University of Bradford eThesis

TRANSFER OF TECHNOLOGY
TO DEVELOPING COUNTRIES

"A methodology to quantify and predict temporal rates of technology transfer from advanced to developing countries"

A thesis submitted to the University of Bradford
in fulfilment of the requirements for the degree of
Doctor of Philosophy

by

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1983

DEDICATIONS

I dedicate this thesis to my dear parents,
Hafsa and Kaddour,

To Djamal and to my little angel, Wafia.

ACKNOWLEDGEMENTS

The author wishes to express gratitude to Dr. A.Z. Keller for providing the opportunity for this research work and offering his help and guidance throughout the course of this study.

Thanks are due to the Ministry of Hydraulics in Algeria for providing financial support during this research.

Thanks are extended to Andrew Coulson and James Betts, respectively lecturers at the Project Planning Centre and at the Department of Industrial Technology and Management of the University of Bradford, for discussions regarding some points of the research.

Sheila Alcock, the librarian of the Project Planning Centre should also be thanked for her constant help in providing much needed references.

I would also like to take this opportunity to thank all my friends and colleagues for their friendly surrounding as well as Djamal for being a fair husband in sharing the housework and looking after our daughter Wafia.

Finally, but not least, I would like to thank Mrs. Elizabeth Keller for her splendid typing of this thesis.

ABSTRACT

The transfer of technology to developing countries constitutes one of the major debates in the literature on development economics. The present empirical investigation is intended to contribute to the large existing literature on technological transfer. Its major contribution lies in demonstrating rigorously that the integration of foreign technologies is greatly affected by the socio-economic conditions of the recipient countries.

The present study attempts to identify the main socio-economic characteristics involved in assimilating transferred technlogy. It first provides a quantifiable measure of the rate of technological absorption. Then, in presenting the selection of indicators, the general procedures followed in choosing the sample of countries are summarized and the principles guiding the choice of variables are examined. The model is based on multiple regression analysis, which is discussed in some detail. Another statistical method is used to explore the interdependence of the economic and social indicators, which provides more exact knowledge about their various interactions and lays the groundwork for the problem at hand.

Three main indicators are identified that explain a significant sixty one percent of the total variance of the dependent variable. These main indicators are the rate of education, trade policies and the availability of certain consumer products. It is found that these variables express different and important dimensions of the third world economy. In general, the results reveal that the rate of technology integration varies greatly with the level of socio economic development. The findings of the investigation are analysed using new and efficient methods of diagnostic techniques, and are also seen within their theoretical perspectives.

The analysis of results is concluded with a discussion of intangible factors that cannot as yet be quantified; factors such as political and managerial quality and yet can be expected to have significant effects on the rate of technological integration.

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INTRODUCTION

CHAPTER 1

1. INTRODUCTION.

The major part of technology transferred to developing countries arises from the historical dominance of research and development in the developed countries.

In this chapter, some general background relations to the problem of technological transfer is initially introduced; in the next section the scope of the proposed study and its objectives are described; finally in the last section the limitations of the present research are discussed.

2 GENERAL BACKGROUND TO THE STUDY OF TECHNOLOGICAL TRANSFER.

The crucial importance of international transfers of technology, as a means to improve the efficiency of investment and the general effectiveness of the productive process, is constantly stressed. The transfer of technology is a complex phenomenon, involving a wide variety of forms. The classical, and perhaps the most dominant form, is the transfer by multinational enterprises, in either partly or wholly owned subsidiaries; the other form is simply the export and import of capital goods embodying technological knowledge.

Although these forms of technology transfer are widely used among the developed market economies as well, they may not be fully efficient ways of transmitting the use of modern technologies between economies at different levels of development. Some would take the view that they may increase the dependence of the less developed countries and hence widen the gaps in development between exporters and importers of technology.

Moreover, the operations of the multinational enterprises under the packaged nature of the investment which have to be viewed as promoters of development, by what is often called a "business school approach", Quinn (1969), are not widely shared, instead, many agree that the multinational enterprises are continuing their historic dominance with a new economic dependency.

Some of the risks that can arise from the dependence on technology may place the purchasing firm in a position of unjustified disadvantage with regard to the exporter requesting higher indefined prices. It is often suggested that there are no official regulations for royalty agreements, nor any systematic policy of technology imports, and that often, firms may be remitting profits as well as royalties when they should be paying only one of the above.

The imperfect character of the international market may result from the very nature of intellectual property; Streeten (1972, p381) defines the know-how in relation to the market, he states:

> "Technical knowledge cannot be marketed like other products or factors because it possesses the following peculiar features: indivisibility, inappropriability, embodiement in other factors, uncertainty, and impossibility to know its full value until bought."

In other words, as technological know-how is embodied to machinery and equipment as well as technical skills, the buyer cannot have more or less of it. The characteristics of technical knowledge may, therefore, explain why the sale of licenses and patents often restrict the recipients' use of the imported technologies.

There are other risks that may result from an imperfect market. In particular, it has been said, Delorme (1982, p95), that the existing terms of world trade with today's financing terms and interest rates, will not enable the developing economies to reach the rate of growth set by the Lima target (New International Economic Order), which will produce twenty five percent of the total world industrial output by the year 2000, as compared with the seven or eight percent contribution at the moment. Furthermore, the existing investment agreements together with the emphasis made on the importance of adequate supplies of foreign exchange, see Wall (1968), may frustrate the governments of many developing countries, which tend to focus on this one factor and makes it easy for the leaders of these countries to attribute the blame for insufficient growth rates to the policies of the developed countries. Wall criticizes the over-emphasis given by Unctad in ascribing the role of "engine of growth" to the imports of machinery. One may also include Johnson's (1967, p65) warnings towards an economy concentrating mainly on the trade as aspects of development, he says:

> "In the first place, the temptation is particularly strong for the less developed countries to attach

too much importance to the trade and other policies of the developed countries as determining factors in the development of the less developed countries. Fundamentally, the process of initiating self-sustaining economic growth is a process of effecting internal social and economic changes. The external trading environment may be influential in determining the relative difficulty of the process, but it is not crucial ... Secondly, emphasis on the denial of trade opportunities tends to divert attention from the equally important question of ability to take advantage of trade opportunities and to generate the mistaken belief that trade policy changes by developed countries offer a magic new route to painless development. The main obstacle to development through trade is very likely to be the condition of underdevelopment itself, which inherently imposes countless impediments to the establishment of profitable trade. Thirdly, concentration on the trade policies of the developed countries obscures the fact that in many ways the policies of the less developed countries themselves impede, either deliberately or incidentally, the exploitation of existing opportunities to trade, and would impede the exploitation of new trade opportunities that might be opened up by policy changes in the developed countries."

