construction activity was marginally higher than the rate of increase in GDP and the degree of spread in the rate of increase appreciably wider amongst European countries. These differences between the rates of growth of GDP and the value of M & C reflect the associated changes in the structures of the economies and reveal that for the UK and most of the other economies examined, excepting Austria and Norway, the proportion of total GDP represented by industrial and constructional activity increased between 1960-69.

Consistent with the growth analysis of GDP, the UK demonstrated the lowest rate of growth in the value of (M and C) and Japan the highest.

7.1.3.

Transport Equipment

Table 6.1.3, shows the values of transport equipment derived from the Time series logarithmic regression analysis of GDP and the structure of economic activity, together with relative rates of

.3 7.1.3
wth. A wide range in the level and rate of change in the
vel of performance is revealed. The UK is observed to have
relatively large transport equipment sector that has grown
owly during the period 1960-69.

7.1.4

7.1.4

Value of Electrical Products

Table 6.1.4 shows the estimated values of electrical machinery, apparatus and appliances derived from the OECD Engineering Series Statistics (43), which represent a different series from that used for the values of GDP, transport and construction and are not strictly comparable in terms of absolute value with the data reported for these sectors. However, comparison of values of electrical products internationally may be made with similar reservations to those already noted concerning international comparability of statistical data. Rates of growth in activity should give a reasonably consistent basis for inter-sector comparison, since these figures are relatively independent of the degree of approximation to the absolute values, provided that they bear the same relationship with the absolute values over a period of time. A wide range of activity and rate of change in activity is observed, however, it is notable that the UK performance reflects a relatively high rate of growth (5.1% per annum). The relative performance of different economies with respect to electrical products shows marked differences compared with the relative performances noted with respect to GDP and the values of transport equipment.

7.1.5 7.1.5

Value of Building and Construction

Table 6.1.5 shows the values of building and construction derived from the time series logarithmic regression analysis of GDP and the structure of economic activity published by OECD. The relationship between the rate of change in constructional activity and GDP is less consistent than the other values investigated. UK, Japan, France, exhibited higher rates of growth in construction than in GDP, whilst the remaining economies showed lower rates of growth in construction. Extremes in rates of growth were represented by the US and Japan and pronounced differences in international comparative performance with other economic sectors is noted.

 7.2.1

7.2

Time Series Logarithmic Regression Analysis of Aluminium Consumption

Primary and Secondary Aluminium Consumption

Table 6.1.6 shows the results of time series logarithmic regression analysis of total aluminium consumption including both primary and secondary metal corrected for the balance of imports and exports of secondary (or semi-finished) products, based upon Metallgeselschaft statistics (4). This measure of aluminium consumption is derived at the input stage of final product manufacture and does not take into account either the loss in aluminium yield during conversion to different end product forms or the balance in export trade in final products manufactured from aluminium. Values of aluminium consumption used in the present investigation are, therefore, a measure of the metal weight absorbed by end-use manufacturing industry in the UK and other economies and not directly the metal absorbed or consumed by the end-use domestic market. It is not possible to obtain data relating to the actual level of aluminium consumption in the end-use market, because statistics are not compiled. This is not surprising, since the final distribution of aluminium in final products would present an extremely diffuse situation involving thousands of firms and organisations in a given economy not lending itself to the accurate compilation of statistical data.

Table 6.1.6 represents a broadly based measure of consumption, therefore, dependent upon the consumption of primary and secondary metal mainly in the form of wrought or cast products forms by the total end-use manufacturing industry, including construction, in each economy. Values are reported for, the terminal year levels of consumption based upon logarithmic time series regression analysis, the value of (r^2) and the rate of growth in consumption. Most countries in the sample demonstrated reasonably consistent levels of growth, when assessed by the respective (r^2) value, although clearly a degree of annual deviation from the mean behaviour is evident. This deviation from the mean behaviour, when comparing performance in a given year with mean performance over a wide period of time, lends support to the use of logarithmic regression analysis to a growth situation in order to minimise the distorting influence of unusual terminal year data. Aluminium consumption behaviour, when measured in the manner indicated, showed an international tendency for a wider annual deviation from the time series mean behaviour than did GDP as indicated by the values of (r^2) reported.

Table 6.1.6, clearly establishes the basic observations that motivated the investigation; namely, that the rate of growth in aluminium consumption in the UK, 4.6% per annum, was low by international standards during the time period 1960-69.

A high proportion of the countries examined demonstrated growth rates in aluminium consumption between, (7.9 and 10.2% per annum), and Japan exhibited an exceptionally high rate of (20.4% per annum). It is clear that a wide range of performance with respect to aluminium consumption occurred with the UK and Japan representing extremes of behaviour when assessed using the criterion, mean annual rate of growth in consumption. Comparisons of the rates of growth in GDP, Table 6.1.1, with those for increase in aluminium consumption, Table 6.1.6, showthat in every case that aluminium consumption has grown more rapidly for a given country than GDP.

Large differences in the level of aluminium consumption between different countries is also shown in, Table 6.1.6, in a similar direction to the differences in the level of GDP. In spite of a low rate of growth in aluminium consumption in the UK, the actual level of consumption in 1969 was still high by international standards. However, the UK consumption in 1969 was marginally less than Germany although it had been higher in 1960, and considerably smaller than total Japaneese or US consumption.

7.2.2

Aluminium Consumption based upon OECD End-use Statistics

Table 6.1.7 shows the results of time series regression analysis of data provided for a narrower range of countries by OECD (3) of aluminium consumption by end-use manufacturing industries. This data is included in the analysis in order to illustrate that the source of statistical data can influence the quantitative results that emerge from analysis. Furthermore end-use statistics are the only means of studying the disaggregated consumption of aluminium in the economy, and it is this data that is subject to more detailed analysis in the investigation.

Comparison of results in Tables 6.1.6, 6.1.7, shows that different quantitative results occur dependent upon the source of data, and that the performance of some countries is more sensitive than others. However, similar relative observations emerge from Table 6.1.7, with respect to the relatively low rate of growth in aluminium consumption in the UK, 4.1% per annum, the range of (r^2) values, the comparison between the growth in aluminium consumption and GDP, and the relative levels of total consumption when compared internationally.

Exceptional behaviour is shown for the Belgium-Luxembourg data, considerably higher rate of growth than Table 6.1.6, and very uncertain growth in consumption behaviour in Austria. However, these are not regarded as key economies in the analysis.

7.3

7.3.1 7.3.1

Time Series Logarithmic Regression Analysis of Aluminium Product Forms Production

Production of Aluminium Castings

Table 6.1.8., shows the results of time series logarithmic regression analysis of total aluminium castings production based upon available data (4). As indicated by the (r^2) values, not all countries have shown consistent annual performance with respect to the time series mean trend. Values of regressed terminal years consumption is reported and the annual rates of growth in castings production. Consistent with total aluminium consumption in the UK the production of aluminium castings was at a relatively high level in 1960, but the rate of growth in production was low, 3.5% per annum in the following period up to 1970. A wide spread in international performance may be observed in Table 6.1.8, with UK and Japan representing the extremes of time series behaviour. OEA have indicated that the production data of aluminium castings in the UK represents reasonably accurately the consumption of castings by end-use industry, since only a small international trade in aluminium castings involving the UK occurs.

Rate of increase in total aluminium castings production in the UK was marginally above that for GDP (2.9% per annum) but below that for total aluminium consumption (4.1 - 4.6% per annum).

7.3.2

Production of Aluminium Pressure Die Castings

Table 6.1.9, shows the results of time series logarithmic regression analysis of aluminium pressure die castings production, based upon available data (4). Values of (r^2) indicate a remarkably consistent annual performance with respect to the time series mean trend for the countries for which data is available. Growth of aluminium pressure die castings production in the UK was high (8.6% per annum) compared with total aluminium consumption (4.1 - 4.6% per annum) and with total castings production (3.5% per annum). However, the rate of increase in aluminium pressure die castings in the UK was lower than any other country in the sample, in which the extremes of growth behaviour were represented by the UK and Italy. Table 6.2.3 also allows the comparison of the relative regressed level of output in 1960 and 1969 for the countries involved.

7.3.3

Production of Total Aluminium Wrought Products

Table 6.1.10, shows the results of time series logarithmic regression analysis of total aluminium wrought products production based upon available data (4). Most countries showed consistent annual performance with respect to the time series mean trend, as indicated by the (r^2) values. Similar observations may be made about total wrought products production as those made about castings production (7.3.1). The UK had a relatively large wrought products industry in 1960 which grew at the slow rate of (3.7% per annum), only marginally higher than castings production (3.5% per annum). Both castings and wrought products production grew more slowly than total aluminium consumption in the UK in the period 1960-1969, indicating that the difference is accounted for by a decline in exports and/or an increase in imports of semi-finished product forms.

7.3.4.

Disaggregated Production Data for Flat, Extruded, Wire and Foil Products

Table 6.1.11, shows the results of time series logarithmic regression analysis of disaggregated wrought products production based upon very limited available data (4). Growth in the UK production of wrought product forms was constituted by a wide range of disaggregated performance when comparing flat products, (0.8% per annum), extruded products (8.2% per annum), wire (12.7% per annum) and foil (3.4% per annum) In contrast the growth in production in Italy, USA and Japan was generally higher than the UK, especially with respect to flat products and foil production.

Time Series Logarithmic Regression Analysis of Disaggregated Aluminium Consumption

7.4.1 Aluminium Consumption in Transport Equipment Applications

Table 6.1.12 shows the results of time series regression analysis of aluminium end-use consumption in the transport equipment manufacturing sector of a range of economies for which data was available. Deviation of annual performance from the mean time series trend, (r^2) values, justifies the use of regression analysis in computing growth rates and terminal year data. A range of international performance is observed including the UK which shows a relatively large sector of aluminium consumption which grew slowly (4.0% per annum) during the period 1960-69. Comparative levels of consumption are shown together with associated rates of growth ranging up to (24.7% per annum) Japan.

7.42 Aluminium Consumption in Electrical Engineering, Appliances and Apparatus

Table 6.1.13 shows the results of time series regression analysis of aluminium end-use consumption in the electrical engineering, appliances and apparatus manufacturing sector of a range of economies for which data was available (4) (3). Values of (r^2) again show annual deviation from mean time series trends, which were based upon non-standard terminal year limits dependent upon the available data, especially that required for correlation analysis. High rates of growth in aluminium consumption are evident in the electrical engineering sector compared with total aluminium consumption and with the rate of increase in consumption in the transport equipment sector. UK performance reveals a relatively high rate of growth

(8.5% per annum) in a large sector. Growth in Japanese aluminium consumption was extremely high (37.5% per annum), but had only reached a level marginally above the UK by 1969. A wide range of international performance behaviour is evident with respect to aluminium consumption in this sector.

7.4 3 Aluminium Consumption in Building and Construction

Table 6.1.14, shows the results of time series regression analysis of aluminium end-use consumption in the building and construction sector of a range of economies for which data was available (4) (3). Values of (r^2) reveal very consistent annual performance with respect to the mean time series trend except in the case of the UK (r^2 =0.552) and Italy (r^2= 0.475).

UK performance includes a low rate of growth (2.4% per annum) which is less than any other end use sector examined on an international basis, and also below the rate of growth in GDP (2.9% per annum) for the period 1960-69. This performance contrasts sharply with the very high rates of growth in aluminium consumption in construction achieved by Germany (17.9% per annum), Belgium-Luxembourg (18.5% per annum), and Japan (47.9% per annum). The level of consumption in the UK construction sector was similar to France, and Italy by 1969, but less than half the Germany level and an even smaller proportion when compared with Japan and the very large US level.

7.4 4 Aluminium Consumption in Packaging

Table 6.1.15, shows the results of time series logarithmic regression analysis of aluminium end-use consumption in the packaging sector of a range of economies for which data was available, (4) (5). Pronounced deviation from the mean time series trend in consumption is noted particularly for the UK, which demonstrated the lowest rate of growth (3.7% per annum) and Belgium-Luxemburg the highest rate, (31.4% per annum). UK level of consumption was similar to France and Italy, but appreciably less than Germany by 1969. Japanese consumption of aluminium was still comparatively low in 1969 but had grown rapidly (17.6% per annum) since 1960. The US sector also grew very rapidly (16.7% per annum), in spite of its previously established high level in 1960, more rapidly than any other sector consumption examined in that country.

7.5 Time Series Logarithmic Regression Analysis of Disaggregated UK Aluminium Consumption

Table 6.3 1, shows the results of time series logarithmic regression analysis of disaggregated UK aluminium consumption based upon the Aluminium Federation statistics of the end-use consumption by manufacturing industry of wrought and cast product forms. Information determined includes, regressed terminal year consumption in a wide range of end-use sectors, annual growth rates (r^2) values, and the percentage of total UK aluminium consumption represented by each sector of use in the terminal years, thus constituting a profile of end-use.

A wide range of behaviour in disaggregated UK aluminium consumption is evident, with sector consumption growth rate having ranged from (-8.0% per annum) for railway equipment to (+ 8.5% per annum) for electrical products. The proportion of total aluminium absorbed by different end-use sectors is not only changing with time as a direct result of the differences in growth rate, but also varies from a large aggregate sector (transport equipment 31.1% in 1969) down to a small disaggregated sector (railways, 0.5% in 1969).

Miscellaneous, railways and aircraft represent the statistically identified contracting sectors of end-use consumption. Miscellaneous consumption may be caused to contract as the end-use is placed in a more clearly defined sector or may join the growing (8.5% per annum) of unidentified end-uses.

7.6 Time Series Logarithmic Regression Analysis of the Consumption of Other Materials

7.6.1 Consumption of Plastics Materials

Table 6.4.1 shows the results of time series logarithmic regression analysis of plastic materials consumption in a range of countries. High (r^2) values indicate annual consumption consistent with the time series mean trends for all countries in the sample. International differences in the growth rate of plastic materials consumption are observed over a wide range from UK (10.9% per annum) to Japan (22.1% per annum). Although the UK growth rate of plastic material is high relative to the growth in UK-GDP (2.9% annum) it is, nevertheless, low by international standards.

For most countries in the sample the plastics materials consumption growth rate is considerably higher than that of aluminium, except for Japan where the rates are very similar, falling in the range (20.4 - 23.3% per annum).

Clearly a wide range also exists in the level of plastics materials consumption between different countries, and although differences between the density of aluminium and plastic materials distorts any meaning in the comparison of total weight consumed, it is noteworthy that the relationship between the two figures is similar for some economies eg UK and USA , Germany and France, and very dissimilar between others eg UK and Germany.

7.6.2
Consumption of Copper

Table 6.4.2shows the results of time series logarithmic regression analysis of copper consumption in a range of countries. Low (r^2) values indicate inconsistent annual consumption with respect to the time series mean trends for many of the countries in the sample, including Germany, Italy Netherlands and Norway. No (r^2) value is obtained for the UK because no significant change in the level of copper consumption occurred during the period examined. In contrast, Japan revealed consistent performance (r^2= 0.893) and USA comparatively consistent performance (r^2= 0.712).

Rates of change in the level of copper consumption also varied considerably from Sweden (-1.1% per annum) to Japan (11.3% per annum). Rate of increase in copper consumption also appear in many countries to fall below the rate of increase in GDP, the notable exceptions were Japan and the USA.

7.6.3 Consumption of Zinc

Table 6.4.3, shows the results of the time series logarithmic regression analysis of zinc consumption in a range of countries. The consistency of annual consumption with the time series mean trend varied considerably from one country to another. A low (r^2) value for the UK is associated with a very low rate of growth in consumption (0.8% per annum). Regressed terminal year data and rates of growth are presented for comparative study, in which the UK and Japan represent extremes in growth performance.

Eight of the eleven countries in the sample examined demonstrated growth rates in zinc consumption below their

 7.6.3

respective growth rates in GDP. The three exceptions to the general case were Italy, Japan and the U.S.A.

7.6.4 Consumption of Lead

Table 6.4.4, shows the results of time series logarithmic regression analysis of lead consumption in a range of countries. The consistency of annual consumption with the time series mean trend varied considerably from one country to another. A low (r^2) value for the UK is associated with a negligible change in the level of lead consumption during the period 1960-69. All countries in the sample, with the exception of Italy, demonstrated an appreciably lower growth rate in lead consumption than GDP, although a wide range in performance between (-0.1% to 6.5% per annum) was observed.

7.6.5
Consumption of Tin

Table 6.4.5, shows the results of time series logarithmic regression analysis of tin consumption in a range of countries. The consistency of annual consumption with the time series mean trend varied considerably from one country to another. A high (r^2) value for the UK is associated with a progressive reduction (-2.1% per annum) in tin consumption. All countries, except Norway, in the sample demonstrated in growth rate in tin consumption below GDP, and a five countries showed an actual reduction in the total of tin consumed per annum. Although the Japanese tin consumption increased by (6.7% per annum) its total annual consumption by 1969 was only marginally above the UK. Norway, the other country to show exceptional growth in tin consumption (8.6% per annum) still had a relatively low level of total consumption, 464 metric tons in 1969.

7.6.6.
Consumption of Steel

Table 6.4.6. shows the results of time series logarithmic regression analysis of steel consumption in a range of countries. Most countries in the sample showed a progressive change in annual consumption consistent with the time series mean trend as indicated by the relatively high (r^2) values. UK is the most notable exception to annual consistency in the change in annual steel consumption, ($r^2 = 0.327$), and an annual growth rate (2.1% per annum). A wide range in performance was observed between countries, however, the rate of change in steel consumption was very similar to GDP for most countries.

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8
International Correlation between Aluminium Consumption and Economic Output Data

8.1.1 Correlation between the Level of Aluminium Consumption and GDP

Tables 6.6.1, 6.6.3, show the international correlation relationships between total aluminium consumption and GDP expressed in US $ at 1963 constant market prices. The data correlated is based upon regressed terminal year data, for both consumption and GDP, derived from time series logarithmic regression analysis. Two sets of aluminium consumption data are used in the correlation:

(i) Primary plus secondary aluminium statistics.

(ii) End-use of aluminium statistics.

Irrespective of the source of aluminium consumption data the following observations may be made:

(a) A high value of co-efficient of determination (r^2) is obtained.

(b) Slope of the international straight line relationship between aluminium consumption and GDP increased between 1960 and 1969.

(c) Inclusion of the US data tends to increase the slope of the relationship and decrease the intercept when GDP is equal to zero.

However, the derived straight line regression equations are influenced by the source of data and cannot be regarded as absolute relationships.

8.1.1

Comparison of the UK consumption of aluminium in 1960 and 1969 with the international correlation between consumption and GDP reveals that:

(a) In 1960, the UK time series regressed consumption was 382 thousand metric tons compared with the corresponding international mean level of consumption 308 or 305 thousand metric tons, dependent upon whether or not the US data is included in the correlation.

(b) In 1969, the UK time series regressed consumption was 572 thousand metric tons compared with the corresponding international mean level of consumption 549 - 562 thousand metric tons.

At the beginning of the period 1960-69, the UK aluminium consumption was approximately 26% above that representing the international regressed mean consumption corresponding to the UK level of GDP. By 1969, however, the UK lead over the international regressed mean consumption level had been progressively decreased to only a marginal, if not insignificant, lead when measured in aggregate consumption and macro-economic terms. Similarly, the German consumption in 1960 was 351 thousand metric tons compared with an international mean level of 335 thousand metric tons and by 1969 was marginally below the mean international level of 714 at 698 thousand metric tons. In contrast France displayed levels of consumption below the international regressed mean consumption in 1960, 212 compared with 274, and in 1969, 387 compared with 646, thousand metric tons. The actual US data fits the international linear regression equations accurately, because it represents an extreme level of GDP and aluminium consumption in international terms.

8.1.2
Correlation between the Level of Aluminium Consumption and the Value of Manufacturing and Construction

Table 6.6.2, shows the international correlation relationships between total aluminium consumption and the value of manufacturing and construction in US $ at constant market prices 1963, based upon regressed terminal year data.

The following observations may be made, which are consistent with the previous correlation 8.1.1:

(a) A high value of the co-efficient of determination (r^2) is obtained, when the US data is included, but ($r^2 = 0.519$) in 1969 when US data is excluded.

(b) Slope of the international straight line relationship between aluminium consumption and the value of manufacturing and construction increased between 1960 and 1969.

(c) Inclusion of the US data tends to increase the slope of the relationship and decrease the intercept when the value of manufacturing and construction is equal to zero.

8.1.2
8.1.3

(d) In 1960 the UK aluminium consumption was above the international regressed mean level 382 compared with 352, but by 1969 was below the international mean level 572 compared with 633 thousand metric tons. 8.1.2 8.1.3

8.1.3

Correlation between the Rates of Growth in, Aluminium Consumption and GDP and the Value of Manufacturing and Construction

Table 6.6.4, shows a number of international correlation relationships, in which the annual rate of growth in aluminium consumption is computed from regressed terminal year data based upon alternative statistical sources, namely primary and secondary metal consumption and end-use consumption.

The following observations may be made:

(a) Higher values of (r^2) are obtained in correlations derived from aluminium consumption data based upon primary and secondary metal compared with end-use statistics.

(b) Relative high values of (r^2) are obtained from the correlation of the rate of growth in aluminium consumption and GDP or the value of manufacturing and construction (0.67 to 0.848).

(c) Slope of the relationship is marginally higher when correlating the growth in aluminium consumption with the value of manufacturing and construction than with GDP, but in both cases approximated to (2.0x) with a constant having a value between approx (-0.5 and -2.4).

8.1.3
(d) Comparison of the UK growth rate performance in total aluminium consumption with the international mean trends determined indicates that, in general, the UK performance was marginally below the forecast level, typical actual performance, 4.6% per annum, compared with a forecast 4.66% per annum based upon the rate of change in the value of manufacturing and construction.

Correlation between the Level of Aluminium Castings Production and the Value of Manufacturing and Contruction

Table 6.6.5, shows two international correlation relationships between the level of aluminium castings production and the value of manufacturing and construction in 1960 and 1969, one based upon total aluminium castings production and the other upon the production of pressure die castings.

The following observations may be made:

(a) A high value of the co-efficient of determination is obtained, between (0.939 and 0.974) irrespective, of the year 1960 or 1969, or the type of information, total castings or pressure die castings, but include the high US levels of consumption.

(b) Slopes of both correlation relationships increased between 1960 and 1969, namely all castings (1.6873x to 3.2430x) and pressure die castings (1.1676x to 1.9351x).

