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A guide to industrialization among selected nations

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A guide to industrialization among selected nations

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Almoez Ledin Ellah Mohammad Shawkat Eltouny

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I. INTRODUCTION

Industrialization has always been regarded as an aid to achieving a better standard of living.

> "Industry is in itself a highly dynamic activity, the incomes per person engaged are (normally) substantially higher in industry than in agriculture. Also industry tends to exercise a dynamic impact on the other sections of the economy." (21)

There are many factors that affect industrialization in any country. Although the intensity of any one factor or factors may be higher then one or the other, they all will be present complicating the analysis.

Politics and political thought play an important role in the process of industrialization. Two principal types are planned industrialization or the five year plan type, versus a free market industrialization growth. Could a mixture of both be a better deal?

The social aspect in industrialization is another one of the factors. The impact of industry on society and social relations and customs, is profound in many instances. The discarding of traditional society and the pains of adapting to new and sometimes conflicting values often are harsh realities of industrialization.

Economic considerations are a major influence in development and growth. What type of industry, how to finance, both are questions to be considered.

Productivity is another one of the factors that is affected by the degree of industrialization and the types of economic activities under consideration.

The road to industrialization then, is neither smooth nor straightforward. There are probably as many pitfalls in it as there are accomplishments. One may find that positive steps often are counteracted by negative steps.

For any country embarking on any plan of industrialization or economic development, the questions that have been, and are still ultimately being raised are: What are the proportions of the different inputs of labor and capital that will give a higher return? What combinations of inputs to industry will achieve a higher level of industrialization, and a higher rate of industrialization? What combinations of inputs are needed to sustain a given level of industrialization?

Industrialization plans and planning for growth and development are more readily used now then they were before the Second World War. Before World War II, data concerning industrialization were sparse and few.

The Second World War had its effect on both the available information and on industrialization. In order to keep track of the economic situation especially after the Second World War, the General Assembly of the United Nations, which was established in 1946 adopted a:

> "Resolution 118 (II), in which the Secretary General was requested to prepare annual factual surveys and analyses of world economic trends." (16)

The Second World War left shattered economies all around the world. Whether actual devastation, or repercussion of such devastation, the consequences were felt nevertheless. Only the United States amongst the participants in the war did not suffer physical destructions of industry.

> "In the present world economic situation the fact looms large that the economic potential of the United States of America has enormously increased during the war, while that of many (other) important production centers has considerably diminished...." (16)

In some other non-participant countries, the war helped in increasing the rate of industrialization. In Latin America for example:

> "There has indeed been a heightened rate of industrial and economic development and, as was the case after the First World War, it is clear that some among these countries have moved towards a stage of more extended industrialization, with a corresponding strengthening of their economies. However, the Latin American countries still have some two-thirds of their aggregate population directly dependent upon agriculture, wi h the greater part of this population engaged in subsistence agriculture despite a substantial production for export." (16)

For the European countries, the situation was not that simple.

> "The impact of the war in terms of physical destruction of industry, transport, agriculture, and other national resouces has been fully recognized because the results of such destruction

were visible and measurable. ... A state of equilibrium had not yet been achieved in the economies of European countries, which continued to be subject to inflationary pressures arising from continuing shortages in the face of huge reconstruction requirements." (16)

The war also affected the financial and monetary aspects of the economies.

> "The invisible devastation wrought by the war, however, was less obvious and its consequences more difficult to assess. It manifested itself in devastation, rather than destruction, of capital and man-power, and in economic dislocations." (16)

Aid programs by the U.S. Government were being initiated to alleviate the financial ills.

> "As 1947 came to a close, the question of external aid from the United States emerged as a major economic issue. While the magnitude and forms of possible aid from the United States are not yet known, a stop-gap program of aid to Austria, France, and Italy was undertaken by the United States Government in December 1947." (16)

One of the key shortages that retarded industrial recovery was that of steel.

> "Next to food and coal deficiencies, the shortage of steel is probably the main bottle-neck to recovery of industry in most European countries. The effects of the shortage of steel are felt in most sectors of industry, in transport, and in agriculture, particularly tractors and agricultural implements." (16)

In Asia and the Far East, the situation was even more bleak.

> "In this region, which at the time it was drawn into the Second World War had not as a whole

achieved any high degree of economic advancement - the vast majority of its predominantly agricultural population still living on a bare subsistence level - the various countries are struggling arduously with the difficulties of rehabilitating their war shattered economies. Many of them had suffered extensive physical devastation and all experienced serious dislocation of production, transport, trade, and finance caused by the war." (16)

Industry suffered great losses:

"Industry suffered serious dislocation if not complete paralysis, while in those other parts which were actively associated in the war efforts of the Allies the industrial equipment was exposed to the strain of incessant intensive use, causing considerable deterioration of machines that could not be adequately maintained."(16)

Japan did not fare well, having been a participant in the war, many of its industries were destroyed. India, on the other hand, made substantial progress in heavy industry.

"By the end of the war, Japan was left with only 3.8 million of its pre-war 11.5 million cotton - spinning spindles. Japan has fared no better in other industries, particularly the heavy industries, a field in which India made substantial progress during the early years of the war. It will be noted that the trend of Japan's manufacturing production as a whole was markedly downward from 1941; steel production culminating two years later, in 1943, came almost to a complete halt for some time after V-J Day, and had by 1947 recovered only to twelve per cent of the 1943 volume. India's iron production also declined, though much more slowly, during the latter part of the war and the first post-war year; in the first half of 1947, a revival set in which brought pig iron production to about eighty per cent, and steel production to ninety per cent of the war-time peak." (16)

As for China

"The incipient heavy industries in China, apart from Manchuria, were all but annihilated by

> the enemy aggression that preceded the world-wide war." (16)

The impact of the war on the Middle East was not significant.

> "The structure of the economy of the Middle East countries did not undergo any substantial change as a result of the war, though new factors were introduced which affected general economic conditions and some significant developments resulted from war conditions. ... The need for certain adjustments in the structural organization of agriculture was increasingly recognized.... Manufacturing activities were increased during the war years; existing industries were expanded and new ones emerged. Though no post-war industrial census has been undertaken, there is every indication that those gainfully employed in industry at the present time exceed the corresponding figures for the pre-war years." (16)

Because of the close association between Africa and Europe, the colonialist relationship, some of Africa suffered seriously economically, while other parts did not.

> "It is also important to bear in mind that a very considerable portion of Africa is under the dominion of European countries and that in consequence problems of economic recovery and development in these areas are intimately associated with European problems ... but a distinction may be made between those African countries and territories which suffered a serious deterioration in their economic life as a result of the war and those which in spite of certain shortages, experienced a net expansion of activity. Some of the territories in the former group, being the scene of actual conflict, suffered direct war damage. Among such were, for example, Tunisia, Tripolitania, Cyrenica, and to a lesser extent, Ethiopia, Erteria, British Somaliland, and Italian Somaliland. There were other areas in which economic deterioration was due rather to the indirect effects of the war, as for example, Algeria, Morocco, Madagascar, and French Tropical Africa." (19)

By 1952 many of the effects of the Second World War on industry around the world had been alleviated.

> "World production, calculated on the basis of official reports by governments, rose to a new high level in 1952, but the rate of expansion, which had been rapid since 1949, slackened off considerably. This slackening was particularly marked in industrial production, which in the first nine months of 1952 was only some two per cent higher than in the corresponding period of 1951, as against an average annual increase in the two preceding years about thirteen or fourteen per cent." (19)

From that time to the present, "National Income" of countries has been increasing every year, with different rates, according to each individual country. This would reflect changes due to industrialization and economic development for each country. Data concerning the National Income per capita began to be published in the Statistical Yearbook of the United Nations.

The production and consumption of steel has also continued to climb.

Although the per capita consumption of crude steel may drop for a period of time, it would pick up again. The total production and the per capita consumption of crude steel data for most countries, are available in the United Nations publications.

About the accuracy of the data present in the United Nations Yearbook, the United Nations states:

> "The basic data used in the report are, in general, as officially reported by the governments.

> The significance of the figures may vary from country to country depending on the statistical concepts and methods followed and on the structure and development of the national economy. For this reason, the compilation of international statistical tables requires that attention be given to any important elements of non-comparability or qualifications attaching to the data; these are usually shown in the tables of the report or in the detailed statistical publications of the United Nations from which the data are derived." (21)

The production and consumption of energy has also been steadily on the increase for all countries. These data were also available, directly or indirectly, from the Statistical Yearbook of the United Nations. The units used throughout the official United Nations publications were metric units. The units for consumption of crude steel were in kilograms per capita. In the case of energy, the units were in equivalent metric tons of coal, and the consumption was kilograms of coal equivalent per capita.

The units of the National Income were national currencies in most instances and in total, but in later editions of the United Nations Statistical Yearbook, it was given in dollars and on a per capita basis. The conversion factors for currencies were also determined from data supplied in the United Nations Statistical Yearbook about the exchange rates.

The questions raised are to try to investigate any relationships that may exist between the consumption of crude steel per capita (steel consumption per capita) and the per capita consumption of energy in coal equivalent units. Are there any discernible patterns among different countries regarding any of the desired "standard" relationships?

Are there any kind of relationships existing between the National Income (as income per capita) and the consumption of steel per capita? What are the patterns if any? What are the similarities if any, and/or the dissimilarities between National Income per capita and the consumption of steel per capita among the different countries?

Are there common characteristics among nations for the consumption of energy per capita (kilograms of coal equivalent per capita) and national income per capita?

II. LITERATURE REVIEW

The emergence of many new nations after the Second World War coupled with their desire to develop economically has led to studies in development, industrialization and Economic growth. One of the studies has been conducted by the United Nations, because:

> "Governments of developing countries generally consider industrialization as synonymous with economic progress, and give the highest priority to industrialization in their strive for accelerated economic development." (16)

A study in the development patterns of developing nations may be informative.

As visualized by the United Nations, the picture of stages of industrialization are as follows:

> "The economic and institutional background is, in general, characterized by scarcity of capital, of managerial talent and technical skills, poor information, lack of external economies and, because of the low level of per capita income and inadequate transportation facilities, limited markets for industrial goods. These conditions tend to favor, as can be expected, the types of industry that are, as a rule, technologically relatively simple to operate, require less capital per unit of output, produce consumer goods in the category of the primary necessities, and can produce these economically at lower levels of ouput. Examples can be found in the food processing and textile industries. Gradually, as more favourable conditions set in, the structure tends to become more diversified through the development of other branches, from light chemicals, leather, pulp and paper, etc., up to steel production, heavy chemicals and other intermediaries, machine building, etc." (16)

The objective of the United Nations study is:

> "To investigate to what extent the development referred to in the preceding paragraph conforms to some pattern, in the sense that the level and composition of manufacturing industry in a given country could be related in some quantitative way to a certain number of general economic characteristics of that country." (21)

A simplified model is used which comprises a limited number of the most important explanatory variables. The three important variables chosen are per capita income, population, and the relative degree of industrialization. The outputs that are used are the total manufacturing output and the output from thirteen sectors of the economy.

> "The objective of this analysis is to express the quantitative relations in the form of a set of equations in which the levels of total manufacturing output and outputs in each of the thirteen sector - both expressed in value added are "explained" in terms of a few selected macro-economic variables." (21)

Although some use may be made of the model and its equations:

> "The model based on the standard equations is not intended to be used as a coin-in-the slot machine which would turn out projected output levels by mechanical computations. To make a justified estimate of these levels in a given country, it is necessary to take into account all the information available on the country's specific characteristics, which are only partly reflected in the explanatory variables of the equations." (21)

There have been other studies conducted by the United Nations dealing with growth of industry in both the developed and developing nations. These studies are broad in perspective and usually divide industry into two categories, heavy and light. The rate of growth of these categories is studied with respect to the rate of change in the Gross Domestic Product. This is done for both the industrialized and industrializing countries.

> "Considered are the ties between growth in the industrial sector - in particular, manufacturing - and that in the total economy and the circumstances that contributed to these relationships. ... In the case of the manufacturing industries, statistical analyses were conducted separately for the light industries (food, beverage, tobacco, textiles, clothing, footwear, furniture, etc.) and for the heavy industries (paper, paper products, chemical, petroleum and coal products, basic metals and metal products, etc. ...)." (25)

The countries that are included in these studies are the industrialized and industrializing countries with market economies for which the required data are available. Countries with centrally planned economies are not included:

> "Countries with centrally planned economies are not included because much of the needed data are not available." (25)

The studies cover the period following the Second World War after the recovery period experienced:

> "The studies relate in the main to the post-war experience of the selected countries after the readjustment to peace-time circumstances was largely completed." (25)

Other parameters are examined in the United Nations study, one is fixed capital formation and its relation to the gross domestic product. This is conducted on both the developing and industrialized countries. Another parameter is the rate of change of the export and import trade in relation to the changes in the gross domestic product. A third parameter studied is population growth with respect to the rate of growth in domestic population.

The relationship between value added per capita in manufacturing and the gross domestic product per capita is also investigated by a United Nations study. This study involves a large number of industrialized and developing countries which have market economies and for which data are available. This has been done on a sample year, 1958. The analysis reveals a consistent pattern of coupling among the countries between per capita manufacturing output and the per capita total product.

> "The pattern of the relationship is such that the expected ratio per capita value added in manufacturing to the per capita domestic product becomes greater as the per capita product enlarges." (25)

However, the trend could have been studied by taking other sample years and the values compared. This relationship between manufacturing and total output per capita is analyzed into the relation between value added for light and heavy industry per capita and the total product per capita.

> "In the case of heavy or light manufacturing, the fitted function predicts that the ratio of value added to the domestic product will increase as the total product per capita rises." (2)

Also, the relationship between manufacturing represented by the value added in manufacturing and the total product per capita differs between the industrialized group of countries and the developing group.

> "Analyses (of this question) indicated that the pattern in which per capita output in heavy or light manufacturing and the per capita total product were related, one to the other, during 1958 did differ for the two groups of countries." (25)

Another relevant parameter studied is the average capacity of installed power equipment or energy consumed, per person engaged in industry. This is coupled to the value added per person engaged in industry.

> "The studies revealed a significant degree of correlation among countries and periods of time, in the pattern in which average value added per person engaged, on the one hand, and average capacity of installed power equipment or energy consumed, per person engaged, on the other, were coupled. ... The fitted lines of regression imply that for a given rate of increase in average capacity of installed power equipment or energy consumed, per person engaged, the rate of increase in average output per person engaged will be less in the heavy industries than in the light industries." (25)

Although the study takes time and the changes that may occur because of the passage of time into consideration, few years for each country have been used; varying from three to four years dispersed throughout the period of study. What appears to have been needed is a number of readings of the same country over a long period of time, lengthening the study period, and this repeated for different countries. Then study the actual results for all countries one year at a time and compare results to determine and explain changes that may have occurred.

In his book " The Growth of Industrial Economies", Dr. W. G. Hoffmann (5) proposes a hypothesis of Industrial growth and development. He contends that countries will pass through three stages of industrialization to reach the fourth and highest stage of industrialization. He stipulates that regardless of the point in time at which any country begins to industrialize, it will pass through so many stages.

> "Whatever the relative amounts of the factors of production, whatever the location factors, whatever the state of technology, the structure of the manufacturing sector of the economy has always followed a uniform pattern. The food, textile, leather and furniture industries - which we define as 'consumer goods industries' - always develop first during the process of industrialization. But the metal working, vehicle building, engineering and chemical industries - the 'capital goods industries' - soon develop faster than the first group. This can be seen throughout the process of industrialization. Consequently the ratio of the net output (value added) of the consumer-goods industries continually declines as compared with the net output of the capital-goods industries." (5)

The author defines the four stages of industrialization as follows:

> "In Stage I the consumer-goods industries are of overwhelming importance, their net output being on the average five times as large as that of the capital-goods industries. In Stage II the initial lead of the consumer-goods industries has been diminished to a point where their net output is only two and one-half times as large as that of the capital goods industries. In Stage III, the net output of the two groups of industries are approximately equal and in Stage IV the

> consumer-goods industries have been left far behind by the rapidly growing capital-goods industries." (5)

One element lacking is that centrally planned economies are not included in the study.

The main criterion of development in Dr. Hoffmann's work is:

> "The relationship between rates of growth of industries within their manufacturing sector of the economy." (5)

The study covers four different historical phases during which the process of industrialization started in various countries, from 1770 - 1820; 1821 - 1860; 1861 - 1890; 1891 and later. The author cautions however, that these phases should not be confused with the four stages of economic development. He also states why such a pattern evolves;

> "The main reason why consumer-goods industries develop first seems to be that expansion of capital-goods industries requires large amounts of capital and advanced techniques of production as well as a skilled labor force. Manufacterers such as the food and textile industries have to be developed before conditions favourable to the growth of capital-goods industries appear. Such consumer-goods industries can utilize the technical knowledge already possessed by skilled craftsmen from domestic industries to a greater extent than is possible in the case of capital-goods industries." (5)

Dr. Hoffmann stresses that although the same overall pattern of growth can be observed for all free economies (market economies), there are significant differences in the expansion of various industries within the two sectors of the industrial economy. He states that these differences may be explained by:

> "... the theories of location and international trade and by certain non-economic factors such as population growth and the political and social framework within which the economy operates." (5)

He goes on to state that in any particular stage of development, one industry will be the dominant one. Owing to the above factors, the theories of location, international trade, etc., the dominant industry will not be the same for each of the countries during a particular stage of development. However, there is a general trend:

> "The dominant industries have, in general, been the food and textile industries during the first two stages of development and the iron, steel and engineering industries during the third stage of development." (5)

Although Dr. Hoffmann may have identified a pattern for industrialization and growth by the four stages he mentions, there does not appear to be any specifications of time periods for each stage.

It would be interesting to study the changes in the consumption of steel and energy and the influence of income in each stage of industrialization mentioned by Dr. Hoffmann. Whether or not his results also hold for these variables for all countries would be valuable to the study of industrialization.

During the course of this study, the growth in the Japanese consumption of steel has been phenomenal. The Japanese Steel Industry is examined by Dr. Kiyoshi Kawahito (9), and this increase in consumption is discussed.

> "The expansion of the Japanese steel industry has been made possible by the existence of a strong demand for its product at home and abroad. The strong demand at home has been caused by a miraculous growth of the economy which has registered an average, annual increase of nearly ten per cent in real gross national product (GNP) during the past two decades. The growth process has involved a heavy investment in manufacturing industries, public utilities, and infrastructure on the one hand, and has given rise to consumption of such desirables as automobiles and refrigerators on the other. Second, during the process, the core of the Japanese industrial structure has shifted to heavy and chemical industries which use more steel than other industries." (9)

Dr. Kawahito states that the basic consumption of steel occurs in four main industries, namely, construction, shipbuilding, automobiles, and machinery. In comparing the consumption markets in the U.S. and in Japan he says:

> "As most shipments to distributors in Japan go eventually to construction, the actual share of the construction industry should be somewhat higher than that in the United States. Also, the ship building industry has a much heavier weight in Japan than in the United States. On the other hand, the weight of the automobile industry is much heavier in the United States than in Japan, it received about twenty percent of the steel shipments in 1968 in contrast with about five percent in Japan." (9)

As for the future of steel consumption in Japan, Dr. Kawahito introduces differing opinions. There is optimism on one hand, and pessimism on the other.

> "As for the future prospect of steel demand, opinions vary. Some pessimistically point out that per capita consumption increased only slowly in the United States after it hit a 600-kilogram mark and fluctuated in West Germany after recording 579 kilograms in 1964. The development of heavy and chemical industries in Japan has already reached the Western level. Japanese per capita steel consumption dropped slightly in 1968 from the 1967 level, and for the first time the elasticity of steel production with respect to the GNP growth became less than one. Moreover, steel exports were expected to slow down.
>
> Others are optimistic about the outlook, at least for the near future. Although Japan's GNP is the third largest in the world, they point out that her income per capita is still about one fourth of that in the United States and half that in Western Europe. Moreover, Japan, along with West Germany, is considered to use proportionally more steel than other countries because of the high ratio of fixed-asset investment in the GNP composition." (6)

Although Dr. Kawahito discusses consumption of steel; there is no effort to pair it with increase in per capita income and study the result. Such a study may be of great benefit to industrial development.

Another study has been conducted by Henry W. Broude (1), dealing with the relationship, if any, between steel production and the national economy.

> "It appeared desirable to substantiate empirically (via time series) what has been assumed theoretically by previous observers to be the relationship between a capital goods material, such as steel, and fluctuation in the national economy." (1)

However, this study is conducted on the total production of steel and the total GNP, and not on the consumption of steel not on a per capita basis.

In a study by the "Economic Commission for Europe", a branch of the United Nations, labeled "Long Term Trends and Problems of the European Steel Industry," (17), the problems of steel consumption and the long-term requirements of steel products in Europe and in the rest of the world for the next fifteen years (1959) are examined. A part of the study is concerned with the relationship between steel consumption and economic development.

> "Since the kind of specialization and degree of industrial development influence the whole economy, specific relations can also be expected between steel consumption and various macro-economic variables." (17)

The variables chosen, all on a per capita basis, are GNP at market prices, manufacturing, mining and construction as a whole; gross domestic capital formation and private consumption expenditure. The data for fifty countries between the years 1952 - 1956 are plotted against apparent steel consumption in kilograms per capita in a scatter diagram. The results are as follows:

> "The form of the scatter suggested roughly hyperbolic or parabolic curves. It has, however, proved impossible to obtain satifactory fits with either hyperbolic or parabolic formulae, and, in order to avoid making inessential calculations, free hand curves have been drawn." (17)

However, the results obtained appear to be significant:

> "The most striking fact emerging is the clear subdivision of countries into three groups at various stages of per capita steel consumption. The first includes countries at the very start of economic development, with per capita steel

consumption up to about five kilograms and very low levels of GNP, industrial production, investment and consumption expenditure. In such countries there is little or no increase in the macro-economic variables when steel consumption first begins to increase. In other words, the coefficients between the growth of per capita steel consumption and of the macro-economic variable are extremely high or even negative. But very little can be said about this group in quantitative terms owing to the absence or dubious quality of statistics. The second group consists of countries at levels of per capita steel consumption varying betweem six and fifty kilograms. All four coefficients are much lower than in the first group. The steepest curves - i.e., those with the highest coefficients between the growth rate of steel consumption and that of the other variables, are, first, that of steel consumption and GNP, and secondly, that of steel consumption and private consumption expenditure. The lowest coefficient is that between steel consumption and industrial production. This may seem surprising at first sight, but is readily explained by the fact that the first stages of industrialization usually consist of the creation of food processing and textiles industries, which consume little or no steel directly. The third group comprises all countries with per capita steel consumption ranging higher than 90 to 110 kilograms. There is a further decline in the coefficient between growth rates of steel consumption and those of the other variables, but now the coefficient for steel consumption and industrial production is highest and those for steel consumption and GNP and steel consumption and private consumption expenditure are lowest. This probably due to the fact that at higher stages of development the metal trades grow in importance within the structure of industry, while services consuming very little steel account for a larger share of both GNP and private consumption expenditure." (17)

However revealing these findings may be, it is clear that a short period of time is used (four years). The scatter diagrams may be a media for examining general trends, but a more specific approach may be required. A study is required to investigate the changes of the consumption of steel and the income per capita, over time, and for each country separately, to determine the relationship(s), and similarities or dissimilarities among the different nations. Another investigation of the consumption of energy on a per capita basis against income per capita, to determine relationships, trends, similarities or dissimilarities, also appears to be beneficial to the study of development and growth.

III. METHODOLOGY

A. Selection of Parameters

Since the end of the Second World War, many countries have adopted, in one form or another, a plan or plans for rapid industrialization, economic growth and development. Some of these efforts have been successful in increasing the national income and the per capita income and others were less fortunate.

Why some have succeeded and others failed is a question that has been raised by economists who are concerned with identifying causes and predicting the results. What has happened is more like an engineering problem waiting to be defined, analyzed and explained.

What are the parameters that may be used in such an endeavor? There are many parameters that may be important indicators in a study of industrialization, but the most relevant ones have to be chosen.

What is the most important alloy used as a primary base in industry? Steel is the answer.

> "We are still living in an Iron Age, and thus consumption of iron and steel are the prime indicators of our material progress. ... Steel output from 1900 to 1970 rose 21 times, from 27.86 million tons to 590.4 million tons per year." (12)

The tremendous increase in the production and consumption of steel clearly expresses the importance of steel in world industry.

There are several base metals that are very important to industrialization, such as copper, zinc, and aluminum. Although there is a great potential for the expansion of their production and consumption, steel stands out as an important indicator.

Other materials, non-metals, are being widely used, they are not being produced or consumed as much as steel.

One of the first industries to be planned in developing countries is a steel industry.

> "It has now become almost a general rule that each developing country tries to establish its own iron and steel production, if the local market offers sufficient encouragement." (12)

However, the levels of production may not necessarily be an indicator of the industrialization stage. This is because a small or large portion of the production may be for export, and some other portion may be imported. The effect felt within a country will be from the net amount of steel consumed in that country whether imported or produced locally.

Steel production plants then, are always in high demand in the industrialization plans of developing countries. No self-respecting developing nation can call itself a nation without having some kind of a steel mill or iron production facilities.

When looking at different countries, there is a problem of the units used and the type of steel. The convention used by the United Nations Statistical Office, as expressed in their Statistical Yearbook of the United Nations uses the Kilograms of Crude Steel consumed, and this expressed on a per capita basis of exports and imports.

With a higher level of industrialization, more energy is required. This goes in as power for machines in plants, new houses and housing projects, larger service facilities, schools, more private usage of energy. The energy may be from coal, petroleum, wood, water, wind, solar, or nuclear, but more of it is required.

> "Minerals are doubtlessly the most important base product of our industrial, agricultural and construction activities and as such the true infrastructure of our contemporary society. Without minerals there would not be raw materials for our factories, fuel for our industries, fertilizers for our crops, or materials for our construction industries. Therefore, the consumption of minerals and products obtained from them is adequate to evaluate our progress and development." (12)

There has been a tremendous increase in the consumption of energy since the beginning of the twentieth century.

> "In the first seven decades of this country, consumption of fuels increased 11.4 times, from an estimated value of 6.9 billion dollars in 1900, to 78.7 billion in 1970, all expressed in 1972 dollars and prices." (12)

However, this elevenfold increase in different kinds of energy sources was not evenly distributed among them.

> "While in 1900 the coal consumption of the world was 763 million tons, in 1970 it rose to only 3,000 million tons, or four times. ...

> ... On the other hand, crude petroleum production and consumption rose from some 166 million barrels in 1900 to about 16 billion barrels in 1970, almost 100 times! While production of natural gas, steadily grew from zero to 900 billion cubic meters, worth about 5.8 billion dollars in 1970." (12)

Because of the different energy sources, and the difficulty in comparison between countries that use more of one source and less of another, the United Nations adopted a unified measure based on calorific value and that was tons of coal equivalent. The units used are metric units, and on a per capita basis, it is kilograms of coal equivalent per capita. This is the second parameter that will be used in the study. The data obtained is net imports and exports and is used as the amount consumed on a per capita basis.

The adoption and implementation of a plan for industrialization influences the national income of such a country. If such a plan is successful, and the goals are met then the national income may increase. If the plan is not successful, then the national income may not increase as much. This increase will affect the population in the form of the per capita income. With an increase in the income more goods and services may be available to the people and this may trigger more growth. Also, a decrease in income will adversely affect the growth of the economy. Income, then, appears to be an important parameter in the study of industrialization and growth. It may serve as an indicator of economic well-being or level of industrialization. It is evident that the "rich" countries are the industrialized countries, and that in most instances, a lower per capita income may mean a lower level of industrialization.

The income per capita is the third parameter chosen. Whereas with the other two parameters, energy and steel, the units used are common to all countries, this is not the case with income. Each country has its own monetary units, and a common denominator is required. Because of the relative strength and stability of the United States currency from the late forties to the early seventies, the dollar is chosen as the monetary unit. All incomes are computed in dollars using the prevailing exchange rates for each period. The third parameter is income in dollars per capita. Because this is an empirical study, it is felt that by using current dollars, not constant dollars, a better interpretation of what has actually occurred can be obtained. However, in the part dealing with the United States of America, a constant dollar income is also used for comparison purposes.

A fourth indicator is studied and that is food. Because of the different countries included in the study, and the fact that being in different parts of the world, the diet that people follow may be influenced by a change in levels of industrialization. Although the calorific values of diets may be more or less relatively constant for each country over a period of time, the base constituents of the diet may be different from country to country.