Although it may be true that the terms of trade of the developed countries have created some problems in acquiring technical knowledge, it should be recognised that these countries are scientifically and technologically dependent, which may affect their low bargaining power in dealing in international world market, but nevertheless, it remains up to them to make the most appropriate choice of the supply of the technology as well as the technology itself in order to use it productively; as Brahimi (1976) succintly puts it:

> "Technological capital is not something that can be passively received by the people of the third world, it has to be acquired."

The successful absorption of foreign technologies does not depend only on the transfer of technical knowledge and methods; often it is the inability to introduce new and foreign development in administrative, financial and social fields that subject a host society to serious pressures.

Much of the discussion on the transfer of technology to developing countries is linked with the choice of techniques. This question arises from the unsuccessful repercussions of the nature of the technology transferred.

This new thinking is mainly concerned with the creation of a new technology, that could be more appropriate to the needs of developing countries; this type of technology is often referred to as "intermediate" or "appropriate".

A great deal of thought has recently been given with regard to investigations of appropriate technology. This is a result of the pioneering work of Shumacher's premise that "small is beautiful", Shumacher seriously questions the use of technology as it exists today in the developed as well as in the developing world. He draws the conclusion that technology is already misused in the initiating technology countries, and that some attention should be drawn to the need to change the aspects of science and technology to a more profitable use for the community as a whole. He goes on to argue that the present technology is not appropriate for the developing areas as it will create the same "diseases" there from which the developed areas are suffering; i.e. pollution, concentration of industries, unemployment, etc. However, it is often argued, on the other hand, that these technologies, Shumacher advocated, often labour intensive, do not promote productivity and as a result, the developing countries should transfer and try to adapt the industrial world's technology.

When dealing with the problem of technological transfer, one is treating one of the basic problems of development, therefore, it is important to examine certain problems related to economic development in order to establish the framework within which the transfer of technology operates. According to Myint (1967), the recent interest in development economics has its roots on the one hand in a number of policies regarding the help of the developing countries and on the other, in the need for an economic understanding of the problem of underdevelopment, a wide development theory is:

> "a discernible rise in total and in per capita income, widely diffused throughout occupational and income groups, continuing for at least two generations and becoming cumulative."

According to this definition, an underdeveloped country is one in which this process has not taken place and where per capita income can be explained by the shortage of capital which necessarily implies a low productivity of the labour force, and by other limitations due to lack of technical and managerial skills, lack of education as well as some problems related to health and nutrition. Sunkel (1969) approaches the problem in a different way; he explains underdevelopment as a state where the capital goods sector does not exist, he goes on to argue that the imports of capital goods necessary to produce consumer goods have been substituted for the imports of consumer goods themselves. As a result, the economics of the poor countries have become unstable and dependent.

The capital goods sector should be encouraged as the imports of machinery directly serve as a training ground for human resources, and taking this viewpoint, it constitutes an important vehicle for technological trade. The transition from machine-operation skills to machine-building capability can be effectively bridged within a reasonable period, provided suitable technological assistance and efficient training is provided in the early stages as Singh (1975) argues.

There are a number of developing countries competing in international markets for machinery products within a few years of starting manufactures, examples are India, Brazil, Mexico and Taiwan.

The problem of underdevelopment is of an extremely delicate nature, and the main factors likely to contribute to its understanding on the one hand and to its abolition on the other are science and technology. It is commonly agreed that science and technology provide the means to banish poverty. When the 1963 U.N.

conference on science and technology for the benefit of developing countries was held in Geneva, Kaplan (1979), it was believed that a massive transfer of science and technology from the developed countries would rapidly solve the problems of poverty, illiteracy and in general terms the problem of underdevelopment. However, this view has not proved successful; this can be explained by the fact that the less developed countries have no significant scientific and technological infrastructure of their own, which makes difficult the assimilation of the technologies, and by the difficulties involved in the transfer of science as such. Streeten (1972), in particular, attributes most of the problems of development to science and technology, and to the obstacles for their use in the social structure of developing economies. The lack of experimental and scientific outlook explains partly why no use of the existing and available science and technology is made. He argues that there are three major effects caused by the extensive and concentrated development of science and technology in the developed areas, as they carry ninety eight percent of world research and development, against a mere two percent in the developing areas. Moreover, of these ninety eight percent, fourty five percent is spent on defence and space and another seven percent on atomic energy. This has the following results:

i) It leads to a misorientation of efforts in the developing countries, because they have to follow what goes on in the research laboratories of rich countries, which may be irrelevant to their specific problems.

ii) It leads to a brain-drain towards these research centres, the scarce professional manpower, educated at the expense of the developing economies, contributes to increasing the science and technology of the rich countries. This is mainly because these economies fail to employ this manpower on the one hand, and they are attracted by high salaries and other conditions by developed economies on another.

iii) The technologies produced are developed such that the least labour, and the more capital are used (this may even explain why developed societies are encountering increased unemployment problems), also the products are often aimed at high-income consumers.

Turning to policies, some questions that may occur to economists are to ask why has the market system not provided incentives for the development of science and technology in developing countries, and why do the industrial countries that have a comparative advantage in manufacture and industry, tend to protect heavily their technologies, by trying to gain the maximum out of developing economies and not diffusing the know-how.