(c) Positive intercepts occurred in the total castings correlations in contrast with negative intercepts with pressure die castings.

(d) UK total castings production in 1960 was above the international regressed mean level (97.8 compared with 77.5 thousand metric tons), but by 1969 had fallen below (133.0 compared with 153.0 thousand metric tons).

(e) Similarly, UK production of pressure die castings was very close to the international regressed mean level in 1960 (24.6 compared with 26.9 thousand metric tons) but had fallen considerably behind by 1969(51.8 compared with 75.7 thousand metric tons).

8.2.2.
Correlation between the Rates of Growth in, Cast Aluminium Production and the Value of Manufacturing and Construction

Table 6.6.6, shows the international correlation relationship, in which the annual rate of growth in cast aluminium production is computed separately from regressed terminal year data for total cast and die cast aluminium.

The following observations may be made:

(a) Moderately high values of (r^2) are obtained for correlations derived for total cast aluminium, in the range (0.65 - 0.668), irrespective of whether or not Italy is included in the sample.

(b) Value of (r^2) obtained for the correlations derived for die cast aluminium is very sensitive to the inclusion of the Italian data, due to the exceptionally high rate of growth in die cast aluminium in Italy in relation to the rate of growth in the value of manufacturing and construction.

(c) Comparison of UK growth rate performance, with respect to total aluminium castings production, with the international correlation indicates that the rate of increase has been appreciably below the international mean, actual performance 3.5% per annum, compared with a forecast, 4.86% per annum, based upon international behaviour.

(d) Comparison of UK growth rate performance, with respect to die castings production, shows a similar low figure, 8.6% per annum, compared with the forecast, 10.2% per annum, based upon international behaviour excluding Italy.

8.3.1

Correlation between the Level of Wrought Aluminium Production and GDP and the Value of Manufacturing and Construction

Table 6.6.7, shows the international correlation relationships between aggregate wrought products production and the levels of GDP and the value of manufacturing and construction, based upon regressed terminal year data.

The following observations may be made:

(a) A high value of (r^2), in the range 0.976 - 0.995, is obtained irrespective of whether aggregate wrought products production is correlated with GDP or the value of manufacturing and construction.

(b) Slope of the linear international regression relationship, between wrought products production and GDP or the value of manufacturing and construction increased appreciably between 1960 and 1969.

(c) Comparison of the level of UK wrought products production in 1960, with the level predicted by the international mean relation relating production to the value of manufacturing and construction, indicates that the level of production was marginally higher, 249.3 against 236.9 thousand metric tons, however, by 1969 UK production was appreciably lower, 345.0 against 464.8 thousand metric tons.

Correlation between the Rates of Growth in, Wrought Aluminium Products Production and GDP and the Value of Manufacturing and Construction

Table 6.6.8, shows a number of international correlation relationships in which the annual rate of growth in aggregate and disaggregated wrought aluminium production is related in the main to the annual rate of increase in the value of manufacture and construction.

The following observations may be made:

(a) Relationship between the annual rate of growth in aggregate aluminium production and GDP or value of manufacturing and construction exhibits considerable international deviation from the mean trend, (r^2) in the range 0.506 - 0.524.

(b) UK annual rate of growth in aggregate wrought products production was considerably below the mean international trend, 3.7% compared with 6.99% per annum.

(c) Relationships between the annual rate of growth in individual wrought product production and the value of manufacturing and construction, exhibited markedly different degrees of international consistency, flat products ($r^2 = 0.698$), extruded products ($r^2 = 0.978$), wire products ($r^2 = 0.475$) and foil ($r^2 = 0.964$), but these relationships were based upon a limited sample size.

8.3.2 8.3.2

(d) International growth rate correlations for individual wrought products showed distinct differencies in response to growth in the value of manufacturing and construction, although the slope was greater than unity in every product form examined.

8.4.1

Correlation between Aluminium Consumption in Transport Equipment and the Value of Transport Equipment

Table 6.6.9, shows the international correlation relationships between aluminium consumption in transport equipment and the value of transport equipment, based upon regressed terminal year data. The sample of countries included in the regression analysis used to obtain the international relationship has been varied in order to observe the degree of dependence of the trend observed on the performance of particular countries.

The following observations may be made:

(a) A high value of ($r^2 = 0.995$) was obtained when all the countries in the sample were included in the analysis, but even when the USA data was excluded a high ($r^2 = 0.863$) was still obtained when analysing the 1960 trend.

(b) By 1969, greater deviation from the mean international trend was observed, all countries in the sample ($r^2 = 0.749$), but by excluding Belgium - Luxembourg and Italy the ($r^2 = 0.996$) deviation was drastically reduced.

(c) Both the slope and the intercept of the international relationships increased appreciably between 1960 and 1969.

(d) UK aluminium consumption in the transport equipment end use sector was slightly below the international mean trend in 1960, 98.95 compared with 107.2 thousand metric tons, and had drifted further below by 1969, 141.3 compared with approximately 178 thousand metric tons dependent upon the relationship used.

8.4.2. 8.4.2.

Correlation between the Rates of Growth in, Aluminium Consumption in Transport Equipment and the Value of Transport Equipment

Table 6.6.10, shows the international correlation relationships between the rates of growth in aluminium consumption in transport equipment and the value of transport equipment. The sample of countries included in the regression analysis used to obtain the international relationship has been varied in order to observe the degree of dependence of the trend observed on the performance of particular countries.

The following observations may be made:

(a) A high value of ($r^2 = 0.973$) was obtained when all the countries in the sample were included.

(b) When the Japanese data was excluded, a high value of ($r^2 = 0.813$) was still obtained, however, the slope of the relationship was reduced which was compensated by an increase in the intercept.

(c) Rate of increase in the consumption of aluminium in transport equipment was shown, by the international relationship derived, to be in excess of the rate of increase in the value of transport equipment.

(d) Comparison with the international trend, excluding the Japanese data, indicated that the UK growth rate of aluminium consumption in transport equipment was marginally higher, 4.0% compared with 3.75% per annum, however, using the trend, including the Japanese data, indicated that the UK performance even better, 4.0% compared with 2.5% per annum.

8.5.1

Correlation between Aluminium Consumption in Electrical Engineering Applications and the Value of Electrical Engineering Products

Table 6.6.11, shows the international correlation relationship between the level of aluminium consumption in electrical engineering products and the value of electrical engineering products. The sample of countries included in the regression analysis, used to obtain the international relationship, has been varied in order to observe the degree of dependence of the trend observed on the performance of particular countries.

The following observations may be made:

(a) A high value of (r^2 = 0.973 - 0.991) was obtained when all the countries in the sample were included, in 1960 and 1967 respectively.

(b) Value of (r^2 = 0.241) was reduced markedly in 1960 when the Belgium - Luxembourg and USA data was excluded, but had less influence in 1967.

(c) Both the slope and the intercept of the international relationships increased appreciably between 1960 and 1967.

(d) Comparison of the level of UK aluminium consumption with the international mean trends indicates that in 1960, UK consumption was marginally higher, 33.9 compared with 32.6 thousand metric tons, and in 1967 the UK consumption coincided almost exactly with the international trend, 60.0 compared with 59.9 thousand metric tons.

Correlation between the Rates of Growth in, Aluminium Consumption in Electrical Engineering Applications and the Value of Electrical Engineering Products

Table 6.6.12 shows the international correlation relationships between the rates of growth in, aluminium consumption in electrical engineering products and the value of electrical engineering products. The sample of countries included in the regression analysis used to obtain the international relationship was varied in order to observe the degree of dependence of the trend observed on the performance of particular countries.

The following observations may be made:

(a) An appreciable degree of deviation was observed from the international mean trend, ($r^2 = 0.648$), which was still evident even when Italy, Belgium - Luxembourg and the Netherlands data was excluded ($r^2 = 0.763$).

(b) Irrespective of the two international trends used, the rate of increase in UK aluminium consumption in the electrical engineering sector was lower than the level indicated by the trend, 8.5% compared with 13.5% per annum, taking into consideration all countries in the sample, or 8.5% compared with 11.1% per annum, using the exclusive trend.

Correlation between Aluminium Consumption in Building and Construction and the Value of Building and Construction

Table 6.6.13, shows the international correlation relationships between the level of aluminium consumption in building and construction and the value of building and construction. The effect of excluding the US data from the regression analysis has been evaluated.

The following observations may be made:

(a) A high value of (r^2 = 0.964 - 0.904) is obtained when all the countries in the sample were included both in 1960 and 1969 respectively.

(b) Value of (r^2 = 0.592) (1960) and (r^2 = 0.253) (1969) was drastically reduced by excluding the US data.

(c) Irrespective of the relationship used, the slope increased between 1960 and 1969.

(d) Comparison of the UK consumption with the international trend that excluded the US data indicated a higher consumption in 1960 than the trend, 29.85 compared with 18.18 thousand metric tons, by 1969 the trend becomes very uncertain, but even when the two countries using exceptionally high levels of aluminium in construction are excluded, the UK consumption in building and construction was low by international standards, 37.2 compared with approximately 43.0 thousand metric tons.

8.6.2

Correlation between the Rates of Growth in, Aluminium Consumption in Building and Construction and the Value of Building and Construction

Table 6.6.14, shows the international correlation relationships between the rates of growth in, aluminium consumption in building and construction and the value of building and construction. The effect of excluding the Japanese data from the regression analysis has been evaluated because of the exceptionally high growth rate involved.

The following observation may be made:

(a) A moderate ($r^2 = 0.691$) is obtained when all countries in the sample were included, however, removal of the Japanese data from the trend analysis, produces a meaningless correlation ($r^2 = 0.002$).

 8.7.1

Correlation between Aluminium Consumption in Packaging and GDP

Table 6.6.15, shows the international correlation relationships between the level of aluminium consumption in packaging and GDP. Although previous correlations were largely based upon the value of output in the relevant economic sector this was not possible for packaging, because international statistics for the value of packaging did not exist as far as could be ascertained, (46). The sample of countries included in the regression analysis, used to obtain the international relationship, has been varied in order to observe the degree of dependence of the trend observed on the performance of particular countries.

The following observations may be made:

(a) A high value of ($r^2 = 0.980 - 0.998$) was obtained in 1960 and 1969, irrespective of whether certain countries displaying apparently unusual behaviour are excluded.

(b) Slope of the relationships increased between 1960 and 1969 and the value of the intercept decreased.

(c) Comparison of the UK consumption with the international trend in 1960 indicated a consumption below the trend (25.2 compared with 30.0 thousand metric tons), however, by 1969 the UK consumption was very close to the international trend (35.0 compared with 35.8 thousand metric tons).

8.7.2
Correlation between the Rates of Growth in, Aluminium Consumption in Packaging and GDP

Table 6.6.16, shows the international correlation relationships between the rates of growth in, aluminium consumption in packaging and GDP. The effect of changing the sample of countries adopted in the regression analysis was studied due to the lack of correlation observed. Although, the exclusion of Belgium - Luxembourg from the sample improved the value of (r^2) from 0.056 to 0.494, considerable deviation from any international trend is evident.

9.1.1

9. International Correlation between the Consumption of Other Materials and Economic Output Data

Correlation between the Level of Plastics Materials Consumption and the Value of Manufacturing and Construction

Table 6.7.1 shows the international correlation relationship between total plastics materials consumption and the value of manufacturing and construction. The data correlated is based upon regressed terminal year data, for both consumption and values, derived from time series logarithmic regression analysis.

The following observations may be made:

(a) A high value of coefficient of determination (r^2) is obtained,

(b) Slope of the international straight line relationship between plastics materials consumption and the value of manufacturing and construction increased considerably between 1960 and 1969.

Comparison of the U.K.consumption of aluminium in 1960 and 1969 with the international correlation: in Table 6.7.1 reveals that:

(a) In 1960, the U.K. time series regressed consumption was 467.7 thousand metric tons compared with the corresponding international mean level of consumption 490 thousand metric tons.

(b) In 1969 the UK time series regressed consumption was 1188 thousand matric tons compared with the international regressed mean consumption 1499 thousand metric tons.

At the beginning of the period 1960-69, the UK regressed consumption of plastics materials was only marginally below the level indicated by the international relationship with the value of manufacture and construction, however by 1969 the level of plastics materials regressed consumption was 20.7% below that indicated by the international mean behaviour.

9.1.2
Correlation between the Rates of Growth in Plastics Materials Consumption and the Value of Manufacturing and Construction

Table 6.7.2 shows the international correlation between the rate of growth in plastics materials consumption and the rate of growth in the value of manufacturing and construction.

The following observations may be made:

(a) A high value of (r^2) is obtained (0.809)

(b) Growth rate of plastics materials consumption in the UK, 10.9% per annum was appreciably lower than the level of growth indicated by the international mean trend relationship, 13.2% per annum, consistent with the observations made 9.1.1, concerning the relative level of UK consumption with respect to the value of manufacturing and construction in 1960 and 1969.

9.2.1
Correlation between the level of Copper Consumption and the Value of Manufacturing and Construction

Table 6.7.3 shows the international correlation relationship between total refined copper consumption and the value of manufacturing and construction, based upon regressed terminal year data.

The following observations may be made:

(a) A high value of the coefficient of determination (r^2)is obtained,

(b) Slope of the international straight line relationship between refined copper consumption and the value of manufacturing and construction decreased marginally between 1960 and 1969.

Comparison of the UK consumption of refined copper in 1960 and 1969 with the international correlations in Table 6.7.3 reveals that:

(a) No appreciable increase in the consumption of copper occurred in the UK between 1960 and 1969.

(b) In 1960 the UK consumption of refined copper (563 thousand metric tons) was considerably above the level indicated by the international correlation (313 thousand metric tons) and remained substantially above in 1969 (563 compared with 403 thousand metric tons),although the gap had reduced due to the absence of growth in UK copper consumption during the period examined.

9.2.2. Correlation between the Rates of Growth in Refined Copper Consumption and the Value of Manufacturing and Construction

Table 6.7.4 shows the international correlation between the rate of growth in refined copper consumption and the rate of growth in the value of manufacturing and construction.

The following observations may be made:

(a) A relatively low value of (r^2) is obtained (0.500).

(b) Although the international relationship Table 6.7.4 relating growth rates indicates a small rate of increase in copper consumption at the economic growth rate in the UK, this did not occur, however as reported in 9.2.1 the UK consumption of refined copper was high both in 1960 and 1969, relative to the level of economic activity.

9.3.1
Correlation between the Level Zinc Consumption and the Value of Manufacturing and Construction

Table 6.7.5. shows the international correlation relationship between total zinc consumption and the value of manufacturing and construction based upon regressed terminal year data.

The following observations may be made:

(a) A high value of coefficient of determination(r^2) is obtained.

(b) Slope of the international straight line relationship between zinc consumption and the value of manufacturing and construction increased only slightly between 1960 and 1969.

Comparison of the UK consumption of zinc in 1960 and 1969 with the international correlations in Table 6.7.5 reveals that:

(a) In 1960, the UK regressed consumption (262.3 thousand metric tons) was considerably higher than the computed international mean level (202 thousand metric tons).

(b) Consistent with a low rate of growth in the consumption (0.8% per annum) the UK and the international mean level had moved closer by 1969 (281.4 and 272 thousand metric tons) although the UK consumption was still marginally higher.

9.3.2.
Correlation between the Rates of Growth in Zinc Consumption and the Value of Manufacturing and Construction

Table 6.7.6. shows the international correlation relationship between the rate of growth in zinc consumption and the rate of growth in the value of manufacturing and construction.

The following observations may be made:

(a) A moderately high value of (r^2) is obtained (0.741)

(b) Growth rate of sinc consumption in the UK (0.8% per annum) is marginally below the level indicated by the international mean trend relationship (0.83% per annum) but is consistent with the observations made 9.3.1.

9.4.1.
Correlation between the Level of Lead Consumption and the Value of Manufacturing and Construction

Table 6.7.7. shows the international correlation relationship between total consumption and the value of manufacturing and construction based upon regressed terminal year data.

The following observations may be made:

(a) A high value of coefficient of determination (r^2) is obtained

(b) Slope of the international straight line relationship between lead consumption and the value of manufacturing and construction decreased during the period 1960 - 1969.

Comparison of the UK . consumption of lead in 1960 with the international correlation in Table 6.7.7. reveals that the actual level of lead consumption in the UK was considerable higher than the international mean behaviour (288 compared with 163 thousand metric tons).

A small decrease in the UK lead consumption occurred by 1969, but the level remained above the international mean level (284 compared with 181 thousand metric tons)

9.4.2. 9.4.2.

Correlation between the Rates of Growth in Lead Consumption and the Value of Manufacturing and Construction

Table 6.7.8. shows the international correlation relationship between the rate of growth in lead consumption and the rate of growth in the value of manufacturing and construction.

The following observations may be made:

(a) A relatively low value of (r^2) is obtained (0.501)

(b) UK showed a small rate of decrease in lead consumption (-0.1% per annum) between 1960 and 1969 in contrast with the 1.29% per annum increase indicated by the international growth rate correlation, however this performance is consistent with observations made in 9.4.1.

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9.5.1.
Correlation between the Level of Tin Consumption and the Value of Manufacturing and Construction

Table 6.7.9 shows the international correlation relationship between total tin consumption and the value of manufacturing and construction decreased during the period 1960-69.

Comparison of the UK tin consumption in both 1960 and 1969 with the international correlations in Table 6.7.9 reveals that the UK level of tin consumption was considerably higher than the international mean behaviour in both terminal years, namely (23.14 compared with 12.56 thousand metric tons in 1960) and (19.21 compared with 11.89 thousand metric tons in 1969).

9.5.2.
Correlation between the Rates of Growth in Tin Consumption and the Value of Manufacturing and Construction

Table 6.7.10 shows the international correlation relationship between the rate of growth in tin consumption and the rate of growth in the value of manufacturing and construction.

The following observations may be made:

(a) A low value of (r^2) is obtained (0.225)

(b) The UK showed a rate of decrease in tin consumption (2.1% per annum) similar to the decrease indicated by the international correlation growth rate relationship in Table 6.7.10, in spite of the very high level of UK consumption in 1960.

9.6.1.
Correlation between the Level of Steel Consumption and the Value of Manufacturing and Construction

Table 6.7.11 shows the international correlation relationship between total steel consumption and the value of manufacturing and construction based upon regressed terminal year data.

The following observations may be made:

(a) A high value of coefficient of determination (r^2) is obtained,

(b) Slope of the international straight line relationship between steel consumption and the value of manufacturing and construction increased marginally during the period 1960-69.

Comparison of the UK consumption of steel in 1960 and 1969 with the international correlation in Table 6.7.11 reveals that:

(a) In 1960, the UK regressed consumption (13,510 thousand tons) was marginally higher than the level computed from the international mean relationship (11,558 thousand tons).

(b) In 1969, the UK regressed consumption (16,290 thousand tons) was less than the level computed from the international mean relationship (20,551 thousand tons).

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9.6.2.
Correlation between the Rates of Growth in Steel Consumption and the Value of Manufacturing and Construction

Table 6.7.12 shows the international correlation relationship between the rate of growth in steel consumption and the rate of growth in the value of manufacturing and construction.

The following observations may be made:

(a) A high value of (r^2) is obtained (0.933)

(b) U.K. showed a rate of increase in steel consumption (2.1% per annum) marginally above the rate of increase computed from the international growth rate correlation (1.8%) in Table 6.7.12.

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10 Specific Consumption of Aluminium and the Rate of Change in Specific Consumption

Aggregate Specific Consumption, Product Form and End-Use Sector Analysis

Specific consumption of aluminium has been computed internationally for aluminium used in different product forms and different end-use sectors and shown in Tables 6.2.2/3/4/5/6/7/8, and rates of change correlated with rates of change in indices of economic output in Tables 6.6.4/6/8/10/12/14/. An explanation of the ratio adopted in order to determine specific consumption of aluminium has been given in section 4.2. and data used in the determination of specific consumption has been outlined in the previous sections devoted to the description of results.

The following observations may be made:

(a) Table 6.2.2 shows that the values obtained for the aggregate specific consumption of aluminium internationally is influenced by the source of statistical data used.
Adopting the more comprehensive series based upon the consumption of primary and secondary metal it appears that in 1960 the aggregate specific consumption of aluminium in the UK (11.9 metric tons per million US $) was relatively high by compared with other countries in the sample. Only the US revealed a

higher value of specific consumption (12.5 metric tons per million US $) and other countries Germany, France, Italy and Japan showed considerably lower levels (8.63, 7.14, 9.63 and 9.4 metric tons per million US $, respectively). Apart from France, the UK showed the lowest rate of increase in specific consumption (1.2% per annum). Rate of increase in specific consumption represents the difference in the rate of increase in the numerator and denominator data used in the ratio, so that in the case of UK aggregate specific consumption of aluminium it represents the difference between the rates of growth in, aggregate aluminium consumption and the value of manufacturing and construction (4.6 - 3.4 = 1.2% per annum).

As a result of the higher rates of growth in specific consumption in other countries, either the lead shown by the UK had been diminished by 1969 and in the case of Japan a substantial lead equal to the US position had been established. Hence, if the trend continued the UK level of specific consumption would deteriorate with respect to Germany and Italy and would not close the substantial lead established by the US. Correlation between the rates of growth in aggregate specific consumption and the value of manufacturing and construction, Table 6.6.4 reveals lower values of $r^2$0.554 - 0.376, then the correlation between the growth rates in aggregate aluminium consumption and the value of manufacturing and construction.

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(b) Table 6.2.3, shows the international values for the specific production of total aluminium castings. In 1960 the UK specific production of aluminium castings (3.05 metric tons per million US $) was equal to that of Germany and similar to Japan, however appreciable international difference existed revealing in particular that the US demonstrated a particularly low level (1.77 metric tons per million US $). During the decade period the UK achieved a negligible increase in the specific production of aluminium castings, while both Japan and Italy achieved progressive exploitation of the cast process. The US also showed a high rate of increase in specific production. Growth rates in the specific consumption of aluminium pressure die castings was generally higher than total castings, even the UK (5.2% per annum) indicating that a progressive movement occured into pressure die castings which grew from 25% to 39% of total castings production. However, the growth rate in the specific production of pressure die castings in the UK was low by comparison with other European countries, especially Italy (17.5% per annum). Correlation between the rates of growth in the specific production of cast aluminium with the value of manufacture and constructio n. Table 6.6.6, revealed a low value of (r^2) in the region of 0.230, irrespective of whether the outstanding performanc e, Italy, is included in the analysis.