In order to get a common denominator in all countries, the consumption of sugar on a per capita basis is studied. However, the results are not conclusive and do not represent any discernible pattern. The first results with sugar consumption do not warrant any further investigation and the investigation has been dropped.

B. Country Selection

It is the intention to have as broad a representation of countries as possible. To have highly developed and industrialized countries, together with not so highly industrialized and some that are industrializing.

The United Nations categorized the countries into different Classes according to the degree of Industrialization. The value added in manufacturing per capita is utilized as the primary measure of extent of industrialization.

It is interesting to note that:

> "As the degree of industrialization decreases the extent to which the population is employed in industrial pursuits falls. The output per person engaged in each kind of mining and manufacturing activity varies directly with the degree of industrialization ... (and which) result in lower value added in industrial pursuits per head of population for the less industrialized countries than for the more industrialized countries." (27)

The United Nations classification has divided the world into four classes in the late 1940's and the early fifties.

> "Class I includes Northern North America, Australia and New Zealand and most of the countries of Europe. European countries such as Finland, Ireland, Italy, Spain, Greece, Yugoslavia and Turkey are excluded.
>
> Class II consists of the Union of South Africa, two Latin America countries - Argentina and Uruguay - and three European countries - Finland, Ireland, and Italy.
>
> A few of the European countries fall into Class III - namely, Portugal, Spain and Yugoslavia. Three Latin American countries and Japan are also included. Japan contributed a greater part of the industrial output and employment of Class III than the Latin American or European countries. The share of Japan in the industrial activity of Class III reflected its pre-eminent role in the manufacturing activity of the class.
>
> The output and employment of Class IV was dominated by the countries of Asia, excluding Japan. These countries accounted for sixty per cent of the industrial output and employment of the class in 1938. ... It is noteworthy that the share of the Asian countries in the industrial employment of the class dropped slightly between 1938 and 1953. It was 76 per cent in 1938 and 71 per cent in 1953. This is indicative of the much greater output per person engaged for the other countries of the class than for the Asian countries." (27)

Greece is thus included in the fourth class together with Egypt; India is also added.

The countries considered for initial inclusion in the study come from all the classes mentioned above with a reasonable representation. They are: the United States, Sweden, West Germany, United Kingdom, Spain, Argentina, Brazil, Chile, Israel, South Africa, Colombia, Taiwan, Egypt, and Yugoslavia. After preliminary investigation, which will be discussed later, some of the countries may need to be dropped. Also, at the end four countries namely, France, Finland, India, and Greece are introduced as an addition to the investigation. the countries that will comprise the study are:

class I: the United States, the United Kingdom, the Federal Republic of Germany, France, Sweden.

class II: Finland.

class III: Japan, Spain.

class IV: Egypt, Greece, India, and Taiwan.

The inclusion of some of the centrally planned economies of the communist countries could have been a positive addition, except that data is not readily available for them.

The four classes of industrialization mentioned above are modified slightly in later United Nations publications. The countries are divided into two classes: industrialized and less industrialized. Although the basis is still the value added in manufacturing per capita as the primary measure of extent of industrialization, the demarkation line in 1958 was 125 United States dollars.

> "Included among the industrialized countries are those for which value added per capita in manufacturing during 1958 was 125 or more United States Dollars." (25)

This change in classification does not change the direction of the investigation.

C. Time Of Study

The span of time of the study has to be sufficient to produce reliable results. The data has to be available, although not necessarily in directly usable form, and has to be consistent.

The United Nations as a world organization is in a relatively good position to obtain as accurate data as available. As a matter of fact, with the inception of the United Nations, a better data gathering organization was formed within the United Nations, to help prepare economic reports on the progress of reconstruction and growth after the war. The Statistical Yearbook of the United Nations, and other United Nations publications are used extensively in this study.

The late forties and the early fifties, after the end of the Second World War, is a period of political change. A change in the American Administration from Democratic to Republican, changes in the United Kingdom, in West Germany, and other European countries, drastic changes in the Middle-East, Asia and Latin America. With the death of Stalin it also signaled the end of the "Stalinist Era". These changes may have been the effects of social changes due to the Second World War. The economic, the social, and the political are all forces that are linked together and may be very difficult to separate.

Another aspect of the late forties and early fifties was the reconstruction of the devastation caused by the Second World War. By 1953, many of the industries that were adversely affected by the war, had recovered and reconstruction of the destroyed facilities was taking place.

> "Between 1948 and 1953 which was a period of rapid growth in industrial output, for the World, the volume of industrial production expanded most in those areas which after the war, were faced with the urgent task of reconstructing their economies and renovating and expanding their industrial plants.
>
> ... Most countries attained and sustained significant growth in industrial output during the period 1948 - 1953. ... The impetus to the growth of industrial activity between 1948 and 1953 resulting from post-war reconstruction and adjustments and the Korean War was probably spent by 1951, and policies and programs directed toward stimulating industrial expansion and providing full but efficient employment played an important part in the growth of output during the last few years of this period." (12)

There was growth in less developed countries also.

> "As might be expected, the efforts to expand industrial activity were focused on manufacturing in the highly industrialized countries and on mining as well as on manufacturing in the less industrialized countries which had considerable unexploited mineral resources. Also, some of the less industrialized countries were more successful in expanding mining than manufacturing." (21)

It can be said then, that with most of the effects of the war behind by 1953, the period from then on should be a period of growth and expansion.

D. Data

With the development of parameters and the selection of countries completed the first task is to collect needed data. Ideally one could wish to obtain a national data book for each country which would have the needed data or may give direction to where it may be obtained. But such a compendium of data per country, is not readily available. One source which does furnish this sort of data is the Statistical Yearbook of the United Nations. The data is furnished by different governments on request from the United Nations. This is compiled, edited and presented in the Yearbook. Because of the different countries involved and because the reporting has to follow uniform rules, the units used by the United Nations are standardized. The measuring system is the metric system. All data furnished is transformed into metric units and then published in the Yearbook.

The three parameters selected are crude steel consumption per capita, energy consumption in kilograms of coal equivalent per capita and income per capita. Data for crude steel consumption per capita is included in the Yearbook in directly usable form. It is given as the net of imports and exports, therefore it is the amount consumed. The energy consumption is also given in tons of coal equivalent per capita, this is easily transformed into kilograms. In the case of income, up till 1965, the National

Income per country is given on a total basis and in the national currency. This is also given at factor cost, that is after subtracting the depreciation values and adding the net of incomes from abroad. This has to be transformed to a per capita basis, and then transformed to dollars. This is done using the prevailing exchange rates included in the Yearbook. After 1965, the National Income is given at market prices which is different from the factor cost used before, is given in dollars. However, after consulting with the Statistical Office of the United Nations, the "Yearbook of National Statistics" is recommended, in its latest edition, as the source for National Income. In order to obtain income on a per capita basis, the mid-year population estimates of each country are utilized. This is obtainable from the "Demographic Yearbook" also published by the United Nations.

E. Preliminary Investigations

After the collection of data a preliminary investigation appears to be in order. This is done by a graphical analysis of the raw data to try to establish the direction of the change of the data or if in fact any change has taken place.

Graphical analysis, plotting graphs and curve fitting, is an important tool. It helps to transmit a more vivid picture of a relationship between two or more variables that are used in any study.

> "Graphical methods of presenting facts are of the utmost importance in engineering, because a

properly constructed chart, graph, or diagram will transmit more information from mind to mind in a given time than will any other known means of communication. It has been said that a single picture tells more than can be said in many thousands of words and that to a very great extent the message is independent of language barriers." (2)

The author says of curve fitting:

"Curve fitting is one important application of the graphic method." (2)

This is determining the relationships between experimental data plotted as graphs and some of the standard types of equations. The data are first plotted on Cartesian coordinates to determine the slope of the curve. If the data plotted approximates a straight line a straight line is fitted to it. If it does not exhibit a straight line trend, and a curve is seen then another try to fit it as a parabolic equation on logarithmic scales. This transformation tends to make it approximate a straight line if it is a parabolic:

$\log y = \log b + m \log x$

If the parabolic equation does not fit, an exponential equation is tried. This will approximate a straight line on semi-log scales. This equation is:

$\log y = (d \log e)\ x + \log b$

$y = b + d \log x$

where d and b are constants.

Other equations may be fitted if need be such as the polynomial, harmonic, etc.

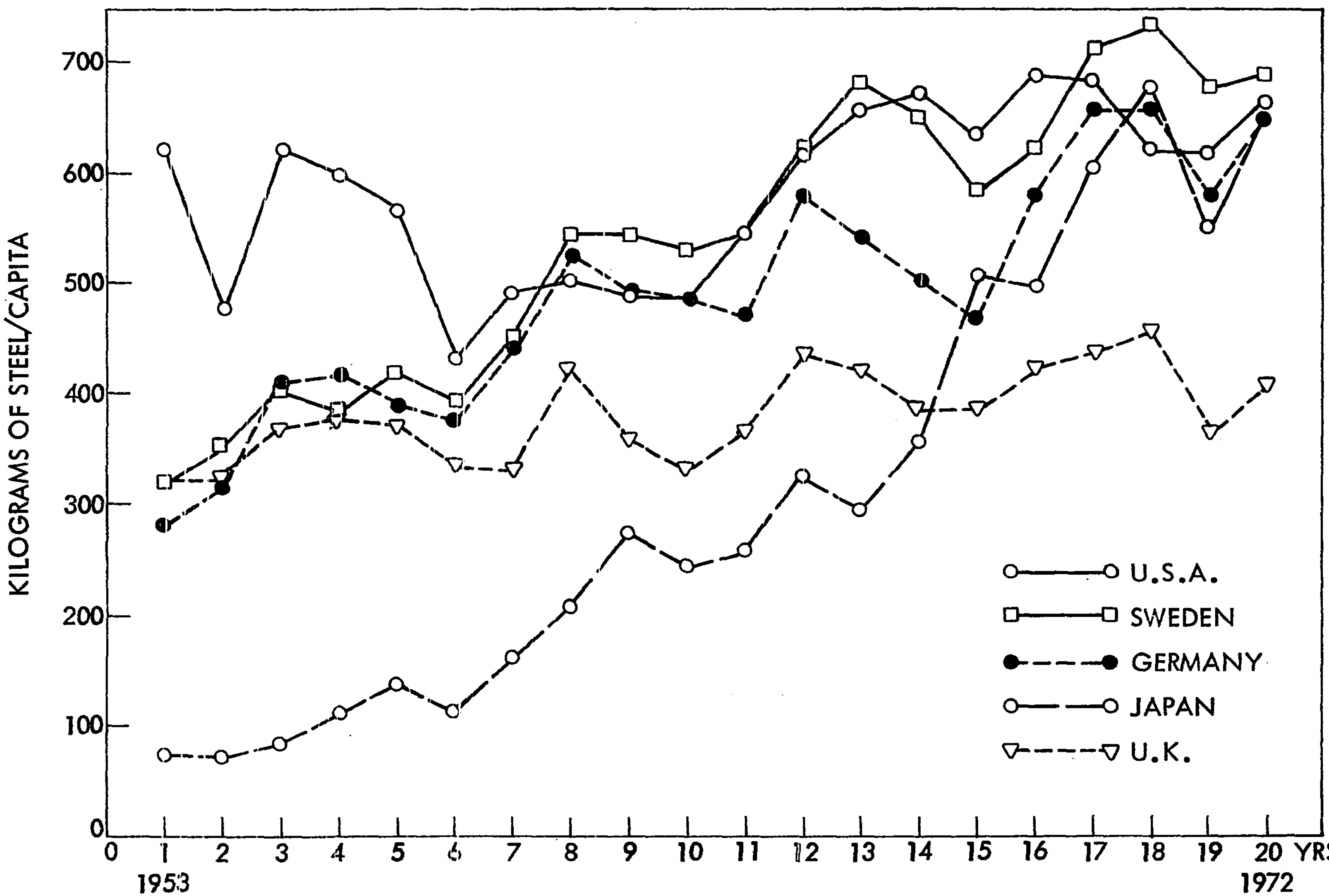


Fig. 1. Industrialized countries

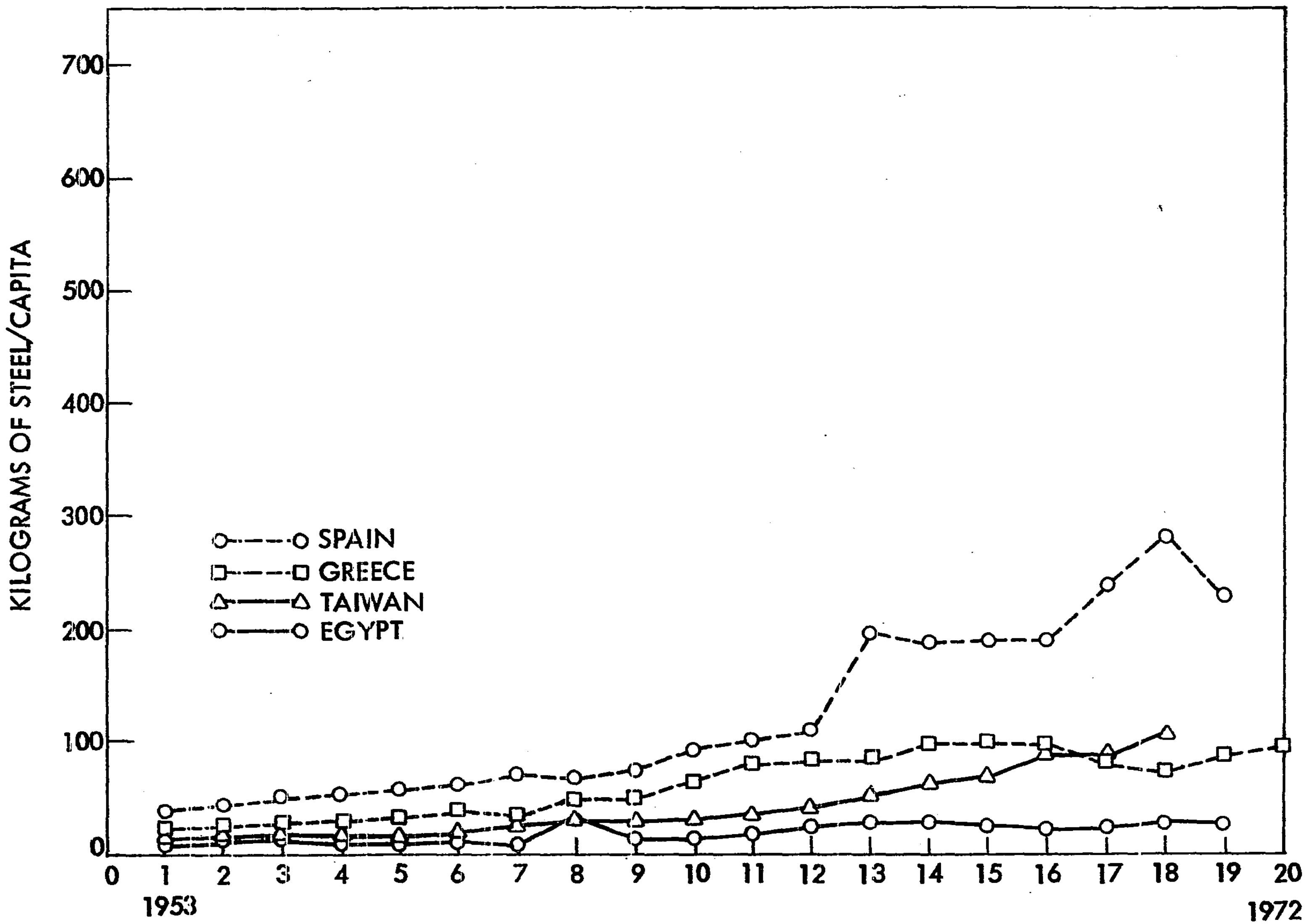
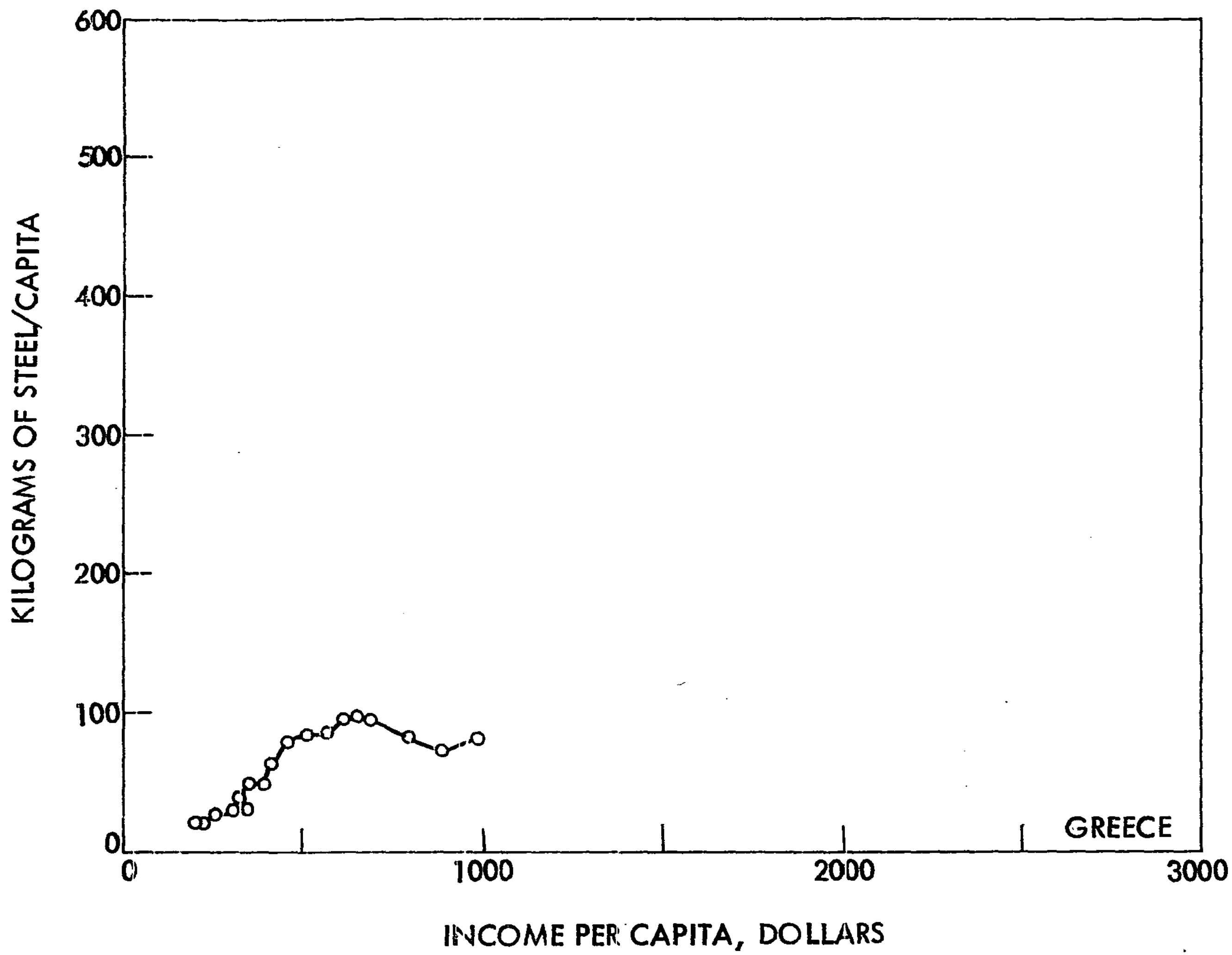


Fig. 2. Industrializing countries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KILOGRAMS OF STEEL/CAPITA
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INCOME PER CAPITA, DOLLARS
GREECE

Fig. 3. Greece

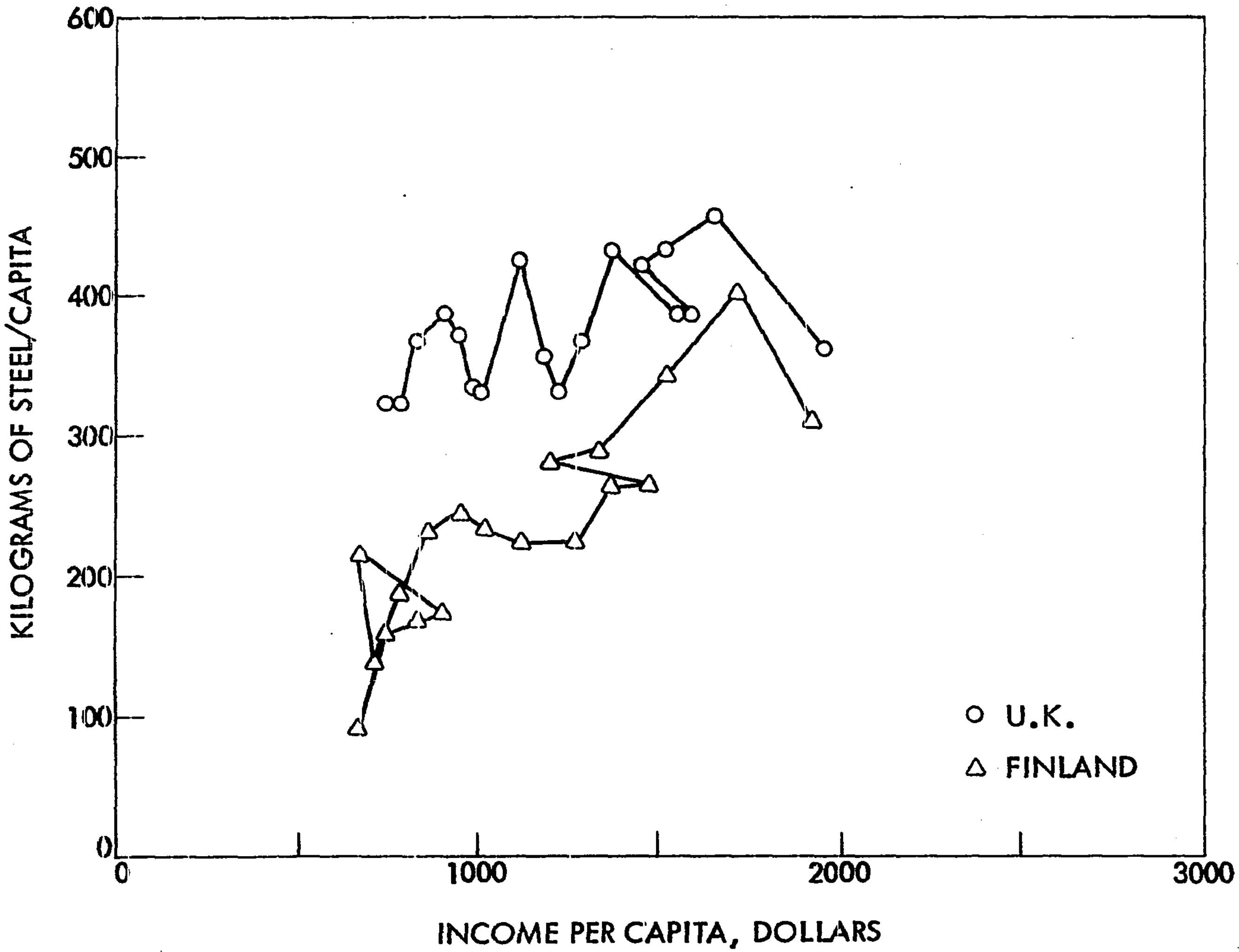


Fig. 4. Finland and U.K.

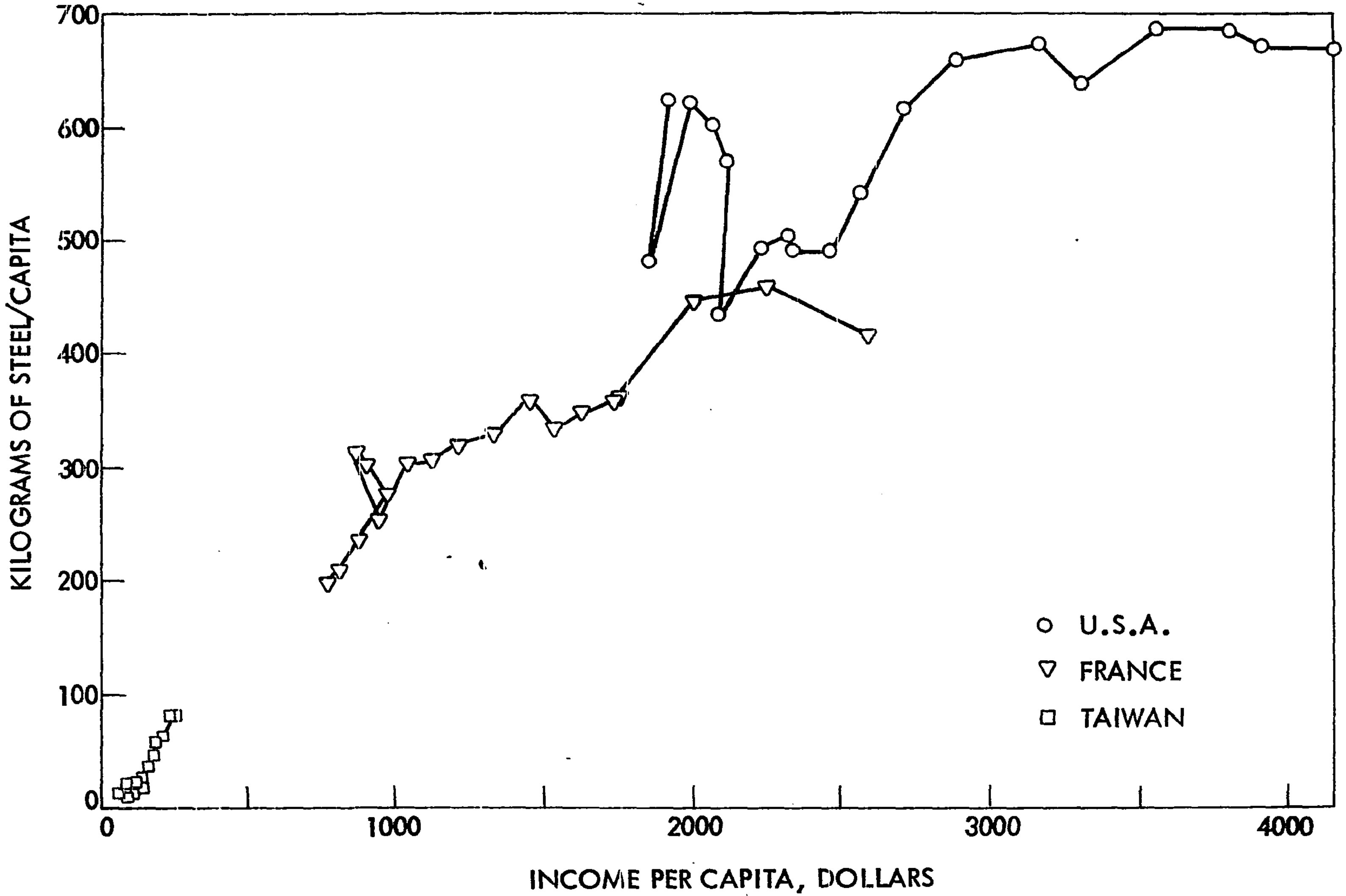


Fig. 5. U.S.A., France, and Taiwan

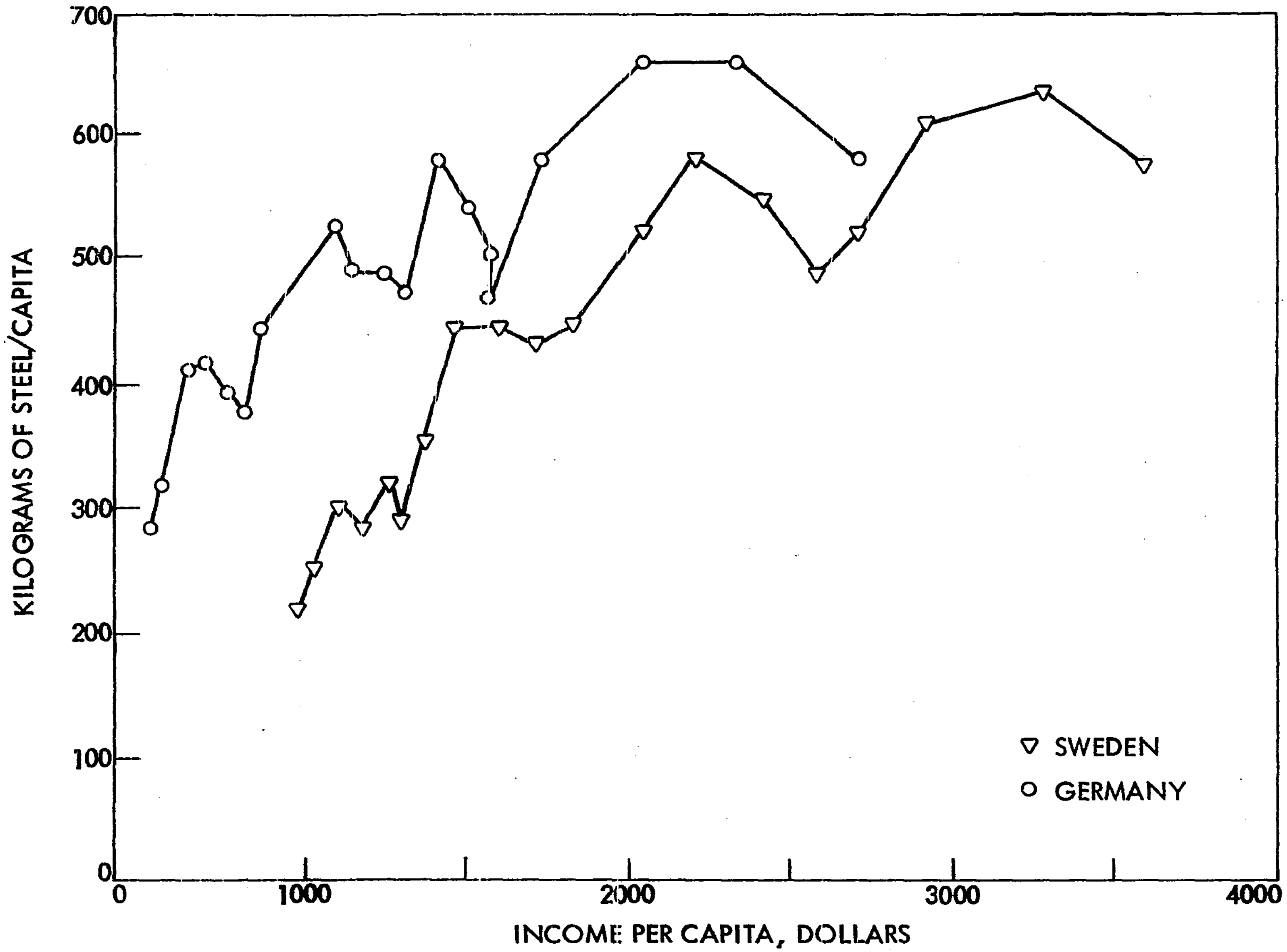


Fig. 6. Germany and Sweden

There are three methods of determining the approximate equation that best fits the given data:

a) Method of selected points

This is the easiest, fastest but probably least accurate of the three.

b) The method of averages

Better than (a) in precision

c) The method of least squares

> "It is the most precise of the three methods and should be used on careful work." (2)

The method of least squares is employed in curve fitting in this study. A step by step approach is detailed in the discussion of mathematical analysis.