It is unfortunate that these points, obviously greatly affecting the assimilation of technology, can only be answered by going beyond economic boundaries. It is however clear that the developing economies serve as a market for the technology as well as the manufactured products of the rich countries, it also serves to expand and develop the economies of the developed world through the operations of the multinationals, and serves as low cost sources of raw material for the developed world. If the developing countries have to become scientifically and technologically independent, the developed world will as a result suffer the consequences as it would no longer retain its present privileges. Hence, one may understand why an existing and continuing developing world may be encouraged and kept as it is by the dominant world. Sometimes, political pressures may be created and encouraged in order to maintain these nations under control.

The literature on the technological transfer is mainly theoretical, and economic theory seems to lag behind the present problems of developing countries. The only model on technology transfer known to the author is that of Bruton (1977). It consists of relating employment growth to a variety of factors, such as productivity growth and substitutability among inputs. This model is based on the Cobb-Douglas production function and is aimed at explaining employment growth through the rate of substitution of labour and capital. A manipulation of the production function is effected such that a rate of output growth is obtained, which placed emphasis on learning and adapting as part of the routine operation of the firm. The learning process is expected to lead to more adaptable production methods; time is given great importance in the adaptation of technologies in Burton's model. Hence he attributes the success of technology transfer to what takes place over time rather than on choosing the appropriate technique from a "shelf" containing several technologies.

This model seems to offer a great deal of information about how a successful technological transfer may be modelled; however, no sign of further research or reference was made in the study of technological transfer. One may attribute the lack of modelling to the nature of economists and policymakers, who are mainly concerned with theoretical implications of technology transfers. Or, one may relate the lack of mathematical modelling in this domain to the unwillingness of economists to make use of statistical analysis. This process could not only explore the existing situation and possibly identify causes, but would also enable one to make predictions regarding specific phenomena and would assist the decision making and the planners to achieve their desired goals.

There is, therefore, an urgent need to explore the factors that significantly affect the integration of the transferred technology; as was mentioned above, this will not only inform one as regards the present situation, but also it would enable one to predict the rate of technological integration in one or more countries.

3. SCOPE AND OBJECTIVES OF THE PRESENT STUDY.

Although a large amount of empirical research has been devoted to the problems of development in general, there are no specific empirical investigations with regard to the technological transfer, which is at the core of the development problem.

The present research is aimed at identifying those factors that significantly affect the rate of technological integration. For this, appropriate statistical methods are used to study a set of specified data. The characteristics selected for study are based on a priori reasoning and the relevant social science literature.

There are mainly two considerations that suggest the desirability of using quantitative techniques as tools for exploring the structure of the underlying phenomena involved in any problem of development, and in particular, the problem of technological transfer. First, the amount of even approximately validated knowledge as regards the rules governing this phenomenon is small, secondly, there are a number of controversial attitudes towards this problem, which may make it difficult to establish a defined hypothesis. Empirical research may then increase one's understanding of certain phenomena.

For this study, the measure of technology integration is defined as the ratio of the growth of gross industrial product in numerator to imported technology (given a percentage of gross industrial product). This ratio is then regressed on a number of economic and social variables, of which only those that are found to affect significantly the rate of technology integration are retained in the econometric model.

One may attribute the success or failure of technology transfer to a number of factors without knowing their relevance in practical terms, also as a theoretical model is lacking in specifying more or less exactly the amount of influence, one cannot be certain of their theoretical formulations.

Hence an attempt to model such a phenomenon may be very useful and may complement the existing literature, in providing more empirical evidence. As will be shown later, some indicators chosen to explain the rate of technology integration are frequently discussed in the literature. On the other hand, other indicators which have received less emphasis could be worthy of further study.

The main reason that made the author approach the problem in the above manner was an awareness that the effectiveness of technology transfer is highly influenced by the social and economic conditions of the recipient countries. It is therefore intended to explore these conditions and to gain a quantitative insight as well as more empirical knowledge, by making use of statistical data.

In this study, particular attention is drawn to social indicators; this is because of the increasing importance given to the study in this area by leading development economists such as Streeten and Seers.

It was preferred to use every aspect of the socio-economic characteristics of developing countries in this analysis in order to have a large variety of elements of which only the important aspects may be later pin pointed. As a result, as many variables as possible are used.

Thirty social and economic variables are included in the analysis; the most recent data for these are published by the World Bank (1980a); some problems were encountered in finding more appropriate data and in finding computer readable tapes, which, if available, would have facilitated the research significantly.

Fourty five countries are analysed in a cross section study; the intention was to include as many countries as possible in order to have an adequate representation of populations, so that appropriate generalisations could be made. All countries found in the published source of data are included, except certain categories which do not conform to the set hypothesis.

The principal method used is statistical correlation analysis, which can provide scattergrams of the relationships involved; it can also eliminate items that are not significantly related. Factor analysis is used to study the dimensions or the factors determined by the whole set of indicators; these two statistical methods are used as preparatory and complementary tools to the main method used for the study i.e. multiple regression analysis.

This thesis is divided into six chapters; the present chapter is intended to introduce the problem of technology transfer, to discuss work already done on this subject and to introduce the present study with its objectives and limitations.

The second chapter is concerned with the review of technological transfer involving many issues, such as the channels, forms and cost of transfer; the choice of techniques, the role of the multinationals as well as some empirical examples of the changing trends in the forms of transfer.

A discussion on the measure of technology integration and its relation to the socio-economic variables is presented in relation with the economic literature in the third chapter; also the significance of the use of social and economic indicators is discussed, referring to studies using these variables and their relationships, correlation analysis used to identify the relationships between economic and social variables. In part two of this chapter, the method of multiple regression analysis is presented and discussed in relation with the data to be later analysed.