(c) Table 6.2.4, shows the international values for the specific production of total wrought aluminium products. In 1960, the UK specific production of wrought products (7.76 metric tons per million US $) was similar to Japan and higher than Germany ,Italy and France and below the US. Specific production grew relatively very slowly in the UK between 1960-69, so that by 1969 it had been over-taken by Germany and Italy and was considerably lower than the Janpanese or US levels.

Belgium-Luxenbourg showed both extremely high levels of specific production of aluminium wrought products and a high rate of growth, revealing the important part played as an exporter of semi-finished product forms. It is evident that since the specific production of castings and wrought products in the U.K. was appreciably below the increase in aggregate specific consumption that the domestic increase in consumption was satisfied by a combination of decreased exports of wrought products from the U.K. and an increase in imports during the period examined.

No international correlation was found between the aggregate specific production of wrought aluminium product form and the value of manufacture and construction, Table 6.6.8, however, when individual product forms were examined a close correlation was found in the case of extruded forms and foil, but the significance of this observation is limited by the small sample size available.

(d) Table 6.2.5, shows the international values for the specific consumption of aluminium in transport equipment. In 1960, the U.K. specific consumption in transport equipment (28.6 metric tons per million U.S. $) was marginally lower than Germany and France and less than half the Italian level. Other countries, apart from France showed a more rapid growth rate in specific consumption in transport equipment, especially Japan, so that by 1969 the U.K. Level was lower than any other major transport equipment producer in the sample. Belgium-Luxembourg clearly had no developed market for aluminium in transport equipment. Italy remained an outstanding performer with respect to specific consumption and Japan, with respect to growth rate. A high value of (r^2) was obtained (0.850), Table 6.6.10, when correlating the international rates of growth in specific consumption of aluminium in transport equipment and the value of transport equipment.

(e) Table 6.2.6, shows the international values for the specific consumption of aluminium in electrical applications. In 1960 the U.K. occupied an intermediate level when compared internationally, although Belgium-Luxembourg had a low level which grew rapidly up to 1967. The differences between the international levels of specific consumption in this sector appeared to be generally small, or in the process of rapid correction, Japan 27.7% annual growth rate. Correlation between the rates of growth in specific consumption and the value of electrical equipment, Table 6.6.12, appeared uncertain and sensitive to composition of the sample of countries used in the analysis (r^2 values between 0.428 and 0.614). Amongst the sectors

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examined the U.K. showed a higher rate of growth in specific consumption of aluminium in electrical equipment than any other sector.

(f) Table 6.2.7, shows the international values for the specific consumption of aluminium in building and construction . In 1960 the U.K. demonstrated a progressive position when compared with the other European countries in the sample. Specific consumption in the U.S. in 1960, however, was more than three times higher than the U.K. The U.K. was unique in the sample by showing a negative increase in specific consumption(-1.2% per annum) whilst other countries in general exhibited high rates of growth in specific consumption in this sector. By 1969, the U.K. had been substantially over taken by Germany and Belgium-Luxembourg. Japan increased at 33.6% per annum so that its specific consumption was beginning to assume US Levels as apposed to European. In spite of the high specific consumption achieved by the US in 1960, its value continued to grow rapidly between 1960 and 1969. Correlation between the rates of growth in specific consumption and the value of building and construction. Table 6.6.14, was uncertain and sensitive to the sample of countries used in the analysis (r^2 values between 0.490 and 0.121). In particular, the international correlation was uncertain when the Japanese data was excluded.

(g) Table 6.2.8, shows the international values for specific consumption of aluminium in packaging. In 1960 the U.K. demonstrated a similar level if specific consumption in this sector, when compared with Germany and Italy, but had achieved a higher level than the U.S. or France. During the period 1960-1969, the U.K. showed a low rate of

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growth in specific consumption in this sector (0.8% per annum). Considerable international differences in the growth in specific consumption are apparent, in which the US achieved a high rate and Belgium Luxenbourg an extremely high rate (27.0% per annum) which transformed a very low specific consumption in 1960 to a typical European level by 1969. Japan appeared to be less developed than the other countries examined with respect to the use of aluminium in packaging, but was progressing at a rapid rate (6.9% per annum in specific consumption). No international correlation between the rates of growth in the specific consumption of aluminium in packaging and GDP could be identified.

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Specific Consumption of Other Materials and the Rate of Change in Specific Consumption.

Aggregate Specific Consumption Analysis of Other Materials.

Specific consumption of plastics materials, copper, zinc, lead, tin and steel has been computed internationally and shown in Tables 6.5.1/2/3/4/5/6 and rates of change correlated with rates of change in the value of manufacture and construction, Tables 6.7.2/4/6/10/12. An explanation of the ratio adopted in order to determine specific consumption has been given in section 4.2 and data used in the determination of specific consumption has been outlined in previous sections devoted to the description of results.

The following observations may be made:

(a) Table 6.5.1, shows the international values for the specific consumption of plastics materials. In 1960, the UK specific consumption of plastics materials, 15.44 metric tons per million US $, was similar to the US but less than Germany and Italy and considerably less than Japan. Most of the countries in the sample showed an annual rate of growth in the range (9.5 - 10.5%) independent of the level in 1960, however, the UK showed only (7.5% per annum) between 1960 - 69. By 1969, considerable international disparity existed in the level of plastics materials specific consumption with the UK occupying a position at the lower end of the scale. No correlation was found between the rate of growth in the specific consumption of plastics materials and the rate of growth in the value of manufacturing and construction Table 6,7.2.

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(b) Table 6.5.2. shows the international values for the specific consumption of refined copper. In 1960, the UK specific consumption of copper (17.55 metric tons per million US $) was relatively high compared with other countries and the UK level decreased appreciably (3.4% per annum) because the actual level of copper consumption remained static. Most countries in this sample showed a similar tendency to decrease their specific consumption of copper even though the actual level of copper consumption increased, however, no correlation was found internationally between the rate of change in specific consumption and the rate of increase in the value of manufacturing and construction, Table 6.7.4.

(c) Table 6.5.3. shows the international values for the specific consumption of zinc. In 1960, the UK specific consumption of zinc (8.16 metric tons per million US $) was relatively high compared with other countries, although Belgium - Luxembourg represented an exceptional case. UK specific consumption decreased between 1960 - 69 by 2.6% per annum, a trend in common with most other countries, however, no international correlation was found with the rate of change in the value of manufacturing and construction, Table 6.7.6.

(d) Table 6.5.4. shows the international values for this specific consumption lead. In 1960, the UK specific consumption of lead (8.93 metric tons per million US $) was relatively high compared with other countries, but decreased appreciably (3.5% per annum) during the period 1960 - 69, because the actual level of consumption remained substantially unchanged. Most countries in this sample showed a trend toward reduction in the specific consumption of lead, but the rate of decrease achieved was found not to be related to the initial level of specific consumption or the rate of change in the value of manufacture and construction, Table 6.7.8.

(e) Table 6.5.5. shows the international values for the specific consumption of tin. In 1960, the UK specific consumption of tin (0.721 metric tons per million US $) was high compared with many other countries in the sample, but decreased rapidly (5.5% per annum) during the period 1960 - 69. Other countries showed even higher rates of decrease in specific consumption in spite of having lower values in 1960, but no correlation was found with the rate of change in the value of manufacturing and construction Table 6.7.10.

(f) Table 6.5.6. shows the international values for the specific consumption of steel. In 1960, the UK specific consumption of steel showed an intermediate level with respect to other countries which showed a tendency to decrease marginally (1.3% per annum) between 1960 - 69 in common with most other countries. Japan demonstrated an exceptional absorption of steel and a growth in specific consumption over the period examined. An interesting correlation was found betweem the rate of change in the specific consumption of steel and the rate of change in the value of manufacturing and construction, $r^2 = 0.642$, Table 6.7.12.

12. Discussion

Criteria for the Evaluation of International Differences in the Aggregate Consumption of Aluminium and Other Materials

Aggregate consumption of aluminium in the UK during the period 1960-1969 demonstrated several important aspects of behaviour compared with aluminium consumption in similarly developed economies:

(1) UK consumption was high by international standards both in 1960 and 1969, Table 6.1.6

(II) UK growth rate in aluminium consumption, 4.6% per annum, was lower than any other country included in the analysis.

(III) UK consumption was less than Germany by 1969 and was considerably less than Japan and the US, but remained higher than France.

(IV) The source of statistical data influenced the quantitative results that were obtained, but very similar relative performance with respect to aluminium consumption was observed between the UK and other economies, in spite of the inevitable lack of absolute accuracy associated with the compilation of consumption statistics.

(V) A higher degree of variance in time series behaviour was observed in aluminium consumption than in GDP when examined internationally, as revealed by the respective (r^2) values, Tables 6.1.6 and 6.1.1.

(VI) Comparison of the growth rates in aluminium consumption and GDP revealed that in every country examined the rate associated with consumption had exceeded GDP.

Cyclic behaviour with respect to the consumption of aluminium is revealed from year to year by the value of (r^2) determined for a given country. Cyclic trends make the use of time series logarithmic regression analysis advisable in order to minimise the distorting influence of unusual terminal year data when examining growth rate behaviour. Greater variance in progression of aluminium consumption compared with GDP is observed to be a common form of international behaviour and is associated with the movement in the level of aluminium stocks held by end-use industries as opposed to wide variation in the actual consumption of aluminium by end-use industries. It may be recalled that international consumption statistics are based upon the supply of primary and secondary metal or the supply of semi-finished product forms to the end-use industries, as opposed to the output of final products containing aluminium. When future product demand is uncertain and unpromising, firms attempt to improve their cash flows by reducing their inventory of materials and conversely when evidence exists for an upturn in product demand, firms tend to build up material stocks in order to be well placed to satisfy the demand. This defensive behaviour tends to produce a larger fluctuation in demand for the intermediate product form than actually occurs in the consumption of final products. Further it is reasonable to hypothesise that the more uncertain the demand, or growth in demand, for a given material becomes the greater the variance that will be shown from the mean trend behaviour in material consumption.

Evidence which supports this proposed hypothesis that explains cyclic demand in relationship with consumption behaviour is provided by a comparison of (r^2) values obtained for the time series logarithmic regression analysis of the consumption of aluminium with other materials, Tables 6.1.6, 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5, 6.4.6. The following observations on (r^2) values lend support to the argument:

(I) Higher rates of growth in consumption of plastics materials are associated with higher values of (r^2) than obtained with aluminium.

(II) Uncertain growth in the consumption of copper, zinc, lead and tin is associated with lower values of (r^2) than obtained with aluminium.

However, it must be recognised that low values of (r^2) may also be produced when negligible growth occurs, that is when a growth relationship is difficult to establish. Further, it is conceivable that forcasting demand for certain materials may be associated with more certainty and these lead to less difference occurring between the recorded levels of demand and consumption. Taking into consideration the uncertainties outlined concerning the accuracy of consumption and economic performance statistics, aggregate consumption of aluminium in the UK does appear to show appreciable differences compared with the similarly developed economies included in the analysis. However, as explained in section 4.2, an analysis of UK aluminium consumption would be incomplete without an attempt to evaluate relative international performance by the use of relevant criteria. Certain criteria of performance emerge directly from the time series analysis of materials, namely gross consumption, disaggregated consumption in end-use sectors and the rate of change in consumption over a period of time. Comparisons involving gross consumption and disaggregated consumption may be expected to be distorted by the size of a given domestic market, differences that exist in the stage of economic development, and the structure of economic activity. These factors may be illustrated by comparing the gross consumption of aluminium in the UK with the US and Belgium-Luxembourg, which shows that the large population in the US market consume a considerably larger quantity of aluminium than the UK market and similarly the UK market consumes more than the Belgium-Luxembourg. This population related consumption effect may be eliminated by a comparison of the per capita consumption, Table 5.2.4, which also shows a substantial and changing difference in the level of consumption between countries. Population differences between countries cannot, however, be regarded as the factor controlling the level and change in level of consumption, since a highly populated undeveloped country would be expected to consume negligible quantities of aluminium in end-use manufacturing industries. Criteria based upon the stage of economic development and economic structure are, therefore, postulated to be more relevant for the evaluation of international differences in the consumption of aluminium.

Economic criteria of consumption adopted in this analysis were based upon the ratio of the weight of aluminium consumed with the added value of output at constant market prices in a given economy referred to as specific consumption and the relationship between the rates of change in the level of aluminium consumption and the added value of output at constant market prices. Appropriate criteria may be formulated in order to facilitate comparison of consumption behaviour at the macro or micro-economic level for which data is available. At the most macro level, added value of economic activity is given by GDP, but dependent upon the structure of the economy will be constituted by a different proportion of elements, Tables 5.1.7 and 5.1.8. Since aluminium consumption is estimated from the input into end-use manufacturing industry and construction, it is logical to argue that a more precise measure of the absorption of aluminium in the relevant sectors of the economy will be provided by using the added value in manufacturing and construction at the macro-economic level and the added value of output from a given economic sector when formulating any criteria intended for the comparison at the micro-economic level, as described in section 4.2.

Similar economic criteria of consumption may be used to advantage when comparing international behaviour with respect to the consumption of other materials examined in the analysis, since the same observations may be made about the relative effects of population, economic development and economic structure.

12.2
International Comparison of the Aggregate Specific Consumption of Aluminium

In 1960 the aggregate specific consumption of aluminium in the UK (11.9 metric tons per million US $)was well advanced compared with similarly developed European economies and only marginally below the US level. Comparing the UK specific consumption with that of Germany in 1960, (8.63 metric tons per million US $) shows that the absorption of aluminium by end-use industry and construction was substantially ahead in aggregate terms. These observations lead to the possibility that one or a number of the following factors are relevant:

(I) That, up until 1960 at least, the UK industry had been aware of the cost and performance benefits associated with the use of aluminium compared with alternative and possibly traditional materials, and had demonstrated successful innovative performance.

(II) The product mix in the UK economy in 1960 was more conducive to the higher level of specific consumption than similar, but not identical European economies.

(III) Alternative new materials had been absorbed by these European economies in preference to aluminium.

Successful innovation performance with respect to materials and processes demands a combination of effective technical management, with respect to the designs of components and structures and process design, together with the need to be able to demonstrate a forecasted cost benefit that may be derived. Forecast cost benefit analysis may be directed at the manufacturing units concerned with producing the final components and will be judged against financial criteria of performance, including return on capital, internal rate of return, cash flow profile analysis, or may be directed at the end use application which may derive improved properties, performance, aesthetics and which may be capable of expression in quantitative cost benefit terms. Since the cost of performances in service is directly dependent upon the cost of manufacture, any cost benefits derived in service are at least in part dependent upon the realisation of cost savings in manufacture.

Forecast cost results obtained when the innovation of a new material or process is proposed is dependent not only upon the technical expertise that determines product and process design, but also upon the demand for the product being produced. Furthermore, the demand and the rate of change in demand will determine the cash flow profile obtained against the capital investment required for the material innovation. In macro economic terms the demand may be expressed in terms of the value of manufacturing and construction. It is relevant, therefore, to examine the relationship between the change in aluminium consumption and the change in the real value of manufactured output and construction since over the long term production is equal to demand.

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During the period 1960-69 the UK showed a low rate of growth in the aggregate specific consumption of aluminium (1.2% per annum) by international standards, although it is important to observe that an increase above the 1960 level had been achieved and only France amongst the countries in the sample showed a lower rate of increase in specific consumption. Since the UK commenced the period with a high level of specific consumption of aluminium and since the ability to innovate is likely to be related to the effect of economic climate on cost benefit performance, it is relevant to note the international relationship between the level of aluminium consumption and the value of manufacturing and construction during the period examined and the correlation between the respective rates of change.

Section 8.1.2 identifies the relevant trends in the relationship between aluminium consumption and the value of manufacturing and construction and the relative position occupied by the UK in 1960 and 1969. This shows that aluminium consumption does tend to be directly related to the value of manufacturing and construction, but that the strength of the international relationship is markedly affected by the inclusion or exclusion of the exceptionally high values representing the US data. Appreciable deviation is found to occur in the level of aggregate aluminium consumption in countries having a similar value of manufacturing and construction. The slope of the relationship tended to increase with time, consistent with the observation that the countries examined increased their levels of specific aggregate aluminium consumption during the period. Furthermore, the slope of the relationship increased with the inclusion of the US data indicating that specific consumption of aluminium tends to increase at higher levels of manufacturing output. At a given value of manufacturing output the specific consumption is tending to increase with time due to the international diffusion of technological innovation, but this does not imply that specific consumption will necessarily increase in a stagnant economy. Growth in aluminium consumption is also linked with the growth in the value of manufacturing output, section 8.1.3 where dependent upon the source of statistical data used, the rate of growth in aluminium consumption is nearly twice as fast as the increase in the value of manufacture and construction, subject to a small constant correction between (-0.5 and - 2.5).

Comparison of the UK aluminium consumption performance with the international trends indicates that the growth rate performance (4.6% per annum) was marginally below the international trend (4.66% per annum) and that during the period 1960-69 the UK consumption declined from a level above that linked with its value of manufacturing and construction in 1960 to marginally below in 1969. UK performance with respect to aggregate aluminium consumption demonstrates that in spite of a technological lead having existed in 1960, and the fact that the international diffusion of technological innovation tends to increase the specific consumption of aluminium at a given value of manufacturing and construction, the rate of real increase in aluminium consumption is closely linked with the rate of growth in the value of

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manufacturing and construction. Rate of economic growth in the UK is clearly an important factor in determining the rate at which the growth in aluminium consumption may continue. It may have been possible in 1960, to postulate that the UK absorption of aluminium was approaching a maturity level associated with the lead position occupied with respect to other European countries and that the US specific consumption represented a non-standard achievement associated with economic wealth and the particular needs satisfied by aluminium in the US. By 1969, the lead shown by the UK in aggregate specific consumption of aluminium had been narrowed by other European countries and had been left far behind by US and Japanese performance. Clearly, the performance shown by US and Japan indicates that considerable potential exists for beneficial increase in the aggregate specific consumption of aluminium in the UK and other European countries beyond the 1969 levels.

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International Comparison of Disaggregated Aluminium Consumption

Comparison of UK aggregate aluminium consumption, using relevant criteria of performance, with consumption in similarly developed economies revealed evidence to support the existence of trends in behaviour linking, the level of aluminium consumption with the value of manufacturing and construction, and the respective rates of change. UK performance could be partly explained by the relationships observed, however, it would be an over simplication to claim that the entire difference in performance could be attributed to these factors. When selecting countries to be included in the analysis the aim was to include developed countries having a similar economic structure from the limited range of countries for which aluminium consumption data is available. It is highly improbable, however, that all the countries will have identical economic structure within the macro sector manufacturing and construction and that they will be at the same stage of technological development. In developing a more detailed explanation for the UK aluminium consumption behaviour, it is necessary to examine the performance of micro-economic sectors, since different sectors may be expected to demonstrate their own response to the absorption of aluminium. Consumption of aluminium by specific micro-economic sectors are likely to demonstrate behaviour that is related to the stage of development of the sector within an economy, the benefits associated with using aluminium in the sector and the rate of growth of output from the sector. Summation of the activity within all sectors of the economy results in the macro-economic behaviour previously identified. Comparison of UK micro-economic aluminium consumption performance with other economies should reveal the differences in the stage of development of a given sector in different economies and the way in which aluminium consumption has grown within a sector dependent upon the growth of the sector. Comparison of specific aluminium consumption between sectors is indicative of the relative importance of aluminium in a given sector, the degree of benefit derived from using aluminium and the compatibility between the properties of aluminium and the needs of the sector.

Analysis of the constitution of aggregate aluminium consumption in a given economy reveals the profile of end-use and identifies those sectors which play a major influential part in determining consumption behaviour. International comparison of the end-use profile of aluminium consumption is, therefore, extremely relevant to the analysis of international differencies in consumption behaviour.

Demand by end-use sectors for aluminium is satisfied by the supply of a range of intermediate product forms, including castings, strip, sheet, foil, extrusion, wire and forgings. Hence, the demand for aluminium is not only related to the compatibility between the properties of aluminium and the needs of the end-use, but also to the ability of a given process route to provide aluminium in a form that achieves the cost benefit which provides the basic incentive for innovation. Product forms are likely to show characteristic linkages with end-use sectors due to the extent to which they satisfy the needs of the respective sectors. Dependent upon the demand for aluminium from these sectors and the cost structure of the process route involved, different responses may be observed within the range of economies studied. The relationship between the demand expressed for a given product form from a given end-use industry is likely to reflect the ability of the semi-finished product manufacturer to produce the form at a competitive cost to the required technical specification. Consumption behaviour by end-use manufacturing industry in an economy may be affected by the efficiency and performance of the semi-finished product manufacturers within the economy, although this may be offset by importing the required product form.

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12.4.1. International Comparison of Cast Aluminium Consumption 12.4.1.

Cast product forms constitute a significant proportion of total aluminium consumption in the UK and in similarly developed industrialised economies. Four of the six countries, for which detailed statistics were available. Table 6.2.3.1. exhibited similar proportions of cast products to total aluminium products, namely the UK, Germany, France and Japan, each having slightly in excess of 30%. In contrast the proportion of cast product forms produced by Italy was closer to 40% and the USA produced only (14.0 - 18%).

Consistent with the relative aggregate specific consumption of aluminium in the UK, consumption of total cast aluminium was well advanced compared with similarly developed European economies. In 1960, the UK specific consumption of cast aluminium was equal to Germany and well in advance of the USA. Table 6.2.3. shows that the output from the UK foundry industry was considerably higher than Italy, France and Japan in 1960 and approximately 25% less than Germany. At the same time the US cast product output was three times larger than the UK output. This contrasting data indicates the advantage provided by using specific consumption/production when making international comparisons.

Comparison of growth rates in the output of cast aluminium products, Table 6.2.3, revealed that the UK displayed the lowest rate of increase during the period 1960-69. Increase in cast product output was so similar to the rate of increase in the value of manufacturing and construction that the specific consumption of cast product forms remained virtually unchanged. During the same period Germany showed a significant increase in specific consumption (1.1% per annum) and the US, Japan and Italy made substantial increases (7.6, 6.4 and 5.1% per annum respectively). By 1969, both Japan and Italy showed exceptional levels of specific consumption, that is above 5.0 metric tons per million US $, compared with the UK level of 3.08 metric tons per million US $.