The first parameter that is examined is the steel consumption. The abcissa is the time period, beginning in 1953 and ending 1971. The first analysis uses the Cartesian coordinates. The steel consumption for each of the countries included in this study is plotted against time. The results that are obtained vary from country to country. However, the general trend is a marked increase in the consumption of steel per capita over the nineteen years. This is shown in figures one through ten.

A general analysis of the results for the countries shows that the United States with an apparent consumption of 624 kilograms of steel in 1953, reaches a low 433 kilograms of steel in 1958, has a peak of 685 kilograms of steel in

1968, and ends the period in 1971 with a consumption of 617 kilograms of steel. There are slight fluctuations in the consumption over the period, but the level at which it starts and ends is relatively constant. Average consumption is 575 kilograms.

Sweden starts in 1953 with a consumption of 320 kilograms of steel, peaks at 733 kilograms in 1970 and ends the period with 676 kilograms, the average consumption is 535 kilograms of steel.

Germany, starts with 285 kilograms, reaches a high in 1969 at 659 kilograms of steel, ends the period at 580 kilograms of steel, and an average consumption of 484 kilograms of steel.

The United Kingdom starts with 322 kilograms, reaches a peak level of steel consumption in 1970 at 458 kilograms, and the average consumption for the period is 380 kilograms.

The consumption of steel in France on a per capita basis in 1953 is 198 kilograms. A peak consumption of 457 kilograms is reached in 1970 and it ends the period with a steel consumption of 414 kilograms. An average of 322 kilograms is consumed over the period.

In Finland, steel consumption starts at 92 kilograms per capita, peaks at 401 kilograms in 1970, and the level of consumption in 1971 is 309 kilograms. The average consumption is 233 kilograms.

With Japan, the increase in consumption is great. In 1953 the consumption is 77 kilograms per capita, in 1971 it is 551, with a peak of 676 kilograms of steel in 1970. The average per capita consumption of steel is 292.

Spain experiences a marked change in steel consumption over the nineteen year period. In 1953 the steel consumed is 35 kilograms per capita, in 1971 it is 226 kilograms, it peaks in 1970 at 280. The average consumption over the period is 121 kilograms.

Taiwan increases its per capita steel consumption from 11 kilograms in 1953 to 103 kilograms in 1970. The average consumption for the period is 40 kilograms.

Greece starts at 22 kilograms of steel per capita consumed in 1953, and ends the period consuming 87 kilograms per capita. The peak consumption of steel is 97 kilograms and that occurs in 1967. The average consumption is 60 kilograms.

In Egypt the steel consumption per capita moves upwards from 9 kilograms in 1953 to 25 kilograms in 1971. The average consumption is 18 kilograms.

India manages to increase the per cpaita steel consumption from 5 kilograms in 1953 to 11 kilograms in 1969 and reaching a peak of 16 kilograms in 1963. The average consumption amounts to 11 kilograms.

Although this is a preliminary investigation, certain trends are discernible. There is an increase in the consumption of steel over time. This increase may be very large as in the case for Japan or small as in the case for Egypt and India. The rate of change of the increase is discernibly different for different periods of time for some countries while for others it is not. There appear to be four different changes in the direction of the plot of steel consumption and time for Japan, 1953 - 1957, 1958 - 1961, 1962 - 1964, and 1965 - 1971. For Spain a constant rate appears between 1953 - 1964 and then a change in the rate. The same thing happens for Taiwan, from 1953 - 1963 and then another rate from 1964 - 1969.

France and Finland appear to be moving at the same rate, United Kingdom fluctuating, Germany and Sweden appear to move at a high rate. The United States appears to have a downward trend from 1953 - 1962 and then picks up again moving apparently with the rate of Sweden and Germany.

The result from this preliminary examination of the graphical analysis is that there appears to be some merit in continuing this investigation further. By pairing steel consumption with another parameter, income, over the same period of time, again using graphical analysis, to investigate whatever relations exist between the two parameters.

The same procedure is followed for the graphical analysis of energy consumption of the different countries. The general trend is for the increase of energy consumption per capita over the period from 1953 - 1971. This increase varies from one country to the other. However, the rate of increase is much lower than that of steel for the same period.

The United States with 8010 kilograms of energy equivalent per capita in 1953, drops to 7620 in 1954, but ends the period at a peak of 11244 in 1971. The average consumption is 8930 and that is only 1.11 times greater than the value in 1953. The ratio between the last value and the average is 1.26.

For Sweden, the average value is 4318, beginning value is 3700 and ends the period with 6089 kilograms of coal equivalent per capita. The ratio of average to beginning is 1.17 times as that between final and average is 1.41 times. -this ratio is called the consumption ratio which is (actual consumption / average consumption); the consumption and average consumption are in kilograms of coal equivalent.

Germany increases its consumption of energy per capita from 2940 in 1953 to 5223 in 1971. The average for the period is 3958 kilograms of coal equivalent and the ratio of beginning value to average is 0.74 times, while the ratio of last value to average is 1.32 times.

France starts with 2330 kilograms and ends with 3928 kilograms with an average value of 2670. The ratio of consumption of energy to the average consumption at the beginning and at the end of the period are 0.8727 and 1.47 times respectively.

Finland consumes 1440 kilograms of coal equivalent of energy in 1953 and 4334 kilograms in 1971. The average value for consumption for the period is 2268. The ratios of consumption of energy in 1953 and 1971 to the average value is 0.63 and 1.91 times respectively.

The consumption of energy in Spain in 1953 is 730 kilograms of coal equivalent (k.c.e.) and in 1971 it is 1614 k.c.e. With an average consumption of 1016, the ratio of consumption in 1953 and 1971 to the average are 0.72 and 1.59 respectively.

Although the steel consumption in Japan increases almost nine times between 1953 and 1971, the energy consumption increases by only 3.4 times. In 1953 the energy consumption is 960 k.c.e. and in 1971 it is 3267 k.c.e. The consumption ratios are 0.5773 and 1.96 for 1953 and 1971 respectively. The average value is 1663 k.c.e.

The United Kingdom shows slight increases in energy consumption from 4530 k.c.e. in 1953 to 5507 in 1971. The average value is 4974 k.c.e. and the ratios of consumption are 0.91 in 1953 and 1.11 in 1971.

Egypt increases the energy consumption slightly from 220 k.c.e. in 1953 to 282 k.c.e. in 1971. The average for the period is 270 k.c.e. The consumption ratio for 1953 is 0.81 and for 1971 is 1.04 times.

There is a slight increase in energy consumption of India between 1953 and 1969. In 1953 it is 110 k.c.e. and in 1969 it is 193, while the average consumption is 149 k.c.e. The consumption ratio in 1953 is 0.74 and in 1963 it is 1.30 times.

The total trend of the consumption of energy per capita over time appears to be upwards. However, there appears to be two general trends that are different for some countries. This first period may be from 1953 until 1960-61, the increase appears to be a "reluctant" increase; fluctuation in the level of consumption. The possible exception may be Germany, where a steady, but minor increase is maintained except for two years (1958 - 1959). In some countries there appears to be a marked decline in consumption of energy between 1956-1960. However, with the beginning of 1961, most countries appear to have recovered and a steady increase in energy consumption is recorded. There appear to be one exception to this trend, and that is Egypt which still maintains a "reluctant" atmosphere of increase.

All countries register increases in their income per capita measured in dollars. The increases vary from a 66%

for Egypt, 75% for India to around 970% for Japan. The United States has an apparent increase of 125% (62% in constant 1963 -$- for the same period); Sweden's income per capita increases from $983 in 1953 to 3607 in 1971, an apparent increase of 267%, Taiwan has a low income of $78 per capita in 1955 and an income of $264 in 1969, an apparent increase of 238%. Spain increases its per capita income from $263 in 1954 to $951 in 1971. This is an appparent increase of 262%. Finland shows an apparent increase of 179% in the per capita income for the period, from $681 in 1953 to $1937 in 1971. The increase in France is from $768 in 1953 to $2591 in 1971, an apparent increase of 237%. In the United Kingdom the per capita income in 1953 is $746 and increases to $1958 in 1971. This is an apparent increase of 162%. The apparent increase in the per capita income of Germany is 415%, from $527 in 1953 to $2716 in 1971. The per capita income of Greece shows an apparent increase of 395%, from $200 in 1953 to 990 in 1970.

In general, these apparent increases are reached taking into account the several devaluations of certain currencies such as the French franc, the Taiwanese dollar, the Spanish peseta, the Egyptian pound, the Indian rupee, the English pound, the Finnish marks and finally the almighty dollar. Included in this is the revaluation of the Japanese yen, the Swedish krona and the German mark in the late sixties and early seventies.

Once again, there is a fluctuating, not very solid increases, in the income per capita from 1953 unitl around 1960. This trend solidifies and a strong stable increase takes place all through the decade of the sixties for most of the countries mentioned above.

Having made the graphical analysis of the three parameters, steel consumption per capita, energy consumption per capita and income per capita over time, a new direction is taken. This is to pair each of these parameters together and graphically analyze the plots obtained, to answer such questions as what may be relationships between the parameters? What similarities or dissimilarities that may exist between the different countries using the same parameters? The first part of the graphical analysis between Steel Consumption per capita and income per capita is plotted in the Cartesian coordinates. Using kilograms of steel consumed as the ordinate and income per capita in dollars as the abscissa, the graphical relationships between them is plotted for each country. In order to facilitate comparison among the different plots of different countries, the same scale is used for all countries and for both ordinates. The time period is from 1953 until 1971 for most of the countries; the exceptions being Taiwan, India until 1969 and Egypt until 1970 because income data is not available after those dates in the latest United Nations publications.

From the graphical analysis of steel vs. income there appears to be certain relationships between them. Whether this is the same for all countries or not cannot be discerned yet. There seems to be a gradual increase in consumption of steel with an increase in income from 1953 - 1960. This is true for the United States, Sweden, Germany, France, and Finland. This increase is more pronounced for Japan. Spain, Greece and Taiwan appear to be moving upwards slowly on the curve with slight fluctuating movements. The increase in the case of the United Kingdom appears to be more of a fluctuation. Egypt and India seem to be moving in no discernible manner in the relationship between steel and income.

The graphical analysis in this case shows an apparent non-linear relationship existing for most countries. Egypt, Spain, Taiwan and India appear to follow a linear relationship, although it is not very distinct. The type of curve has to be determined by further investigation using log-log scales and semi-log scales to clarify the relationship further if possible. If the analysis is not conclusive polynomial fitting may have to be tried.

The semi-log scales are used first. The ordinate is the Cartesian coordinate and steel is plotted along it. The abscissa is the log scale and has the income plotted along

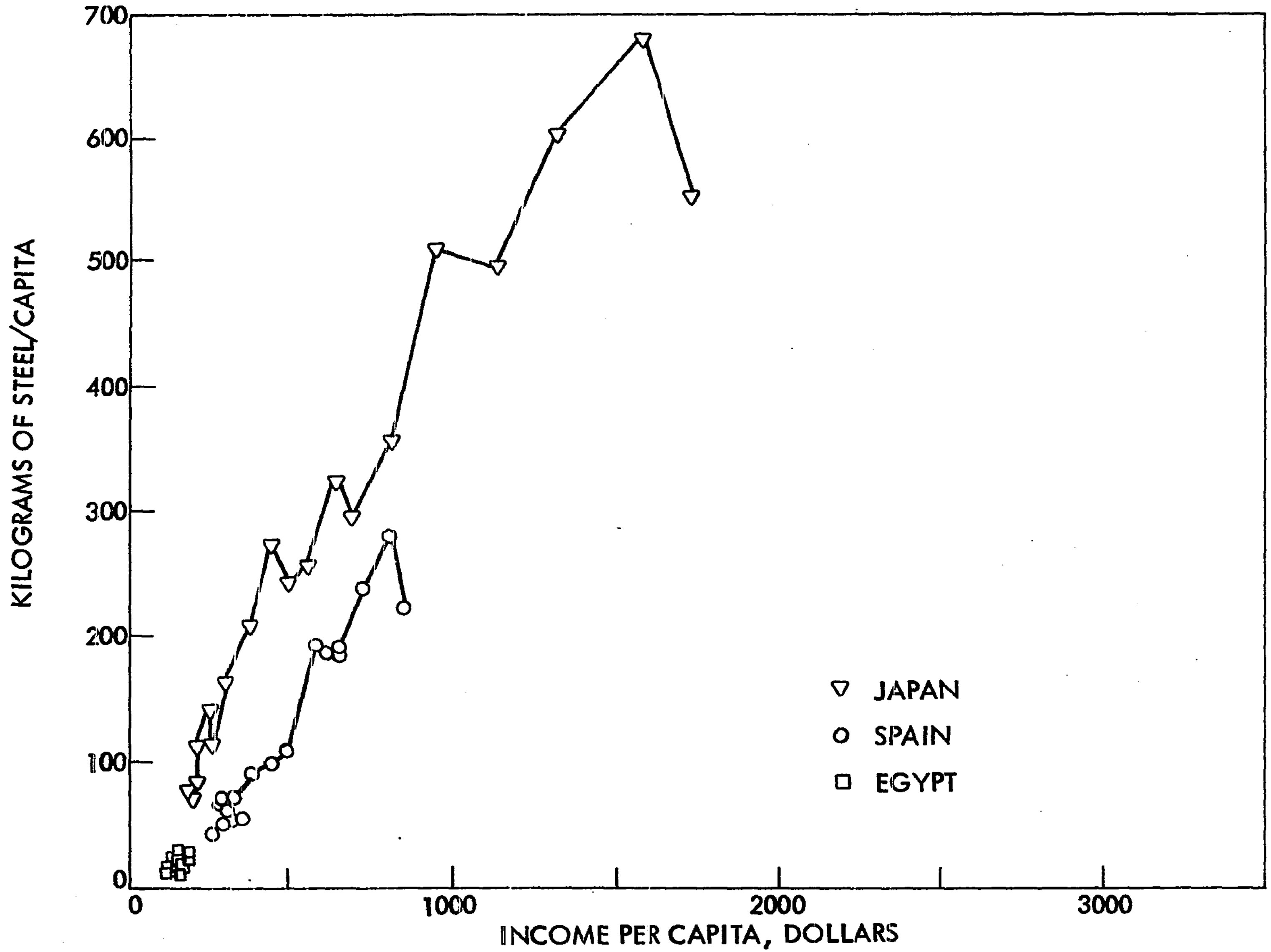


Fig. 7. Japan, Spain, and Egypt

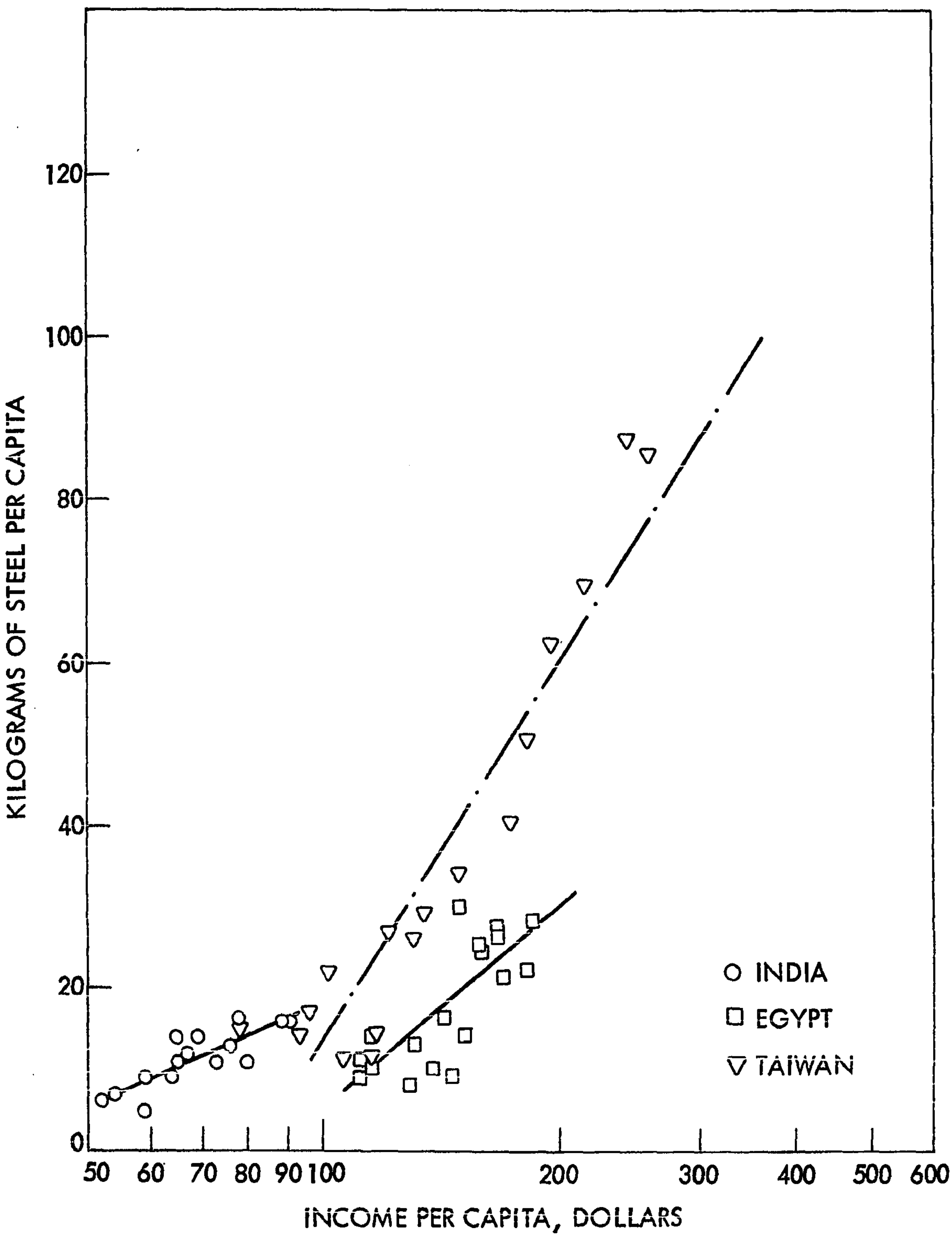


Fig. 8. India, Egypt, and Taiwan

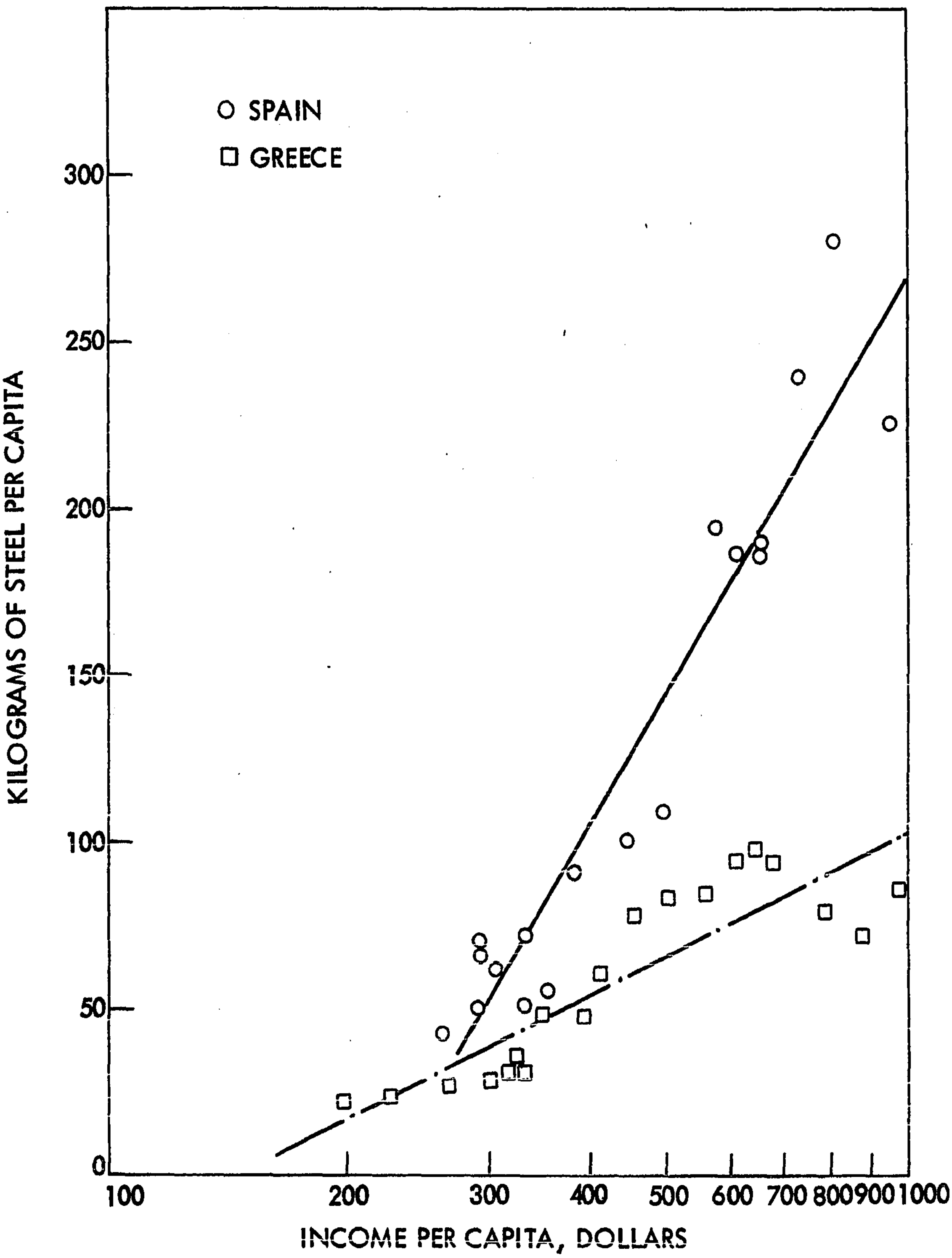


Fig. 9. Spain and Greece

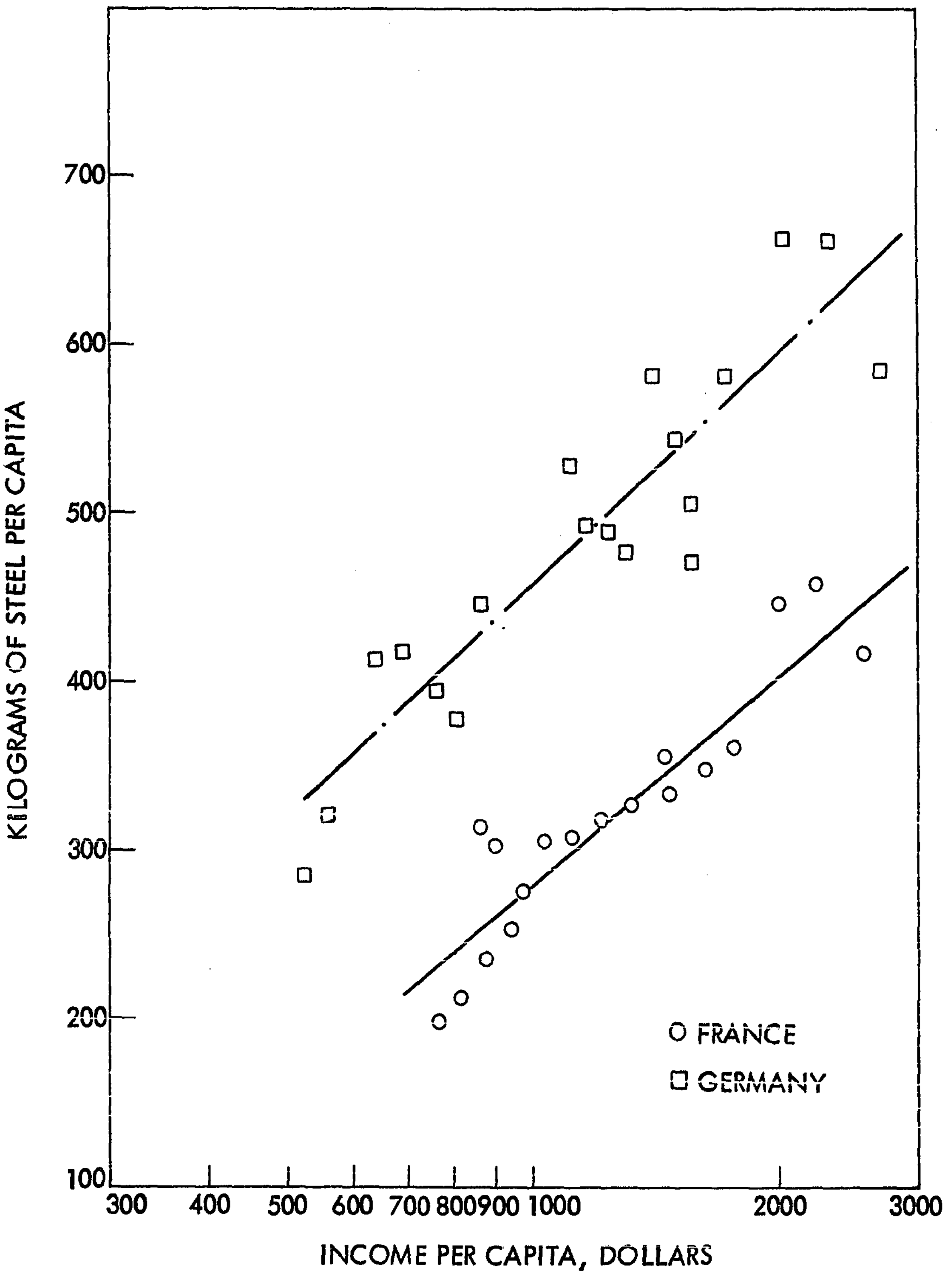


Fig. 10. France and Germany

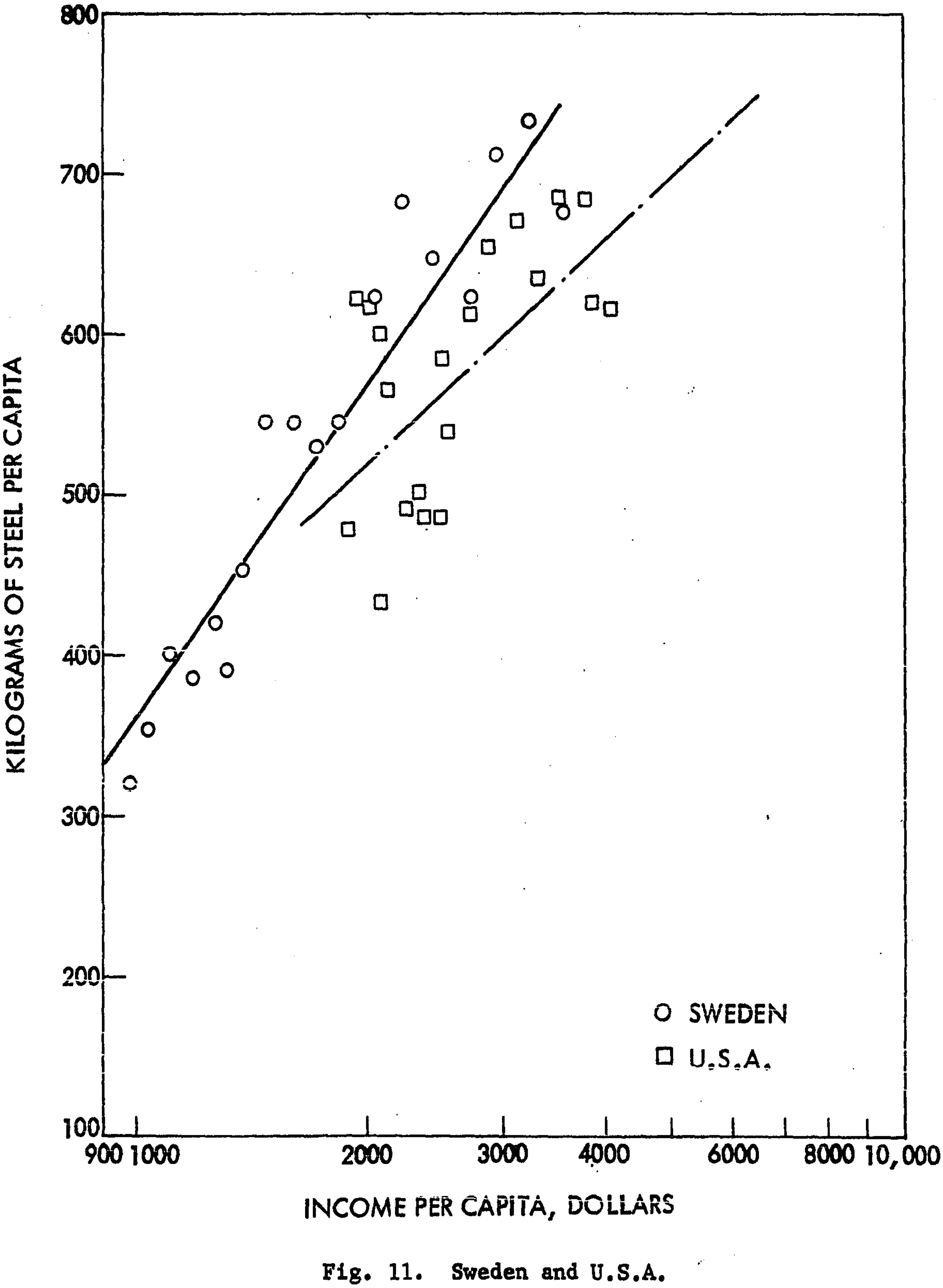


Fig. 11. Sweden and U.S.A.