Chapter four lays the ground for the final analysis of results. It consists of a presentation of the method of factor analysis as a means to identify these variables that may explain the same dimension, and of using this method on the data in order to find the dimensions explained by the data. This consists of gaining more knowledge regarding the relationships of the indicators, and of their importance, it is particularly used besides regression analysis, as Adelman and Morris (1971) stress, as it enables one to retain variables that do not explain the same dimension in the final multiple regression model. The results of these factors are discussed in relation to the existing literature concerning these aspects.

The fifth chapter discusses the methods used for the selection of variables as well as the diagnostics used for the retention of the most statistically reliable indicators. These indicators are further analysed and other qualitative factors which could not be included in the study are discussed.

Finally, the sixth chapter concludes the study and proposes specific research.

The present study has several objectives:

i) To provide an empirical understanding of technological transfer, based on a wide range of recent data.

ii) Secondly to identify the main socio-economic characteristics involved in assimilating transferred technology.

iii) Thirdly, to provide results simple to use for any researcher interested to know the rate of technology integration of a specific or of a number of countries, this consists of using the values of the present parameters with the required data on either countries included or not included in the analysis. The parameters of the present variables may be used for other periods as well.

iv) Fourthly, if the results are considered reliable, economists, policy makers as well as governments could use the present findings to determine the present rate of integration and to predict future rates and use them for more efficient economic and social planning.

v) Fifthly, it can draw attention to those particular socio-economic areas which are found to affect the assimilation of technology.

4. LIMITATIONS OF THE PRESENT ANALYSIS.

As in any research, the present study has some limitations, these are mainly due to the availability of data.

i) The main limitations to this study are the incapacity to include very important variables directly related to technological productivity, such as management and productivity factors as well as political implications and policies. It is realized, however, that the entire question of collection of data suffers from finding a way to quantify the above aspects. Also, it is commonly agreed that some phenomena may not be possible to quantify. These aspects are given theoretical considerations in the analysis of results; these are particularly seen as complementary factors to the ones found in the equation.

ii) Secondly, the data used is entirely dependent on the published sources, therefore, the reliability of the results depends on the accuracy of the data collected.

iii) Thirdly, as the analysis is over a period of eight years (1970 -1977) in order to eliminate casual perturbations and to have a more accurate picture of the integration (also, this period is very characteristic of the beginning of technological transfer for many countries) and as data was not often available for many years and many variables (especially since the data for the years 1970 and 1977 was averaged in order to give the value for the whole period of eight years), there is a degree of bias present, again due to data availability.

CHAPTER TWO

TECHNOLOGICAL TRANSFER:

SOME MAJOR ISSUES.

CHAPTER 2

TECHNOLOGY TRANSFER: SOME MAJOR ISSUES.

Technology is a vital part of the development process, an essential input into economic activity. As is well known the historical dominance of scientific and technological research have emerged in the economically developed nations, and a significant proportion of these technologies are transferred to the developing countries. The transfer of technology raises many issues; those of the cost of technology and its appropriateness as well as those concerned with economic independence and technological learning. It is intended in this chapter to discuss these issues.

This chapter is divided into six principal sections. The succeeding section introduces the general features of technology transfer. The next section gives a brief historic review of technological transfer. The third deals with definitions, mechanisms, as well as other aspects of transfer; the fourth section offers some views on technology transfer policy in relation to the multinational corporations, which constitute the main form of transfer. Then a discussion on the choice of techniques follows where technology is analysed within the appropriate and inappropriate perspectives and finally, some conclusions are drawn.

1 INTRODUCTION.

Most developing countries industrialize in order to acquire economic independence and wealth; as the necessary machinery and equipment required is not available and cannot be produced by these economies, they have a main objective to maximize the quantity of technology transferred and a number of incentives are generally introduced to encourage the inflow of technology from the developed countries. The unrestricted inflow of technology in the past has led to many undesirable consequences; it has often resulted in high and rising costs and inhibited the development of local technological capacity which in turn engendered further technological dependence and increased the heavy burden of unemployment. A result of using capital intensive techniques is the limitation of the learning effect of technology transfer. The above factors have led to a need to regulate the rate of inflow of technology and the requirement to adopt a much greater interventionist strategy at both national and international levels. The new objectives regarding technology transfer in many ways conflict with the initial objectives of maximizing the inflow of technology; they also suggest a more restrictive and selective policy towards technology transfer from developed countries.

An analytical analysis of technological transfer necessitates the investigation of questions such as:

i) What is being transferred : is it machinery, technical assistance, licenses, educational resources, research and development facilities, etc ...?

ii) Is the technology transferred to affiliates or to independent agents ?

iii) What is the cost of the transfer ?

iv) How well is the technology being absorbed and used ?

The subsequent sections of this chapter will discuss these aspects as well as other relevant aspects such as the role of the multinationals and technological choice.

2 THE INTERNATIONAL TRANSFER OF TECHNOLOGY: A HISTORICAL PERSPECTIVE.

In the world's long history of industrialization, the transfer of technology has played a predominant role in the establishment of new industry in many countries. Hence the transfer of technology is not a recent phenomenon but has been going on throughout all history. About four hundred years ago, Francis Bacon observed that three great mechanical inventions, printing, gunpowder and the compass, have changed the whole course of life, particularly literature, warfare and navigation, see Dunning (1982); however, none of these great inventions had originated in Europe, rather, they represented a successful technology transfer from earlier civilizations. The beginning of the industrial revolution took place in England and the resulting technologies provided the basis for industrial development. First in Western Europe, then in the United States and then in a number of other countries which had favourable conditions, such as Canada, Australia, Japan and the Soviet Union. These examples proved that the technological transfer required high levels of skills and technical competence in the recipient country and that a successful transfer of technology is not merely transporting machines from one location to another. International transfer of technology between industrialized countries is continuously increasing as a result of better transportation and communication between countries.