Correlation analysis reported, sections 8.2.1 and 8.2.2, indicated a close relationship between the level of cast products production and the value of manufacturing and construction in the economies examined, but a slightly weaker relationship between the respective rates of growth. Analysis revealed that the slope of the relationship between cast products production and the value of manufacturing and construction increased appreciably between 1960 and 1969 indicating that an international trend existed for an increase in the absorption of total aluminium castings and pressure die castings. This is consistent with the international tendency for the specific consumption of cast aluminium products to to increase. However, the ability of a given country to achieve an increase in specific consumption is partly dependent upon, the rate of growth in the value of manufacturing and construction, the level of specific consumption achieved at the beginning of the period examined and a predisposed capacity to absorb or produce aluminium castings.

International Comparison of Pressure Die Castings Production

Table 6.2.3 shows marked international differences in the proportion of total castings produced by pressure die casting. As far as European countries are concerned the UK produced the highest proportion of pressure diecastings in its total production in 1960 (26%) but had been overtaken by all except France by 1969. The US occupied a remarkable lead over all countries in 1960, but had been overtaken by Italy by 1969, however, both countries exhibited a remarkably high propensity to exploit the technologically advanced process whilst the UK lost its European lead position. Japan showed a more balanced increase in output between different casting processes, but still achieved a high proportional output (48.0%) by pressure die casting.

Although the growth in output of aluminium cast products appears to be closely linked with the macro-economic performance of the countries examined the same consistency of behaviour is not shown with respect to the exploitation of the pressure die casting process. More detailed analysis is necessary in order to explain the contrasts observed in international performance and in particular the apparent inability of the UK to maintain a leading position. A number of basic factors are relevant and may assume different levels of significance dependent upon the economic circumstances and end-use industry product mix within a given economy:

(1) Consumption of aluminium castings is largely a derived demand

12.4.2
from end-use manufacturing industries and the ability of these industries to make technological innovations and associated capital investment is closely linked with the rate of economic growth.

(ii) Capital cost of die casting plant is relatively low, say up to £110,000 (1970 prices) and does not constitute a large barrier to progressive increase in productive capacity; ie the process is highly divisible.

(iii) In order that the process should be technically feasible and that the full techno-cost benefit should be derived, in the situation where an alternative process and or material is being displaced, a redesign of the final product is essential. This pre-requisite of using the pressure die casting process usually involves high development costs on the part of the end-use manufacture as well as as close co-operation with the die casting foundry.

(iv) High fixed costs are introduced by the expenditure involved in making the metal dies which are specific to a given component. The range of cost for one die set is about, £6000 - £20,000 (1970 prices) dependent upon the size and geometrical complexity of the final product. High specific tool cost for a given component or product must be distributed over a high production rate and volume in order that any cost benefit may be derived. As a direct result of this process cost structure, the pressure die casting process is only economically compatible with mass produced products.

(v) A close linkage is likely to occur between the consumption of aluminium pressure die castings and mass production industries, which are able to take advantage of the increase in productivity achieved by this process in terms of manpower, material, energy, capital and even space.

(vi) Products will have varying compatibility with the pressure die casting process and aluminium dependent upon their size, geometry and end-use functions.

(vii) Two types of growth in the specific consumption of pressure die cast aluminium castings may occur:

(a) Displacement of alternative aluminium castings made by other casting processes:

(b) Displacement of alternative materials, irrespective of the previous process route used.

The elementary generalised observations relevant to process selection that emerge are:

(i) Pressure die casting is a potentially competitive process for mass produced products with definable constraints associated with material compatibility, size and geometry of the final product.

(ii) The potential maximum proportion of total aluminium castings in a given economy will approach a maximum, which will almost inevitably be less than 100%, dependent upon the product mix of aluminium castings in the economy.

(iii) The rate at which the maximum proportion of pressure die castings is approached will be influenced by the related cost benefit incentive, ability of the die casting industry and the end-use industry to exploit these advantages in a given economic environment. Where the motivation or restraint exerted by the economy are those relevant to the performance of mass production industries.

12.4.3. End-use for Aluminium Castings

International statistics are not published that indicate the distribution of aluminium cast product consumption over the end-use industrial sector, apart from the data published by OEA, in 1967, which provided information about the UK, Germany France and the USA for the year 1966, Table 6.2.3.2, but unfortunately do not include Italy. Four countries represent a very small sample for generalised conclusions and data for a single year does not permit trend analysis, however, it is evident that a high proportion of total aluminium castings production is absorbed by the transport equipment industry sector indicating a high level of technical and economic compatibility. A very strong linkage exists between the output of the aluminium foundry industry and input into the transport equipment end-use sector in all four countries. with remarkably little diversification in France and marginally more in the US.

Specific consumptions of all aluminium, cast and wrought product forms are compared, Table 6.2.3.2. for the transport equipment, electrical engineering, building and construction sectors for the four economies UK, Germany, France and the US.

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Specific consumption of total aluminium in the transport equipment is very similar in the UK, France and the USA (between 32.0 and 36.0 metric tons per million US $ of transport equipment output) and slightly higher in Germany (44.5 metric tons per million US $) in 1966. However, the composition of specific consumption when analysed in terms of cast and wrought aluminium product forms is markedly different, so that the UK total specific aluminium consumption is comprised of approximately equal cast and wrought aluminium specific consumptions, whilst in Germany and France the ratio of cast to wrought specific consumptions is approximately 3:1 and in the US the ratio is 1:2. Although some difference in the ratio of cast to wrought specific consumptions may be postulated to occur as a direct result of competition between alternative processes producing different results nationally, the pronounced difference recorded in the analysis is more plausibly attributed to international differences in the product structure of the transport equipment end-use industry. Table 6.3.5 reveals the inhomogeneous constitution of the transport sector of the UK economy. So that although aluminium has a strong linkage with each sub-sector of the transport equipment main sector, each will have a different level of linkage with wrought and cast process routes dependent upon the product description and aspects of demand including size of market and rate of output required.

An international correlation was tested between the rate of growth of all aluminium cast product forms, because more detailed statistics are unavailable, and the rate of increase in the value of transport equipment, resulting in the straight line regression ($y = 1.03x + 1.65$, $r^2 = 0.945$) having a remarkably high degree of correlation involving value of manufacturing and construction, this transport sector relationship does not show any appreciable gearing effect between the rate of growth in aluminium consumption and the sector growth rate, mainly as a result of the Japanese performance at the extremity of the regression line. This suggests the possibility of a constant, but small, increase in specific consumption in the sector independent of the growth rate in the sector. UK cast aluminium consumption is below the international mean regression line, but marginally above the line $y = x$, consistent with previous analysis of the UK transport sector, 6.6.9. The coefficient of determination, $r^2 = 0.945$, is in agreement with the previously identified strong linkage between the consumption of cast aluminium products and the transport equipment sector, but the significance of the regression relationship must be viewed against the fact that total cast aluminium consumption was plotted and not aluminium used in the transport equipment sector. Increase in the Italian cast product consumption above the mean international regression line suggests either, that the transport equipment sector has demonstrated an exceptionally high propensity to consume aluminium, or more likely that other, unidentified, industrial end-use sectors are more significant in Italy. This latter explanation for the high Italian growth rate in cast aluminium consumption and the exceptionally high proportion of pressure die cast products (67.3% in 1969) is logically related to the expansion in the manufacture of consumer durables eg vacuum cleaners, washing machines and type-writers.

Specific aluminium consumption in the electrical engineering sector, Table 6.2.3.2 reveals a very consistent international overall level of both cast and wrought forms, (between 12.75 and 15.0 metric tons per million US $) but a higher proportion of wrought material, wire and cable, than cast product. In fact, a fairly wide spread in cast product aluminium specific consumption occurs internationally, from Germany (5.02) to the USA (1.61 metric tons per million US $) with the UK occupying an intermediate position (3.67 metric tons per million US $) although having the lowest overall specific consumption.

Wide differences in specific aluminium consumption in the building and construction sector occur not only with respect to the use of cast products but also overall. In particular the specific cast aluminium consumption in Germany is nearly 1.0 metric tons per million US $, compared with only 0.51 metric tons per million US $ in the UK, and a relatively high value of 1.27 metric tons per US $ in the USA. Only a minor share of total castings production enter this end-use sector, more variation is observed in the absorption of wrought product forms (sheet and extrusion) than cast forms, however, it would appear that many potential building and construction applications for cast aluminium appear either unexploited or remained relatively unexploited in the UK compared with Germany and especially the US in 1966, but France appeared even less progressive.

12.4.3 12.4.3

Cast aluminium product forms represent an important way of exploiting the processing and end-use techno-economic advantages of aluminium as illustrated by the high proportion of total aluminium consumption absorbed in this way. Furthermore, recycled scrap in the form of secondary metals and alloys provides the raw material for most commercial aluminium alloy castings, Table 5.2.6.1, which constitutes a feature of the industry which is assuming growing economic importance with respect to the conversation of energy and raw materials. Casting is the shortest process route from raw material to final product and therefore is potentially associated with high productivity, low capital intensity, minimal working capital and responsiveness to development, eg pressure die casting. Casting in general provides a wide range of design freedom in the final product however, Table 6.3.3, the distribution of total cast products consumption in the UK shows very strong linkages with certain end-use sectors, namely mechanically driven road transport (52.3%), electrical plant and equipment (13.03%), domestic, office and medical equipment (13.69%), cumulative engineering and industrial machinery (9.26%) in 1969. In particular, the UK cast aluminium consumption linkage with mechanically driven road transport increased from 44.32% in 1960. Although statistics of comparable detail are not available for countries other than the UK, these figures underline the compatibility that exists between the properties of cast aluminium products and the end-use requirements of a narrow range of end-use sectors, more particularly the competitive cost of producing a required level of performance in service. Cost of performance in service is related to the cost per unit of relevant properties, where the cost is derived by a combination of raw material and processing costs. As previously indicated the processing costs are partly characterised by the shortness of the process and by the type of casting process adopted. Nevertheless, the use of re-cycled scrap, together with the compatibility between the properties of aluminium (alloys), comparatively low melting point and density, clearly make cast aluminium products potentially cost effective in this narrow range of end-use sectors, but capable of more intensive application in other sectors, particularly building and construction in the UK which has absorbed a decreasing share of total cast aluminium consumption.

 12.5.1.

International Companies of Wrought Aluminium Consumption

Wrought aluminium product forms have a more evenly distributed consumption pattern than cast aluminium product forms with several end-use sectors consuming similar proportions of total wrought products production, Table 5.4.6. This even distribution of wrought products consumption is consistent with the wide range of geometrical form, product characteristics and processing capability of the range of products involved. Aggregate statistics merely reveal that the range of wrought products is capable of satisfying the cross-sectional complexity, surface area to volume ratio, length, thickness, surface finish and dimensional accuracy requirements of a similar wide range of final processing operations and end-use functions together with competitive added cost.

Each type of wrought product from will tend to have strong linkages with particular end-use industries, but these linkages are not highly exclusive, because a wide range of end-use sectors manufacture or use final products that are required to fulfill similar functions which are best satisfied by a common or similar geometrical form. Reference to the changes that occurred in the level of exports and imports of wrought product forms Table 6.1.11 indicated that the spectrum of rates of growth in production shown by the range of product forms in the UK is not attributable in a simple way to the change in the level of demand in the UK.

Domestic Production and Demand for Flat Products

Limited international data is available on the production and consumption of flat products, Table 6.1.10, but nevertheless showing the UK Market to have demonstrated the lowest level of growth in consumption, consistent with previous overall analysis. A further additional feature is that the UK domestic production of flat products increased by only 0.8% per annum between 1960-69, whilst consumption by the end-use industries increased by 2.7% per annum. This discrepancy between domestic production and consumption is explained by an accompanying change in the trade balance in flat products, which progressed from net export to net import to the UK, Table 5.2.11. Thus, half the UK increase in flat products consumption was satisfied by imported material and the remainder largely by reduction in exports.

All other countries, for which flat products production statistics are available, demonstrated more rapid growths in levels of production than consumption, thereby achieving increased exports or decreased imports. Aggressive net exporters of flat products include especially Belgium, Luxembourg, USA, Germany, Austria and Italy.

Decline in the export of flat products from the UK and growth in consumption linked with increased imports indicates that the UK flat products producers were internationally non-competitive during the period 1960-69.

Rolling mill and ancilliary plant installations necessarily require multi-million pound capital investments and represent a particularly capital intensive industrial activity, because of the large unit and plant size that is essential in order to be economically and technically feasible (16). A market which is assessed as potentially slow growing does not provide an attractive environment for the expansion of flat products production capacity. This postulation is derived from the observation that large increments of newly created productive capacity entail a long period of under utilisation in a slow growing market, involving unprofitable operation below the break-even levels of production and associated unattractive cash flow profiles. It is a readily demonstrated phenomenon that, as the degree of capital intensity increases, the sought after reduction in cost per unit of production becomes increasingly sensitive to the level of productive capacity utilisation, ie demand, and that the break even level of production tends to move toward higher levels of plant utilisation.

Two observations follow from the statistics of performance:

(1) Flat products producers have apparently assessed the UK market, during the period examined, as potentially unattractive for large scale capital investment and expansion in flat products productive capacity.

(11) The assessed potential demand related financial barriers to the expansion of the UK flat products productive capacity would encourage the high utilisation of existing plant capable of meeting established product demand specifications, but provides little incentive to push the domestic consumption of flat products to the point where difficult investment decisions must be faced in a

highly competitive European market.

Problems associated with the profitable production of aluminium flat products in the UK have been reviewed in an HMSO report(19) which supports the above observations. It is evident that international companies have invested in Belgium-Luxembourg which export in excess of 70% of their total semis production and increased flat products exports from 33.6 to 76 thousand metric tons between 1960-69, accompanied by particular attention to the rationalisation of the product selling range in terms of gauge, width, composition and other specification detail, in order to minimise production and stockholding costs.

Separation of cause and effect related to the slow growth of the UK flat products market is difficult. Statistics show that domestic production did not keep pace, even with the slow rate of increased consumption, suggesting failure on the part of flat products produces to push consumption by a combination of competitive prices and marketing activity linked with active capital investment in new technically advanced processing plant, regarded by Eltis (47) as a pre-requisite to growth. This apparent failure, however, is logically linked with the capital intensity of flat products production and uncertainty about the potential profitability of flat products production in the UK. However, there is no evidence to suggest that the supply of flat products was inadequate in the UK (between 1960-69) or that the price of European material was uncompetitive. The decision to use imported material possibly requires more initiative on the part of the end-use industry, because of the inevitably more remote technical support and encouragement from the producer.

12.5.3. 12.5.3.

Domestic Production and Demand for Aluminium Foil

Aluminium foil is a specialised flat product form which may be produced from hot coil produced either, on a continuous hot strip mill or continuous casting plant, which is cold rolled on purpose built cold mill units to foil gauges. By its very nature the consumption of aluminium foil is closely linked with demand and requirements of the packaging industry(consumer preferences for containers and wrappers and demand direct from the consumer market for foil), although significant quantities, which are not identified separately in the statistics, is used for electrical applications.

Availability of international statistical data on foil production is limited and is summarised in Table 6.1.11. Increase in UK foil production did not completely satisfy the rate of increase in demand and the importation of foil grew from 1.9 to 6.1 thousand metric tons, whilst the UK export of foil remained relatively stagnant, Table 5.2.11. No increase in the specific production of foil occured in the UK, Table 6.1.11.1. during the period 1960-69 when the growth in domestic consumption was so largely dependent upon imported material. However, it is recognised that the criterion of specific production, based

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upon value of manufacturing and construction, does have limited significance when analysing the consumption of a product form that displays a strong linkage with a particular end-use industry.

A relatively high rate of growth in aluminium foil production and consumption in the UK, compared with other flat products, occured in the packaging end-use sector which itself has shown a high rate of growth in activity (46).
Expansion of production has occured in order to partially satisfy the increase in demand of a world wide rapid growth sector, which is partially facilitated by the lower capital intensity of extended plant capacity based upon continuous casting.
Furthermore, the use of imported foil is facilitated by its readily standardised specification, so that insufficient capital investment by UK foil producers may have a less inhibiting effect upon domestic foil consumption, compared with less standardised or more technically sophisticated product. Unless, of course, the demand for foreign foil exceeded supply.

The impact of increase in UK domestic foil production has only a marginal effect upon total flat products production, 3.4% compared with 0.8% per annum, due to the small proportion of total flat products production constituted by foil.

12.5.4. 12.5.4.

<u>Domestic Production and Consumption of Aluminium Sections</u>

Table 5.4.5., shows the overall distribution of section consumption, revealing a relatively broad spectrum of end-use sectors, including 'other transport' (identified in later Aluminium Federation statistics as mainly caravans), freight containers, building and construction, domestic, office and medical equipment, and miscellaneous unidentified end-use. Exports and imports were active, but the actual figures reported vary considerably dependent upon the source of data (Metallgesellschaft or the Aluminium Federation).

Section and in particular extruded sections provide a wide range of cross-sectional design freedom, which explains the wide spectrum of end-use sector compatibility. This design freedom is achieved by a process that has few intermediate stages and relatively high material yield when related to section complexity and allows minimum subsequent processing to final product. These process design characteristics represent potential cost benefit to the end-user and have logically contributed to the relatively high rate of growth by UK standards of 8.2% per annum. Table 6.1.11.

Extruded section production has a relatively low unit capital intensity (50) as illustrated by the estimated £250,000 required (at 1969 prices) for a new press and ancilliary plant, marginally higher than die casting. Continuous casting plant for rod is appreciably more capital intensive, requiring at least £1min investment(49). Low capital intensity of aluminium

 12.5.4.

extrusion plant constitutes a minimal barrier to the expansion of productive capacity and allows producers to both increase their productive capacity and modernise plant with relatively small increments of capital investment. Competition and market stimulation is also increased by the large number of small independent producers capable of entering a market characterized by a relatively low economic barrier to entry (13).

Aluminium extruded product forms have a cost structure which is largely dominated by material cost, Fig.7. Table 5.2.12. Chadwick (50), calculations based upon a virgin ingot price of £215 per ton. Specific die costs, related to a given section, are commonly covered independently by the customer.

Consistent with the high level of growth in specific production of aluminium sections in the UK (4.8% per annum) Table 6.1.11.I, the percentage of total wrought products constituted by extrusions increased from 12 to 18% between 1960-69. In spite of the progressive approach to extruded product forms in the UK during this period, it is interesting to note that the proportions of extruded product forms in Italy increased from 23 to 30% and from 20 to 27.6% in the US.

 12.5.5.

Domestic Production and Demand for Aluminium Wire and Forgings

Aluminium wire and forgings production are specialised products because of their respective linkages with specific end-use sectors, namely, wire with the transmission of electricity and electrical conduction, forgings with aircraft components. The contrasting international situation for wire is shown in Table 6.1.11, which reveals wide differences in the proportion of total wrought metal production constituted by wire and is associated with a given countries need for aluminium wire for power transmissions and general electrical conductors at a given period of time in history. In the UK, a growth rate in aluminium wire production of 13.2% per annum was recorded for the period 1960-67 compared with a growth in the value of electrical engineering products production of 4.5% per annum. However, the inter-relationship between these two figures is not strong since the output of electrical engineering products is not directly related to the amount of aluminium wire used in electrical transmission in a given period of time.

Aluminium forgings represent a small proportion of total aluminium consumption in the UK. Supply of forging bar increased from 1.07 to 1.35% of the total wrought metal market between 1960-69. Growth in forgings consumption is unlikely to have any significant impact upon total aluminium consumption, not only because of the small market share, but also because of the highly competitive strength of die castings and wrought metal sections in general engineering applications. Specialised requirements involving high strength to weight ratio, combined with high integrity requirements in service and complex three dimensional geometry are necessary in order to justify aluminium alloy forgings in the aircraft and other engineering applications on a cost per unit of performance basis. This is a direct result of the indirectness of the process, low material yields and the high cumulative processing costs associated with forgings.

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12.6 12.6

International Comparison of the End-Use of Aluminium

12.6.1.

Consumption of Aluminium in the Transport Equipment Sector of End-Use Manufacturing Industry.

In 1960 the UK specific consumption of aluminium in the transport equipment sector, 28.6 metric tons per million US $, was marginally lower than Germany and France and less than half the Italian figure, Table 6.2.5. By comparison with the U.K., other countries, apart from France, made more rapid progress in specific consumption of aluminium, so that by 1969 the UK level was lower than any other major transport equipment producer in the sample. Analysis has shown a remarkably high degree of correlation between the level of aluminium consumed in the transport equipment and the value of output from this sector, section 8.4.1, both in 1960 and 1969, especially when countries that are known not to have a developed manufacturing sector of this type were omitted from the correlation.

Analysis has also shown that the UK consumption fell progressively further behind the international consumption function between, 1960-69, so that although the UK specific consumption increased by (1.7% per annum) the transport equipment manufacturing sector failed to keep pace with the international trend exhibited for an increase in the propensity for the use of aluminium in this sector. It is important not to exaggerate the discrepancy that had resulted between UK specific consumption by 1969 and other countries. Italy has been isolated as a

 12.6.1.

special case, which has been noted previously with respect to the production of aluminium pressure die castings, section 12.4.2. UK specific consumption in this sector was similar, in 1969, to France and the USA but compared most unfavourably with Germany and Japan, Table 6.2.5.

A close international correlation has been shown to exist between the rate of growth in aluminium consumption in transport equipment and the value of output, 8.4.2, although the precise form of the relationship was particularly sensitive to the inclusion of the Japanese data which constituted an extreme value of growth. If consumption performance relative to the international function relating growth rates is used as a criterion, the UK appears to have performed reasonably consistently at the lower extreme. Irrespective of the specific aluminium consumption achieved by a given developed transport equipment sector, continued increasing propensity to increase aluminium consumption was demonstrated internationally within the decade period. However, the rate at which the level of consumption increased appeared closely linked with the rate of expansion of the transport equipment sector, and consistent with previous analysis, to the rate of capital investment which provides the instrument for technological innovation.