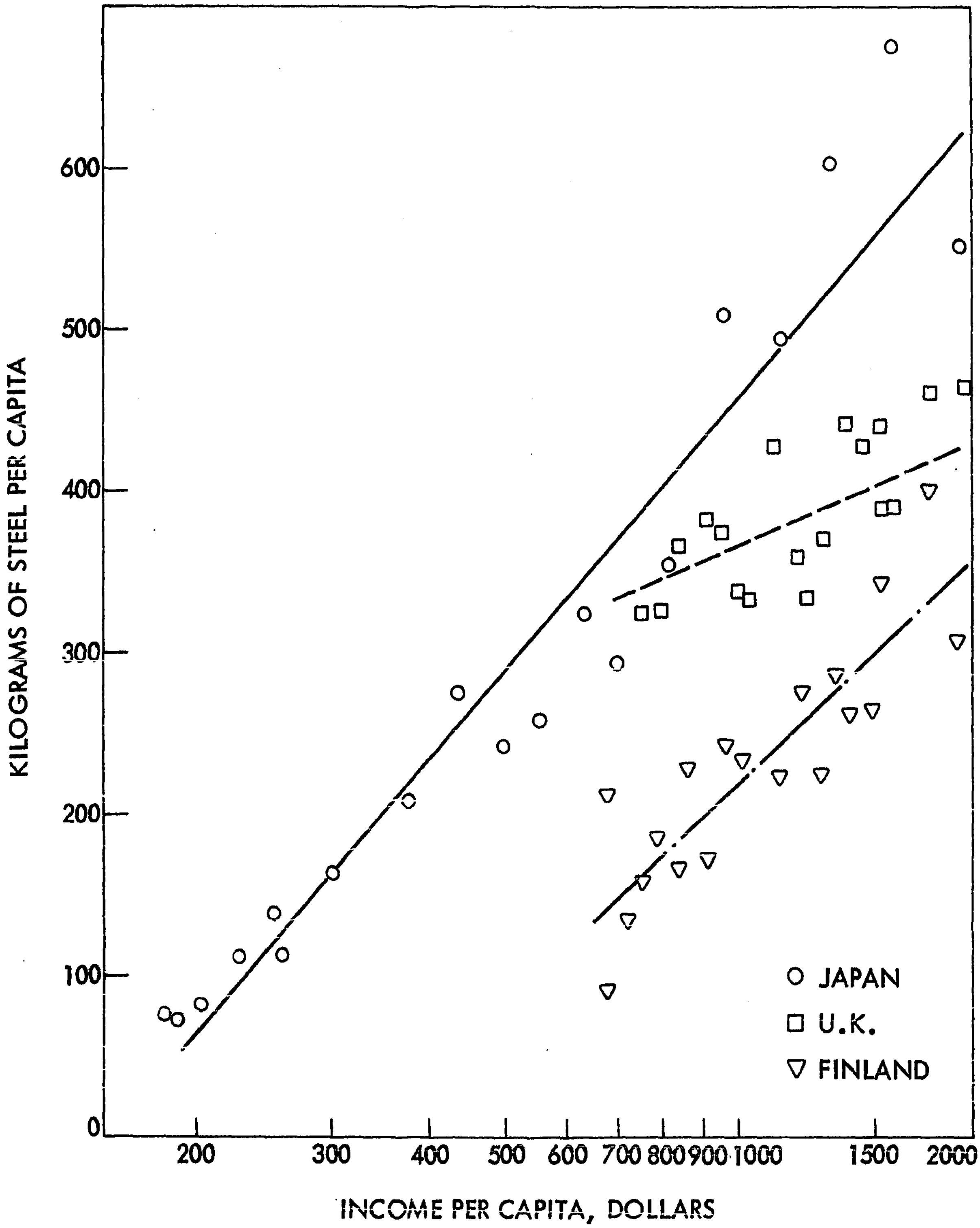
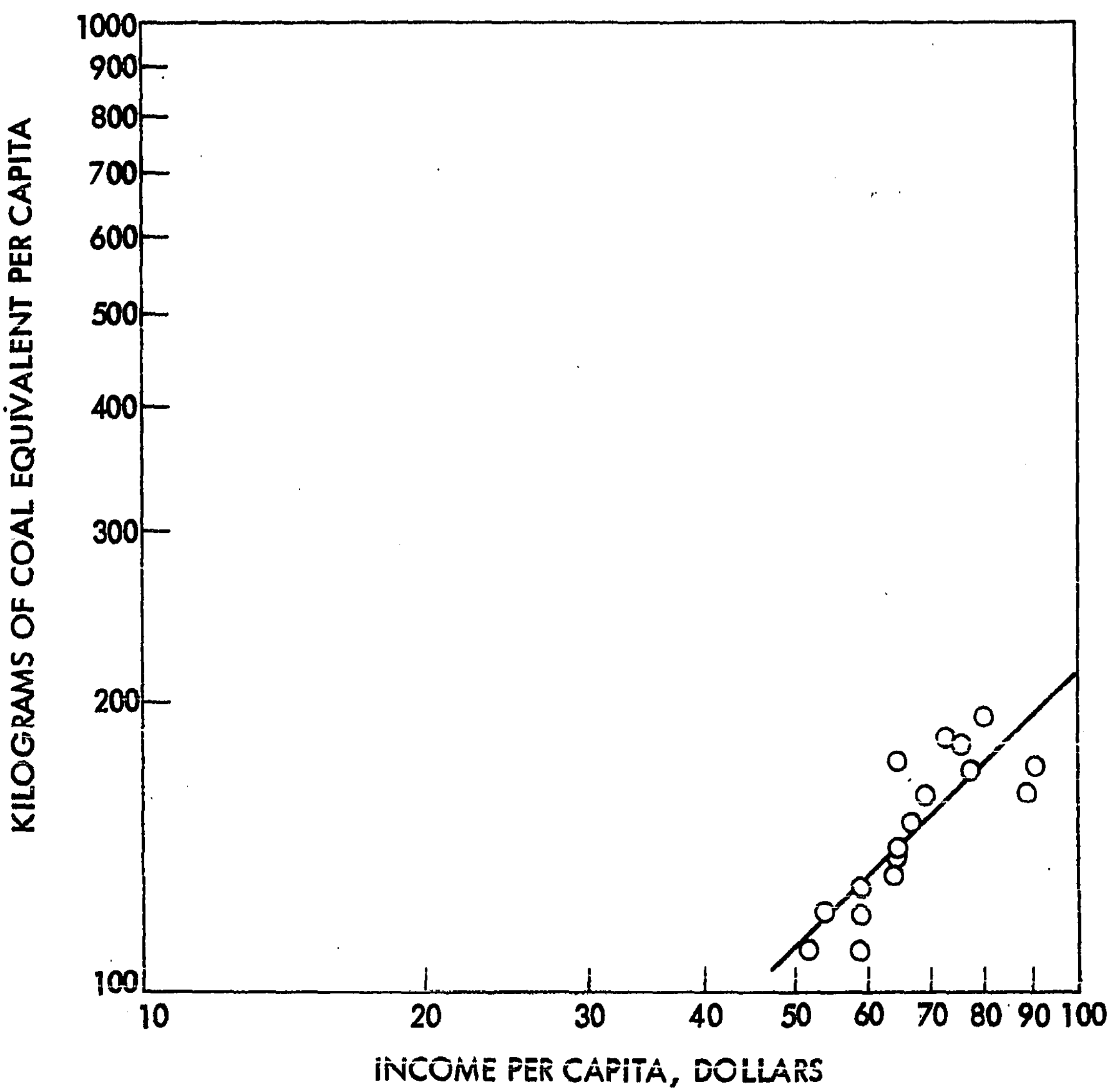


Fig. 12. Japan, Finland, and U.K.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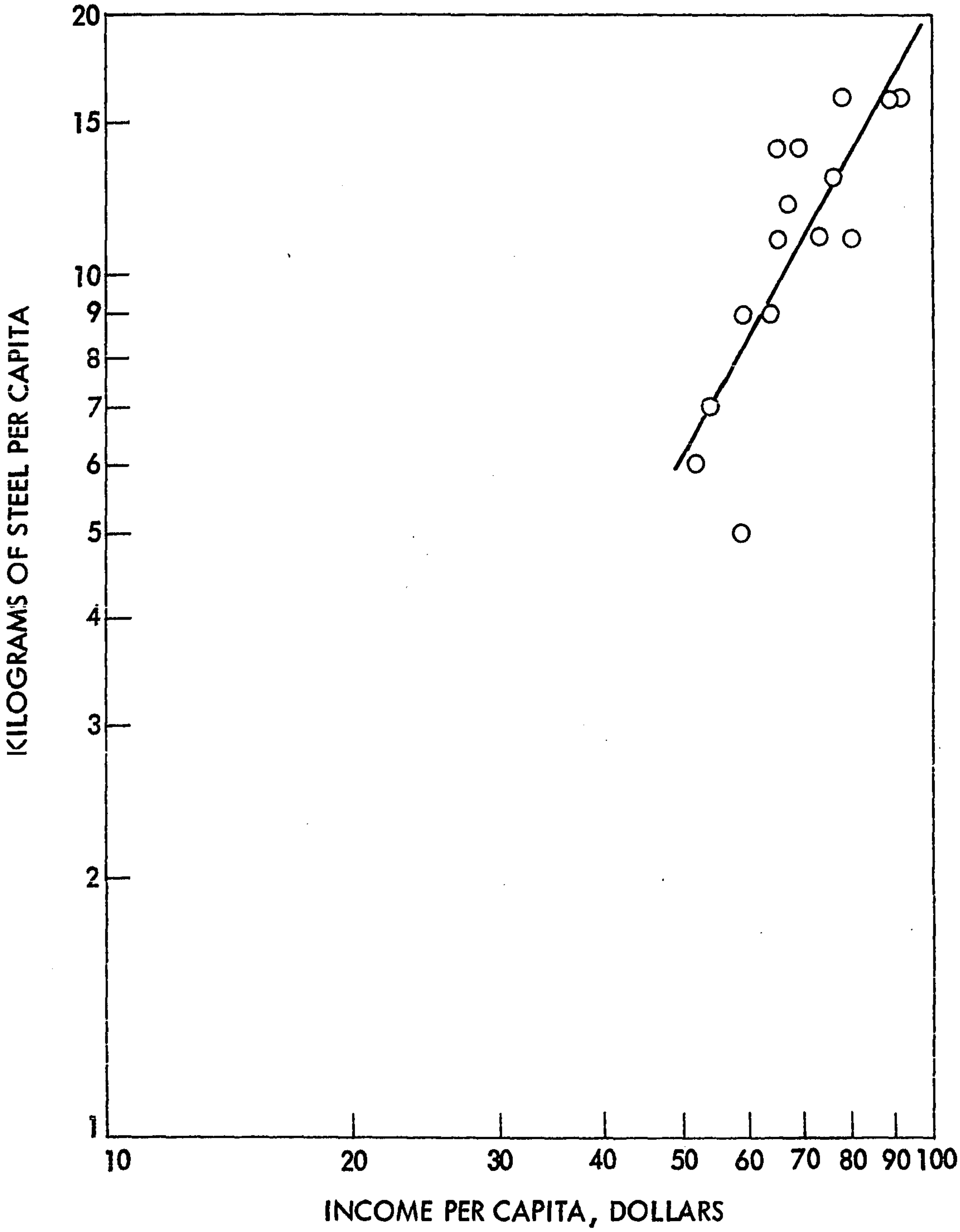
INCOME PER CAPITA, DOLLARS

Fig. 13. India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INCOME PER CAPITA, DOLLARS