During the 1960's, when most of the developing countries obtained their political independence, there was a growing awareness of the importance of international co-operation, based on the transfer of technology. However, the conditions and environments of the recipient countries were not as yet favorable for successful technological assimilation and the international environment did not appear to be a promoter of technological integration; indeed as was shown earlier, the strengthening and rising technology transfer between industrialized countries, which led to a broad exchange of knowledge and to a rapid technological progress, has most certainly contributed to the continuous widening gap between industrialized and developing countries.

3 THE TECHNOLOGICAL TRANSFER.

It is intended in this section to define the term technology and the transfer of technology as well as discuss the general trends of technological transfer to developing countries.

3.1 Some Definitions.

The term technology has been variously defined; one of the simplest definitions is attributable to Root (1968) and is "The body of knowledge that is applicable to the production of goods and the creation of new goods." It is often seen not only as a factor contributing to greater production but also as an asset which improves the quality of a product, reduces its cost and constantly leads to the creation of new, and often sophisticated products. A definition of technology seen as a commercial element, basically embodied in machines, documents and human beings is provided by UNCTAD (1972), "Technology is an essential input to production, and as such it is bought and sold in the world market as a 'commodity' embodied in one of the following forms:

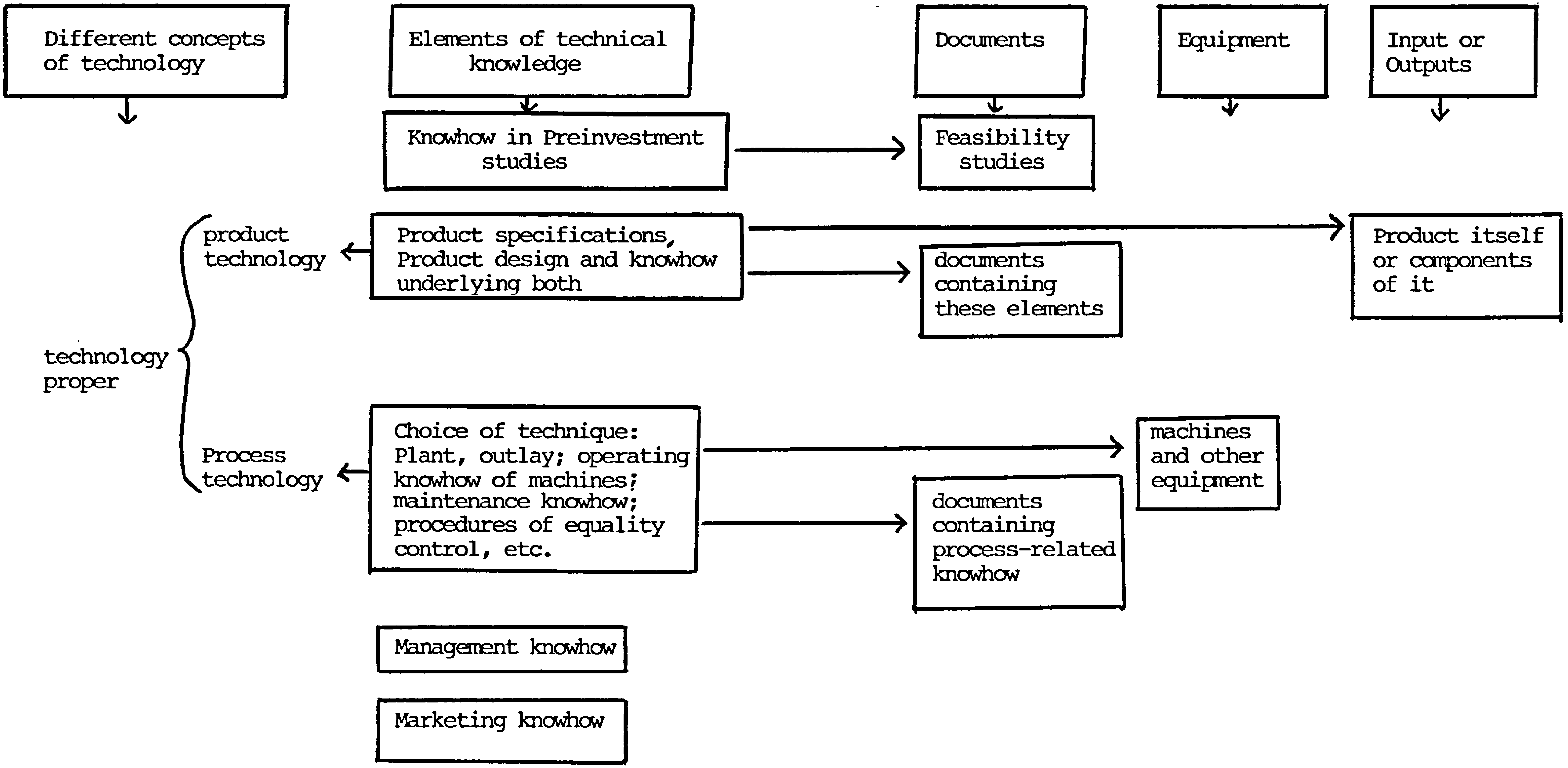
i) in capital goods and sometimes intermediary goods which are bought and sold in markets, particularly in connection with investment decisions;

ii) in human labour, usually qualified and sometimes highly qualified and specialized manpower, with capacity to make correct use of the equipment and techniques and to master the problem solving and information producing apparati;

iii) in information, whether of a technical or of a commercial nature, which is provided in markets, or kept secret as part of monopolistic practices."

Another way to look at technology is to distinguish between product technology from process technology, OCDE (1982,p11) and Siggel (1983, p86). The former consists of the specifications and characteristics of the product, and the latter comprises all the know how necessary to produce a product. Fig.1.1 may usefully

Fig. 1-1 ELEMENTS OF TECHNOLOGY



Source: Siggel. E. (1983, p111).

be used to clarify these definitions.