12.6.2

12.6.2

Consumption of Aluminium in Electrical Engineering Applications Sector of the End-Use Manufacturing Industry

Comparison of the UK consumption of aluminium in electrical engineering applications with the international mean consumption function showed that the UK consumption was marginally higher in 1960, but coincided with mean performance in 1967 (value for 1969 output were not available from OECD statistics). Consistent with aluminium consumption in transport equipment, the slope of the consumption function increased during the period examined, indicating a growing international propensity to increase aluminium consumption in this sector, together with a high degree of correlation.

Differences between the international levels of specific consumption in this sector were generally small, Table 6.2.7, or in the process of rapid correction (Japan 27.7% per annum). However, by 1967, UK specific consumption of aluminium in this sector was appreciably lower than Germany, France and Italy, Table 6.2.6.

In contrast with the transport equipment sector, appreciable but not excessive international deviation was observed from a mean correlation relationship between the rates of growth in consumption and the value of output, and was sensitive to the range of data used, section 8.5.2. Irrespective of the two trends used to predict UK performance, the growth in UK consumption in the electrical engineering sector was lower than the international mean relationship would suggest. This sector, however, is associated with a higher UK rate of growth in the specific consumption of aluminium than any other UK sector analysed, and does

12.6.2

not represent an international extreme in behaviour. UK electrical engineering aluminium consumption was progressive by UK sector standards, but was inhibited by the rate of growth in the sector, similarly to the transport sector behaviour. However, the inhibiting effect of sector growth need not have been so restrictive, since if the international growth rate function has any meaning, the UK electrical engineering application end-use industry may have been capable of achieving a marginally higher rate of growth in aluminium consumption, section 8.5.2. Forecasting growth rates with precision is not one of the aims of this analysis, thus the marginal failure of the UK to conform accurately to the international consumption function is just as likely to be due to limitations in its general relevance as any other reason. It is also interesting to note that the German growth rate in specific consumption in this sector was less than the UK, but was associated with a higher level of specific consumption throughout the period examined.

12.6.3 12.6.3.

Consumption of Aluminium in Building and Construction Sector

The UK building and construction sector is distinguished by the fact that it was the only sector, within the broad sub-divisions of end-use sectors identified by OECD, that demonstrated a reduction in the specific consumption of aluminium in the UK, (- 1.2% per annum). United Kingdom specific aluminium consumption was comparatively high by European and Japanese standards in 1960, Table 6.2.7, but, had declined to a level approximately half that reached by Germany by 1969. International comparison reveals wider differences in specific aluminium consumption in the building and construction sector, both in 1960 and 1969, than occured in the other major end-use sectors subjected to analysis. France and the USA remained at the extremes of performance throughout the period 1960-69 (2.64 to 2.97 and 20.8 to 34.8 metric tons per million US $ respectively). These extremes in specific consumption in the building and construction sectors of different countries reveals important and remarkable contrasts in behaviour, since each of the countries examined had a building industry consistent with a developed economy.

The strength of the correlation between the level of aluminium consumption and the value of building and construction was found to be very sensitive to the inclusion of the US data, since this provides situation that considerably strengthens the relationship. However, the slope of the relationship increased between 1960 and 1969, indicating an international trend towards an increased propensity to consume aluminium in this sector, which is contrary to the UK

12.6.3

behaviour. Comparison of the UK performance with the derived international consumption functions reveals a decline in consumption from a level above the function to one below, section 8.6.1.

In attempting to relate the rate of growth in aluminium consumption with the rate of growth in the value of building, consumption and the marginal decline in specific consumption in the UK cannot be attributed to the level of consumption in 1960, or to the rate of growth in the value of construction. Material selection decisions are influenced by a completely different set of factors in the building and construction sector compared with manufacturing activities like transport equipment and electrical engineering. This is mainly due to the discrete architectural decisions and materials choice for each individual building erected, as opposed to the relatively long run materials selection committment involved in manufacturing when a given combination of process and product design have been established. Assuming that other countries follow the US lead, increasing potential will develop which will tend to activate the UK building industry into more progressive use of materials. This change in selection behaviour, however, is less likely to be linked with rates of growth in construction, no correlation could be identified unless the extreme Japanese performance was included, representing a phenomenal growth in specific consumption of 33.6% per annum, which raised the Japanese specific consumption from below European levels to one more similar to the outstanding US position. However, the tendency to increase aluminium consumption was independent of the level of specific aluminium consumption at the beginning of the

12.6.3

period examined. The high level of propensity to increase specific aluminium consumption in building when viewed internationally supports the existence of a strong collection of incentives for expanding the use of aluminium to which UK builders and architects, in common with France, have not responded.

Building and contruction sector in the UK economy was particularly unresponsive to the benefits that other countries found compelling with respect to aluminium, where the low rate of growth in output is less critical than with manufacturing industry, since the investment made in construction in not so dependent upon demand growth in order to achieve acceptable financial return. This is supported by the absence in growth rate correlation reported earlier and indicates the possibility of rapid change in consumption behaviour in the building sector which is apparently not related to economic activity. Furthermore, the choice of materials for building applications is often less concerned with readily quantified cost benefit or effectiveness and relatively more concerned with attitude of the architect and client to invest in aesthetic qualities and comfort. Similar apparent reluctance or inability of the UK construction industry to exploit new materials during the period examined was reported by Freeman (25) with respect to synthetic polymeric materials.

 12.6.4

Consumption of Aluminium in Packaging

The international consumption functions derived for the packaging end-use sector were based upon the value of GDP, as opposed to the value of the output of packaging, due to the absence of data relating to the latter. A high degree of correlation was observed between the international consumption of aluminium in packaging and GDP, both in 1960 and 1969. Comparison of the UK consumption behaviour with the international consumption function showed that it achieved a consumption below the trend in 1960, but agreed very closely with the trend by 1969. The slope of the international consumption function increased between 1960 and 1969 indicating an increased propensity to consume aluminium in this sector.

Correlation between the rate of growths in aluminium consumption in packaging and GDP was found to be low and sensitive to the population of the sample selected.

International comparison of specific aluminium in this sector revealed some remarkable differences in this degree of maturity in 1960, showing that the UK was amongst the most progressive countries, together with Germany, Italy and France. Surprisingly, the US was behind these European countries in 1960, but advanced extremely rapidly during the decade, 12.8% per annum increase in specific consumption, and thereby assuming a lead position by 1969. Both Japan, Belgium and Luxembourg had relatively low levels of specific consumption in 1960 and demonstrated different reactions to this

 12.6.4

situation. Belgium and Luxenbourg underwent an explosive change in this sector, 27.0% per annum in specific consumption, thereby assuming a level of specific consumption equal to Germany and appreciably in excess of the UK by 1969. However, Japan showed a modest response taking into consideration its specific consumption in packaging in 1960 and the higher rates of growth achieved in each of the other sectors examined. France was the only country to show a decrease in the level of specific consumption in this sector (- 0.7% per annum).

The packaging sector is characterised by very rapid changes in materials consumption behaviour which are not consistent with the rates of other economic changes, as reflected by GDP, although the overall relationship between aluminium consumption in packaging and GDP shows a trend toward international consistency and increasing in propensity. It has been noted by Mills (46) and others, that if one material can suddenly better another for some reason, in that particular application there can be a sudden change and the original material can find itself floundering out of favour. It appears that changes in the selection of packaging materials are not subject to the same level of capital investment barriers as other sectors, transport equipment and electrical engineering, but can swing in a particular direction either quickly or slowly according to the change in overall preference of the sector, quite independently of the rate of increase in output. In this respect the packaging sector is more similar to the building and construction sector than to the engineering sectors of the economy.

12.6.4 12.6.4

The PIRA report on packaging statistics in the UK (46) included the following conclusions which refered to changes in the selection of packaging materials:-

1) Related to changes in consumer purchasing habits, including convenience meals, deep frozen food and bulk buying.
2) Consumers usually have more loyalty to the product than preference for packaging.
3) Consumers assume that the food manufacturer will offer a package that is functionally adequate and will rarely question its efficiency.
4) Government legislation can change entire markets overnight.
5) Output of packaging materials since 1960 has tended to exceed the rate of increase in industrial production.
6) The range of traditional and new materials available are often similarly suitable for a given application. This leads to aggressive marketing and intensive research activity by the packaging material suppliers in order to preserve existing application and develop new areas which may involve active displacement of alternative materials.

As a result of the reported rapid growth in the packaging sector, which suffers from inadequate statistics, it is impossible to quantify the proportions of increase in specific consumption that has occured due to market expansion within economy as opposed to the displacement of alternative materials.

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End-Use Distribution of Aluminium Consumption

Table 5.3.1, shows the distribution of aluminium consumption over different end-use sectors within selected economies and serves to emphasise that considerable international contrasts exist in the proportional end-use of aluminium. Consumption in the transport equipment sector constitutes the largest consumption sector in the UK (32%) in common with Germany (27.0%), France (33%) and Italy (37%) and a large consumption sector in the US (22%) and Japan (22.0%). In contrast , other economies consume between (7 and 11%) of total aluminium consumption in the transport equipment sector. Similar comparisons may be made with respect to the other identified end-use sectors using the UK distribution as a base line. Proportional UK aluminium consumption in the building sector (8.0%) is amongst the smallest in the group (1969) and is consistent with the low level of specific aluminium consumption in construction, Table 6.2.7. By 1969, both the US and Japan were consuming in the region of (24.0%) of their total aluminium consumption in construction with Germany and Italy consuming an intermediate level of (15%). Proportional UK aluminium consumption in the electrical engineering sector (13.0%) in 1969 was very similar to most of the other countries. The packaging sector proportional consumption in the UK (8.0%) was again similar to Germany, France and Italy, appreciably less than the US (12%), but the Japanese market (2.0%) undeveloped by 1969. Domestic and office appliance manufacturers proportional consumption was also a significant share of UK consumption (10%) similar to the US, Japan, and France, but revealing a low German figure (2.5%).

National profile characteristics of proportional aluminium consumption tend to be determined by the presence or absence of at least one major end-use sector. By the very nature of proportional assessment, the existence of a relatively large consumption sector inevitably limits the percentage of total consumption constituted by other sectors. It is important, therefore, when assessing the absolute propensity of any national end-use sector to adopt the criteria specific consumption and total tonnage consumption. However, the profile of proportional consumption does reveal the relative strength of linkage between aluminium consumption and given end-use sectors and the nature of the derived demand for aluminium in different economies. UK aluminium consumption shows a very strong linkage with the transport equipment sector, important linkages with electrical engineering, packaging, domestic and office appliances and an important, but relatively undeveloped, linkage with construction by 1969. Relative strengths of end-use market linkages are relevant to the choice of criteria used for comparing consumption performance. The impact of a given rate of growth in consumption in a given sector upon total aluminium consumption is dependent upon the proportional size of that sector's consumption. Over a period of time, however, the relative rate of growth in consumption of different sectors will determine the changes that occur in the profile of proportional aluminium consumption, ie a sector that displays a high relative rate of growth in consumption will also show an increasing proportional consumption and a consequent stronger consumption linkage.

The concept of economic linkages between different industrial sectors and the end market has been discussed by Hirschman (26), Chenery and Watanabe (27), in which the existence of backward and forward linkages are demonstrated and quantified where;

(a) Forward linkage effect (Output utilisation) is described as, every activity that does not by its nature cater exclusively to final demands, will induce attempts to utilise its outputs as inputs in some new activities (Non-ferrous Metals 88%).

(b) Backward linkage effect (Input provision) represents the input provision and determines the derived demand experienced by other industrial sectors.

The profile of proportional aluminium consumption shows, therfore, the relative strengths of linkages constituting the total forward linkage behaviour.

12.6.6. 12.6.6.

Structure of the End-Use Market for Aluminium in the UK

Preceeding analysis has revealed similarities and differences in international behaviour with respect to the relationship between the growth in specific aluminium consumption and the growth in the value of product from end-use industrial sectors. International mean consumption functions and other correlations were determined, relating the level and rate of growth in aluminium consumption to the level and rate of growth in value of product in the transport equipment, electrical engineering, building and construction and packaging sectors of the economies studies.

When making comparisons of national aluminium consumption, account must not only be taken of, the comparability and accuracy of available statistical data (23), but also the possible effects of differences in economic structure and the micro-economic structure of given end use sectors. The relevance of micro-economic detail is partly revealed with respect to the UK by closer examination of the available end-use statistics, Tables, 5.3.1, 6.3.1. Statistics providing similar detailed analysis of end-use consumption are not available for other economies, hence international comparisons are not possible.

Disaggregation of the UK transport equipment end-use sector, Table 6.3.1, reveals a very inhomogeneous constitution, in which the mean rate of growth (4.0% per annum) in transport equipment sector was not representative of any single sub-sector of the aggregate sector transport equipment. A wide range of consump-

12.6.6.
tion performance was evident in this UK sector, from (-8.0% per annum) for rail transport to (14.0% per annum) for other transport applications not specifically identified. More recent Aluminium Federation statistics indicate that 'other' transport application is comprised largely of end-use in caravans.

Table 6.3.2, shows the relative strength of linkages between UK aggregate aluminium consumption and selected end-use sectors by showing the relationship between the profile of proportionate end-use consumption and specific aluminium consumption. Transport equipment sector maintains not only the highest proportion of total UK aluminium consumption, but also a considerably higher level of specific consumption than any other sector. It is not surprising that the UK growth in specific aggregate aluminium consumption (1.2% per annum) is very similar to the overall growth inthe transport equipment sector specific consumption.

The electrical engineering sector showed the highest rate of growth in specific aluminium consumption in the UK (3.4% per annum), as reflected by the growth in proportional consumption in this sector, however, the level of specific consumption remainded less than half that achieved by the transport equipment sector. The building and construction sector showed an even lower level of specific consumption, which unlike other developed economies declined during the period 1960-69, associated with a diminishing market share. The packaging sector is not strictly comparable in terms of specific consumption, because the GDP was adopted as the denominator in the computation, in the absence of reliable data relating to the value of output from the packaging industry. This has the effect of markedly reducing the value of specific consumption, even compared with the other sectors examined, even though the proportion of total consumption in this sector is similar to building and construction. The packaging sector showed a slower rate of increase in specific consumption than transport equipment and electrical engineering in the UK and showed a marginal reduction in the market share of total aluminium absorbed.

Several end-use sectors of the UK economy displayed either declining aluminium consumption, including aircraft, rail and marine applications, whilst others showed no appreciable growth in consumption, both textile and machine tools. Consequently the detailed structure of the end-use market at a given time and the independent behaviour of sub-sectors will have a pronounced influence upon the rate of change in total consumption and aggregate specific consumption. The relative strength of the independent effects of sub-sectors is proportional to their respective economic linkage. However, if a progressive decline of consumption in a given sub-sector occurs over a decade period, or more, the strength of the economic linkage becomes less significant and continued decline has a diminishing influence upon gross consumption. The effect is interesting, because in 1960 aircraft, rail and marine applications constituted approximately (8%) of total UK aluminium consumption which represented a similar level of economic linkage as that constituted independently by electrical engineering (10%), building and construction (9.0%), and packaging (8%). However, by 1969, due to the differences in consumption growth rate performance, the proportion of total aluminium consumed by aircraft, rail and marine applications had reduced to (4%).

Three important observations emerge:

1) Sectors exhibiting a progressively changing level of aluminium consumption influence the total consumption in proportion to the strength of the economic linkage.

11) Dependent upon the direction and rate of change in sub-sector aluminium consumption the strength of given economic linkage changes with time.

111) The strength of the economic linkage existing between aluminium consumption and the transport equipment sub-sectors aircraft, rail and marine in 1960, had a pronounced retarding influence on the growth of aggregate specific aluminium consumption in the UK between 1960 and 1969, but due to the diminishing strength of the linkage can have less influence in the short-term future.

End-use market structure should be taken into consideration when formulating criteria for the evaluation and comparison of international aluminium consumption. This analysis should complement micro-economic study of the level and change in level of specific aluminium consumption. Change in micro-sector specific aluminium consumption indicates the relative performance of aluminium in a given type of application in competition with other materials. Evaluation of the strength of economic linkages with end-use manufacturing industries helps to quantify the effect upon aggregate consumption.

Analysis of this type reveals that during the period 1960-69, mechanically driven road transport applications together with electrical engineering plant and equipment accounted for the largest increments of growth within the UK. Other transport applications (caravans) showed appreciable proportional gains with respect to total consumption, which when combined with the high rate of growth in consumption was beginning to make very significant impact upon total UK aluminium consumption by 1969. Chemical, food plant and equipment made a similar contribution to increased consumption as that achieved by the packaging sector, due to the high rate of growth of the former and the larger market share of the latter. Consistent with specific consumption analysis the building sector accounted for a small amount of increased consumption in relation to its market share (economic linkage) and the same observation applies to domestic office and medical equipment.

12.7 - 12.7.1
International Comparison of the Consumption of other Materials

12.7.1 International Consumption behaviour with respect to Steel, Copper, Zinc, Tin.

Aluminium and its alloys constitute part of a very large range of materials consumed by manufacturing and construction industries. Materials consumption may be viewed as a diversified matrix of end-use sectors, which consume the whole range of commercially available materials in order to satisfy in-service functions or requirements. These end-use sectors have the primary objectives of minimising cost and maximising added value linked with the need for profitable activity. Detailed analysis and explanation of the reasons underlying the level and change in level of materials consumption, even over the comparatively narrow range of materials, selected for this analysis, is beyond the scope of the investigation. However, comparison of international consumption behaviour with respect to aluminium, steel, traditional non-ferrous metals (copper, zinc, lead, tin) and synthetic polymeric (plastics) materials, facilitates the placing of aluminium consumption behaviour into economic perspective. Comparison makes it possible to determine whether natural or international materials consumption behaviour is common to all the materials in the sample or whether any particular aspect of behaviour are peculiar to the UK, or aluminium, or perhaps anyone of the materials considered.

From the reasoning developed earlier, the initial basis selected for the comparison of aluminium consumption with that of other materials was aggregate specific consumption, which may be defined as the ratio between, weight of apparent domestic consumption of the given material divided by the value of total manufacturing and construction, measured in US$ at constant market prices (1963), relevant to a given year. Adoption of the unit of weight in the criterion is a simplification of any absolute comparison, since other criterion eg: material value or material value consumed ; would present a significantly different picture. Translation into a criterion based upon volume of material used, simply requires the figure for macro-specific consumption by weight to be divided by the density of material. However, translation into a criterion based upon value of material used would be extremely difficult to do accurately, because the value of material input into the end-use manufacturing sector will be subject to wide variation, even for a given material, due to the added value that occurs by processing between the extracted material and semi-finished or the final product. The level of added value for a given material will be subject to variation due to the cost characteristics of the processing involved. Further difficulty is introduced by the price instability of certain materials, particularly the traditional non-ferrous metals.

Specific consumption of steel throughout the period 1960-9 is considerably higher than any of the other materials in the sample Table 6.5.7. where in the UK the specific consumption of steel was 3500% higher than aluminium in 1960 and 2860% higher in 1969. Similar ratios of aluminium to steel consumptions, and reductions in ratio are shown by other countries, eg; Germany 5000% to 3700%, Italy 4300% to 3400%, Japan 8500% to 5600%, US 3000% to 2100%, France 4000% to 3500%.

The high value of aggregate specific consumption for steel indicates the relative strength of the linkage between steel consumption and the end-use manufacturing and construction industries, with respect to other metallic and plastics materials. It further shows the effect of a rapidly growing economy, Japan which necessary uses large quantities of steel in construction as well as machinery, compared with a highly developed economy, US, and a slow growth economy like the UK.

Comparison of the specific consumption of aluminium and copper shows that generally, within the decade examined the values for a given country were similar except that a tendency existed for the specific consumption of copper to reduce during the period 1960-69. However, the USA and Japan appear to represent exceptional cases, since the specific consumption of copper in the US remained substantially unchanged at a level below that exhibited by most other countries in the sample, (7.5 metric tons per million US$) and appreciably below the specific assumption of aluminium. At the same time the specific consumption of aluminium grew rapidly from a level below copper to one appreciably higher by 1969.

Specific consumption behaviour with respect to zinc, tends to behave more similarly with copper than with aluminium, since except for Japan, the specific consumption of zinc has declined during the decade and the specific consumption of zinc is without exception less than copper. A certain degree of inter-relationship between copper and zinc consumption is to be anticipated, because of their important use in brass and their established historical application, although they do exhibit other quite independent end-use linkages namely, zinc with die cast components and galvanised steel, copper with electrical conductors. It is noteworthy, that the UK specific consumption of zinc was relatively high by comparison with European and US standards throughout the period examined.

Specific consumption of tin, showed a different order of magnitude compared with aluminium, copper, zinc, lead, and plastics materials consumption Table 6.5.7. Tin is observed to be considerably less significant in terms of specific consumption which has declined appreciably and without exception during the decade.

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12.7.2.

International Plastics Materials Consumption Behaviour

In the sense that plastics materials may be classified as relatively new by comparison with more traditional materials like copper, zinc and tin, and that its consumption has grown rapidly during the last twenty years or so to a position where it constitutes a very significant share of total materials consumption, it invites comparison with aluminium. Furthermore, the introductory section of the present thesis makes reference to the suggestion that a progressive, exploitive and innovative approach to new materials and related process and design technology is essential and in order that productivity is continually improved. It is relevant, therefore, to investigate whether the UK in particular and other developed countries in general, have shown consistent behaviour with respect to their demonstrated ability to exploit newer materials and effectively displace traditional materials.

A number of papers have been published, notably Freeman (18) and others (51) (52) (53) (54) (55) (56), which have drawn attention to the relatively low rate of growth in plastics materials consumption in the UK during the period, approximately (1960-70), leading to low per capita consumption, a falling share of international trade and poor penetration of key markets. Raw materials producers complained that low economic growth meant low prices, adverse cash flows, longer pay-off periods and generally older, less efficient production plants in the UK, consistent with the current analysis of factors affecting aluminium consumption. Thus low prices did not lead to higher market penetrations in the UK. Germany was quoted as consuming 34 kg per car against UK's 22 kg per car by 1970. In construction, which in both countries accounts for about (25%) of total plastics consumption, Germany achieved over twice the UK consumption.

Government officials closely concerned with the plastics industry also considered that raw material producers were too production oriented and switched belatedly to market oriented development in the UK. Sectors that have been subjected to this development, including film, fibre and automotive parts in more recent years, are quoted as examples where growth in consumption has been achieved. Even if the UK government succeeds in providing the economic background needed for growth according to (54) (56) many plastics processers are ill-equipped to take full advantage of the opportunity because of past stagnation. The NEDO report (56) cited the following factors which were also supported by OECD (55) as relevant to the relatively poor growth performance in plastics materials consumption in the UK.