Fig. 14. India

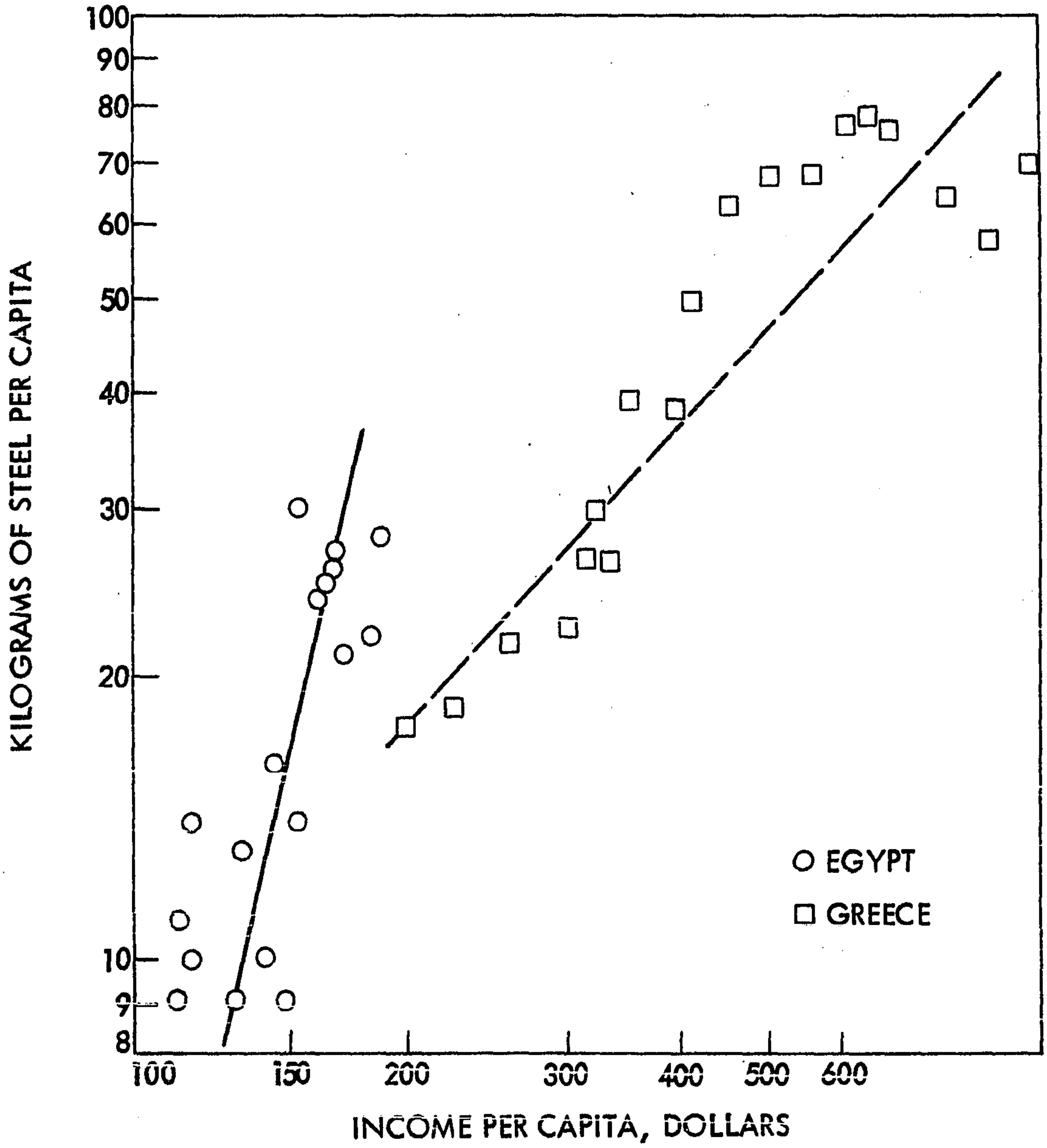


Fig. 15. Egypt and Greece

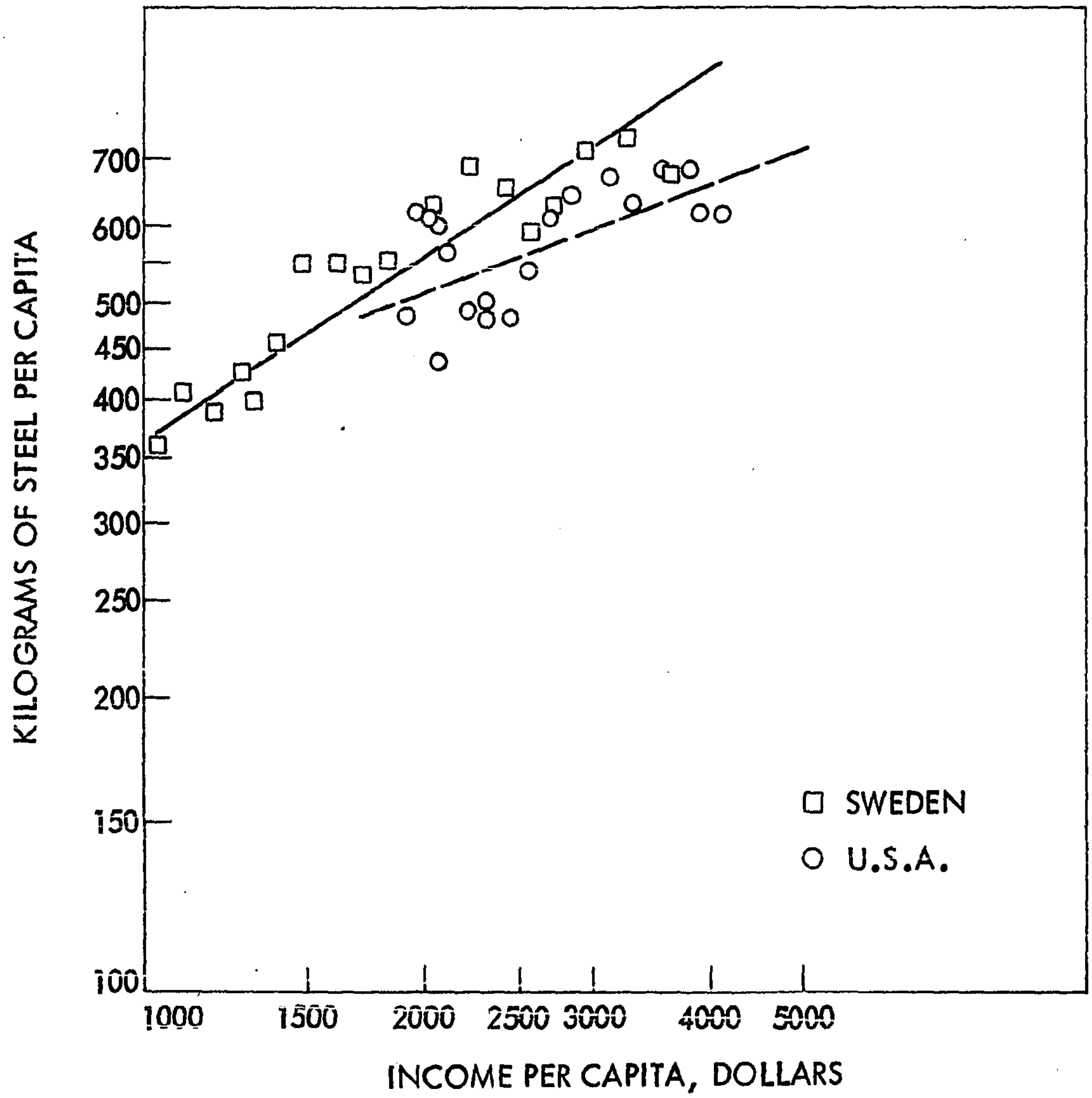


Fig. 16. U.S.A. and Sweden

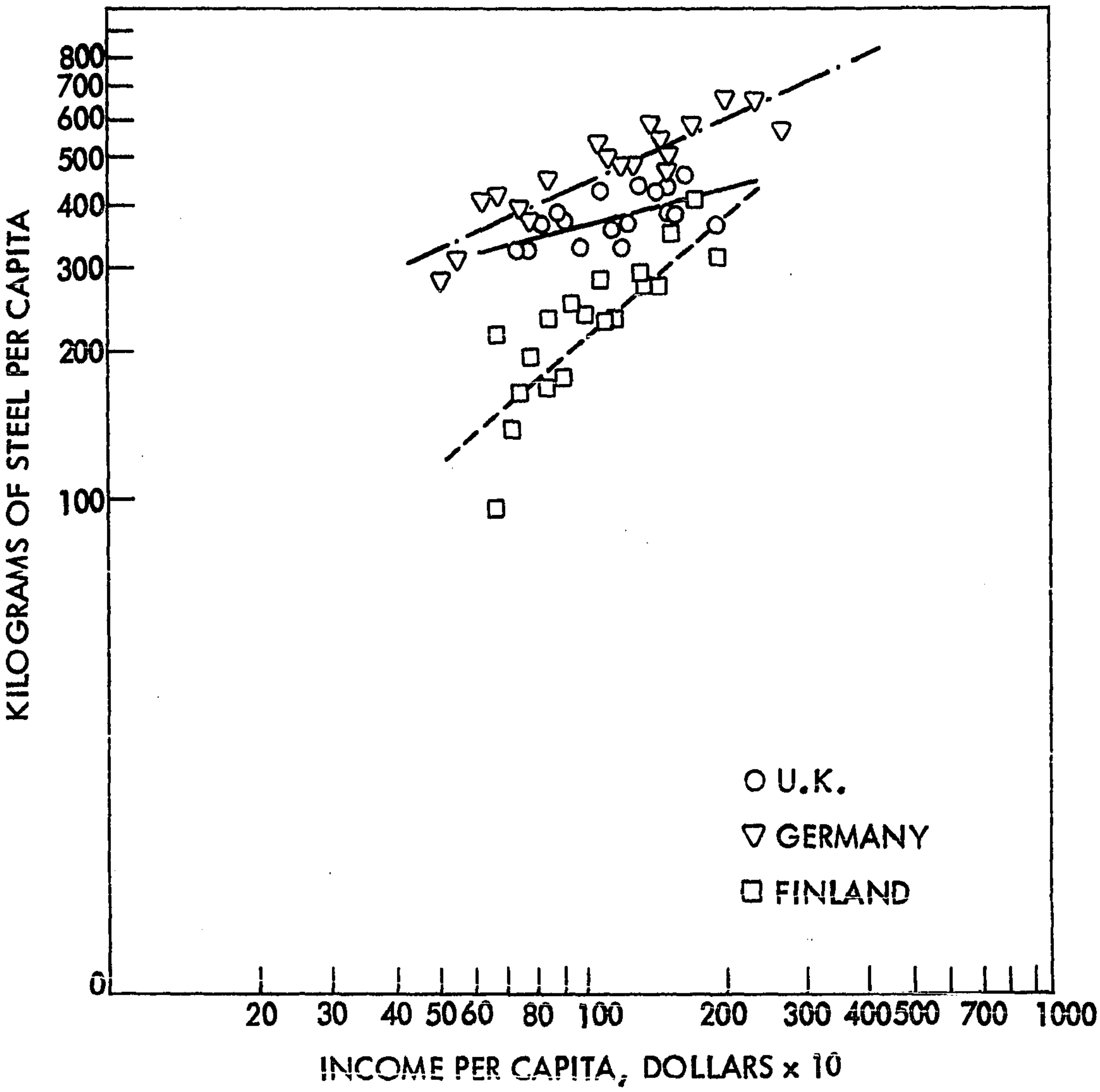


Fig. 17. U.K., Germany, and Finland

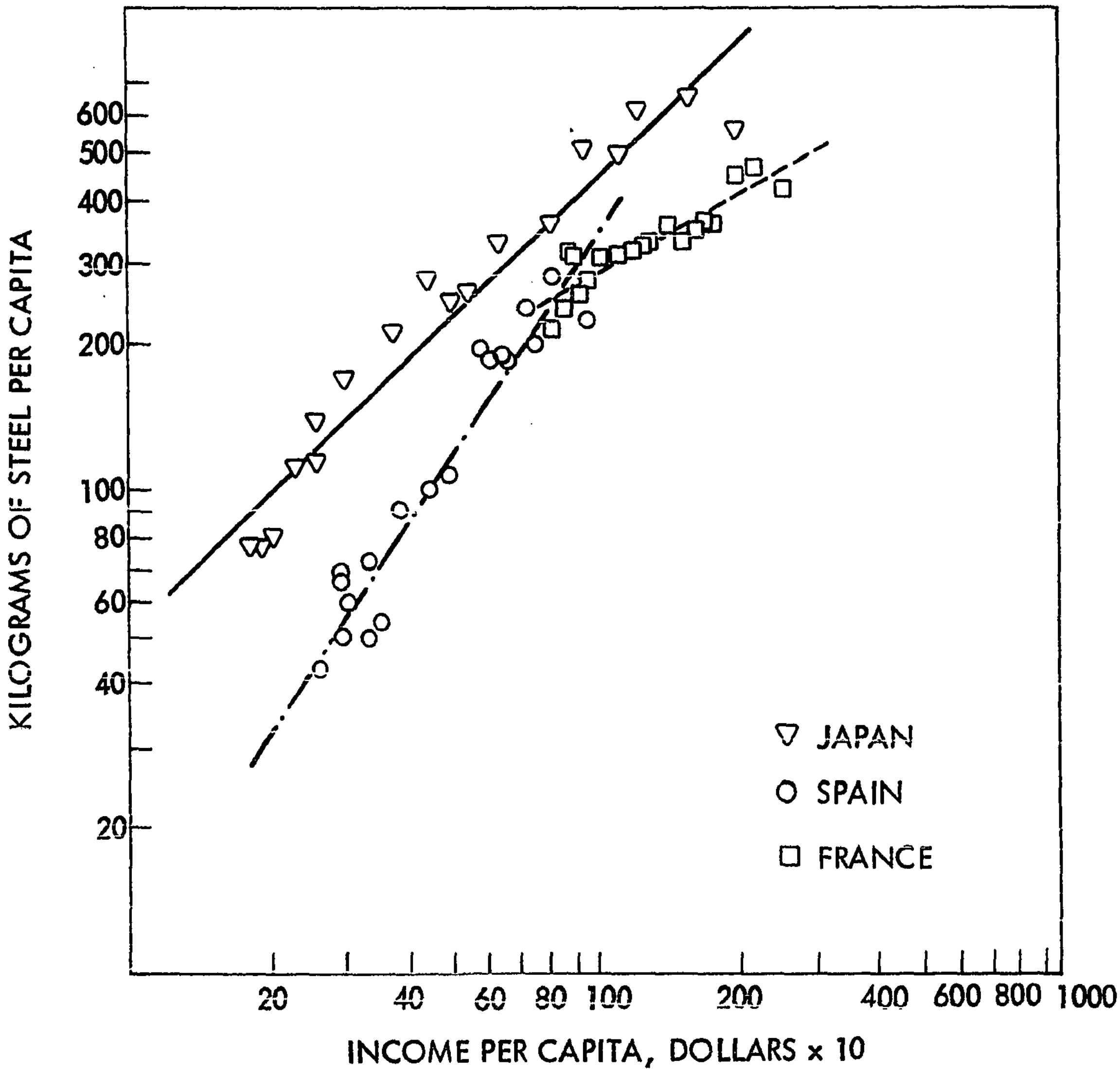


Fig. 18. France, Spain, and Japan

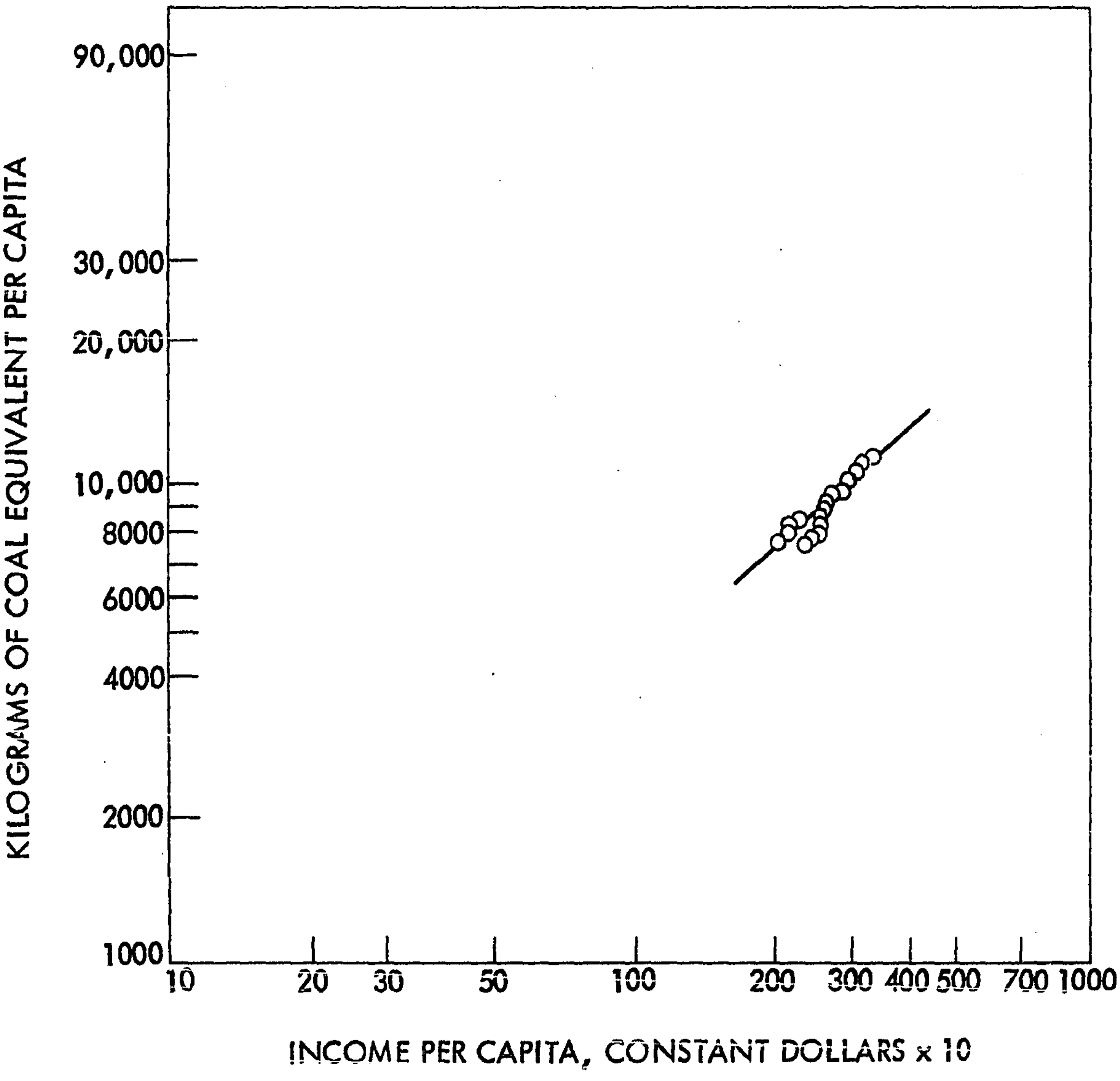

90,000
30,000
20,000
10,000
8000
6000
4000
2000
1000
KILOGRAMS OF COAL EQUIVALENT PER CAPITA
10
20
30
50
100
200
300
400
500
700
1000
INCOME PER CAPITA, CONSTANT DOLLARS x 10

Fig. 19. U.S.A.

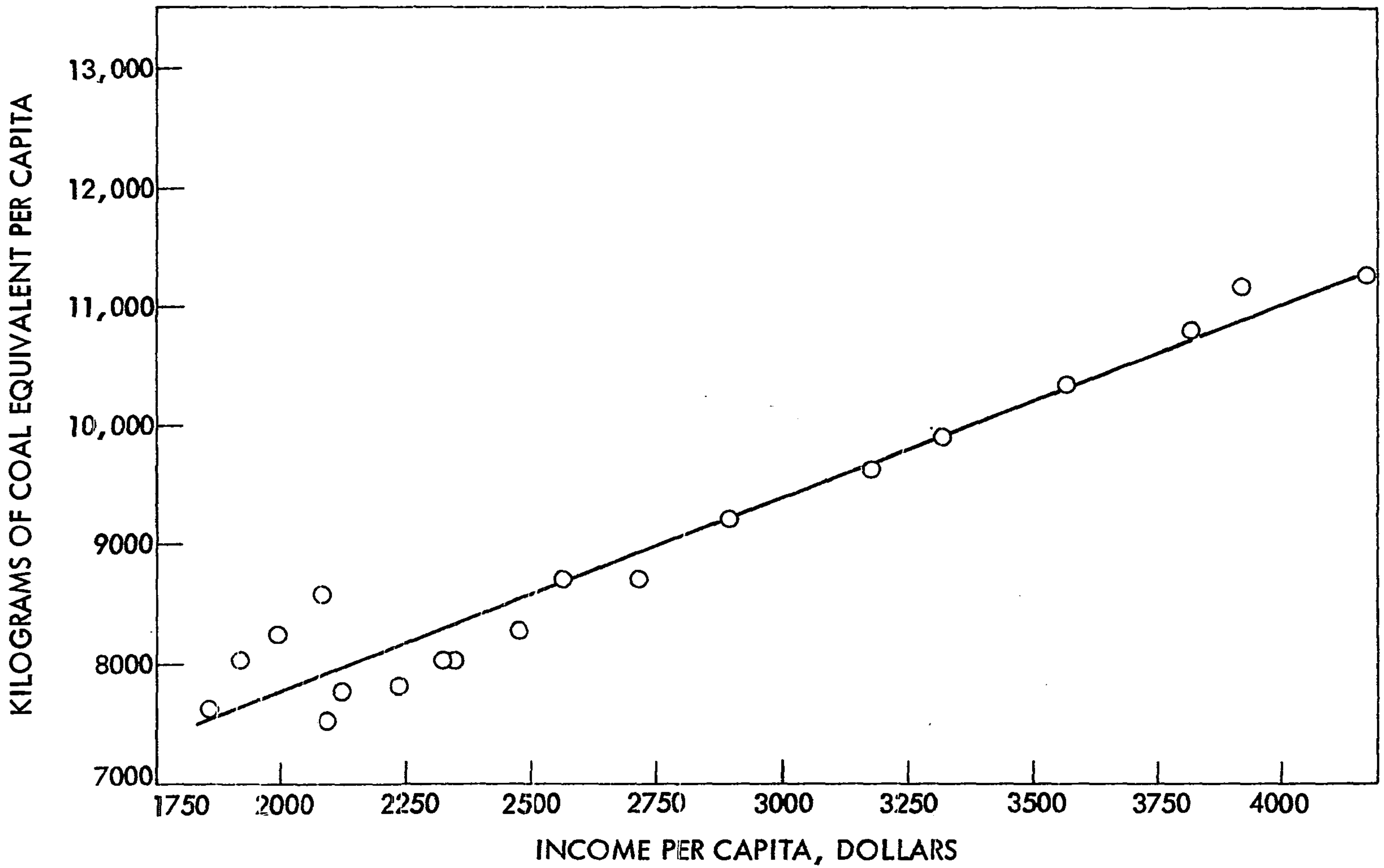

KILOGRAMS OF COAL EQUIVALENT PER CAPITA
13,000
12,000
11,000
10,000
9000
8000
7000
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
INCOME PER CAPITA, DOLLARS

Fig. 20. U.S.A.

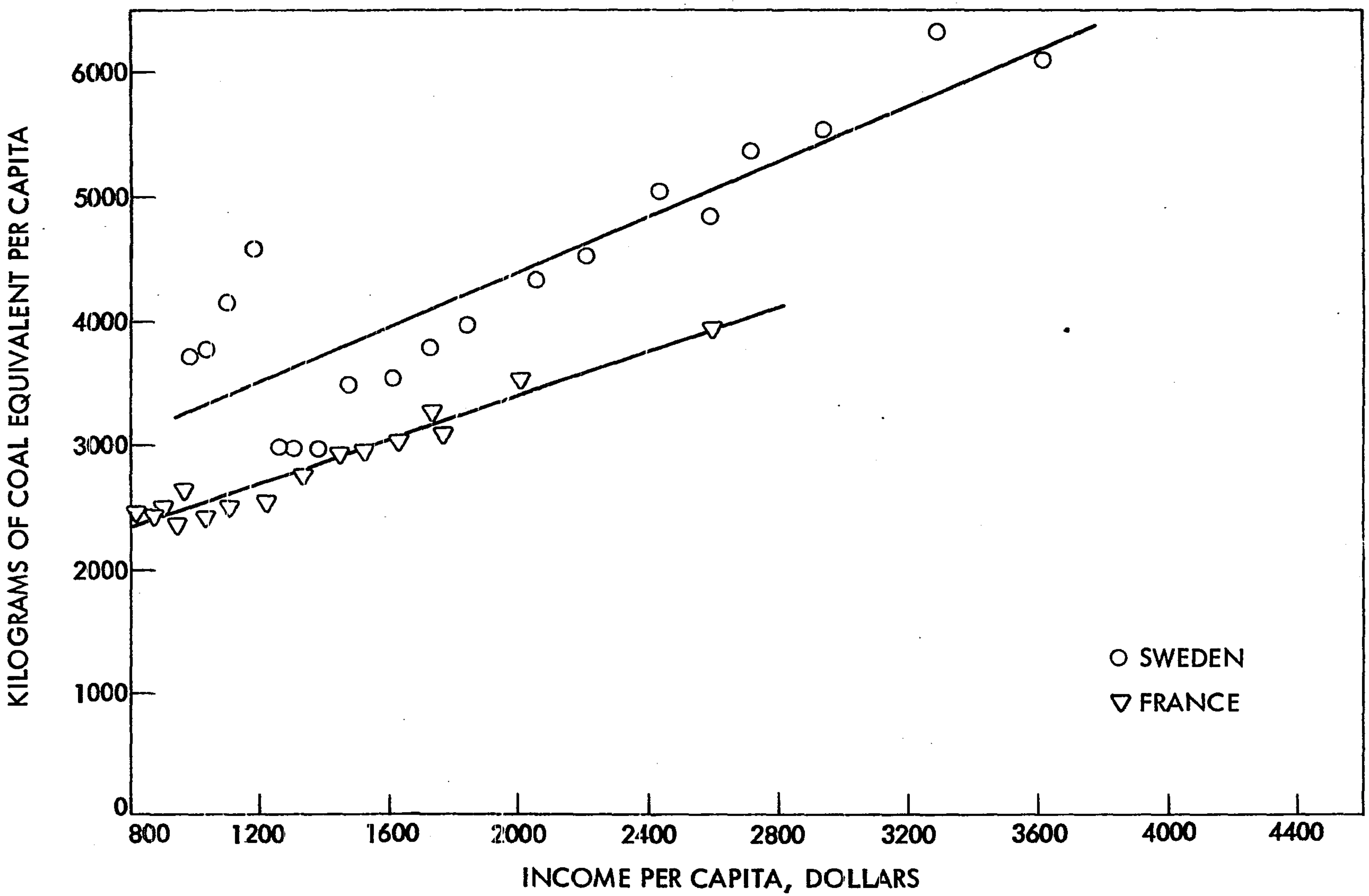


Fig. 21. France and Sweden

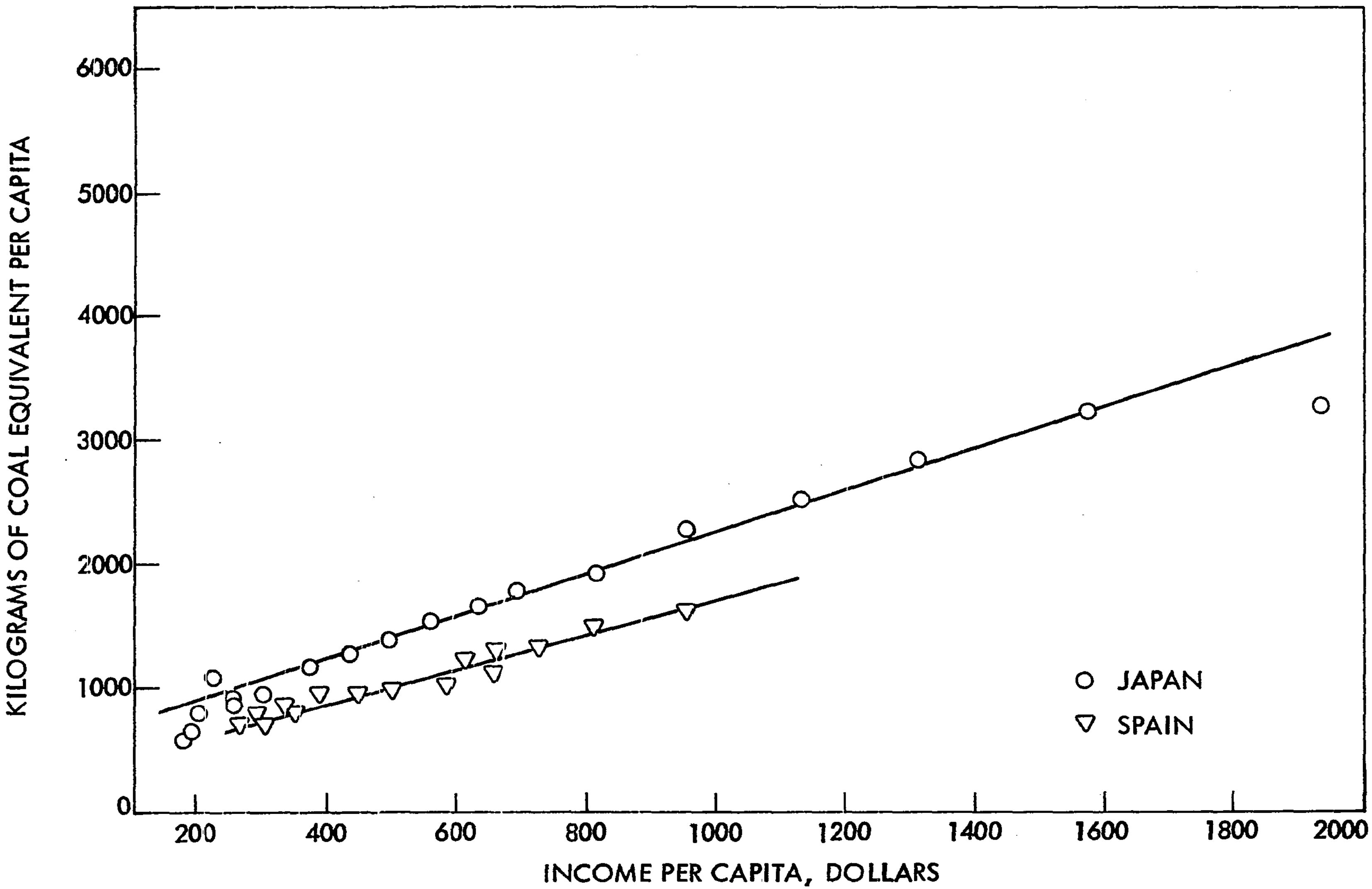


Fig. 22. Japan and Spain

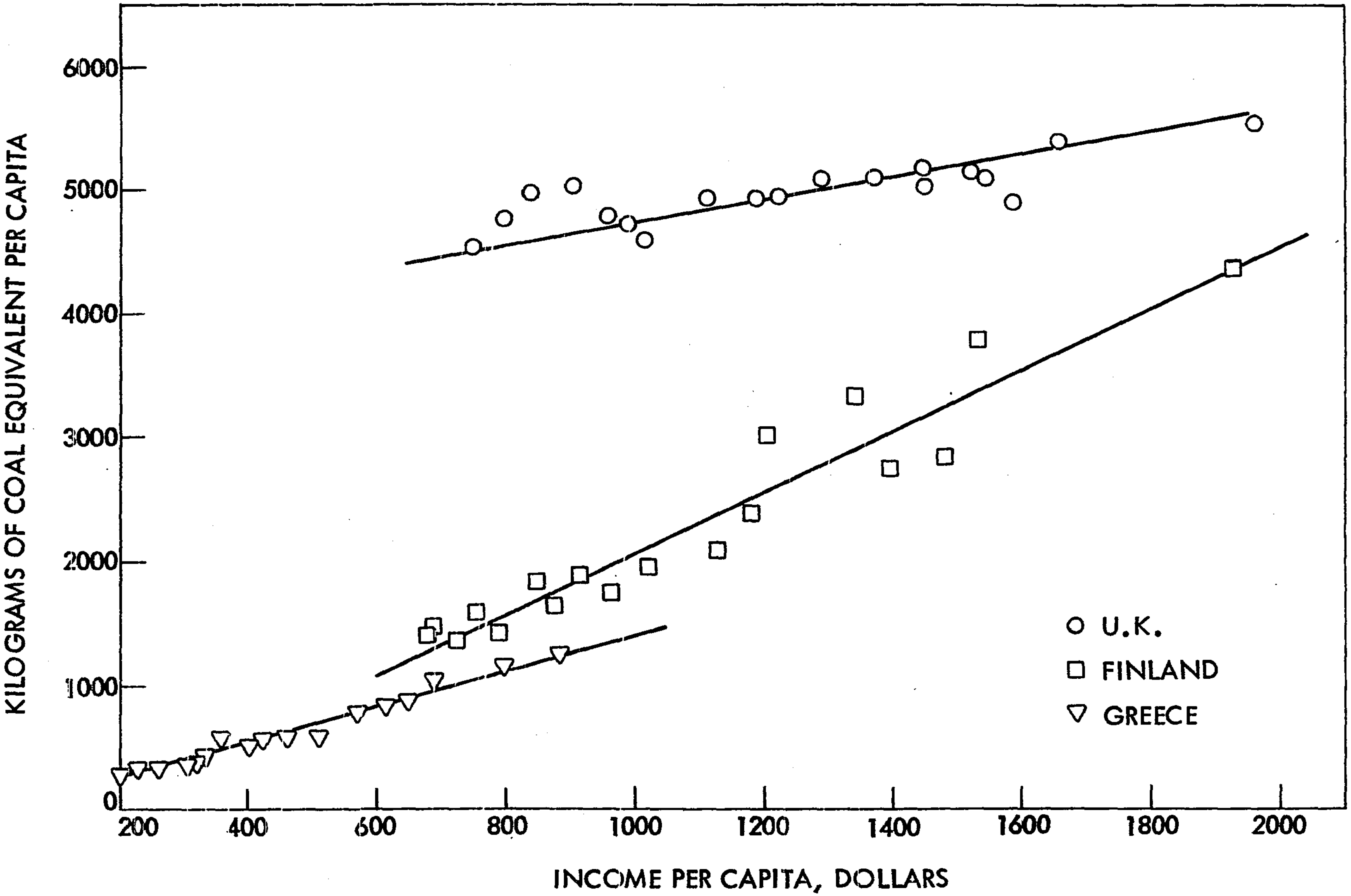


Fig. 23. Finland, Greece, and U.K.