It is also useful to differentiate between proprietary technology and non-proprietary technology, as first distinguished by Quinn (1968). The former category comprises technologies owned by the technology supplying firm, most often transferred through private foreign investment; usually the ownership is guaranteed by patents in the case of process technologies and by registered brands in the case of product technologies. Non-proprietary technologies are generally bought in a freely available market, and do not involve any proprietary right to the seller; in transfer agreements for non-proprietary technologies, the product and process technology play a minor role compared to management and training, which in this case constitute the main elements.

Technology should, therefore, not be viewed simply as a basic factor of production, when examining technological transfer, but mainly as a commercialised asset bought and sold in a technology market which is imperfect due to the features of technological know-how, on one hand and to the nature of the buyer and seller on another. UN (1974, p47) and Balogh and Graham (1979, p184).

The transfer of technology is broadly distinguished in two types, which Brooks (1966) calls vertical and horizontal. Vertical transfer is a process by which scientific knowledge becomes part of a technological system, by making a technology out of unrelated and different techniques, and horizontal transfer is the adaptation of a technique from one use to another, or from one country to another. The transfer of technology to developing countries is mainly related to the second type of transfer, it could be defined as any group of measures used to set up and extend production facilities by importing machinery and elements of technical knowledge from abroad. Thus the definition by Cooper and Sercovitch (1970,p3):

> "The transfer of technology from advanced to underdeveloped countries may be taken to cover the transfer of those elements of technical knowledge which are normally required in setting up and in operating new production facilities- and which are characteristically in very short supply (and often totally absent) in the developing countries."

This definition opens the way to many questions as to whether such a transplantation does occur in reality, whether knowledge is transferable or whether it is tied to a particular locality. Some authors, particularly those representing the dependency school of thought, Dos Santos (1966) and Amin (1973) argued that technology transfers necessarily lead to ever-increasing economic and technological dependence. Siggel (1983) notes, however, that these statements of dependence depend on the nature and completeness of technology transfers. If that transfer is merely viewed as transplanting modern technologies into developing countries without generating learning effect, then it could be said that it obviously leads to economic dependence, whereas if technology transfer focus on acquiring technological capacity through learning, it can contribute successfully to economic development, hence reducing the technological and economic dependence.

There are mainly three conditions necessary for the international transfer of technology, either between developed countries, or between the latter and developing countries. Stewart (1979, Chapter 1):

i) first, decision makers in one country wish to use a particular technology;

ii) second, that this technology is not available locally. (The developed countries account for 97 percent of world research and development expenditure and the less developed countries import over 90 percent of plant and machinery from developed countries).

iii) thirdly, it is believed that the needed technology is cheaper to transfer than to produce locally.

Nau (1970) attempted to classify the objectives of the United States motives in transfering technology to developed as well as developing countries. The classification of Nau is reproduced in Table 1.1.

Table 1-1 Motivations of United States to Transfer Technology

Motivation	Definition
Military - Strategic	Use or value of technology transfer for the development, manufacture or deployment of military capabilities, i.e. weaponry and forces. a. directly enhance military capabilities. b. improve civilian capabilities and release resources to military outlays.
Foreign Policy - Diplomatic	Use or value of technology transfer for influencing intentions (as compared with capabilities) in the international arena.
Economic - Commercial	Use or value of technology transfer for profit or commercial gain.
Social - environmental	Use or value of technology transfer for improving the "quality of life", i.e. consequences for equity and ecology (as compared with commercial gain).
Administrative - institutional	Use or value of technology transfer to advamce organizational or bureaucratic interests within US domestic system

Source: Dunning (1982 p15)

3.2. Forms, mechanisms and channels of transfer.

The various elements of technology required for setting up production facilities and technical assistance are transferred in forms involving a wide variety of contractual arrangements which take broadly two organizational forms, the most predominant form, which can be divided into two, is a direct foreign investment by a multinational firm in a wholly owned subsidiary or a joint venture with majority or minority participation by the foreign firm, the second form is basically a transfer agreement between independent enterprises, either private, semi-public or public. Table 1-2 shows the pattern of contractual forms of transfer for some countries.

Table 1.2. Ownership of the Contracting Enterprises in the Technology Receiving Country, end 1970.

Country	percent of Contracts in Enterprises with		
	Foreign direct investment		wholly nationally owned
	Majority foreign ownership	Minority foreign ownership	
Cyprus	48	44	8
Colombia	45	12	43
Brazil	36	#	64 #
Sri lanka	29	42	29
Peru	28	19	55
Rep. Korea	13	#	87 #
Pakistan	12	8	79*
India	3	12	85

Source: UNCTAD (1975_a, table 3).

minority Foreign ownership treated as wholly national

* Specified as "100% Government controlled."

Many projects may involve a combination of two or more of these methods, the majority owned direct investment may be subject to a contractual plan or be of indefinite duration. Each of these methods has its advantages and disadvantages to the importing country. The major considerations of the host nations are the objectives of sharing the gains and of asserting control; the suppliers of technology, on the other hand, have their own judgement on the costs and benefits in entering into these contractual arrangements. United Nations (1974, p23). They protect their interests by registered brands, agreement with government for monopoly positions and by various forms of contracts. Siggel (1983,p90). In fact it is often true that direct foreign investment remains a substantial source of capital and is sometimes the only source of specific technologies. The United States as well as other major capital exporting countries prefer, for economic as well as ideological reasons, to transfer their capital outflows through private investment, and it is most probable, as Root and Ahmed (1979) put it, that developing countries will continue to rely on foreign direct investment to carry out their development programs. There are, however, certain conditions in developing countries that could either be attractive or unattractive to foreign direct investment; the above study found that substantial urbanization, a relatively advanced infrastructure, a comparatively higher growth of per capita G.D.P. and political stability were major factors in attracting foreign investment. Thus foreign direct investment, despite the disadvantages it involves for the developing areas, as will be seen in part four of this chapter, continues to be geared towards the wealthier nations of developing countries.

For the second form of transfer which is a transfer agreement between enterprises, and which do not involve proprietary rights to the transferor, the decision of transfer may be left to a local private enterprise, although governments are increasingly intervening in such decisions, either in local or public firms. This point joins the new objectives noted earlier, which involve more interventionist government actions.