(i) Size of the UK market

(ii) Size of plant in relation to the size and rate of growth of market, together with achieving economies of scale.

12.7.2.

(iii) Government incentives to invest in the UK have been less favourable than in EEC, and less support for applied research.

(iv) Low profit margins achieved by UK producers makes it difficult to finance adequate R & D activity to develop new applications.

(v) Government policy that has used the motor industry as an economic regulator, and other policies that have affected the building industry has discouraged expenditure on new plastics applications in the UK.

(vi) The proportion of relatively small processing firms has limited R & D activity, investment and marketing.

(vii) Inadequate research has been conducted into the development of processing equipment and the application of plastics.

(viii) Absence of a competitive UK industry concerned with producing processing machinery. A technically advanced machinery industry will principally benefit the country of location, since machinery makers and fabricators and end-users can more readily co operate in experiment, development and design.

 12.7.2

The Freeman (18) analysis provided a certain amount of evidence for the relationship between plastics consumption and the level of national income, the importance of economic growth in stimulating the change to new materials that offer technical and cost advantages. Attention was focused upon the need for R & D activity and how historically this appears to have contributed to the German lead position, which was accompanied by a similar lead with respect to machinery and processing techniques. However, this lead in processing was not entirely exclusive, since R H Windsor (UK) produced and marketed a twin screw injection moulding machine in 1953, the importance of which was not appreciated in the US. The building end-use sector was isolated as a particularly non-progressive plastics materials user in the UK (18). This was attributed to the small research expenditure, the predominance of small firms, the separation of design and fabrication responsibility, and the inhibiting effect of national and local building specifications and standards. Results obtained in the present analysis support the existence of a strong correlation between the level of plastics consumption and economic prosperity, in particular the value of manufacture and construction, Table 6.7.1, but also that the international propensity to consume plastics materials increased significantly between 1960 and 1969, as indicated by the international trend to increase aggregate specific consumption. In section, 9.1.1, it was reported that, in 1960, the UK consumption corresponded closely with the international mean consumption function, but that by 1969 it had fallen considerably behind (approx 20%). This position was supported by the international comparison of specific plastics materials consumption which showed that in 1960, the UK level was similar to the US, but less than Germany and Italy and considerably less than Japan. Most of the countries examined showed an annual rate of growth in specific consumption in the range (9.5 - 10.5%) independent of the level in 1960, however, the UK showed only (7.5%). By 1969, the UK specific consumption of plastics materials compared unfavourably with other countries, although it is noteworthy that compared with other materials including aluminium in the UK, the rate of growth in the consumption of plastics materials was outstanding. International comparison also shows, Table 6.7.2, a high degree of correlation between the rate of growth in plastics materials consumption and the rate of growth in the value of manufacturing and construction, however, the growth rate achieved by the UK (10.9% per annum) was appreciably below the level indicated by the international function and is consistent with the previously reported relative decline by international standards of specific consumption.

Analysis of international trend behaviour with respect to plastics materials indicates many similarities and consistent elements of behaviour with those observed with aluminium, even though the rate of change and level of aggregate specific consumption associated with the two materials show important differences. Furthermore, many of the factors contributing to the international differences in consumption behaviour considered to be relevant with respect to plastics materials have been discussed in relation to aluminium and have been judged as highly relevant in the present analysis.

12.7.3. 12.7.3.

Generalisations relevant to the International Comparison of the Consumption Behaviour with respect to Other Materials

Foregoing observations suggest the possibility that either:

(I) High rates of national economic growth in manufacturing and construction was a necessary pre-requisite for a substantial increase in the aggregate specific consumption of aluminium, or

(II) Countries that have demonstrated the technical and innovative ability to exploit certain new materials and associated process changes, also have part of the essential foundation for rapid economic growth as a direct result of the related cost benefit and technical supremacy of their products (47)

Although a similar pattern of behaviour was observed with respect to plastics materials, the rate of growth associated with plastics, both in the UK and elsewhere, was well in excess of the increase in aluminium consumption and the increase in the value of manufacture and construction.

This observation lends support to the alternative suggestions that:

i) Increase in the specific consumption of plastics materials is associated with a wider based and greater technical and cost incentive than increase in specific aluminium consumption.

ii) Innovation of plastics materials involves less difficult processing and design problems which make it easier for the end-use industry to exploit the advantages of plastics.

12.7.3.

(iii) Distribution of end-use consumption of the two materials is sufficiently different to cause a different response to macro-economic growth.

The observation that the UK aggregate specific consumption of plastics materials increased from 14.5 to 27.5 metric tons per million US $, while that for aluminium showed only a marginal increase (1.2% per annum) is fundamental to these suggestions.

Further factors that may be postulated as relevant but difficult to substantiate include:

1) Reduction in the first cost of products by making them from plastics materials has made the producer and buyer less critical of the subsequent performance in service, aesthetic qualities, or conservation aspects, resulting in failure to optimise design with respect to material and to choose the optimum material.

II) Low cost plastics products have created a demand for products that would not otherwise have been manufactured, if materials other than plastics had had to be used.

III) Product mix changes accompanying progressive increase in the real level of GDP possibly introduces a rapid increase in the consumption of product forms or services (packaging) which are more efficiently produced in plastics. This may constitute a transient stage in economic development as tastes and spending power progressively change.

 12.7.3.

Although the ability of the UK economy to exhibit an increase in the aggregate specific consumption of the newer materials, aluminium and plastics, is either inhibited or linked with the slow rate of growth in the value of manufacturing and construction, appreciable reduction in the specific consumption of steel, copper, zinc, lead and tin was achieved during the period (1960-65). This leads to the identification of three broad categories of materials:

i) Newer materials that internationally are inclined to demonstrate an increase in specific consumption.

ii) Steel, within the sample of materials studied, because of the relatively high level of specific consumption exhibited and the consequential contribution made in any industrial economy. Nevertheless, steel is observed to be vulnerable to a reduction in specific consumption in many economies, although exceptions were noted eg. Italy and Japan, especially where economic structural changes are taking place.

iii) Traditional non-ferrous metals, copper, zinc, tin and lead were particularly prone to reduction in their respective levels of specific consumption. The rate of reduction showed a low degree of correlation with the rate of increase in the value of manufacturing and construction, but appeared partly linked with the level of specific consumption at the beginning of the period examined. It is not surprising to discover that a relatively high level of specific consumption of a material that is vulnerable to displacement tends to accelerate the rate of displacement.

12.7.3.

Thus the reduction in the specific consumption of traditional non-ferrous metals in the UK was not completely inhibited by the slow rate of economic growth in the UK.

In general it may be claimed that, in spite of the diverse international behaviour observed, especially when comparing other materials, UK material consumption behaviour was consistent in aggregate terms with international trends.

The Concept of a Materials Consumption Matrix with Particular Reference to the UK

Specific consumption of a given material, at a given time, either at the aggregated or disaggregated level provides a logical basis for the evaluation and comparison of the real level of a materials utilisation or absorption by an economy. When comparing a wide range of materials it is also necessary to carry out an integrated evaluation of behaviour, which leads to the postulation that, any increase in the specific consumption of one material in an economy must be balanced by a reduction in the specific consumption of alternative materials which have been effectively displaced.

Total material consumption in an economy may be considered as a large complex matrix which includes a measure of all manufactured output, building and construction and the associated material inputs. Preparation of such a matrix is not the purpose of this analysis.

Output consumption matrix analysis shows that materials are not absorbed uniformally throughout an economy and that large proportions of total consumption of a given material are consumed by particular end-use economic sectors. Furthermore, profiles of consumption show important contrasts when comparing different materials, Table 6.5.8, in the UK and other economies. Similar proportions of aluminium and steel are consumed by the transport equipment sector in the UK economy, approximately (30%) of total consumption. By comparison, only (8.7%) in 1960 and (5.0%) in

1969 of total plastics materials consumption was consumed by the transport equipment sector. Stronger linkages existed between plastics materials consumption and the end-use sectors construction and packaging, which absorbed 25.0% and 21.0% respectively of total plastics consumption by 1969, having demonstrated (20.8% per annum) and 13.2% per annum) growth respectively.

Differences in the distribution of materials consumption is determined by the relative technical compatibility between the end-use requirements of given end-use sectors and the properties of the alternative materials. Material technical compatibility, combined with the relative size of end-use sectors, has led historically to a given national profile of commercial and economic linkages with respect to materials consumption. A given national profile of materials consumption is subject to change, as shown by a study of specific consumption, over a period of time due to:

(i) Changes in the relative technical compatibility, especially when measured in terms of cost per unit of performance.

(ii) Variation in the rates of growth of output from end-use sectors within an economy leading to a change in economic structure. As discussed by Hill (23) pronounced differences are observed in the strength of the international correlation between micro-economic sector growth and growth in GDP. Many sectors show no appreciable correlation with GDP, and their rate of growth tends to vary independently of movement in the remainder of the economy. Other sectors, particularly with respect to a given economy, show high degrees of correlation with GDP.

(iii) Cumulative Innovative capacity of given end-use sectors with strong linkages with a given material and the type and influence of barriers to innovation in those sector in the economy being studied.

Change in the aggregate consumption of a given material is, therefore, more sensitive to the performance of end-use sectors with which historically a strong techno-economic linkage has been established than to those sectors having a weaker linkage. This observation is more true in the short term, but even over a decade period only a marginal change in the relative strength of linkages may be expected unless very dramatic rates of change in specific consumption are achieved in a particular end-use sector.

Analysis has shown, however, that the definition of micro economic sectors used in this investigation still represents a relatively coarse aggregate of heterogeneous sub-sectors, which are capable of independently showing wide differences in consumption behaviour. Aluminium Federation statistics made it possible to partially disaggregate the transport equipment sector, which revealed the anticipated wide differences in behaviour over the decade period related to very specific techno-economic factors influencing a given sub-sector.

12.7.4 12.7.4

Micro-economic analysis tends to reveal many exceptions to any macro-economic trend, even though the macro trend may be very strong and consistent with time. Detailed analysis is, however, limited by the availability of statistical data and the diminishing accuracy of data as the degree of detail required increases.

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Technological Innovation and Change in the Consumption of Aluminium

Previous publications (1) (2) (18) (56) have underlined the linkage between the efficient use of materials, productivity and economic progress. These observations are based upon the hypothesis that, if and when traditional materials are replaced by new materials, the change is based upon an actual or projected increase in efficiency with respect to a firm or an industry. This increase in efficiency is normally translated into a reduction in the level of cost associated with achieving a given level of added value in the final product, or alternatively an increase in added value associated with a given cost, or more generally a trend which causes a divergence between added cost and added value so that the capital employed in processing is used more efficiently. Increasing the efficiency with which capital is used will involve a balance between improved profitability and reduced selling price, thereby, strengthening the firm and through economic linkages help to make the end-user more efficient. Assuming that improved efficiency, as measured by the difference between added cost and added value, is the primary motive for the displacement of one material by an alternative, then it may be reasonably postulated that the greater the demonstrated ability of an economy to achieve this displacement of traditional materials and effective use of new materials the greater the efficiency of the economy.

Changing from one material to an alternative, however, often requires the investment of considerable resources, over a protracted time period, involving research and development, change in the design of the final product and the introduction of new or modified processes, together with market development activity, often necessary in order to modify the attitude or educate of the end-use industry with respect to the potential advantages of the new material. Eltis (47) has shown by analysis that continued capital investment aimed at economic growth results in diminishing returns on capital unless accompanied by technological innovation.

The increasing use of new materials and the defensive reaction from traditional materials by counter developments, introduces more efficient designs and processing routes which maintain or increase the returns on capital invested if certain conditions are fulfilled.

Capital investment in new processing plant and product design and the R & D investment preceeding innovation must ultimately be repaid by sales revenue, which is proportional to demand and product mix in final demand. Rate of change in demand will, therefore, tend to condition the attitude of entrepreneurs with respect to all aspects of capital investment associated with materials oriented innovation. An economy, like the UK, which has historically demonstrated a slow rate of economic growth, or a slow rate of increase in demand, will appear unattractive especially if Government attempts to motivate the economy have failed in the past. Time scale in repaying capital investment is shown to be crucial (58) in determining whether the return on capital invested is acceptable to the entrepreneur. This is because discounted cash flow analysis attaches diminishing value to given cash flows as the time elapsing beyond the initial investment increases. It is not difficult to appreciate that in a slow growing economy, like the UK, the slow rate of increase in demand produces unattractive cash flow profiles and less attractive results with respect to the efficient use of capital compared with faster growing economies. The economic environment and its forecast future potential is, therefore, critical with respect to innovation.

This situation isolates the dilemma, since as previously analysed, without innovation a diminishing return is obtained on capital investment, even that which is used to replace obsolescent plant. Furthermore, the increasing return on capital investment which occurs as a result of successful innovation in a growing economy provides capital necessary to fund subsequent innovation and investment. Progressive innovation over long periods of time leads to technical supremacy in the final product form and international competitiveness with respect to the selling price. Increased income arising from sucessful innovation and capital investment has also been demonstrated by the multiplier hypothesis (29) to generate economic growth as measured by demand, since part of the increased income derived from one economic activity tends to be spent on the output from other activities. The converse of this set of interrelationships is also held to be true and particularly relevant to the UK between 1960-69.

Analysis in this investigation has shown that the rate of change in the consumption of aluminium in the UK is linked very strongly with the value and rate of change of manufacturing and construction. This linkage may be shown in the form of an international consumption function which when examined over a period of time, using constant market prices, reveals an increasing capacity of developing economies to use more aluminium per unit of output. Tendency to absorb proportionately larger quantities of aluminium with real increase in the value of output is revealed by the increase in specific consumption. Specific consumption of aluminium in the UK tended to increase more slowly between 1960-1969, than other developed countries which demonstrated more rapid rates of economic growth. Marginally different quantitative results were obtained in different end-use sectors of the UK economy when more detailed micro-economic analysis was applied. This detailed analysis which is limited by the availability of relevant statistics served to illustrate the heterogeneous nature of the end-use consumption profile of aluminium. Even within a given end-use sector like transport equipment, considerable divergence of performance was recorded dependent largely upon the stage of historical development or decline of a given sub-sector. In addition, different end-use sectors showed varying capacity to effectively innovate with respect to aluminium in the context of the UK economy. Packaging was identified as being relatively progressive during the 1960-69 period whilst the building industry was particularly backward.

12.7.5.

12.7.5.

It was further recognised that the cost structure of a particular manufacturing activity would influence the ability to innovate, particularly in a slow growing economy. Certain types of processing activity and manufacturing industry are characterised by being capital intensive, especially with respect to the miniumum techno-economic size of manufacturing unit or plant. The larger the minimum economic size of unit, the larger the incremental capital investment associated with innovation and the greater the barrier, especially in a slow growing economy. This is largely because the cost benefit motivating the investment is only realised when the unit is operating at high levels of productive capacity utilisation. Both secondary product and final product manufacturers exhibit a range of capital intensity barriers to growth in productive capacity. Thus flat secondary products is considerably more capital intensive than extruded products. Further, both the building and the packaging industry have lower unit capital investment barriers than the automobile industry. The fact that the building industry in the UK demonstrated a non-progressive attitude toward aluminium between 1960-69, is not attributable to the capital investment barrier, but to a wide combination of factors including, attitudes, divided responsibilities between architect and builder, local authority regulations, uncertainty in demand, all of which were identified by investigations (18) (56) into the UK absorption of plastics materials. None of these detailed aspects have been investigated with respect to micro-economic sectors in the present investigation, since they would constitute developments beyond the broad scope of investigation intended. However, in attempting to determine more definite explanations for the micro-economic behaviour observed with respect to the UK consumption of aluminium more detailed examination would be necessary.

In achieving economic growth it is essential to manage both the productive and the demand side of the economic equation so that they are mutually stimulative, and not damaging. Evidence has been quoted in the literature (34) Tables 5. 1. 12. 1 and 5. 1. 12. 2. which indicates that insufficient capital is being devoted to aspects of R & D in the UK which would directly benefit aluminium consumption and therefore the efficient use of materials. Further evidence concerning capital investment in new plant and machinery, Table 5.1.12, is insufficiently detailed to lead to definite conclusions but would suggest that the UK should be investing a larger proportion of GDP in new plant, especially when the age structure of present investment is taken into consideration. This observation was supported by the mechanical engineering EDC (57).

13. Summary and Conclusions.

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13.1 13.1

Summary and Conclusions

Structure of the Aluminium Industry and the Price of Aluminium

Six companies produced more than 80% of the western world's primary aluminium during the 1960's. This situation developed from the limited patent rights in the early days of aluminium extraction, aluminium cartels and the large capital barrier to entry into the modern day industry.

Production of primary aluminium in modern plants is a capital intensive operation in which a production cost below the published selling price can be achieved only by large scale plants operating at high levels of productive capacity utilisation. Alcoa has been described as the price leader and the low cost preference firm, due to its large scale activity and its declared policy of stable competitive prices for aluminium designed to promote long-term growth in the consumption of aluminium and profitability. Price increases for aluminium, however, have been restricted by the US Government, which threatended release of material from strategic stockpiles, and by the availability of low price soviet block aluminium.

Previous analyses of the aluminium industry have identified constraints upon pricing policy which included; the need to motivate increased consumption achieved by the substitution of traditional materials; provision of a secure supply by the provision of adequate productive capacity in advance of demand; the need to secure orders, in the face of competition from alternative suppliers, which at least made a contribution toward the high fixed cost of production.

13.1

No significant international differences in the list price of primary aluminium was observed for the period 1960-69 and price, therefore, is not regarded as an important factor in determining international differences in primary aluminium consumption. Secondary aluminium is consumed predominantly in the form of castings. Production of secondary aluminium does not have the same capital barrier to entry as that associated with primary production, and approximately thirty firms in the UK alone are active producers and suppliers to the foundry industry. The price of secondary aluminium is not regarded as a factor that has influenced the difference in performance when comparing the consumption of cast product forms in the UK with other economies.

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13.2
Technological Innovation and Economic Activity

Effectively managed technological innovation increases the efficiency with which resources are utilised and is an important element in maintaining and improving competitiveness, both at the national level and in the firm.

Failure to innovate introduces the danger of diminishing returns on additional capital investment. Increasing use of new materials and the efficient use of processes is recognised as having beneficial effects with respect to the added value of the product and the unit cost of production. However, materials-related innovation requires substantial capital investment in research, design, development and new processing plant. Consequently, the cost benefit of materials-related innovation can only be achieved if the demand for the product forms involved creates an adequate utilisation level of new productive plant capacity.

The level of utilisation that must be achieved for profitable activity is related to the capital intensity of the operation and the added value of the product. Although technological innovation is an essential input for economic growth, it is evident that the rate of the observable increase in demand, in a given market, will influence the attitude and performance of the entrepreneur

The need to promote technological innovation, increase capital intensity, reduce the life of capital investment, improve cash flow profiles and profitability was recognised by the UK Government, in the 1960's, by the introduction of investment grants and depreciation

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allowances against corporation tax. However, this followed a long period of relative economic stagnation in the UK going back to 1950.

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13.3

The Derived Demand for Aluminium

Consumption statistics, in the main, record the amount of aluminium and other materials used by end-use manufacturing and construction industries and not the quantity consumed by the end-use market. This type of demand for a material, or product form, is referred to as a derived demand, the level of which is determined by the forward relationship between the material and end-use industries performance. Previous analyses (7) (8) have shown strong correlations between the growth in GDP and aluminium consumption, however, a more direct correlation exists between the growth in the value of manufacturing and construction and aluminium consumption, since the capacity of an economy to consume more aluminium, as measured in the statistics, is dependent upon activity in the manufacturing and construction sectors of the economy. However, the correlation with GDP will produce similar results, provided that the structure of the economy remains unchanged.
The multiplier hypothesis (29) explains the gearing effect of economic growth, by postulating that a proportion of the increase in income from one economic sector tends to be repeatedly respent on the out-out from other sectors. This geared stimulative effect upon economic activity is reflected in the rate of change in demand for materials and is an important factor in determining the relative ability to achieve technological innovation.

Criteria for the Evaluation of International Differences in Materials

Consumption

Analysis of the factors influencing the differences in international performance with respect to aluminium consumption requires that relevant criteria for comparison must be identified. Criteria based upon the stage of economic development and structure are shown to be relevant. These criteria were based upon the relationships between, the level of materials consumption and the added value of output in the economy or sectors of the economy, the rates of change in materials consumption and the added value of output, and the ratio of the level of materials consumption and the added value of output, where values were determined at constant market prices. Criteria based upon the ratio of the level of materials consumption and the added value of output is referred to as specific consumption. Specific consumption remains constant unless the rate of change in materials consumption is different from the rate of change in the added value of output. Appreciable change in specific consumption reveals the relative displacement of one material by an alternative, although minor variation may occur due to a change in the efficiency with which a given material is utilised.

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Cyclic Behaviour with respect to Aluminium Consumption

Cyclic behaviour, from year to year, with respect to aluminium consumption necessitated the use of time series logarithmic regression analysis in order to minimise the distorting influence of untypical terminal year data, especially when computing growth rates in consumption. More fluctuation about time-series mean trends occured in aluminium consumption than in GDP, or the value of output from manufacturing and construction industries, when comparing international behaviour. Since the statistical data, employed in the analysis, measures consumption by the end-use industries, it follows that the excess in cyclic behaviour in aluminium consumption over the value of output is caused by a variation in the level of aluminium stock held by end-use industries. Material stock levels are adjusted by industry according to their interpretation of the short term forecast in demand for their products.

MP

Aggregate Consumption of Aluminium in the UK compared with other Economies.

In 1960 the aggregate specific consumption of aluminium in the UK was well advanced compared with similarly developed European economies and only marginally below the US level. Comparison of UK with German specific consumption shows that the UK was 40% ahead in aggregate terms, indicating that, at least until that time, the UK end-use manufacturing industry had actively exploited the cost and performance benefits associated with aluminium compared with alternative and possibly traditional materials.