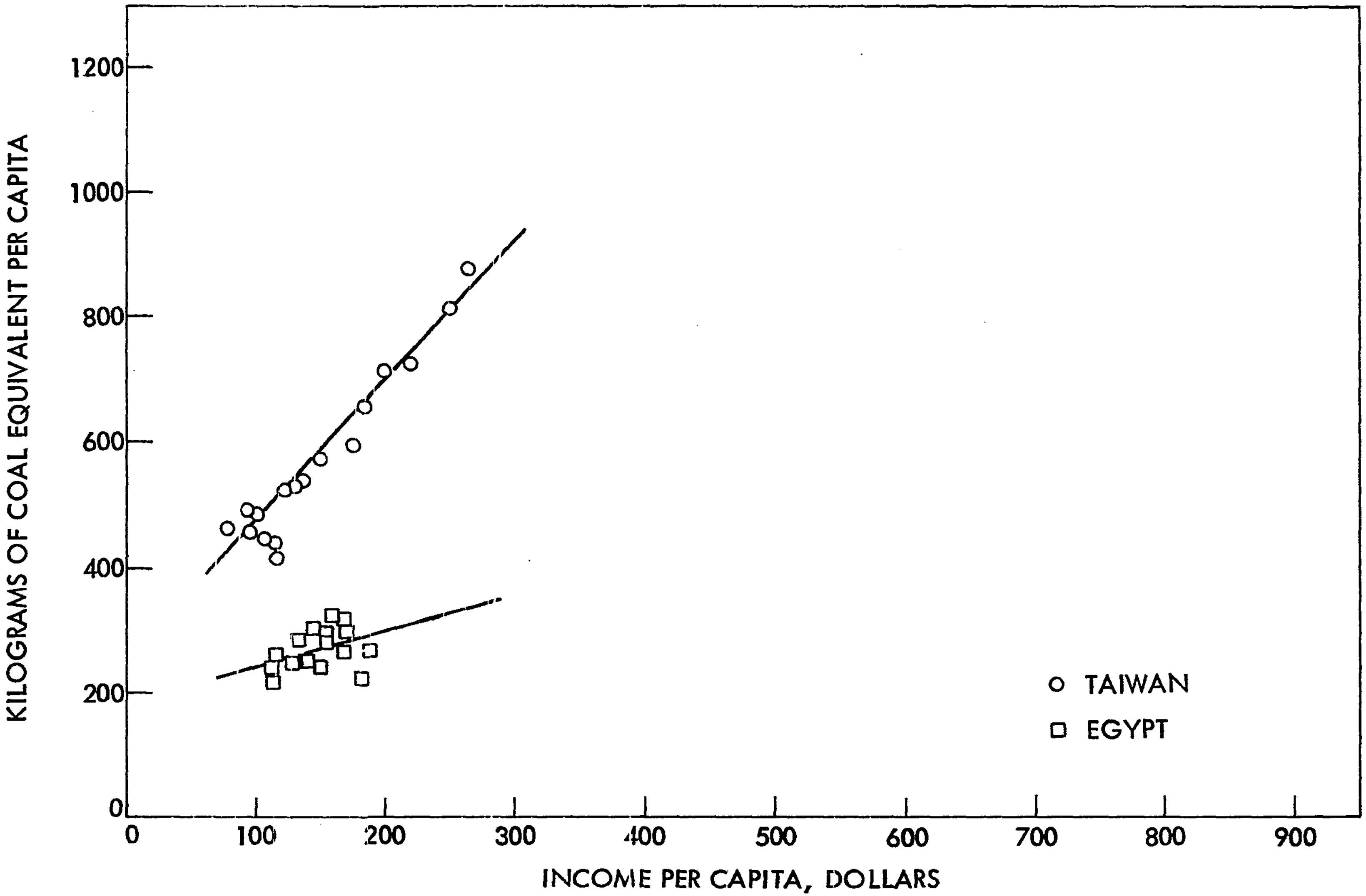


Fig. 24. Egypt and Taiwan

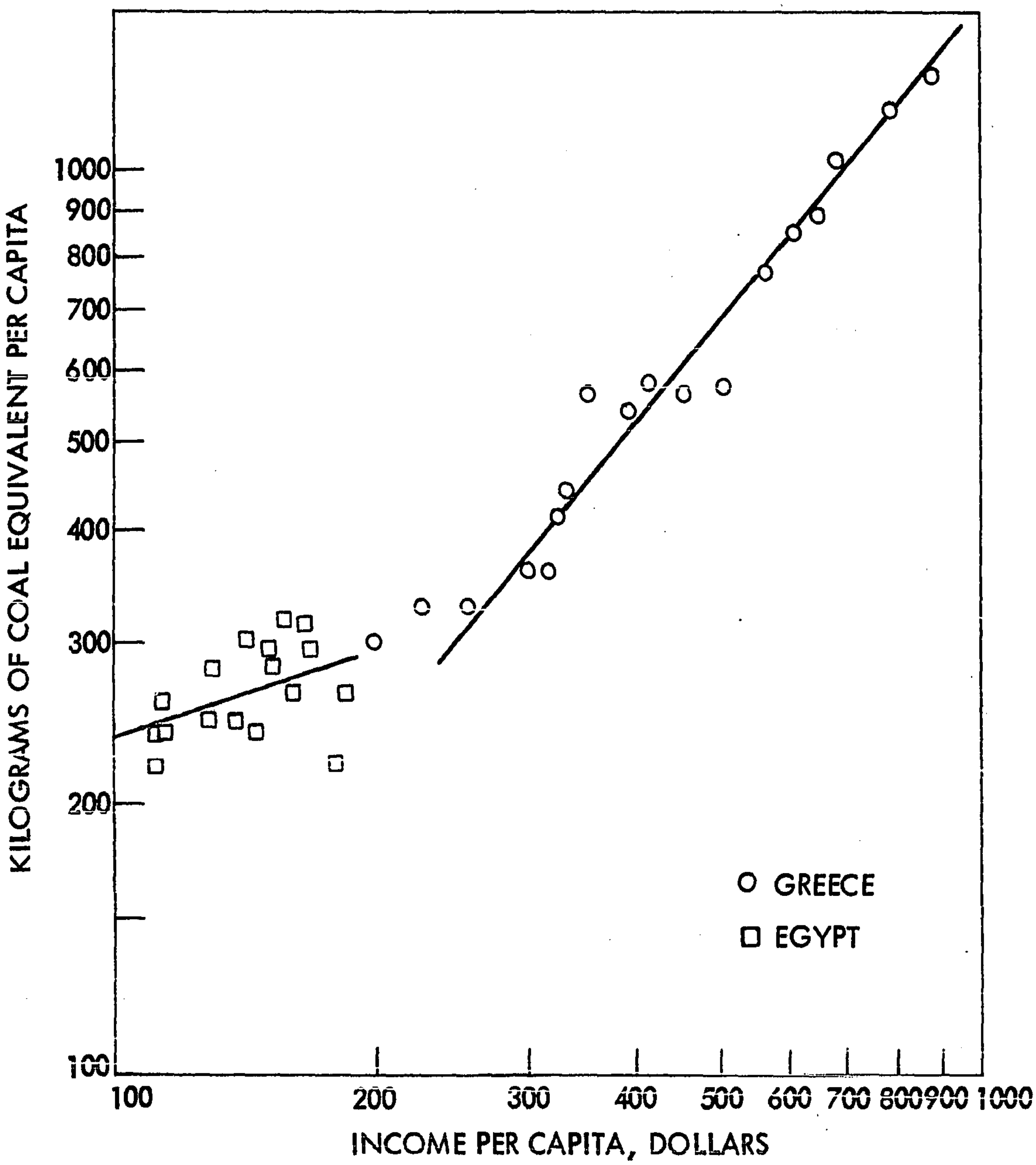


Fig. 25. Greece and Egypt

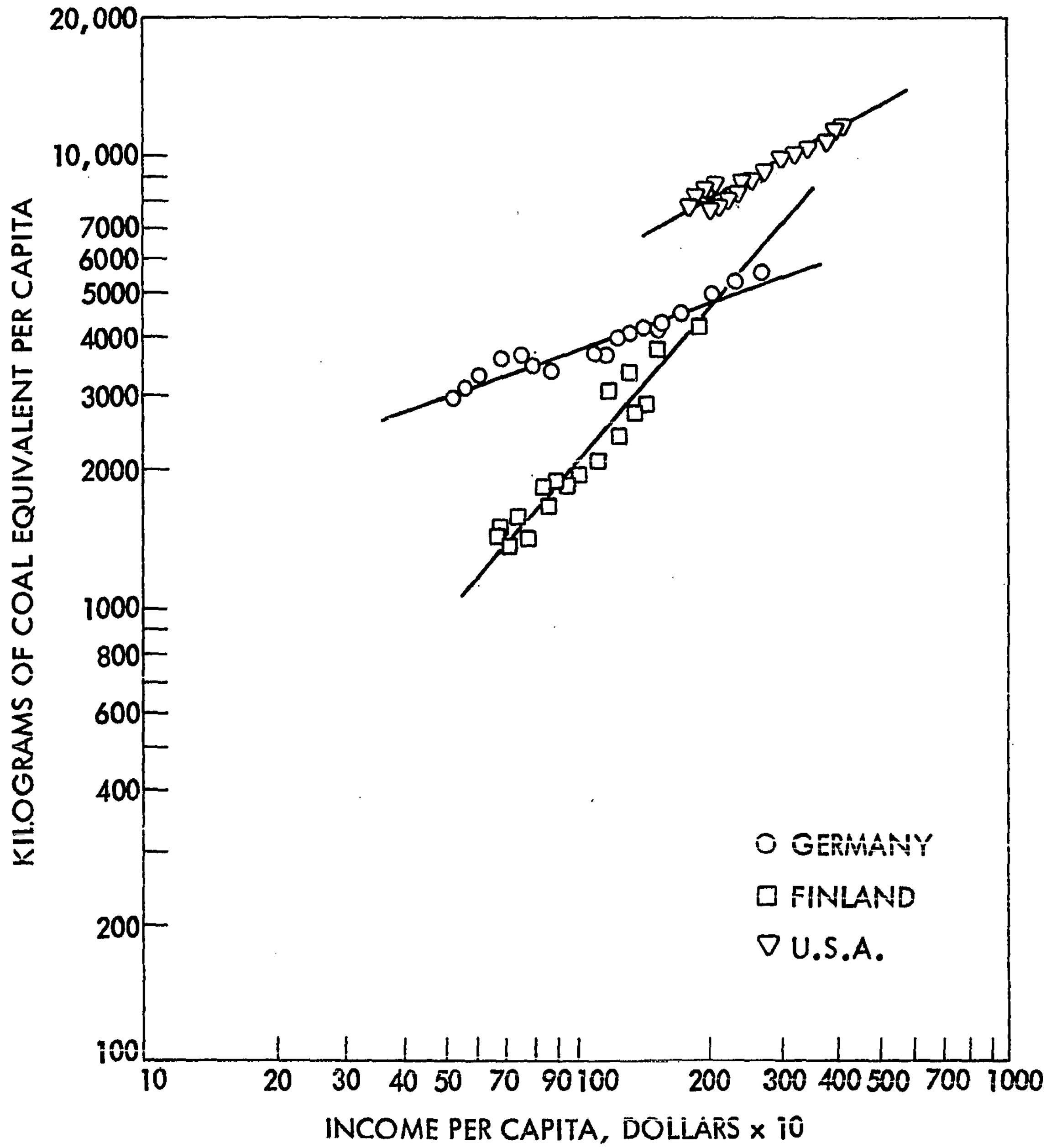


Fig. 26. Germany, Finland, and U.S.A.

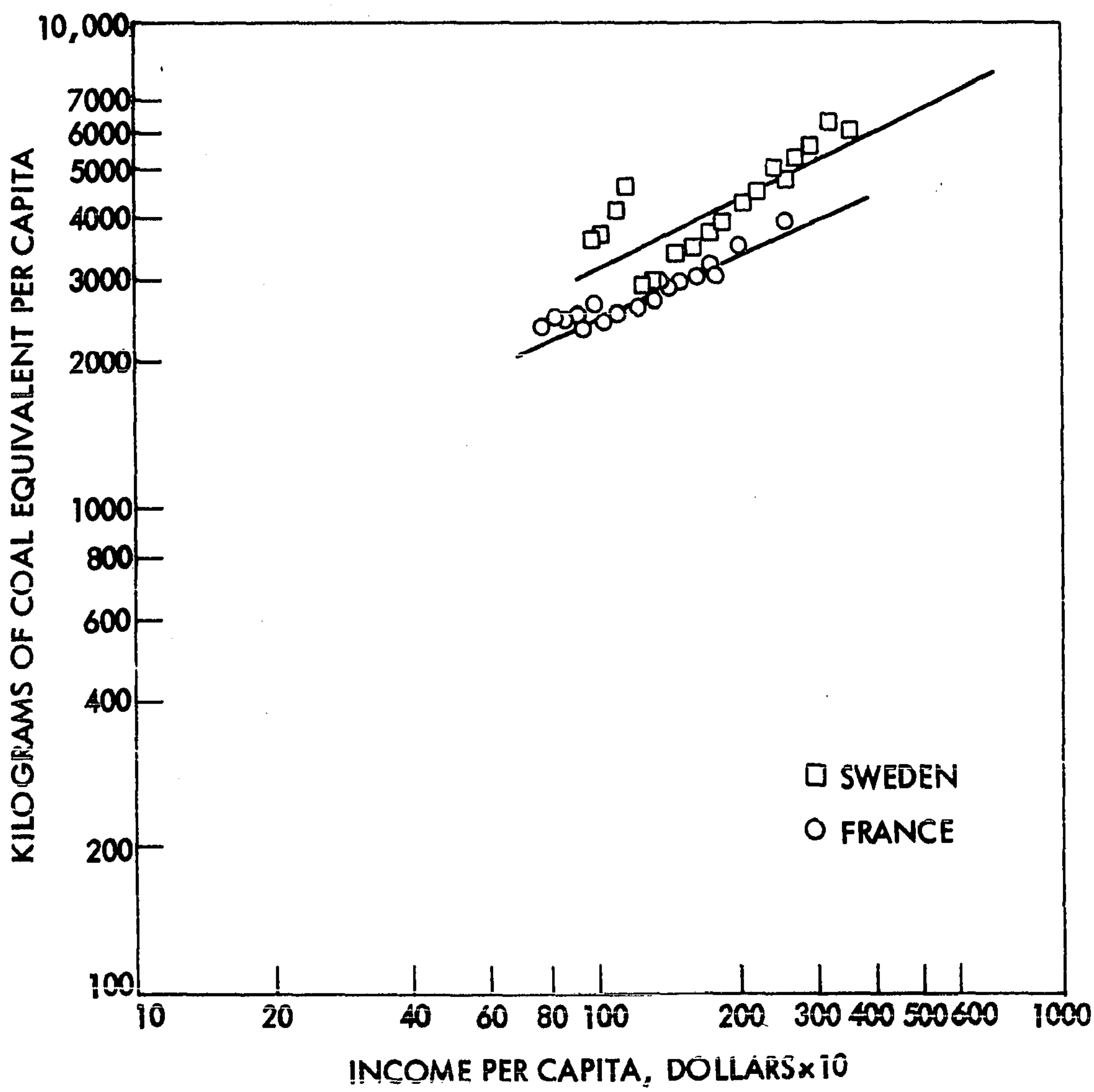


Fig. 27. France and Sweden

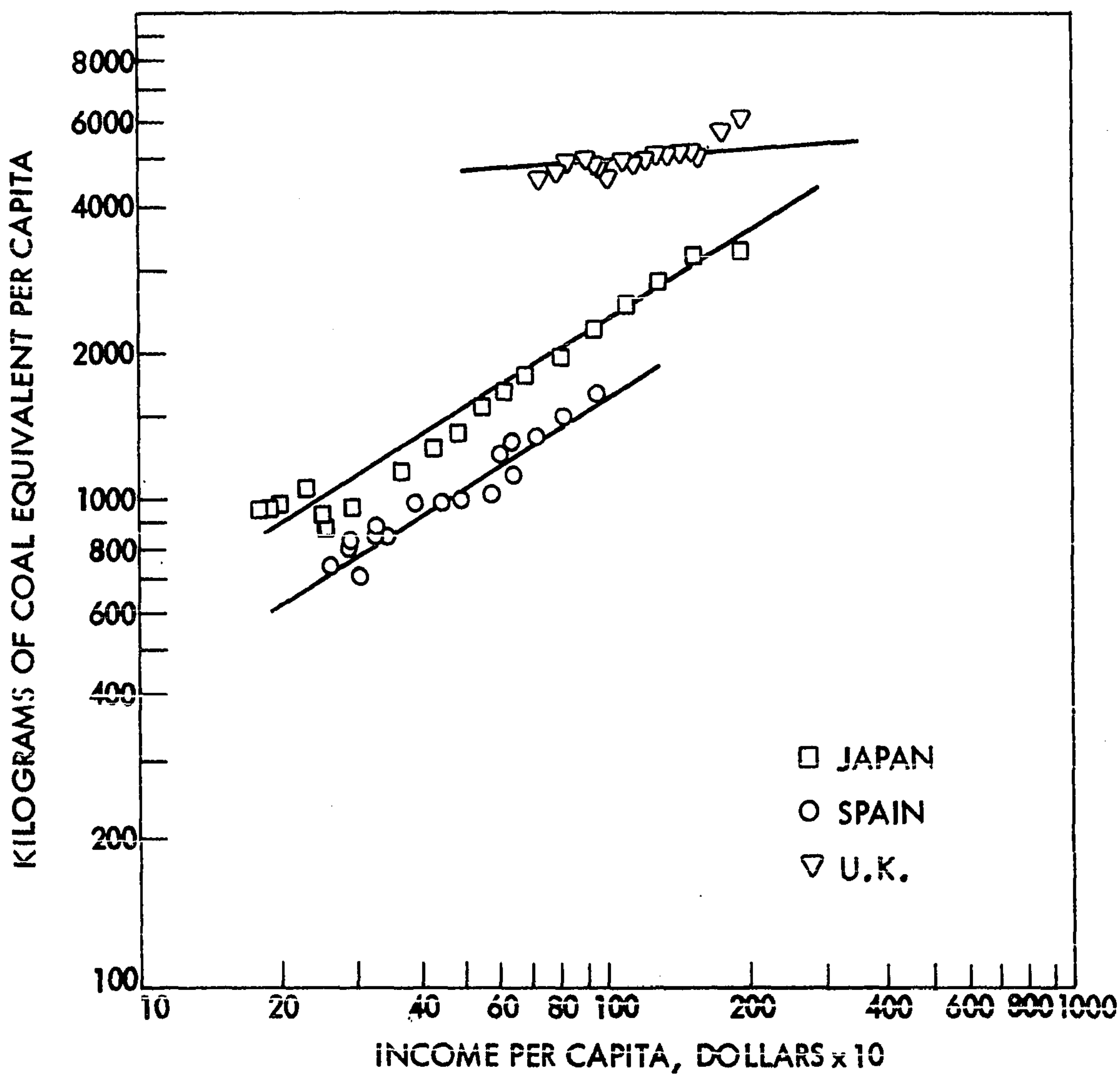
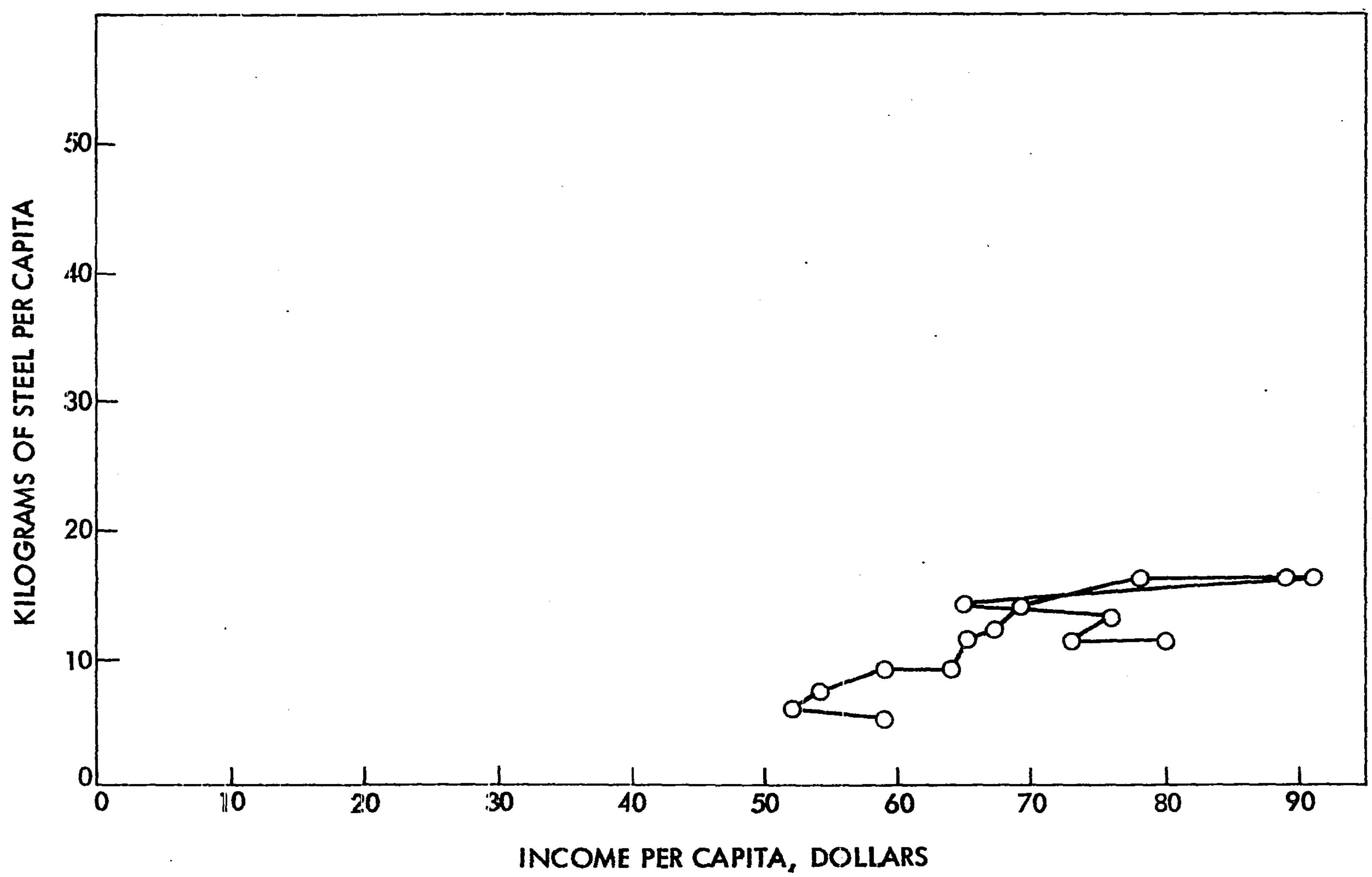


Fig. 28. Japan, Spain, and U.K.



KILOGRAMS OF STEEL PER CAPITA
0
10
20
30
40
50
0
10
20
30
40
50
60
70
80
90
INCOME PER CAPITA, DOLLARS

Fig. 29. India

it. The scales may be different for each country in order to obtain a better picture of what has actually occurred. After plotting the data, none of the plots obtained resembles a true straight line. Although for some, namely, Sweden, Spain, and Japan a straight line may be fitted. How good such a fit is, will have to be determined by further studies. For Egypt, India, and United Kingdom, the semi-log does not appear to give a straight line fit, and the plots are scattered. The remaining countries exhibit an orderly upward increase but the data does not straighten out on the semi-log scale.

After completing the semi-log graphical analysis, the log-log analysis is started. Both coordinates are in the log scale, having steel on the ordinate and income on the abscissa. In this case also, the scales of both coordinates depend on the levels of the two variables to obtain a clearer view of the direction of the plots. From the graphs that result, it appears that the log-log scale gives a better fit. The plots for most countries group in together into a straight line, and the grouping of the points appears better than that for the semi-log. With this in mind, it is then necessary to try to formulate a mathematical model (through mathematical analysis) to fit the data. Another analysis to be done is a statistical analysis to determine the goodness of the fit of this model compared to the other models tried, namely the semi-log and the polynomial of second degree.

The graphical analysis of the energy consumed per capita and income per capita will follow the same procedures as that for steel and income. Because of the success of the log-log transformation over the semi-log, the log-log fit will be tried before the semi-log fit, but the first to be tried is the Cartesian coordinates. For all the countries plotted, there appears to be a strong steady increase of both income and energy. In the case of Egypt and India the data appears scattered widely. For the United Kingdom there appears to be more fluctuation than for the other countries. There appears to be different rates of increase along the curve. It is important to note here that a devaluation of the Finnish currency does not seem to change the direction of increase, it only dislocates the curve.

The log-log transformation appears to give a good fit for all the countries. The straight line direction of the points appears evident. A mathematical analysis is to be used to formulate a model of this relationship; energy and income. Another analysis, a statistical one is to be done to determine the goodness of fit.

F. Mathematical Analysis

The mathematical analysis involves the formulation of a mathematical model to fit the actual data. The graphical analysis has directed the way towards this mathematical model. Since it appears that the log-log graphical presentation gives a better fit, the model for the graphs is the parabclic equation:

$$\log (y) = \log b + m \log (x)$$

In the analysis of the steel and the energy data, income per capita is the independent variable (x) and the dependent variable (y) is steel and energy, respectively.

The method used to fit the data is that of the least squares. The various operations that are executed to obtain the fit are :

> "1- Tabulate the values of x and y
> 2- Tabulate the values of log x and log y, then get summation of log x and summation of log y for all the data
> 3- Compute and tabulate the values of the square of log (x) and the product (log x) (log y)
> 4- Get the totals by summation of the square of log (x) and the summation of the product of (log x) (log y)
> 5- Substitute the proper sums in the two standard equations: Summation of (log y) = m (summation of log x) + n log b
> Summation of (log y) (log x) = m (Summation of the square of log x) + (Summation of log x) (log b)
> 6- Solve these simultaneous equations for m and b, and write the equations of the curve." (2)

Having determined the mathematical model to fit the data, the data for each country is applied in the model to determine the parameters of the equations, namely, the constant coefficient (b) and the power of the independent variable (m). From the preliminary investigation of the consumption of steel over time, it is apparent that there may be two phases where the rate of increase of the consumption of steel is different. These two periods are from 1953 - 1960 and from 1961 - 1971. They are investigated separately, and the model is fitted to them to determine the changes that may have occurred from the one period to the other. Therefore we are investigating the total period which is then divided into two periods which are examined further.

The mathematical equation for each part of the investigation is obtained by following the "Least Squares" method mentioned above to fit the data to a parabolic curve. This procedure is followed for each country separately and the calculations and results are shown.

The same procedure is followed to obtain the mathematical equation for energy consumption per capita and income per capita. Again, the equation for the whole period is fitted, then this period is further examined by dividing it into two parts and obtaining the equations for these two parts. The two time periods are from 1953 - 1960 and from 1961 - 1971. The calculations are carried out for each country separately and the results follow.

Germany

Steel and Income

1953 - 1971

$$50.8159 = 58.2587\,m + 19 \log b$$
$$156.1482 = 179.4191\,m + 58.2587 \log b$$
$$2960.4683 = 3394.0761\,m + 19 \log b$$
$$2966.8162 = 3408.9629\,m + 58.2587 \log b$$
$$6.3479 = 14.8868\,m$$
$$m = 0.4264$$
$$50.8159 - 24.8423 = 19 \log b$$
$$25.9736 / 19 = \log b$$
$$1.3670 = \log b$$
$$b = 23.2827$$
$$\log(\text{Steel}) = 1.3670 + 0.4264 \log(\text{Income})$$

1953 - 1960

$$20.7314 = 22.9042\,m + 8 \log b$$
$$59.4095 = 65.6545\,m + 22.9042 \log b$$
$$474.8361 = 524.6024\,m + 8 \log b\ (22.9042)$$
$$475.2760 = 525.2019\,m + 8 \log b\ (22.9042)$$
$$0.4399 = 0.5995\,m$$
$$m = 0.7337$$
$$3.9272 = 8 \log b$$
$$\log b = 0.4909$$
$$b = 3.0967$$
$$\log(\text{Steel}) = 0.4909 + 0.7337 \log(\text{Income})$$

1961 - 1971

$$30.0844 = 35.3545\,m + 11 \log b$$
$$96.7387 = 113.7643\,m + 35.3545 \log b$$
$$1063.6189 = 1249.9407\,m$$
$$1064.1257 = 1251.4073\,m$$
$$0.5068 = 1.4666\,m$$
$$m = 0.3455$$
$$30.0844 - 12.2164 = 11 \log b$$
$$17.868 / 11 = \log b$$
$$1.6244 = \log b$$
$$b = 42.1078$$
$$\log(\text{Steel}) = 1.6244 + 0.3455 \log(\text{Income})$$

Energy and Income

1953 - 1971

$$68.2483 = 58.2587\,m + 19 \log b$$

$$209.5234 = 179.4191\ m + 58.2587$$

$$3976.0572 = 3394.0761\ m$$

$$3980.9453 = 3408.9629\ m$$

$$4.8880 = 14.8868\ m$$

$$m = 0.3283$$

$$68.2483 - 19.1291 = 19 \log b$$

$$49.1192 / 19 = \log b$$

$$2.5852 = \log b$$

$$b = 384.7886$$

$$\log (\text{Energy}) = 2.5852 + 0.3283 \log (\text{Income})$$

<u>1953 - 1960</u>

$$\begin{aligned}
28.2178 &= 22.9042\ m + 8 \log b \\
80.8090 &= 65.6548\ m + 22.9042 \log b \\
646.3061 &= 524.6024\ m \\
646.4721 &= 525.2384\ m \\
0.1659 &= 0.6360\ m \\
m &= 0.2608 \\
28.2178 - 5.9731 &= 8 \log b \\
22.2447 &= 8 \log b \\
\log b &= 2.7806 \\
b &= 603.3795 \\
\log (\text{Energy}) &= 2.7806 + 0.2603 \log (\text{Income})
\end{aligned}$$

<u>1961 - 1971</u>

$$\begin{aligned}
40.0305 &= 35.3545\ m + 11 \log b \\
128.7144 &= 113.7643\ m + 35.3545 \log b \\
1415.2583 &= 1249.9407\ m + 11 \log b \\
1415.8584 &= 1251.4073\ m \\
0.6001 &= 1.4666\ m \\
m &= 0.4092 \\
40.0305 - 14.4657 &= 11 \log b \\
\log b &= 2.3241 \\
b &= 210 \\
\log (\text{Energy}) &= 2.3241 + 0.4092 \log (\text{Income})
\end{aligned}$$

Sweden

Steel and Income

1953 - 1971

51.5971 = 61.7838 m + 19 log b
168.1120 = 201.4645 m + 61.7858 log b
3187.8649 = 3817.2379 m
3194.1280 = 3827.8255 m
6.2631 = 10.5876 m
m = 0.5916
51.5971 - 36.5483 = 19 log b
log b = 0.7920
b = 6.1950
log (Steel) = 0.7920 + 0.5916 log (Income)

1953 - 1960

20.8517 = 24.6549 m + 8 log b
64.2819 = 76.0093 m + 24.6549 log b
514.0966 = 607.8641 m
514.3152 = 608.0744 m
0.2186 = 0.2103 m
m = 1.0395
log b = - 0.5972
b = 0.2528
log (Steel) = - 0.5972 + 1.0395 log (Income)

1961 - 1971

30.7457 = 37.1289 m + 11 log b
103.8226 = 125.4552 m + 37.1289 log b
1141.5429 = 1378.5552 m
1142.0486 = 1380.0072 m
0.5057 = 1.4520 m
m = 0.3483
30.7454 - 12.9318 = 11 log b
log b = 1.6194
b = 41.6313
log (Steel) = 1.6194 + 0.3483 log (Income)

Energy and Income

1953 - 1971

68.8541 = 61.7838 m + 19 log b
224.1563 = 201.4645 m + 61.7838 log b
4254.0679 = 3827.2379 m
4254.0679 = 3817.2379 m

4258.9701 = 3827.8255 m
4.9022 = 10.5876 m
0.4630 = m
68.8541 - 28.6068 = 19 log b
40.2473 = 19 log b
log b = 2.1183
b = 131.3047
log (Energy) = 2.1183 + 0.4630 log (Income)

1961 - 1971

40.4686 = 37.1289 m + 11 log b
136.6923 = 125.4552 m + 37.1289 log b
1502.5546 = 1378.5552 m
1502.5546 = 1380.0072 m
1.0609 = 1.4520 m
m = 0.7307
40.4686 - 27.1296 = 13.3390
13.3390 = 11 log b
log b = 1.2126
b = 16.3167
log (Energy) = 1.2126 + 0.7307 log (Income)

Steel and Income

1953 - 1970

48.7672 = 58.2268 m + 18 log b
158.0460 = 188.8121 m + 58.2268 log b
3839.5580 = 3390.3602 m
2844.8280 = 3398.6178 m
5.2700 = 8.2576 m
m = 0.6382
48.7672 - 37.1605 = 18 log b
11.6067 / 18 = log b
log b = 0.6448
b = 4.4138
log (Steel) = 4.4138 + 0.6382 log (Income)

1953 - 1960

20.8517 = 24.6549 m + 8 log b
64.2894 = 76.0093 m + 24.6519 log b
514.0966 = 607.8461 m
514.3152 = 608.0744 m
0.2186 = 0.2103 m
m = 1.0395
b = 0.2528
log (Steel) = log 0.2528 + 1.0395 log (Income)

<u>1961 - 1970</u>

$$27.9155 = 33.5719\,m + 10 \log b$$
$$93.7566 = 112.8028\,m + 33.5719 \log b$$
$$937.1764 = 1127.0725\,m$$
$$937.5660 = 1128.0280\,m$$
$$0.3896 = 0.9555\,m$$
$$m = 0.4078$$
$$27.9155 - 13.6892 = 10 \log b$$
$$14.2263 = 10 \log b$$
$$1.42263 = \log b$$
$$b = 26.4623$$
$$\log (\text{Steel}) = 1.42263 + 0.4078 \log (\text{Income})$$

United States of America

Steel and Income

1953 - 1971

$$
\begin{aligned}
52.4243 &= 64.9655\ m + 19 \log b \\
179.3250 &= 222.3619\ m + 64.9655 \log b \\
3405.7709 &= 4220.5162\ m \\
3407.1750 &= 4224.8761\ m \\
1.4041 &= 4.3599\ m \\
m &= 0.3221 \\
52.4243 - 20.9226 &= 19 \log b \\
31.5017 / 19 &= \log b \\
1.6580 &= \log b \\
b &= 45.4973 \\
\log (\text{Steel}) &= 1.6580 + 0.3221 \log (\text{Income})
\end{aligned}
$$

1950 - 1960

$$
\begin{aligned}
30.08085 &= 36.2555\ m + 11 \log b \\
99.14570 &= 119.51863\ m + 36.2555 \log b \\
1090.59626 &= 1314.46128\ m \\
1090.60270 &= 1314.70493\ m \\
0.00644 &= 0.24365\ m \\
m &= 0.02643 \\
29.12257 &= 11 \log b \\
2.64751 &= \log b \\
b &= 444.12598 \\
b &= 444.1260 \\
\log (\text{Steel}) &= 2.64751 + 0.02643 \log (\text{Income})
\end{aligned}
$$