Technology is transferred through mechanisms ranging from the completely packaged in the form of direct investment overseas in a wholly-owned subsidiary, through joint ventures, turn-key arrangements and license contracts between independent parties. Usually, as Stewart (1979, p12) argues, these mechanisms called indirect tend to be adopted when the country lacks the capacity to undertake direct purchase, or when for marketing or other reasons the recipient wishes to acquire trade-marks. Technology may also be transferred through direct forms such as training, books, etc.

1- Indirect forms of transfer

a) Foreign Direct Investment.

Foreign direct investment takes place in a packaged form, that is in a combination of funds, management and marketing skills, technological knowhow, etc.. There is however, a growing concern of host countries to increase joint venture types of transfer. It seems, according to Stopford and Wells (1972) that certain multinationally oriented firms are favouring such joint venture arrangements. This is due to their lack of financial resources and to the tendency to increase their vertically integrated organization so as to ensure the supply of a product over which they have quasi-monopolistic control. Other factors are most probably linked with the changing balance of world economic relations and with a tendency towards greater autonomy on the part of certain developing countries, also as Vaitsos (1974) put it, the increasing shift from fully-owned subsidiaries by multinational companies towards joint venture arrangement may be due to the enhanced knowledge and increasing concern of government authorities in developing countries over the nature of multinational enterprises activities.

b) Joint Ventures.

Joint ventures can be a majority or minority participation of the multinational firm, or it could be equally distributed between foreign and local interests. Joint ventures may behave like subsidiaries when they have a major participation, they thus exercise full control of the company, however, most often they are used to acquire the technology while retaining national control over a firm or an industry. Because they participate in the holdings, the multinational enterprises will be interested in the efficient and profitable operations of these firms, as they will share the profits. This method is often viewed as an important advantage to the recipient firm. When operating in joint ventures, the multinationals provide the machinery and equipment, the know-how and patents*, and the recipient firm supplies the capital funds. The know how supplied by the foreign participant may be

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* patent means an exclusive right, granted under the law, related to the exploitation of a technical invention.Unido (1973,p2).

related to the construction phase, to the production process and may involve brand-names and marketing skills, which involve a licensing agreement.

c) License agreement

Technology licensing varies from one developing country to another, and hence the impact of foreign technology also varies. Nevertheless, the basic problems of licensing tend to be similar. According to Unido (1973, p2) a license means:

> "The consent given by the owner of an exclusive right (licensor) to another person (licensee) to perform certain acts which are covered by an exclusive right, or consent as to use of knowledge."

A license agreement is, according to U.N. definition, see Cooper and Sercovitch (1970):

> "A contract under which the licensee is granted certain rights to manufacture and sell products utilising inventions, process techniques and other industrial property rights of the licensor."

This definition applies irrespective of whether the licensee is a fully-owned subsidiary, a joint venture or a locally-owned firm. The contractural agreement may be related to patents, trade-marks* as well as other forms of proprietary and non-proprietary technology. The licensing agreement contract include, according to UNCTAD (1975_b), certain restrictive clauses related to the acquisition of technology, to its use in the production process and to the distribution of the

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*Trade mark is a visible sign, protected by an exclusive right granted under the law, which serves to distinguish goods of one enterprise from those of other enterprises, UNIDO (1973, p2).

commodities produced. Through these clauses, the licensor can exert control over a series of operations of the licensee, in particular those concerning the production; the clauses often refer to the quality of the product, the choice of process technologies, and possible technical innovations, improvements and modifications that would be carried out by the licensee. Other clauses are concerned with the procurement of raw materials, parts, intermediates and machinery, which put the licensee in a position to purchase from the referred supplier. There may also be restrictive clauses as to the quantities the licensee is entitled to produce, pricing policies, packaging and marketing, such as advertisement and sales promotion. Stewart (1979, p12).

The reasons for all these limitations are aimed at reducing the uncertainty as there is always a danger that the recipient firm may exploit the technology transferred after the contract expires, Sercovitch (1974). Thus this serves the licensor not only in avoiding competition but also in appropriating the returns, which are effected through royalties, the payment of technichal fees, and through over-pricing of the materials supplied on a tie-in-clause basis.

The licensing agreement may provide a good arrangement for the recipient firm in that it enhances their competitive position in the local market and often secures profitable operation because of the use of brand names etc., however, and most often, because of the restrictive clauses it may restrict the growth prospects of the firm.

d) On Turn-key contracts:

Another form of technological transfer (other than foreign direct investment, joint ventures or license agreement) is the turn-key contract. Turn-key agreements are made particularly at an early stage of industrialization, when the country lacks local skills and when the operations involved are technologically complex. This form of contract implies a completely packaged transfer that is a supply of technical and managerial operations required to run the enterprise for the allocated period of time. Depending on the nature of the plant and the technology involved, the turn-key contractor may be either the owner of the technology or the main supplier of machinery or a consulting engineering organization. When the project is large, many foreign organizations may combine to take up turn-key operations. Unido (1973, p9).

The main problems with this arrangement is the substantial foreign exchange costs involved. It is increasingly believed that a gradual 'unpackaging' of the technology package and the increasing reliance on more direct types of transfer, such as technical services agreements, management contracts, etc., will restrict the contractor's control over price setting, procurement of materials etc., also it provides the recipient with the capacity to'learn by doing' as Cooper and Sercovitch (1970) put it.

2- Direct Forms.

Another way to transfer technology is through direct forms which Siggel (1983, p85) classified as:

1) The acquisition of productive equipment;

2) The transfer of the technology proper, i.e. the trans-

mission of technical knowhow concerning the plant and its operation, embodied in feasibility studies, plant designs, equipment, product design, quality control specifications, etc.;

3) The provision of technical and managerial knowhow for the use of the technology through employment of foreign skilled manpower;

4) The training of local personnel.