During the period 1960-69, the UK showed a low rate of growth in aggregate specific consumption of aluminium (1.2% per annum) by international standards. International correlation analysis showed that aluminium consumption does tend to be directly related to the value of manufacturing and construction, but that the strength of the relationship is markedly dependent upon the inclusion of exceptionally high US values. Appreciable deviation is found to occur among countries having a similar value of manufacturing and construction. The slope of the relationship tended to increase with time, consistent with the observation that the countries examined increased their levels of specific aggregate aluminium consumption and indicating that the specific consumption of aluminium at a given value of manufacturing and construction was tending to increase with time, due to the international diffusion of technological innovation. This does not suggest that increase in specific consumption would necessarily occur in the absence of

13.6
growth in output in a given economy, since all the economies had grown with respect to manufactured output during the period examined.

International correlation between the growth rates in aluminium consumption and the value of manufacturing and construction shows a strong relationship, in which the growth in aluminium consumption tends to approach twice the rate of increase in the value of manufacturing and construction. Rate of economic growth in the UK was clearly an important factor in affecting the rate at which growth in aluminium consumption occurred. This behaviour is consistent with the inadequate growth in demand barriers to innovation described previously, which make it difficult for industry to realise the potential cost benefit. By 1969, the lead shown by the UK in aggregate specific consumption of aluminium had been narrowed by other European countries and was considerably less than the US and Japan.

JB

13.7 13.7

International End-Use Sector Consumption of Aluminium

It would be an over simplification to claim that the difference between UK aluminium consumption performance and other similarly developed economies could be explained entirely by the differences in the level and rate of change in the value of manufacturing and construction. In developing a more detailed explanation of UK performance, it is necessary to examine the performance of micro-economic sectors, and to compare their international performance with respect to aluminium consumption. Furthermore, the distribution of aluminium consumption over the range of end-use manufacturing and construction sectors exhibited considerable international differences. Several countries, including the UK, consumed a high proportion of their total aluminium consumption in the transport equipment sector (32% in the UK and 22% in US and Japan) whilst other developed countries consumed a much smaller proportion (7-11%). In contrast, the UK consumed only (8.0%) of total aluminium consumption in building and construction compared with (24.0%) in the US and Japan. Sectors having a strong linkage with aluminium consumption clearly played a more important role in determining the change in aggregate consumption than those with a weaker linkage in a given economy, even over the ten year period. In 1960, the UK specific consumption of aluminium in the transport equipment sector was marginally lower than Germany and France and less than half the Italian level. Other countries, apart from France, made more rapid advancement in specific consumption, so that by 1969

13.7

the UK level was lower than any other major transport equipment producer in the sample. Analysis has shown a remarkably high degree of international correlation between the amount of aluminium consumed in transport equipment and the value of output from this sector, although the UK transport equipment manufacturing sector failed to keep pace with the international trend exhibited for an increase in specific aluminium consumption. However, contrast between UK performance and other countries should not be exaggerated, by 1969, the UK specific consumption in the transport equipment sector was similar to France and the USA, but compared most unfavourably with Germany and Japan.

International differences between the specific consumption of aluminium in the production of electrical engineering products was generally small, or in the process of rapid correction. Although the UK specific consumption of aluminium in this sector was appreciably lower than Germany, France and Italy by 1967, the rate of growth in the UK specific consumption was higher in electrical engineering applications than any other UK sector.

Building and construction was the only sector in the UK economy, based upon OECD aluminium end-use statistics that demonstrated a reduction in specific consumption of aluminium (-1.2% per annum) during the period examined. Wider international difference in specific aluminium consumption are revealed in this sector than any other sector analysed. USA demonstrated exceptionally high levels of specific consumption and Japan exceptionally high levels of growth; these results made correlation analysis extremely sensitive to the range of data included. Reference is made to the contrast in selection factors when comparing the building sector with manufacturing, suggesting that the rate of market expansion is less likely to be a key factor in affecting the changing from one material to another, than the traditional building methods, aesthetic aspects, climatic conditions and the attitudes toward change reflected by the architect, builder and customer.

Internationally, a high degree of correlation was observed between the consumption of aluminium in packaging and GDP, both in 1960 and 1969. The slope of the consumption function increased between 1960 and 1969 indicating an international trend towards increased specific aluminium consumption in this sector. UK consumption fell marginally below the international trend in 1960, but agreed very closely by 1969. Packaging revealed large international differences in specific consumption in 1960, showing that the UK was among the most progressive users of aluminium in this sector. Rapid changes in materials consumption behaviour, that are unrelated to the rates of other economic changes, are a feature of the packaging end-use sector, however, there does appear to be an underlying trend toward international consistency with respect to specific aluminium consumption in this sector.

UK End-Use Sector Consumption of Aluminium

More detailed analysis of disaggregated aluminium consumption in the UK was made possible by the availability of statistics data. In particular, this analysis revealed the inhomogeneous constitution of the transport equipment sector represented by the international OECD aluminium end-use consumption statistics. A wide range of consumption performance was contained within this sector, from (-8.0%) for rail transport to (14.0%) for "other transport" applications, later revealed to be end-use in caravans. Transport equipment sector not only maintained the highest proportion of total UK consumption, but also a considerably higher level of specific aluminium consumption than any other sector. Consequently, it is not surprising that the growth in specific aggregate aluminium consumption (1.2% per annum) is very similar to the overall growth in the specific consumption in the transport equipment sector.

The electrical engineering sector not only showed the highest increase in specific consumption (3.4% per annum), but showed a related increase in proportion of total consumption. Packaging and building end-use sectors consumed similar proportions of total aluminium consumption (8.0%) and both showed a slightly diminishing share of total aluminium consumption. Chemical, food plant and equipment sector made a similar contribution to increased aluminium consumption to that achieved by the packaging sector, due to the high rate of growth in consumption of the former and the larger proportional consumption of the latter.

13.9

Consumption of Aluminium Compared with other Selected Materials

Specific consumption of steel, using the unit weight consumed per unit value of output, was considerably higher than any other material in the sample when examined internationally. This level of consumption indicates the dependence that end-use manufacturing and construction industries have upon steel and its relative insensitivity to displacement by alternative engineering materials. Consistent international trends in materials consumption were observed, especially when correlating consumption with the value of output and rate of change of output in the economies studied. Change in aluminium consumption was similar to plastics materials, both in the UK and internationally, in so far that both types of material exhibited an increase in specific consumption between 1960 - 69. However, the rate of increase in plastics materials consumption was higher than aluminium and the profile of end-use was also very different.

UK exhibited a small reduction in the specific consumption of traditional non-ferrous metals, showing that an improvement in material and process efficiency took place, but relatively slowly by international standards.

Consumption of Different Aluminium Product Forms

Aluminium is supplied to end-use industries in a wide range of semi-finished product forms and each tends to show a characteristic pattern of consumption. Cast aluminium products consumption is strongly related to the transport equipment end-use sector. UK showed a relative decline in the specific consumption of aluminium castings between 1960-69, compared with other economies. Furthermore, in spite of the fact that die cast aluminium product forms grew rapidly compared with other aluminium product forms in the UK, performance was low compared with the other economies for which data was available. Factors affecting the consumption of die castings were identified, including the relationship with mass production industries and the high die cost involved for a given component or product. Wrought aluminium product forms are consumed more uniformally than cast forms across the range of end-use sectors identified in the OECD statistics. Increase in flat products consumption in the UK was lower than any other country examined. Increase in UK production of flat products was even lower than consumption, which was compensated by a corresponding change in the trade balance in flat products, suggesting that the UK flat products industry was internationally non-competitive. Consumption of extruded aluminium sections, used by a broad spectrum of end-use industries, achieved a high level of increase in specific consumption in the UK compared with other product forms. This performance is attributed to the design freedom made possible by using extruded section, accompanied

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by the competitive process cost structure and the relatively low incremental capital investment required for the expansion of productive capacity.

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 13.11

The Relationship between Economics Progress and the Ability to Achieve Technological Innovation with respect to Materials and Processes

Correlation analysis supports the existence of a strong relationship between the efficient use of materials and economic growth. High rates of growth in the manufacturing and construction sectors of the economy appeared to be a pre-requisite, in the economic conditions prevailing between 1960-69, for a substantial increase in the aggregate specific consumption of aluminium. High rates of growth in the value of output from end-use sectors,that derive increased efficiency by the increased use of aluminium,were also accompanied by related increases in the micro-specific consumption of aluminium. This increase is, no doubt, affected by the ability of the sector to exploit the opportunity and the level of benefit derived from the change.

Countries that demonstrate the technical and innovative ability essential to exploit new materials, related processes and design changes, possess part of the essential foundation for economic progress.

Motivation to select new materials is created by recognition of the opportunities that exist for potential cost savings, increased added value of the product, more efficient performance by the product in service, or a combination of these and other opportunities for improving the efficiency with which resources are utilised.

Improvement in economic efficiency requires both technological innovation and capital investment in research design and development and new processing plant. Usually,ultimate cost benefit is only achieved when demand for the product gives rise to high levels of utilisation of new plant capacity. The time required to fill new plant capacity is reduced as the rate of demand increases. This introduces the importance attached to the results of discounted cash flow analysis in different economic circumstances. This evaluates the effect upon the forecast present day value of money,dependent upon the time delay between cash flows during investment and operation.

An economic environment that is favourable to a rapid growth in demand is more conducive to shortening the period in which unit costs of production may be decreased and achieving an attractive discounted cash flow profile following capital investment. These aspects feature predominantly when companies appraise schemes for capital investment in new products, designs and processes. The aggregate outcome of the decisions that follow from these appraisals determines the changes that occur in the specific consumption of materials, including aluminium.

UK performance with respect to the specific consumption of aluminium is a symptom of the difficulties and inability in obtaining improvement in economic efficiency,associated with effective technological innovation,in the UK economy during the period 1960-69. This is recognised as having important

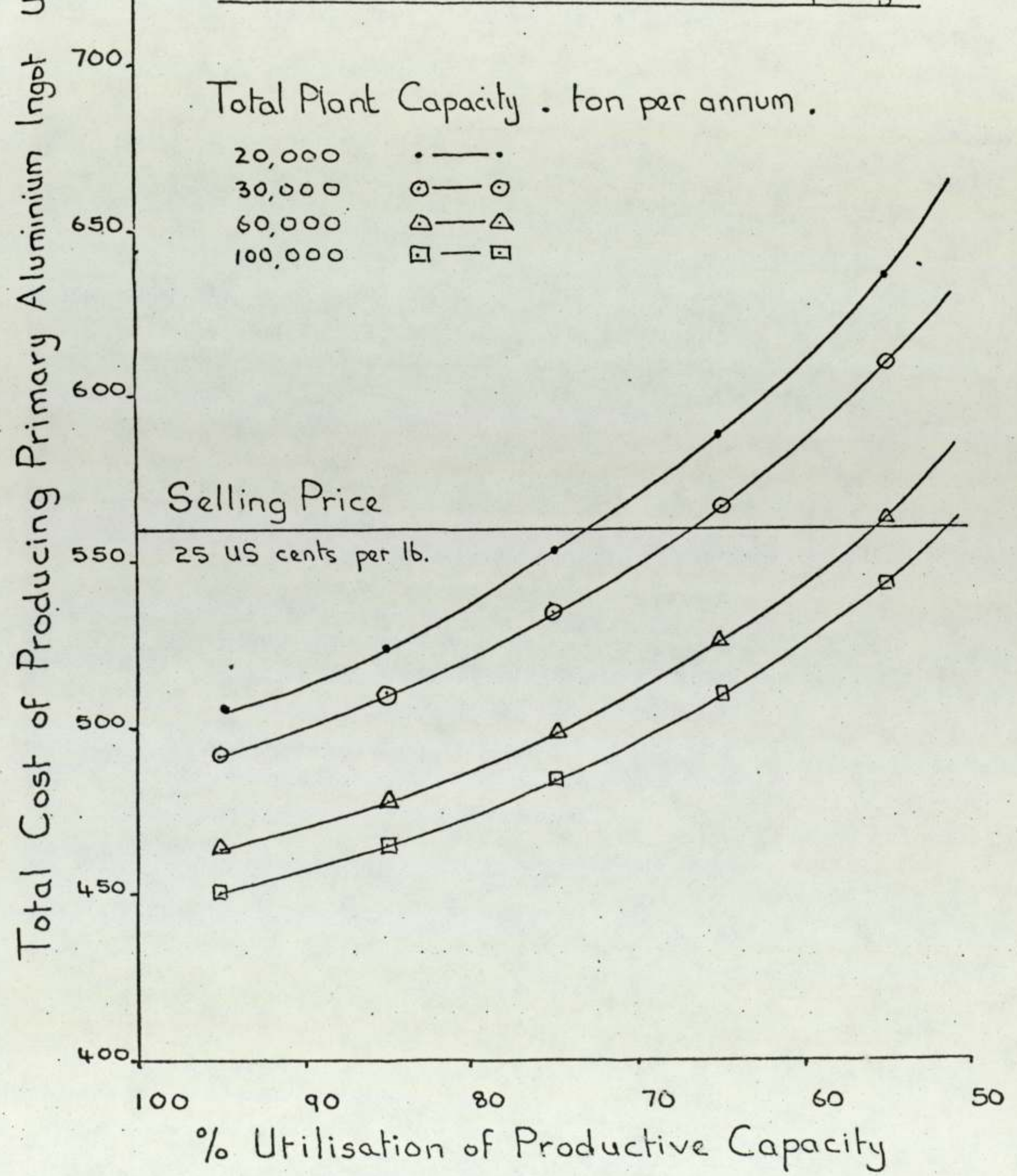
13.11

economic implications with respect to failure to reduce the unit costs of production, increase the added value of products in a highly competitive international market and diminishing returns on capital investment. If these trends are allowed to continue, they will give rise to further deleterious effects upon the ability of UK industry to contribute to economic growth and to compete both in domestic and export markets.

LL

14. Figures

Fig. 1.



Total Cost of Primary Aluminium Production
- % Utilisation of Productive Capacity.

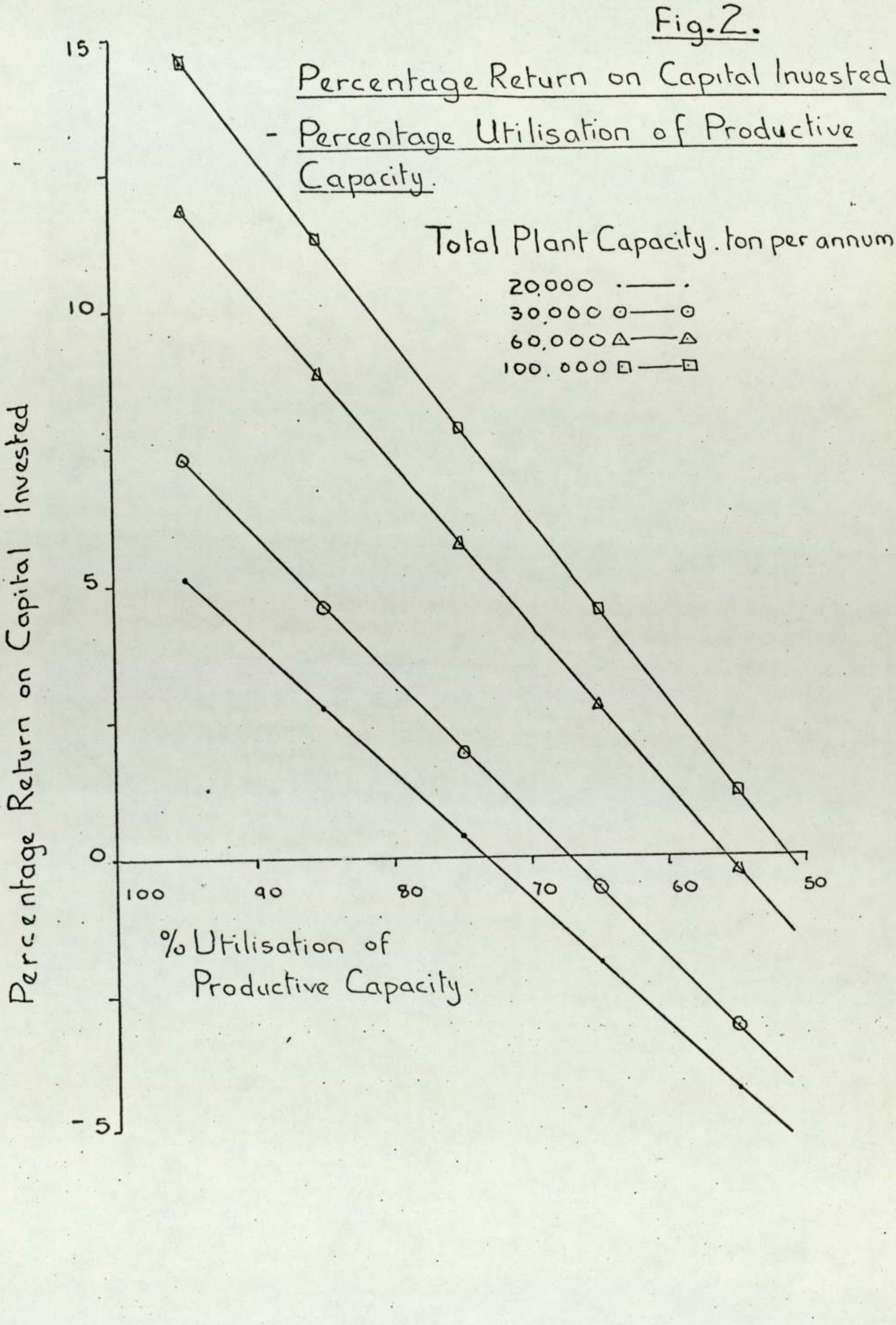


Fig.2.
Percentage Return on Capital Invested
- Percentage Utilisation of Productive Capacity.
Total Plant Capacity. ton per annum
20,000
30,000
60,000
100.000
Percentage Return on Capital Invested
% Utilisation of Productive Capacity.
15
10
5
0
-5
100
90
80
70
60
50

Fig. 3.

Percentage Return on Capital Invested - Productive Capacity of Primary Aluminium Plant.

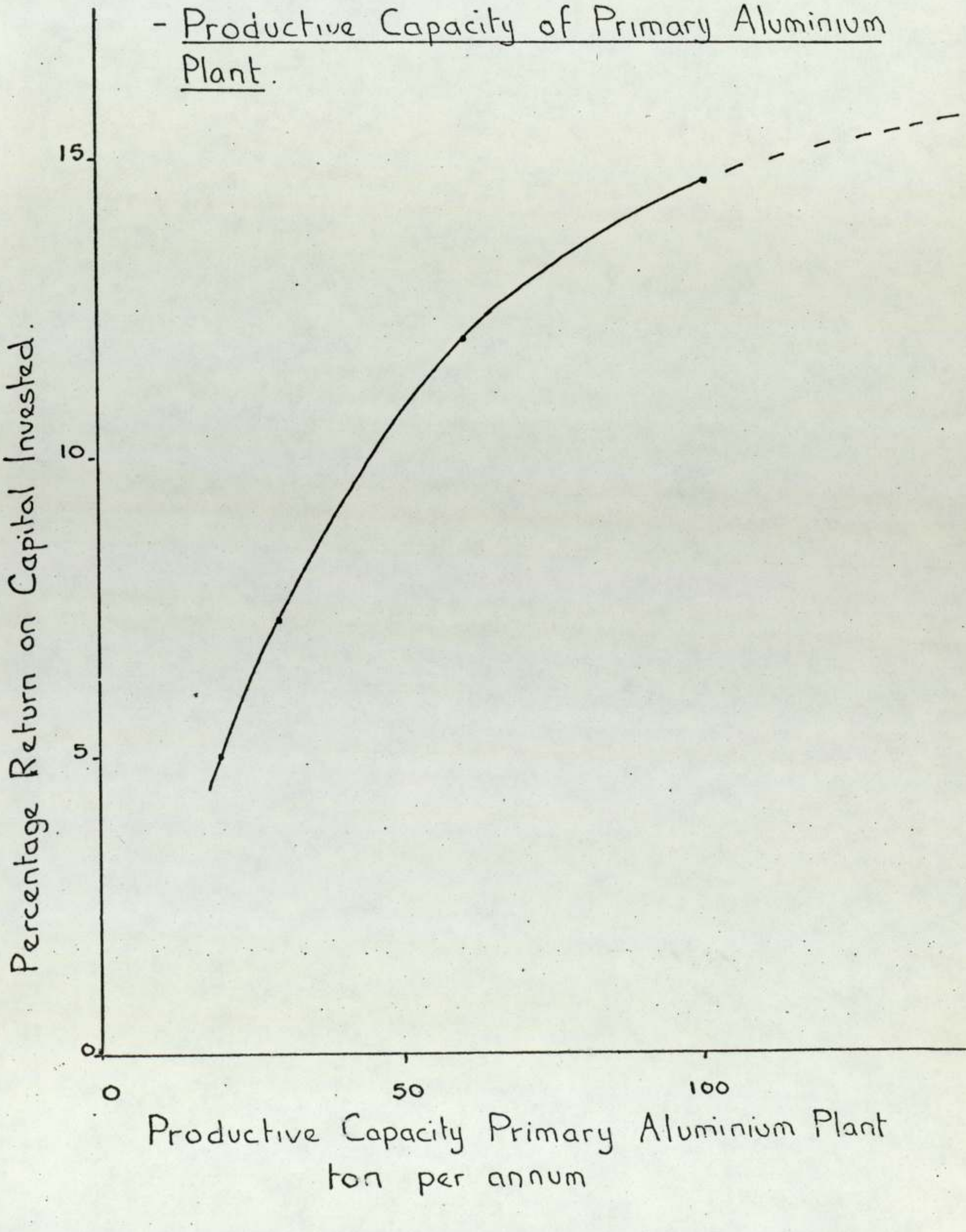


Fig. 4.

Total Consumption, Primary + Secondary Aluminium x1000 metric ton. - Year.