1961 - 1971

$$
\begin{aligned}
30.5974 &= 38.4355\ m + 11 \log b \\
106.9335 &= 134.3746\ m + 38.4355 \log b \\
1176.0264 &= 1477.2877\ m \\
1176.2685 &= 1478.1203\ m \\
0.2421 &= 0.8326\ m \\
m &= 0.2908 \\
30.5974 - 11.1771 &= 11 \log b \\
\log b &= 1.7655 \\
b &= 58.2755 \\
\log (\text{Steel}) &= 1.7655 + 0.2908 \log (\text{Income})
\end{aligned}
$$

Energy and Income

1953 - 1971

$$
74.9975 = 64.9655\ m + 19 \log b
$$

$$256.5440 = 222.3619\ m + 64.9655 \log b$$
$$4872.2505 = 4220.5162\ m$$
$$4874.3363 = 4224.8761\ m$$
$$2.0858 = 4.3599\ m$$
$$m = 0.4784$$
$$74.9975 - 31.0791 = 19 \log b$$
$$43.9184 / 19 = \log b$$
$$2.3115 = \log b$$
$$b = 204.8773$$
$$\log (Energy) = 2.3115 + 0.4784 \log (Income)$$

1961 - 1971

$$43.7916 = 38.4355\ m + 11 \log b$$
$$153.0576 = 134.3746\ m + 38.4355 \log b$$
$$1683.1520 = 1477.2877\ m$$
$$1683.6332 = 1478.1206\ m$$
$$0.4812 = 0.8329\ m$$
$$m = 0.5777$$
$$43.7916 - 22.2031 = 11 \log b$$
$$21.5885 / 11 = \log b$$
$$1.9626 = \log b$$
$$b = 91.7467$$
$$\log (Energy) = 1.9626 + 0.5777 \log (Income)$$

Spain

Energy and Income

1954 - 1971

$$
\begin{aligned}
54.0168 &= 47.7514\ m + 18 \log b \\
143.6127 &= 127.2200\ m + 47.7514 \log b \\
2579.3778 &= 2280.1962\ m \\
2585.0286 &= 2289.9600\ m \\
5.6508 &= 9.7638\ m \\
m &= 0.5787 \\
54.0168 - 27.6360 &= 18 \log b \\
\log b &= 1.4656 \\
b &= 29.2145 \\
\log (\text{Energy}) &= 1.4656 + 0.5787 \log (\text{Income})
\end{aligned}
$$

1961 - 1971

$$
\begin{aligned}
33.7077 &= 30.3878\ m + 11 \log b \\
93.2317 &= 84.1388\ m + 30.3878 \log b \\
1024.3028 &= 923.4184\ m \\
1025.5487 &= 925.5268\ m \\
1.2459 &= 2.1084\ m \\
m &= 0.5909 \\
33.7077 - 17.9561 &= 11 \log b \\
\log b &= 1.4320 \\
b &= 27.0375 \\
\log (\text{Energy}) &= 1.4320 + 0.5909 \log (\text{Income})
\end{aligned}
$$

1954 - 1960

$$
\begin{aligned}
20.3091 &= 17.3636\ m + 7 \log b \\
50.3810 &= 43.0812\ m + 17.3636 \log b \\
352.6391 &= 301.4946\ m \\
352.6670 &= 301.5684\ m \\
0.0279 &= 0.0738\ m \\
m &= 0.3782 \\
20.3091 - 6.5874 &= 7 \log b \\
13.7417 / 7 &= \log b \\
b &= 91.8554 \\
\log (\text{Energy}) &= 1.9631 + 0.3782 \log (\text{Income})
\end{aligned}
$$

Steel and Income

1954 - 1971

$$
\begin{aligned}
36.3708 &= 47.7514\ m + 18 \log b \\
97.2835 &= 127.2200\ m + 47.7514 \log b \\
1736.7566 &= 2280.1962\ m
\end{aligned}
$$

$$1751.1030 = 2289.9600\ m$$
$$14.3464 = 9.7638\ m$$
$$m = 1.4693$$
$$36.3708 - 70.1632 = 18 \log b$$
$$-33.7924 / 18 = \log b$$
$$-1.8774 = \log b$$
$$b = 0.0133$$
$$\log (\text{Steel}) = -1.8774 + 1.4693 \log (\text{Income})$$

<u>1961 - 1971</u>

$$24.1405 = 30.3878\ m + 11 \log b$$
$$66.9429 = 84.1388\ m + 30.3878 \log b$$
$$733.5767 = 923.4184\ m$$
$$736.3719 = 925.5268\ m$$
$$2.7952 = 2.1084\ m$$
$$1.3257 = m$$
$$24.1405 - 40.1865 = 11 \log b$$
$$b = 0.0341$$
$$\log (\text{Steel}) = -1.4672 + 1.3257 \log (\text{Income})$$

United Kingdom

Energy and Income

1953 - 1971

$$70.2276 = 58.4924\ m + 19 \log b$$
$$216.2341 = 180.3278\ m + 58.4924 \log b$$
$$4107.7809 = 3421.3609\ m$$
$$4108.4483 = 3426.2282\ m$$
$$0.6674 = 4.8673\ m$$
$$m = 0.1371$$
$$70.2276 - 8.0203 = 19 \log b$$
$$\log b = 3.2741$$
$$b = 1879.6133$$
$$\log (\text{Energy}) = 3.2741 + 0.1371 \log (\text{Income})$$

1961 - 1971

$$40.7878 = 34.8097\ m + 11 \log b$$
$$129.0811 = 110.1952\ m + 34.8097 \log b$$
$$1419.8111 = 1211.7152\ m$$
$$1419.8921 = 1212.1472\ m$$
$$0.0810 = 0.4320\ m$$
$$m = 0.1875$$
$$40.7878 - 6.5283 = 11 \log b$$
$$\log b = 3.1145$$
$$b = 1301.6757$$
$$\log (\text{Energy}) = 3.1145 + 0.1875 \log (\text{Income})$$

1953 - 1960

$$29.4398 = 23.6827\ m + 8 \log b$$
$$87.1530 = 70.1326\ m + 23.6827 \log b$$
$$697.2140 = 560.8703\ m$$
$$697.2240 = 561.0608\ m$$
$$0.0100 = 0.1905\ m$$
$$m = 0.0527$$
$$29.4398 - 1.2491 = 8 \log b$$
$$28.1907 / 8 = \log b$$
$$\log b = 3.5238$$
$$b = 3340.7193$$
$$\log (\text{Energy}) = 3.5238 + 0.0527 \log (\text{Income})$$

Steel and Income

1953 - 1971

$$48.9759 = 58.4924\ m + 19 \log b$$
$$150.8374 = 180.3278\ m + 58.4924 \log b$$

$$2864.7179 = 3421.3609\ m$$
$$2865.9106 = 3426.2282\ m$$
$$1.1927 = 4.8673\ m$$
$$0.2450 = m$$
$$48.9759 - 14.3327 = 19 \log b$$
$$\log b = 1.8233$$
$$b = 66.5776$$
$$\log(\text{Steel}) = 1.8233 + 0.2450 \log(\text{Income})$$

1953 - 1960

$$20.4080 = 23.6827\ m + 8 \log b$$
$$60.4245 = 70.13261\ m + 23.6827 \log b$$
$$483.3165 = 560.8703\ m$$
$$483.3960 = 565.4616\ m$$
$$0.0795 = 4.5913\ m$$
$$m = 0.01731$$
$$20.4080 - 0.40986 = 8 \log b$$
$$\log b = 2.4998$$
$$b = 316.0587$$
$$\log(\text{Steel}) = 2.4998 + 0.01731 \log(\text{Income})$$

1961 - 1971

$$28.5679 = 34.8097\ m + 11 \log b$$
$$90.4129 = 110.1952\ m + 34.8097 \log b$$
$$994.4400 = 1211.7152\ m$$
$$994.5419 = 1212.1472\ m$$
$$0.1019 = 0.4320\ m$$
$$m = 0.2358$$
$$28.5679 - 8.2089 = 11 \log b$$
$$\log b = 1.8508$$
$$b = 70.9287$$
$$\log(\text{Steel}) = 1.8508 + 0.2358 \log(\text{Income})$$

Egypt

Energy and Income

1953 - 1960

$$
\begin{aligned}
43.6979 &= 38.8848\ m + 18 \log b \\
94.4272 &= 84.0900\ m + 38.8848 \log b \\
1699.1841 &= 1512.0277\ m \\
1699.6896 &= 1513.6200\ m \\
0.5055 &= 1.5923\ m \\
m &= 0.3175 \\
43.6979 - 12.3443 &= 18 \log b \\
\log b &= 1.7419 \\
b &= 55.1908 \\
\log (\text{Energy}) &= 1.7419 + 0.3175 \log (\text{Income})
\end{aligned}
$$

1961 - 1970

$$
\begin{aligned}
24.5623 &= 22.0683\ m + 10 \log b \\
54.1960 &= 48.7198\ m + 22.0683 \log b \\
542.0482 &= 487.0099\ m \\
541.9600 &= 487.1980\ m \\
0.0882 &= 0.1881\ m \\
m &= 0.4688 \\
24.5623 - 10.3465 &= 10 \log b \\
\log b &= 14.2160 \\
b &= 26.3986 \\
\log (\text{Energy}) &= 1.4216 + 0.4688 \log (\text{Income})
\end{aligned}
$$

1953 - 1960

$$
\begin{aligned}
19.1356 &= 16.8165\ m + 8 \log b \\
40.2311 &= 35.3702\ m + 16.8165 \log b \\
321.7938 &= 282.7947\ m \\
321.8488 &= 282.9616\ m \\
0.0555 &= 0.1669\ m \\
m &= 0.3294 \\
19.1356 - 5.5390 &= 8 \log b \\
\log b &= 1.6996 \\
b &= 50.0695 \\
\log (\text{Energy}) &= 1.6996 + 0.3294 \log (\text{Income})
\end{aligned}
$$

Income and Steel

1953 - 1970

$$
\begin{aligned}
21.6746 &= 38.8848\ m + 18 \log b \\
47.0145 &= 84.0900\ m + 38.8848 \log b \\
842.8125 &= 1512.0277\ m
\end{aligned}
$$

$$846.2607 = 1513.6200\ m$$
$$3.4483 = 1.5923\ m$$
$$m = 2.1655$$
$$-62.5322 = 18 \log b$$
$$-3.4740 = \log b$$
$$b = 0.0003$$
$$\log(\text{Steel}) = -3.4740 + 2.1655 \log(\text{Income})$$

1961 - 1970

$$13.2005 = 22.0683\ m + 10 \log b$$
$$29.1719 = 48.7198\ m + 22.0683 \log b$$
$$291.3126 = 487.0099\ m$$
$$291.7190 = 487.1980\ m$$
$$0.4064 = 0.1881\ m$$
$$m = 2.1602$$
$$\log b = -3.4471$$
$$b = 0.0004$$
$$\log(\text{Steel}) = -3.4471 + 2.1602 \log(\text{Income})$$

1953 - 1960

$$8.4741 = 16.8165\ m + 8 \log b$$
$$17.8426 = 35.3702\ m + 16.8165 \log b$$
$$142.5047 = 282.7947\ m$$
$$142.7408 = 282.3616\ m$$
$$0.2361 = 0.1669\ m$$
$$m = 1.4144$$
$$-15.3106 = 8 \log b$$
$$\log b = -1.9138$$
$$b = 0.0122$$
$$\log(\text{Steel}) = -1.9138 + 1.4144 \log(\text{Income})$$

Japan

Energy and Income

1953 - 1971

$$60.3777 = 51.3234\ m + 19 \log b$$
$$164.2196 = 140.5748\ m + 51.3234 \log b$$
$$3098.7888 = 2634.0914\ m$$
$$3120.1732 = 2670.9212\ m$$
$$21.3843 = 36.8298\ m$$
$$m = 0.5806$$
$$60.3777 - 29.7997 = 19 \log b$$
$$30.5780 = 19 \log b$$
$$\log b = 1.6094$$
$$b = 40.6790$$
$$\log (\text{Energy}) = 1.6094 + 0.5806 \log (\text{Income})$$

1961 - 1971

$$36.4265 = 32.2673\ m + 11 \log b$$

$$107.1553 = 95.1026\ m + 32.2673 \log b$$
$$1175.3848 = 1041.1786\ m$$
$$1178.7083 = 1046.1286\ m$$
$$3.3235 = 4.9500\ m$$
$$m = 0.6714$$
$$36.4265 - 21.6649 = 11 \log b$$
$$\log (\text{Energy}) = 1.3420 + 0.6714 \log (\text{Income})$$

1953 - 1960

$$23.9512 = 19.0561\ m + 8 \log b$$
$$57.0643 = 45.4722\ m + 19.0561 \log b$$
$$470.3728 = 385.6825\ m$$
$$456.5144 = 363.7776\ m$$
$$13.8584 = 21.9049\ m$$
$$m = 0.6327$$
$$23.9512 - 12.4247 = 8 \log b$$
$$\log b = 1.4408$$
$$b = 27.5935$$
$$\log (\text{Energy}) = 1.4408 + 0.6327 \log (\text{Income})$$

Steel and Income

1953 - 1971

$$44.9401 = 51.3234\ m + 19 \log b$$
$$123.2082 = 140.5748\ m + 51.3234 \log b$$
$$2305.4873 = 2634.0914\ m$$

$$
\begin{aligned}
2340.9560 &= 2670.9212\ m \\
34.4771 &= 36.8298\ m \\
m &= 0.9361 \\
44.9401 - 48.0448 &= 19 \log b \\
-\ 3.1047\ /\ 19 &= \log b \\
b &= 0.6864 \\
\log(\text{Steel}) &= -\ 0.1634 + 0.9361 \log(\text{Income})
\end{aligned}
$$

1961 - 1971

$$
\begin{aligned}
28.5126 &= 32.2673\ m + 11 \log b \\
83.9580 &= 95.1026\ m + 32.2673 \log b \\
920.0246 &= 1041.1785\ m \\
923.5380 &= 1046.1286\ m \\
3.5134 &= 4.9500\ m \\
m &= 0.7098 \\
28.5126 - 22.9027 &= 11 \log b \\
5.6099 &= 11 \log b \\
\log b &= 0.5100 \\
3.2359 &= b \\
\log(\text{Steel}) &= 0.5100 \div 0.7098 \log(\text{Income})
\end{aligned}
$$

Taiwan

Energy and Income

1953 - 1969

$$
\begin{aligned}
46.7300 &= 36.4665\ m + 17 \log b \\
100.4696 &= 78.6217\ m + 36.4665 \log b \\
1704.0795 &= 1329.8056\ m \\
1707.9832 &= 1336.5689\ m \\
3.9037 &= 6.7633\ m \\
m &= 0.5772 \\
46.7300 - 21.0473 &= 17 \log b \\
\log b &= 1.5107 \\
b &= 32.4125 \\
\log (\text{Energy}) &= 1.5107 + 0.5772 \log (\text{Income})
\end{aligned}
$$

1961 - 1969

$$
\begin{aligned}
25.3903 &= 20.3818\ m + 9 \log b \\
57.5644 &= 46.2546\ m + 20.3818 \log b \\
517.5000 &= 415.4178\ m \\
518.0796 &= 416.2914\ m \\
0.5796 &= 0.8736\ m \\
m &= 0.6634 \\
25.3903 - 13.5217 &= 9 \log b \\
\log b &= 1.3187 \\
b &= 20.8321 \\
\log (\text{Energy}) &= 1.3187 + 0.6634 \log (\text{Income})
\end{aligned}
$$

1953 - 1960

$$
\begin{aligned}
21.3397 &= 16.0847\ m + 8 \log b \\
42.9052 &= 32.3671\ m + 16.0847 \log b \\
343.2427 &= 258.7176\ m \\
343.2416 &= 258.9368\ m \\
0.0011 &= -\ 0.2192\ m \\
m &= -\ 0.0050 \\
\log b &= 2.6776 \\
b &= 475.9399 \\
\log (\text{Energy}) &= 2.6776 - 0.0050 \log (\text{Income})
\end{aligned}
$$

Steel and Income

1951 - 1969

$$
\begin{aligned}
26.6227 &= 40.3106\ m + 19 \log b \\
57.4101 &= 86.0186\ m + 40.3106 \log b \\
1073.1770 &= 1624.9448\ m \\
1090.7919 &= 1634.3543\ m
\end{aligned}
$$

$$17.6149 = 9.4095\, m$$
$$m = 1.8720$$
$$-\ 48.8404 = 19 \log b$$
$$-\ 2.5705 = \log b$$
$$b = 0.0027$$
$$\log(\text{Steel}) = -\ 2.5705 + 1.8720 \log(\text{Income})$$

1961 - 1969

$$15.2100 = 20.3818\, m + 9 \log b$$
$$34.6175 = 46.2546\, m + 20.3818 \log b$$
$$310.0072 = 415.4178\, m$$
$$311.5575 = 416.2914\, m$$
$$1.5503 = 0.8736\, m$$
$$m = 1.7746$$
$$-\ 20.9519 = 9 \log b$$
$$\log b = -\ 2.3288$$
$$b = 0.0047$$
$$\log(\text{Steel}) = -\ 2.3288 + 1.7746 \log(\text{Income})$$

France

Steel and Income

1953 - 1971

$$
\begin{aligned}
47.4502 &= 58.9767\ m + 19 \log b \\
147.54123 &= 183.5277\ m + 58.9767 \log b \\
2798.4562 &= 3478.2511\ m \\
2803.2828 &= 3487.0263\ m \\
4.8266 &= 8.7752\ m \\
m &= 0.5500 \\
47.4502 - 32.4389 &= 19 \log b \\
15.0113 &= 19 \log b \\
\log b &= 0.7901 \\
b &= 6.1669 \\
\log (\text{Steel}) &= 0.7901 + 0.5500 \log (\text{Income})
\end{aligned}
$$

1961 - 1971

$$
\begin{aligned}
28.1515 &= 35.3708\ m + 11 \log b \\
90.5798 &= 113.8606\ m + 35.3708 \log b \\
995.7416 &= 1251.0949\ m \\
996.3778 &= 1252.4666\ m \\
0.6362 &= 1.3717\ m \\
m &= 0.4638 \\
28.1515 - 16.4052 &= 11 \log b \\
\log b &= 1.0678 \\
b &= 11.6908 \\
\log (\text{Steel}) &= 1.0678 + 0.4638 \log (\text{Income})
\end{aligned}
$$

1953 - 1960

$$
\begin{aligned}
19.2987 &= 23.6059\ m + 8 \log b \\
56.96141 &= 69.6671\ m + 23.6059 \log b \\
455.5632 &= 557.2385\ m \\
455.6912 &= 557.3368\ m \\
0.1280 &= 0.0983\ m \\
m &= 1.3023 \\
-11.4440 &= 8 \log b \\
\log b &= -1.4305 \\
b &= 0.0371 \\
\log (\text{Steel}) &= -1.4305 + 1.3023 \log (\text{Income})
\end{aligned}
$$

Energy and Income

1953 - 1971

$$
\begin{aligned}
61.9482 &= 55.6243\ m + 18 \log b \\
191.5967 &= 172.2891\ m + 55.6243 \log b
\end{aligned}
$$

$$3445.8246 = 3094.0628\ m$$
$$3448.7406 = 3101.2041\ m$$
$$2.9160 = 7.1411\ m$$
$$m = 0.4083$$
$$61.9482 - 22.7138 = 18 \log b$$
$$\log b = 2.1797$$
$$b = 151.2473$$
$$\log(\text{Energy}) = 2.1797 + 0.4083 \log(\text{Income})$$

1961 - 1971

$$34.8285 = 31.9573\ m + 10 \log b$$
$$111.5719 = 102.6220\ m + 31.9573 \log b$$
$$1113.0248 = 1021.2690\ m$$
$$1115.7190 = 1026.2200\ m$$
$$2.6942 = 4.9511\ m$$
$$m = 0.5442$$
$$34.8285 - 17.3898 = 18 \log b$$
$$\log b = 0.9688$$
$$b = 9.3072$$
$$\log(\text{Energy}) = 0.9688 + 0.5442 \log(\text{Income})$$

1953 - 1960

$$27.1197 = 23.6059\ m + 8 \log b$$
$$80.0248 = 69.6671\ m + 23.6059 \log b$$
$$640.1849 = 557.2385\ m$$
$$640.1984 = 557.3368\ m$$
$$0.0135 = 0.0983\ m$$
$$m = 0.1371$$
$$27.1197 - 3.2361 = 8 \log b$$
$$23.8836 = 8 \log b$$
$$2.9854 = \log b$$
$$b = 967.0511$$
$$\log(\text{Energy}) = 2.9854 + 0.1371 \log(\text{Income})$$

Finland

Energy and Income

1953 - 1971

$$59.8981 = 54.2907\ m + 18 \log b$$
$$181.0054 = 164.0587\ m + 54.2907 \log b$$
$$3251.9098 = 2947.4801\ m$$
$$3258.0972 = 2953.0571\ m$$
$$6.1874 = 5.5770\ m$$
$$m = 1.1094$$
$$59.8981 - 60.2320 = 18 \log b$$
$$\log b = -\ 0.0186$$
$$b = 0.9581$$
$$\log (\text{Energy}) = -\ 0.0186 + 1.1094 \log (\text{Income})$$

1953 - 1960

$$25.5662 = 23.1383\ m + 8 \log b$$
$$73.9596 = 66.9390\ m + 23.1383 \log b$$
$$591.5584 = 535.3809\ m$$
$$591.6768 = 535.5120\ m$$
$$0.1184 = 0.1311\ m$$
$$m = 0.9033$$
$$25.5662 - 20.9002 = 8 \log b$$
$$\log b = 0.5833$$
$$b = 3.8305$$
$$\log (\text{Energy}) = 0.5833 + 0.9033 \log (\text{Income})$$

1961 - 1971

$$34.3319 = 31.1524\ m + 10 \log b$$
$$107.0458 = 97.1197\ m + 31.1524 \log b$$
$$1069.5211 = 970.4720\ m$$
$$1070.4580 = 971.1973\ m$$
$$0.9369 = 0.7252\ m$$
$$m = 1.2919$$
$$-\ 5.9135 = 10 \log b$$
$$\log b = -\ 0.59135$$
$$b = 0.2562$$
$$\log (\text{Energy}) = -\ 0.59135 + 1.2919 \log (\text{Income})$$

Steel and Income

1953 - 1971

$$44.5332 = 57.5275\ m + 19 \log b$$
$$135.1532 = 174.5356\ m + 44.5332 \log b$$
$$2561.8837 = 3309.4133\ m$$

$$2567.9108 = 3316.1764\ m$$
$$6.0271 = 6.7631\ m$$
$$m = 0.8912$$
$$44.5332 - 51.2667 = 19 \log b$$
$$- 6.7335 / 19 = \log b$$
$$b = 0.4422$$
$$\log(\text{Steel}) = - 0.3544 + 0.8912 \log(\text{Income})$$

<u>1961 - 1971</u>

$$26.8165 = 34.3892\ m + 11 \log b$$
$$83.8911 = 107.5966\ m + 34.3892 \log b$$
$$922.1980 = 1182.6171\ m$$
$$922.8021 = 1183.5626\ m$$
$$0.6041 = 0.9455\ m$$
$$m = 0.6389$$
$$26.8156 - 21.9720 = 11 \log b$$
$$\log b = 0.4404$$
$$b = 2.7568$$
$$\log(\text{Steel}) = 0.4404 + 0.6389 \log(\text{Income})$$

<u>1953 - 1960</u>

$$17.7167 = 23.1383\ m + 8 \log b$$
$$51.26210 = 66.9390\ m + 23.1383 \log b$$
$$409.9343 = 535.3809\ m$$
$$410.0968 = 535.5120\ m$$
$$0.1625 = 0.1311\ m$$
$$m = 1.2396$$
$$17.7167 - 28.6826 = 8 \log b$$
$$\log b = - 1.3707$$
$$b = 0.0426$$
$$\log(\text{steel}) = - 1.3707 + 1.2396 \log(\text{Income})$$

Greece

Energy and Income

1953 - 1970

49.5902 = 47.2625 m + 18 log b
130.8246 = 124.6942 m + 47.2625 log b
2343.7568 = 2233.7439 m
2354.8428 = 2244.4953 m
11.0860 = 10.7513 m
m = 1.0311
49.5902 - 48.7335 = 18 log b
0.8567 = 18 log b
b = 1.1158
log (Energy) = 0.0476 + 1.0311 log (Income)

1961 - 1970

28.9509 = 27.6237 m + 10 log b
80.1128 = 76.4287 m + 27.6237 log b
799.7310 = 763.0688 m
801.1280 = 764.2870 m
1.3970 = 1.2180 m
m = 1.1470
28.9509 - 31.6838 = 10 log b
log b = - 0.2733
b = 0.5330
log (Energy) = - 0.2733 + 1.1470 log (Income)

1953 - 1960

20.6393 = 19.6388 m + 8 log b
50.7118 = 48.2655 m + 19.6388 log b
405.3311 = 385.6825 m
405.6880 = 386.1240 m
0.3569 = 0.4415 m
m = 0.8084
20.6393 - 15.8751 = 8 log b
b = 3.9403
log (Energy) = 0.5955 + 0.8084 log (Income)

Steel and Income

1953 - 1971

32.7351 = 50.2581 m + 19 log b
87.3440 = 133.6678 m + 50.2581 log b
1645.2039 = 2525.8766 m
1659.5360 = 2539.6882 m

$$14.3320 = 13.8116\ m$$
$$m = 1.0377$$
$$32.7351 - 52.1518 = 19 \log b$$
$$\log b = -\ 1.0219$$
$$b = 0.0951$$
$$\log (\text{Steel}) = -\ 1.0219 + 1.0377 \log (\text{Income})$$

1961 - 1971

$$20.8570 = 30.6193\ m + 11 \log b$$
$$58.1216 = 85.4023\ m + 30.6193 \log b$$
$$638.6267 = 937.5415\ m$$
$$539.3376 = 939.4253\ m$$
$$0.7109 = 1.8838\ m$$
$$m = 0.3774$$
$$20.8570 - 11.5550 = 11 \log b$$
$$\log b = 0.8456$$
$$b = 7.0087$$
$$\log (\text{Steel}) = 0.8456 + 0.3774 \log (\text{Income})$$

1953 - 1960

$$11.8781 = 19.6388\ m + 8 \log b$$
$$29.2224 = 48.2655\ m + 19.6388 \log b$$
$$233.2716 = 385.6825\ m$$
$$233.7792 = 386.1240\ m$$
$$0.5076 = 0.4415\ m$$
$$m = 1.1496$$
$$11.8781 - 22.5759 = 8 \log b$$
$$\log b = -\ 1.3372$$
$$b = 0.0460$$
$$\log (\text{Steel}) = -\ 1.3372 + 1.1496 \log (\text{Income})$$

E. Statistical Analysis

Although a mathematical equation for the data is fitted to a parabolic function, a regression analysis is a logical step to determine the goodness of fit and as a check on the mathematical model.

A regression analysis is made on the steel consumption and income, leaving the steel as the dependent variable and income as the independent variable. A linear regression is not fitted since the data on the Cartesian coordinates did not resemble a straight line. A polynomial fit of the second degree, an exponential fit and a parabolic fit are tried. This is done on the data for the total time period as a unit. The data is divided into two parts from 1953 - 1960 and 1961 - 1971 and the best fit for the period 1953 - 1971 is tried for them. The computations are facilitated by using the computer programs for regression analysis. The coefficient of determination R^2 is used as a measure of goodness of fit and is defined as:

> "The proportion of a total sum of squares that is attributable to another source of variation, the independent variable" (11)

Another regression analysis is made on the energy consumption and income. In this case, the energy consumption per capita is the dependent variable, and the income per capita in dollars, is the independent variable. The data are fitted to the parabolic, exponential and linear functions.

The polynomial of the second degree is not tried because the graph on Cartesian gives a reasonably linear relationship. This analysis is applied to the data in the period 1953 - 1971 for all the countries. The goodness of fit is measured using R^2, the coefficient of determination.

IV. RESULTS

A. Mathematical Results

The fitting of the data to the mathematical model gives the mathematical equation for each country. As has been mentioned, the analysis is carried further by examining the two periods within the total period, namely, from 1953 - 1960, and 1961 - 1971.

In the results of Energy and Income, there appears to be one general trend. The power (m), of the independent variable increases for all countries from the first period to the second. However, this increase is different for each country. There are three countries that have negative power, a decreasing rate, in the first period, 1953 - 1960. The countries are the United States, Sweden, and Taiwan. This trend is reversed in the second period and an increase is registered. The remainder of the countries have a lower positive value in the first period than the second period.

In the case of Steel and Income, there are basically two broad categories, the first category of countries is that in which the power is high during the first period 1953 - 1960 and then decreases considerably during the second period 1961 - 1971. This category includes Sweden, Germany, France, Japan, India, and Greece. The second category of countries is that in which the power is low in the first period 1953 - 1960 and increases in the second period. The countries in this category are the United States of America, the United Kingdom, Spain, Egypt, and Taiwan.

There are two interesting facts to note here, one deals with the first category which includes India, apparently an industrializing country, with the rest of the category mostly industrialized countries. The second fact to note is that the United States and the United Kingdom, two highly industrialized countries, are included in the second group which includes Spain, Egypt, and Taiwan, the industrializing countries.

The first category appears to have a higher rate of consumption of steel with respect to income in the first period and this rate decreases in the second period. The second category, on the other hand, has a lower rate of consumption of steel with respect to income in the first period than it does in the second period.

Table 1

Mathematical Results
Parabolic Fit
Steel and Income

	1953-1960		1961-1971		1953-1971	
country	coef	power	coeff	power	coeff	power
Sweden	0.25	1.0395	41.63	0.3483	6.20	0.5916
Germany	3.097	0.7337	42.11	0.3455	23.28	0.4264
France	0.037	1.3023	11.69	0.4638	6.17	0.5500
Finalnd	0.043	1.2396	2.76	0.6389	0.44	0.8912
Japan	0.033	1.4799	3.24	0.7098	0.69	0.9361
India	0.0013	2.139	0.92	0.5826	0.0067	1.7440
Greece	0.046	1.1496	7.0087	0.3774	0.095	1.0377
U.S.	444.13	0.02643	58.28	0.2908	45.50	0.3221
U.K.	316.059	0.01731	70.93	0.2358	66.58	0.2450
Spain	10.50	0.2938	0.034	1.3257	0.0133	1.4693
Egypt	0.012	1.4144	0.0004	2.1602	0.0003	2.1655
Taiwan	4.44	0.2722	0.0047	1.7746	0.0027	1.8720

Table 2

Mathematical Results
Parabolic Fit
Energy and Income

	1953-1960		1961-1971		1953-1971	
country	coeff	power	coeff	power	coeff	power
U.S.	7445.6	-0.0087	91.75	0.5777	204.88	0.4784
U.K.	3340.72	0.0527	1301.68	0.1875	1879.61	0.1371
Sweden	268000	-0.6098	16.32	0.7307	131.30	0.4630
Germany	603.38	0.2608	210.89	0.4092	384.79	0.3283
France	967.051	0.1371	9.30	0.5442	151.25	0.4083
Finland	3.83	0.9033	0.2562	1.2919	0.96	1.1094
Japan	27.59	0.6327	21.98	0.6714	40.68	0.5806
Spain	91.86	0.3782	27.04	0.5909	29.21	0.5787
Greece	3.94	0.8084	0.53	1.1470	1.12	1.0311
Taiwan	475.94	-0.0050	20.83	0.6634	32.41	0.5772
Egypt	50.07	0.3294	26.40	0.4688	55.1908	0.3175
India	2.773	0.9310	98.61	0.1274	2.7221	0.9468

B. Statistical Results

The relationship between steel and income is examined by a regression analysis. The data for the time period 1953 - 1971 for all countries, is fitted by a polynomial of second degree, and exponential and a parabolic function. The standard deviation for each type of fit is computed. Comparisons among standard deviations are permissible and viable as long as the same units and scales are used. As the scales and units are changed by a transformation such as a log-log transformation, then the original standard deviation and the value of standard deviation obtained by the log-log are not comparable. However, comparisons are made for the variables within each type of transformation. Another parameter is used for the goodness of fit measure and that is R^2, the coefficient of determination.

For our data it is observed that, generally, R^2 for the polynomial function of the second degree, is higher than that for either the exponential or the parabolic functions, but such a difference is very small for most cases. R^2 is computed for the periods 1953 - 1961 and 1961 - 1971 to examine the parabolic function, and the values appear to be higher for 1961 - 1971 period than for the 1953 - 1960 period.

The energy and income data are investigated by using a linear, exponential and parabolic fit. The R^2 values for the parabolic and the linear fits are very similar in most cases and the differences between them are very small. The R^2 for the exponential is usually smaller than either the parabolic or the linear. Only in India, Egypt, Sweden, and the United Kingdom is the R^2 for the parabolic and exponential functions less than 0.87. The same countries plus Taiwan have R^2 less than 0.87 for the linear fit.

Table 3

Statistical Results
R squared
Energy and Income (1953-1971)

country	linear	lglg	semilg
Greece	0.9737	0.9620	0.9205
U.S.A.	0.9557	0.9088	0.9170
India	0.5401	0.6822	0.6661
Egypt	0.4230	0.1980	0.2032
Sweden	0.7986	0.6347	0.6757
Spain	0.9461	0.9302	0.9108
Finland	0.9079	0.9153	0.8714
Japan	0.9741	0.4567	0.9163
Germany	0.9478	0.9335	0.9239
U.K.	0.6439	0.5788	0.6090
France	0.9555	0.9191	0.9051
Taiwan	0.0374	0.8733	0.8125

Table 4

Statistical Results
R squared
Steel and Income (1953-1971)

country	poly	lglg	semilg
Greece	0.8995	0.8175	0.7898
India	0.7237	0.6705	0.6661
Egypt	0.6235	0.6215	0.6105
U.S.	0.3839	0.3613	0.3754
Sweden	0.9187	0.8745	0.8942
Finland	0.7513	0.7044	0.7492
Taiwan	0.9597	0.8610	0.8876
Germany	0.8400	0.8258	0.8319
Japan	0.9620	0.9473	0.9347
France	0.8365	0.8023	0.8370
Spain	0.9253	0.9250	0.9120
U.K.	0.4371	0.3583	0.3500

Table 5

Statistical Results
R squared
Parabolic Fit
Steel and Income

country	1953-1960	1961-1971
Egypt	0.1825	0.6536
India	0.4426	0.2016
Sweden	0.8230	0.6652
Germany	0.7975	0.5365
Japan	0.9440	0.8713
France	0.5154	0.8023
Spain	0.024	0.8952
U.K.	0.3543	0.0950
Finland	0.2347	0.5587
Taiwan	0.0155	0.9786
U.S.	0.0714	0.5348

V. SUMMARY AND CONCLUSIONS

"Goodness of fit" of the mathematical relationship to the data is not as uniform as one might expect in engineering studies of physical phenomena. Some of the countries appear to follow a linear pattern rather than the parabolic form others follow. This may be due to the near unity value of the power; but final determination must await further data in later years.

The objective of the study is to discover indicators which discriminate between differing levels of industrial development among nations, and the rates of change in industrialization which these nations have experienced, and to quantify these similarities or differences and trends as well as possible. This is to be done by studying the consumption of steel and energy with respect to income.

Then steel consumption and income are analyzed for the same period of time, no uniform monolithic growth pattern, such as with energy and income is seen. Instead, the countries follow two distinctly different growth patterns which are identifiable when the total study period is subdivided into an earlier and a later group of years. These are:

1. Low growth in early years, and noticeably faster growth in later years.

Or, 2. Noticeably higher growth in the earlier years than in the later half of the period.

Studying absolute values and trends over time, there is an indicator that a limited few of the countries may have reached a saturation level by the end of this study period; but a more reasonable conclusion could be that other countries have not yet reached any such plateau as yet.

From the above, the following conclusions may be drawn.

1. A study of energy usage vs. income does not discriminate according to level of industrialization.

2. Growth patterns in steel usage do discriminate and do indicate non-saturation levels for most of the countries studied.

3. If non-growth in steel consumption for a decade may be taken as conclusive evidence of arrival at a saturation level, the United States of America, and the United Kingdom, can be so classified.

4. Using the data available to date the existence of a single saturation level of usage cannot be supported or refuted.

5. Inclusion of centrally controlled economies in any study must await availablitiy of data about their internal affairs, not furnished at this time.

VI. DISCUSSION

With many forces interacting in the process of industrialization, it may well be difficult to approach a study such as the one just completed with no preconceived ideas.

The phenomenon under study, is by no means a simple one, nor is it one whose data can be easily reproduced whenever required. The countries involved in such a study have very different characteristics. Some have long sturdy, stable political and economic institutions; others are in constant turmoil of change of the economic and political systems. Fluctuations of currencies with respect to the dollar are numerous, and even the dollar is no longer such a stable currency. For a long time, during the span of time covered by this study, the dollar has been the strongest currency and is used as the unit of the per capita income.

One may have expected some economies of scale revealed in the larger countries with more people. The per capita figures do not seem to indicate this.

The data is furnished by the governments of countries, some of these data are not consistent and may not be accurately reported to the United Nations, the data base of this study.

It is thought that food would have been fruitful for use as a factor to be investigated. But it was not, with the present state of the art in data reporting. Somehow it would seem that adequate food should be a threshold on which industrial development may progress.

It might have been fruitful to have included some of the centrally planned economy countries, but data is not available.

Despite these limitations it has been satisfying to know that a start has been made in investigating one of the more frustrating phenomena - the question of national industrial development.

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To my parents, I dedicate this dissertation. To my father for his courage, nationalism, perseverance and fortitude in the face of political persecution.

To my mother for her steadfast loyalty, patience, endurance and love.

And finally to my Egypt, whose future will be better than her glorious past.

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XI. APPENDIX

The following symbols refer to:

x	Income per capita in dollars
y	Steel consumption in kilograms of crude steel per capita
z	Energy consumption in kilograms of coal equivalent per capita
LgLg	Log-log
Semilg	Semi-log
Poly	Polynomial of second degree

Table 6

SWEDEN

Yr	Y	Z	X[1]	LgX	LgY	LgZ	LgYLgZ	LgXLgZ	LgXLgY
53	320	3700	983	2.9926	2.5051	3.5682	8.9387	10.6782	7.4968
54	354	3760	1038	3.0162	2.5490	3.5752	9.1132	10.7835	7.6883
55	402	4150	1105	3.0434	2.6042	3.6180	9.4220	11.0110	7.9256
56	385	4590	1184	3.0734	2.5855	3.6618	9.4676	11.2542	7.9463
57	420	2974	1267	3.1028	2.6232	3.4733	9.1112	10.7770	8.1393
58	391	2971	1309	3.1169	2.5922	3.4729	9.0025	10.8247	8.0796
59	453	2968	1380	3.1399	2.6561	3.4725	9.2233	10.9033	8.3399
60	545	3496	1478	3.1697	2.7364	3.5436	9.6967	11.2321	8.6736
61	544	3523	1605	3.2055	2.7356	3.5469	9.7029	11.3696	8.7690
62	530	3755	1723	3.2363	2.7243	3.5746	9.7383	11.5685	8.8167
63	545	3950	1836	3.2639	2.7364	3.5966	9.8417	11.7389	8.9313
64	623	4320	2048	3.3113	2.7945	3.6355	10.1594	12.0382	9.2534
65	682	4506	2204	3.3432	2.8338	3.6538	10.3541	12.2154	9.4740
66	649	5037	2415	3.3829	2.8122	3.7022	10.4113	12.5242	9.5134
67	585	4832	2583	3.4121	2.7672	3.6841	10.1946	12.5705	9.4420
68	623	5360	2707	3.4325	2.7945	3.7292	10.4212	12.8005	9.5921
69	711	5768	2937	3.4679	2.8519	3.7610	10.7260	13.0428	9.8901
70	733	6311	3283	3.5163	2.8651	3.8001	10.8877	13.3623	10.0746
71	676	6089	3607	3.5570	2.8299	3.7845	10.7098	13.4615	10.0660

[1]Income per capita from Gross Domestic Product

Table 7

U.S.A

Yr	Y	Z	X	LgX	LgY	LgZ	LgYLgZ	LgXLgZ	LgXLgY
53	624	8010	1914	3.2819	2.7952	3.9036	10.9113	12.8112	9.1735
54	478	7620	1857	3.2688	2.6794	3.8820	10.4014	12.6895	8.7585
55	620	8250	1998	3.3006	2.7924	3.9165	10.9364	12.9268	9.2166
56	600	8580	2078	3.3176	2.7782	3.9335	10.9280	13.0498	9.2168
57	568	7771	2119	3.3261	2.7543	3.8905	10.7156	12.9402	9.1611
58	408	7640	2088	3.3197	2.6365	3.8831	10.2378	12.8907	8.7524
59	491	7817	2232	3.3487	2.6911	3.8930	10.4765	13.0365	9.0117
60	501	8013	2325	3.3664	2.6998	3.9038	10.5395	13.1418	9.0886
61	488	8042	2340	3.3692	2.6884	3.9054	10.4993	13.1581	9.057
62	488	8263	2470	3.3927	2.6884	3.9171	10.5307	13.2895	9.1209
63	540	8705	2563	3.4087	2.7324	3.9398	10.7651	13.4296	9.3139
64	615	8772	2712	3.4333	2.7889	3.9431	10.9969	13.5378	9.5751
65	656	9201	2893	3.4613	2.8169	3.9638	11.1656	13.7199	9.7501
66	671	9619	3175	3.5017	2.8267	3.9831	11.2590	13.9476	9.8983
67	636	9880	3316	3.5206	2.8035	3.9948	11.1994	14.0641	9.8700
68	685	10331	3570	3.5527	2.8357	4.0141	11.3828	14.2609	10.0744
69	682	10774	3818	3.5818	2.8338	4.0324	11.4270	14.4433	10.1501
70	620	11144	3918	3.5931	2.7924	4.0470	11.3008	14.5413	10.0334
71	617	11244	4172	3.6203	2.7903	4.0509	11.3032	14.6655	10.1018

Table 8

TAIWAN

Yr	Y	Z	X	LgX	LgY	LgZ	LgXLgY	LgYLgZ	LgXLgZ
53	11	440	115	2.0607	1.0414	2.6435	2.1460	2.7529	5.4475
54	14	420	116	2.0645	1.1461	2.6232	2.3661	3.0064	5.4156
55	15	460	78	1.8921	1.1761	2.6628	2.2253	3.1317	5.0383
56	14	490	93	1.9685	1.1461	2.6902	2.2561	3.0832	5.2957
57	11	448	106	2.0253	1.0414	2.6513	2.1091	2.7611	5.3697
58	17	459	96	1.9823	1.2304	2.6618	2.4390	3.2751	5.2765
59	22	488	102	2.0086	1.3424	2.6884	2.6963	3.6089	5.3999
60	27	523	121	2.0828	1.4314	2.7185	2.9813	3.5846	5.6621
61	26	529	130	2.1139	1.4150	2.7235	2.9912	3.8538	5.7572
62	29	568	135	2.1303	1.4624	2.7543	3.1154	4.0279	5.8675
63	34	573	150	2.1761	1.5315	2.7582	3.3327	4.2242	6.0021
64	40	595	175	2.2430	1.6021	2.7745	3.5935	4.4450	6.2232
65	50	654	184	2.2648	1.6990	2.8156	3.8479	4.7837	6.3768
66	62	710	199	2.2989	1.7924	2.8513	4.1205	5.1107	6.5549
67	69	724	219	2.3404	1.8388	2.8579	4.3035	5.2584	6.6928
68	87	816	247	2.3927	1.9395	2.9117	4.6406	5.6472	6.9668
69	85	874	264	2.4216	1.9294	2.9415	4.6722	5.6753	7.1231

Table 9

SPAIN

Yr	Y	Z	X	LgX	LgY	LgZ	LgXLgZ	LgYLgZ	LgXLgY
54	43	740	263	2.4200	1.6335	2.8692	6.9435	4.6868	3.9531
55	50	800	290	2.4624	1.6990	2.9031	7.1486	4.9324	4.1836
56	51	880	331	2.5198	1.7076	2.9445	7.4196	5.0280	4.3028
57	55	829	353	2.5478	1.7404	2.9186	7.4360	5.0795	4.4342
58	61	712	306	2.4857	1.7853	2.8525	7.0905	5.0926	4.4377
59	70	807	291	2.4639	1.8451	2.9069	7.1623	5.3635	4.5461
60	66	821	291	2.4639	1.8195	2.9143	7.1805	5.3026	4.4831
61	73	855	332	2.5211	1.8633	2.9320	7.3919	5.4632	4.6976
62	91	987	384	2.5843	1.9590	2.9943	7.7382	5.8685	5.0626
63	100	991	447	2.6503	2.000	2.9961	7.9406	5.9922	5.3006
64	109	996	498	2.6972	2.0374	2.9983	8.0870	6.1087	5.4953
65	194	1023	581	2.7642	2.2878	3.0099	8.3200	6.8860	6.3239
66	185	1122	656	2.8169	2.2672	3.0500	8.5915	6.9150	6.3865
67	187	1244	614	2.7882	2.2718	3.0948	8.6289	7.0308	6.3342
68	188	1313	655	2.8163	2.2742	3.1183	8.7821	7.0916	6.4048
69	239	1354	729	2.8627	2.3784	3.1316	8.9648	7.4482	6.8086
70	280	1495	810	2.9085	2.4472	3.1746	9.2330	7.7689	7.1177
71	226	1614	951	2.9782	2.3541	3.2079	9.5538	7.5517	7.0110

Table 10

FRANCE

Yr	Y	Z	X	LgX	LgY	LgZ	LgXLgY	LgYLgZ	LgXLgZ
53	198	2330	768	2.8854	2.2967	3.3674	6.6269	7.7339	9.7163
54	211	2490	814	2.9106	2.3243	3.3962	6.7651	7.8938	9.8850
55	235	2440	877	2.9430	2.3711	3.3874	6.9781	8.0319	9.9691
56	276	2680	972	2.9877	2.4409	3.4281	7.2927	8.3676	10.2421
57	302	2508	903	2.9557	2.4800	3.3993	7.3301	8.4303	10.0473
58	314	2420	862	2.9555	2.4969	3.3838	7.3296	8.4490	9.9331
59	253	2365	940	2.9731	2.4031	3.3738	7.1447	8.1076	10.0306
60	306	2419	1035	3.0149	2.4857	3.3836	7.4941	8.4106	10.2012
61	308	2508	1114	3.0469	2.4886	3.3993	7.5825	8.4595	10.3573
62	318	2606	1217	3.0853	2.5024	3.4160	7.7207	8.5482	10.5394
63	326	2788	1332	3.1245	2.5132	3.4453	7.8525	8.6587	10.7648
64	356	2945	1415	3.1617	2.5514	3.4691	8.0668	8.8511	10.9683
65	331	2968	1542	3.1830	2.5198	3.4725	8.0205	8.7500	11.0530
66	347	3019	1637	3.2140	2.5403	3.4799	8.1645	8.8400	11.1844
67	360	3093	1762	3.2460	2.5563	3.4904	8.2977	8.9225	11.3298
68	359	3282	1740	3.2406	2.5551	3.5161	8.2801	8.9840	11.3943
69	444	3514	2009	3.3030	2.6474	3.5485	8.7444	9.3872	11.7118
70	457	0000	2251	3.3524	2.6599	0.0000	8.9170	0.0000	00.0000
71	414	3928	2591	3.4135	2.6170	3.5942	8.9331	9.4060	12.2688

Table 11

GREECE

Yr	Y	Z	X	LgX	LgY	LgZ	LgXLgY	LgXLgZ	LgYLgZ
53	22	300	200	2.3010	1.3424	3.0889	5.6999	2.4771	3.3253
54	23	330	227	2.3560	1.3617	3.2082	5.9336	2.5185	3.4295
55	27	330	259	2.4133	1.4314	3.4544	6.0779	2.5185	3.6050
56	28	360	301	2.4786	1.4472	3.5870	6.3361	2.5563	3.6995
57	33	360	319	2.5039	1.5185	3.8022	6.4007	2.5563	3.8817
58	38	414	326	2.5123	1.5682	3.9412	6.5770	2.6170	4.1040
59	33	437	334	2.5237	1.5185	3.8322	6.6638	2.6405	4.0096
60	49	569	354	2.5490	1.6902	4.3083	7.0227	2.7551	4.6567
61	48	540	398	2.5999	1.6812	4.3710	7.1040	2.7324	4.5937
62	62	584	416	2.6191	1.7924	4.6945	7.2455	2.7664	4.9585
63	78	562	458	2.6609	1.8921	5.0347	7.3167	2.7497	5.2027
64	84	579	507	2.7050	1.9243	5.2052	7.4731	2.7627	5.3163
65	85	784	567	2.7536	1.9294	5.3128	7.9697	2.8943	5.5843
66	95	847	617	2.7903	1.9777	5.5184	8.1697	2.9279	5.7905
67	97	887	650	2.8129	1.9868	5.5887	8.2921	2.9479	5.8569
68	94	1017	684	2.8351	1.9731	5.5939	8.5260	3.0073	5.9337
69	80	1154	797	2.9015	1.9031	5.5218	8.8500	3.0622	5.8277
70	72	1259	882	2.9455	1.8573	5.4707	9.1311	3.1000	5.7576

Table 12
JAPAN

Yr	Y	Z	X	LgX	LgY	LgZ	LgYLgZ	LgXLgZ	LgXLgY
53	77	960	181	2.2577	1.8865	2.9823	5.6261	6.7331	4.2592
54	72	970	189	2.2765	1.8573	2.9868	5.5474	6.7995	4.2281
55	82	980	202	2.3054	1.9138	2.9912	5.7246	6.8959	4.4121
56	111	1080	226	2.3541	2.0453	3.0334	6.2042	7.1409	4.8148
57	139	926	251	2.3997	2.1430	2.9666	6.3575	7.1190	5.1426
58	112	869	258	2.4116	2.0492	2.9390	6.0226	7.0877	4.9419
59	163	968	300	2.4771	2.2122	2.9859	6.6054	7.3964	5.4798
60	209	1164	375	2.5740	2.3201	3.0660	7.1134	7.8919	5.9719
61	274	1298	437	2.6405	2.4378	3.1133	7.5896	8.2207	6.4370
62	24	1388	496	2.6955	2.3838	3.1424	7.4909	8.4703	6.4370
63	258	1532	556	2.7451	2.4116	3.1853	7.6817	8.7440	6.6201
64	324	1660	633	2.8014	2.5105	3.2201	8.0841	9.0208	7.0329
65	294	1783	690	2.8388	2.4683	3.2512	8.0249	9.2295	7.0070
66	355	1945	814	2.9106	2.5502	3.2889	8.3874	9.5727	7.4226
67	508	2253	955	2.9800	2.7059	3.3528	9.0723	9.9913	8.0635
68	494	2515	1130	3.0531	2.6937	3.4005	9.1599	10.3821	8.2241
69	602	2828	1312	3.1179	2.7796	3.4515	9.5938	10.7614	8.6665
70	676	3210	1576	3.1976	2.8299	3.5065	9.9230	11.2124	9.0488
71	551	3267	1936	3.2868	2.7412	3.5141	9.6329	11.5501	9.0097

Table 13

EGYPT

Yr	Y	Z	X[1]	LgX	LgY	LgZ	LgYLgZ	LgXLgZ	LgXLgY
53	8.7	220	112	2.0492	0.9395	2.3424	2.2007	4.8000	1.9252
54	10.	240	112	2.0492	1.0253	2.3802	2.4404	4.8775	2.1010
55	13.	260	115	2.0607	1.1430	2.4150	2.7603	4.9766	2.3554
56	9.9	240	115	2.0607	0.9956	2.3802	2.3697	4.9049	2.0516
57	9.1	248	129	2.1106	0.9590	2.3945	2.2963	5.0538	2.0241
59	8.6	240	146	2.1644	0.9345	2.3802	2.2243	5.1517	2.0226
60	30	281	152	2.1818	1.4771	2.4487	3.6170	5.3426	3.2227
61	14	297	152	2.1818	1.461	2.4728	2.8341	5.3952	2.5005
62	13	284	131	2.1173	1.1139	2.4533	2.7327	5.1944	2.3585
63	16	303	143	2.1553	1.2041	2.4814	2.9879	5.3482	2.5952
64	24	321	159	2.2014	1.3802	2.5065	3.4595	5.5178	3.0384
65	26	301	166	2.2201	1.4150	2.4786	3.5072	5.5027	3.1414
66	27	316	166	2.2201	1.4314	2.4997	3.5781	5.5496	3.1779
67	25	265	163	2.2122	1.3979	2.4232	3.3874	5.3606	3.0926
68	21	298	170	2.2304	1.3222	2.4742	3.2714	5.5185	2.9490
69	22	221	182	2.2601	1.3424	2.3444	3.1471	5.2986	3.0340
70	28	268	186	2.2695	1.4472	2.4281	3.5139	5.5106	3.2844

[1] Income per capita from Gross Domestic Product

Table 14

WEST GERMANY

Yr	Y	Z	X	LgX	LgY	LgZ	LgYLgZ	LgXLgZ	LgXLgY
53	285	2940	527	2.7218	2.4548	3.4683	8.5140	9.4400	6.6815
54	319	3030	563	2.7505	2.5038	3.4814	8.7167	9.5756	6.8867
55	410	3350	640	2.8062	2.6128	3.5250	9.2101	9.8919	7.3320
56	417	3600	694	2.8414	2.6201	3.5563	9.317	10.1049	7.4446
57	393	3631	767	2.8848	2.5944	3.5600	9.2361	10.2699	7.4843
58	377	3438	815	2.9112	2.5763	3.5363	9.1106	10.2949	7.5000
59	444	3374	870	2.9395	2.6474	3.5281	9.3403	10.3708	7.7821
60	527	3651	1119	3.0488	2.7218	3.5624	9.6961	10.8610	8.2983
61	490	3626	1168	3.0674	2.6902	3.5594	9.5755	10.9181	8.2520
62	488	3889	1242	3.0941	2.6884	3.5898	9.6508	11.1072	8.3182
63	473	4121	1311	3.1176	2.6749	3.6150	9.6698	11.2701	8.3393
64	579	4230	1417	3.1514	2.7627	3.6263	10.0184	11.4279	8.7064
65	540	4234	1504	3.1772	2.7324	3.6268	9.9099	11.5231	8.6814
66	504	4256	1580	3.1987	2.7024	3.6290	9.8070	11.6081	8.6442
67	468	4171	1572	3.1965	2.6702	3.6202	9.6667	11.5720	8.5353
68	579	4484	1732	3.2385	2.7627	3.6517	10.0886	11.8260	8.9470
69	659	4850	2044	3.3105	2.8189	3.6857	10.3896	12.2015	9.3320
70	658	5112	2337	3.3687	2.8182	3.7086	10.4516	12.4932	9.4937
71	580	5223	2716	3.4340	2.7634	3.7179	10.2740	12.7673	9.4895

Table 15

FINLAND

Yr	Y	Z	X	LgX	LgY	LgZ	LgXLgY	LgXLgZ	LgYLgZ
53	92	1440	681	2.8331	1.9638	3.1584	5.5637	8.9481	6.2025
54	159	1580	757	2.8791	2.2014	3.1987	6.3381	9.2093	7.0415
55	166	1850	846	2.9274	2.2201	3.2672	6.4991	9.5643	7.2534
56	172	1890	914	2.9609	2.2355	3.2765	6.6191	9.7013	7.3245
57	213	1463	684	2.8351	2.3284	3.1652	6.6012	8.9738	7.3700
58	136	1366	726	2.8609	2.1335	3.1355	6.1037	8.9704	6.6896
59	188	1404	792	2.8987	2.2742	3.1474	6.5922	9.1234	7.1578
60	229	1650	877	2.9430	2.3598	3.2175	6.9449	9.4691	7.5927
61	244	1743	963	2.9836	2.3874	3.2413	7.1230	9.6707	7.7383
62	232	1959	1020	3.0086	2.3655	3.2920	7.1168	9.9043	7.7872
63	223	2072	1129	3.0527	2.3483	3.3164	7.1687	10.1240	7.7886
64	225	2396	1281	3.1075	2.3522	3.3795	8.3095	10.5018	7.9493
65	262	2719	1394	3.1443	2.4183	3.4344	7.6039	10.7988	8.3054
66	264	2838	1458	3.1717	2.4216	3.4530	7.6806	10.9519	8.3618
67	276	3013	1209	3.0824	2.4409	3.4790	7.5238	10.7237	8.4919
68	286	3339	1341	3.1274	2.4564	3.5236	7.6821	11.0197	8.6554
69	341	3765	1538	3.1870	2.5328	3.5758	8.0720	11.3961	9.0568
70	401	0000	1725	3.2368	2.6031	0.0000	8.4257	00.0000	0.0000