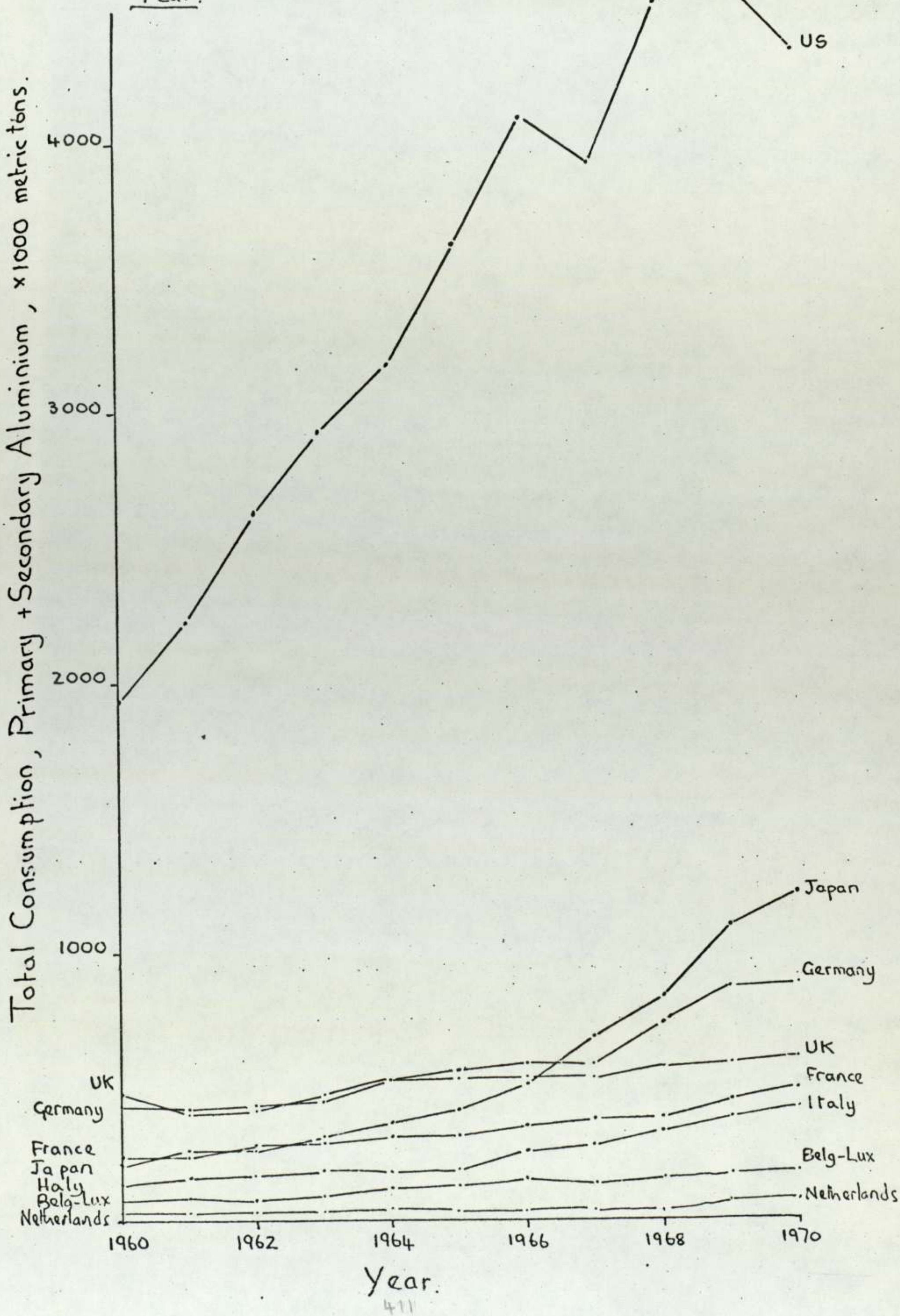


Fig. 5.

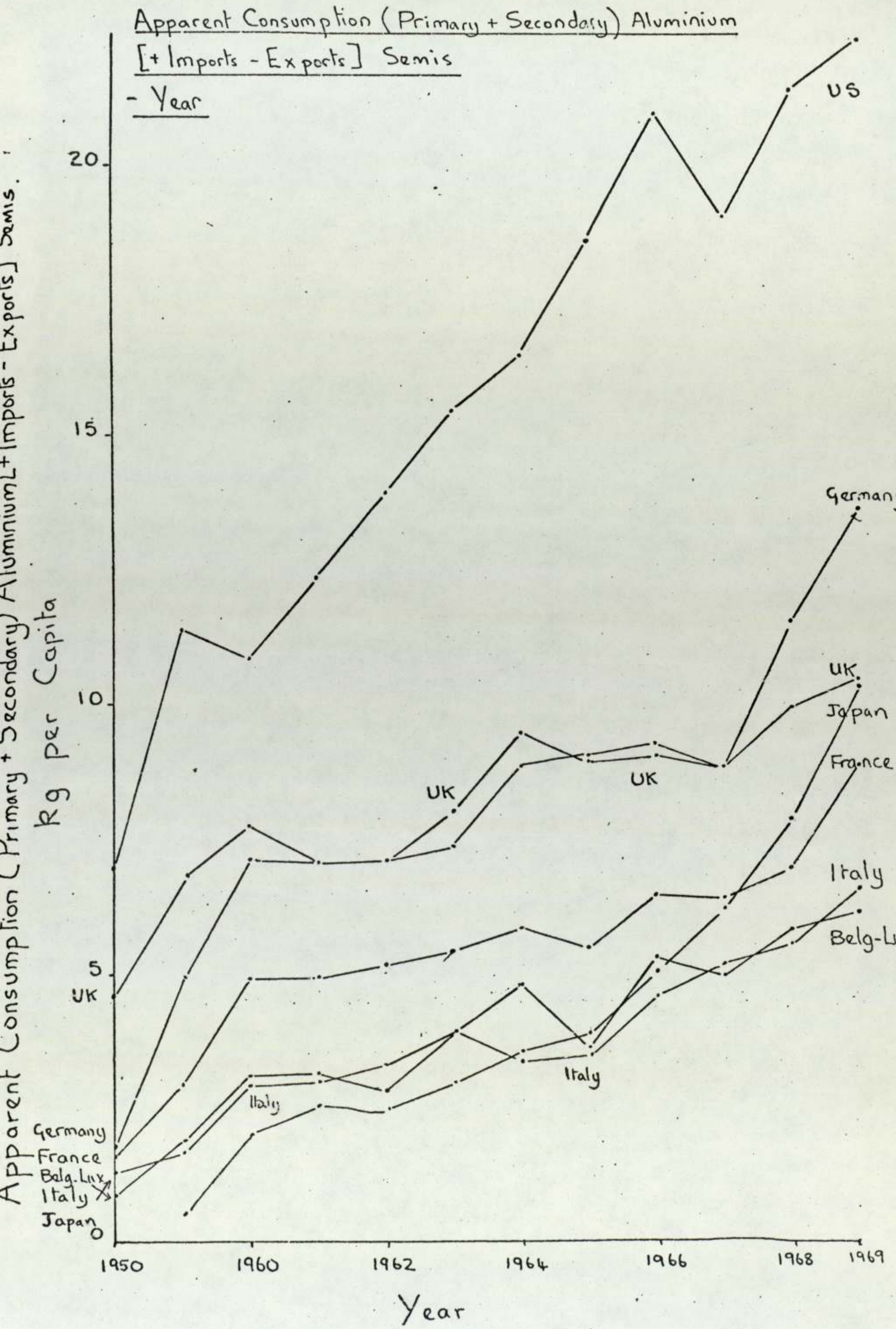
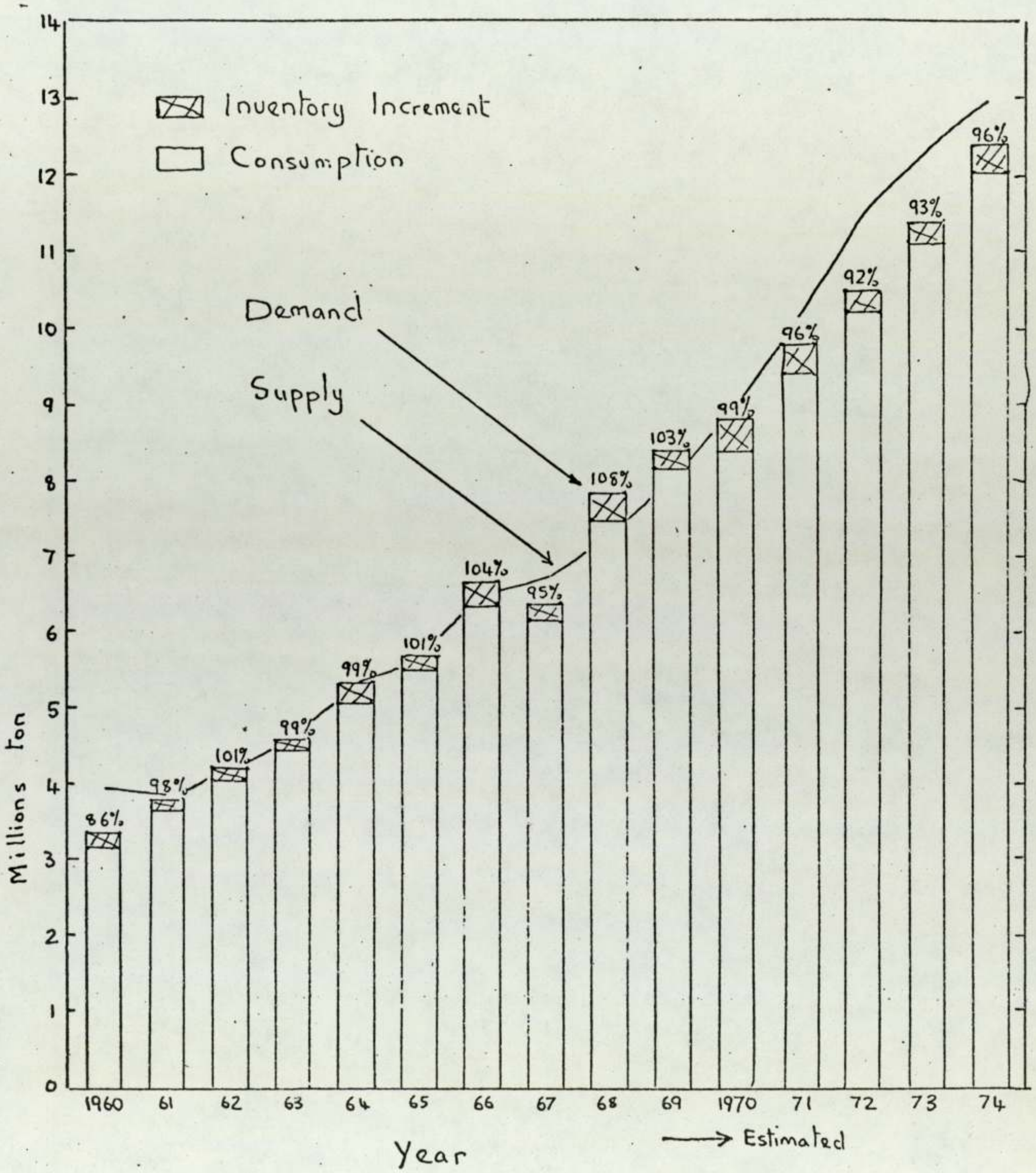

Apparent Consumption (Primary + Secondary) Aluminium
[+ Imports - Exports] Semis
- Year
Apparent Consumption (Primary + Secondary) Aluminium [+ Imports - Exports] Semis.
Kg per Capita
20
15
10
5
0
US
Germany
UK
Japan
France
Italy
Belg-Lux
UK
UK
UK
Italy
Italy
Germany
France
Belg. Lux
Italy
Japan
1950
1960
1962
1964
1966
1968
1969
Year

Fig. 6.

Free World Demand of Primary Aluminium

- Supply



Spector.

Fig. 7.

Cost Chart

New Extrusion Press Making Aluminium Sections

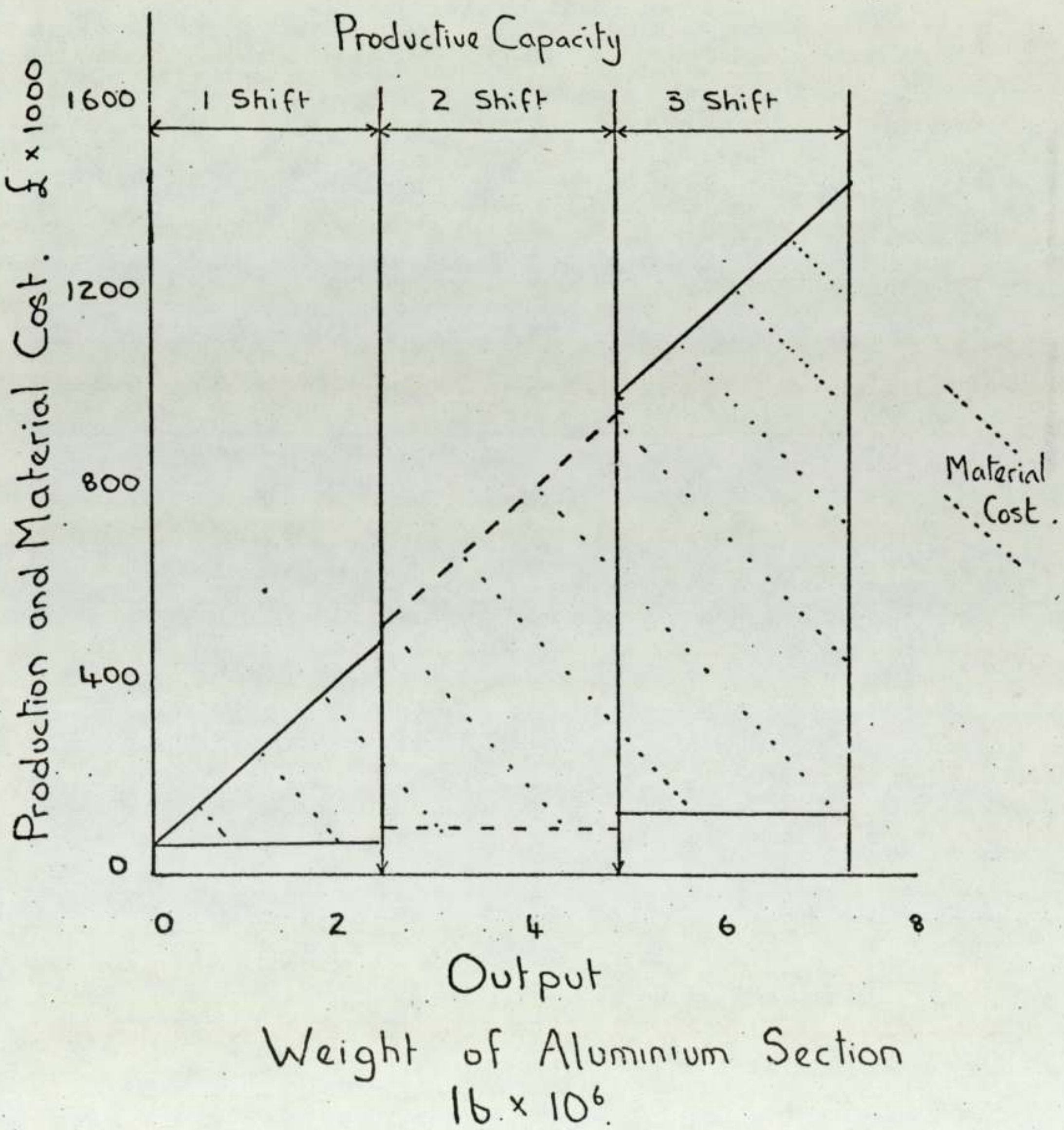


Fig. 8.

Growth in Output - Time

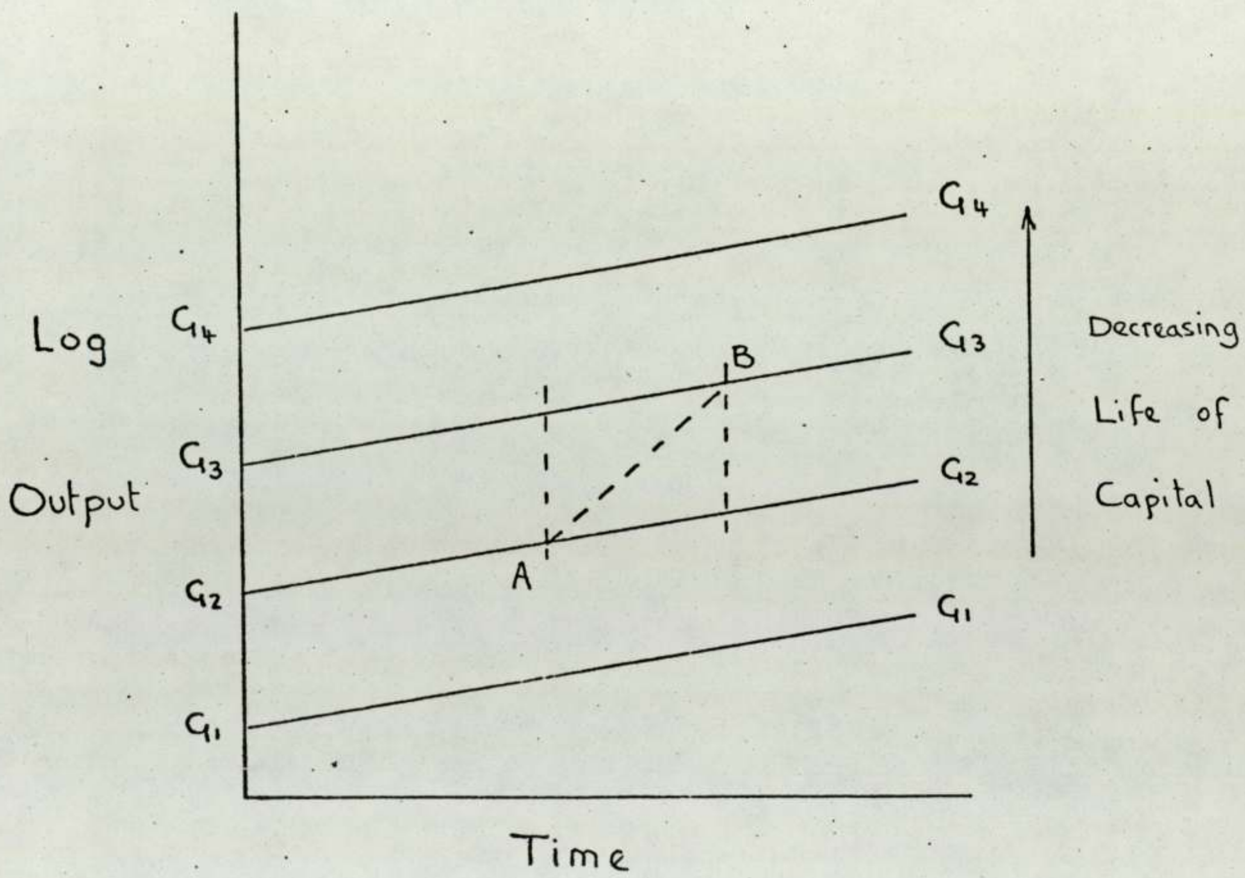
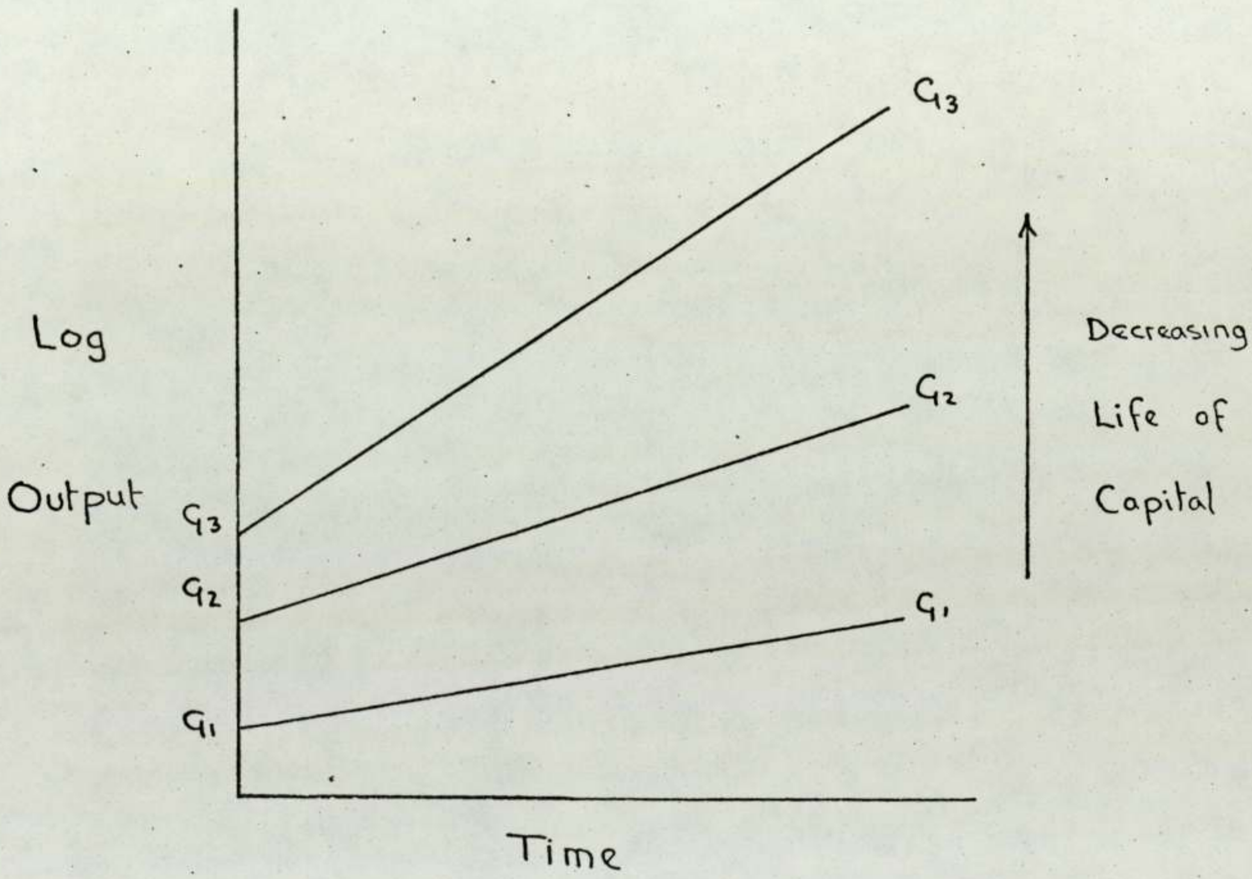


Fig. 9.

Growth in Output - Time



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