The productive equipment is usually available from machine producers at market prices without proprietary restrictions, a certain amount of knowhow transfer is included in the purchase of machines with the operating instructions. However, there are certain types of machines that may not be freely available from the producers unless they are acquired within a larger package, such as licensing contract, or they may involve proprietary rights to the supplier, in the form of direct investment, Siggel (1983, p85) argues that the acquisition of machinery, which constitutes the hardware of a technology, is the most costly part of the transfer; and that the element that constitutes the most important part of the transfer is the software, which is either disembodied knowledge (knowhow and experience of managers and technicians) or the knowledge embodied in documents, which may require a high level of training to be understood. The actual transmission of productive knowhow may involve the employment of foreign experts, the training of personnel, the inflow of information through documentation and visits by specialists to domestic plants.

3.3 Costs of Technology Transfer.

Much of the literature has focused on the cost aspect of technology transfers as an imperfect market, Vaitsos (1974) and Stewart (1979) among others. Moreover, since the market for technology, protected by patents, trade-marks, commercial secrets and by semi-monopolistic control is largely imperfect, it is difficult to assess the cost of a particular technology. The price and the conditions for the transfer of technology from one enterprise to another may differ from case to case, and depends greatly on the value the recipient firm attaches to it. The licensee is usually unaware of the complexities of negotiating a license agreement, therefore he is in a particularly weak position vis-a-vis the licensor, whose bargaining strength is much bigger. Unido (1973, chapter 3).

Stewart (1979) divides the cost of technology into actual or direct costs and indirect costs. The former constitute the payment of technology royalties, profits, and transfer pricing mechanism. The indirect costs, on the other hand, which may account for over-pricing, etc., represent the largest part of the transfer cost, in doing so, the activities of recipient enterprises are greatly restricted. These operations have often been called manipulations of transfer pricing by the multinationals, see Lall (1978_a, p209) for instance.

The major element weighing most heavily is the cost of knowledge. Siggel (1983, p107) reports that foreign supervisors and managers which represent only three to five percent of employment often account for a larger proportion of the production cost than ordinary labour.

An essential feature of the market for technology is that it is a considerable area for bargaining, as the price may vary greatly and could in the long run, be not so distorted, if measures are taken by the contractors, and essentially the recipient.

3.4 Stages of Transfer.

The fulfilment of project implementation requires foreign technological expertise at more than one of the following stages of transfer, Okita and Tamura (1975, p72) and Unido (1973, p4) discuss these stages. The first stage of the transfer usually takes place when a country imports the machines along with the flow of technological knowhow, and start to learn to operate them. The second stage requires the maintenance and repair technology. Sometimes the machines may be complex and automatically controlled which requires specialized tools and parts. The third stage is the establishment of engineering technology, which requires a great accumulation of productive facilities, various kinds of specific material and skilled workers. The planning and design technology constitute the final stage, it includes the research and development activities for new products, and the design of actual products. It is this stage which permits the developing country to develop its own technology. The local expertise for most of these stages is practically nonexistent in the receiving country and often, even the plants and equipment are installed by the transferor.

3.5 Transfer Effectiveness.

Effectiveness of technology transfers can be satisfied when the last stage of transfer is attained, that is, when the receiving firm has mastered the technologies, there are, according to Siggel (1983, p99), three factors responsible for the effectiveness of transfer, first, technologies must be transferred in all their required parts, an incomplete technology transfer may be acquiring a turn-key plant without training the personnel, on the other hand, a pure training arrangement is an incomplete technology transfer if the receiving firm does not obtain the documentation and managerial knowhow it needs for operating the training. Secondly, the effectiveness depends on how the transfer mechanism is organised, there is particularly a high risk that the transfer may be incomplete when it is in an 'unpackaged' form with independent dealers, as preliminary studies, the delivery of equipment as well as the training of personnel and management are not sufficiently coordinated, thirdly, it depends on the receptivity of the receiving firm, that is, management capacities and technical absorption.

3.6 Adaptation of Technology.

Other factors influencing the success of technology transfer are mainly due to how the technologies are adapted to the conditions of the receiving firm. For example, in the early period of Japan's modernization, the transfer of technology to the silk industry, which was one of the most important industries in Japan's economy, was unsuccessful. Even after purchasing very expensive silk spinning machines from France and Italy and inviting a number of technicians from European countries to apply modern technology to its best effect. The failure of this transfer resulted in stopping the use of new technology altogether, as Japan could not establish a modern sector to absorb this specialised technology. One of the main reasons for the failure, very characteristic of developing countries at the moment, is that only a very few technicians had been properly trained to operate and repair the imported machines, and the general level of most technicians and skilled workers was not high enough to make adequate use of the modern technology. However, the following method was then adopted by Japan which has not been used by developing countries. Despite Japan's and other countries' experiences the above method has not apparently been applied by developing countries. After the failure, Japan concentrated on modifying the modern technology as Otsuka (1982) and Okita and Tamura (1975) report; the modification consisted of combining ideas developed in European countries with those of Japan's traditional sector. These modifications spread to most industrial activities such as coal mining, iron and steel etc. Examples of modifications are replacing iron parts by wood, engines by manpower or water-power, reducing the size of the machinery considerably. These modified machines affected greatly the cost which made cheaper machines readily available and resulted in increased production, also, and most important, the modified machines improved the production methods of the traditional sector. Another effect of modified machines allows the workers to learn and discover what the foreign technology is, how it evolved and was conceived, and of what it is actually capable. Thus knowledge, which is supposed to be beyond their reach allows the workers of the receiving company to familiarise themselves with the technology and enhances their confidence.

One of the most important factors created by technological transfer, and which in turn creates an unfavourable atmosphere for the absorption of technology, is that, the introduction of the new technology necessarily creates a dual structure between the modern and the traditional sectors. Often the conditions created by the modern sector, such as different prices and different capacities of production, weaken the traditional sector and often forces it to start using modern techniques. Already the new modern sector which is supposed to be able to adapt the techniques, often fails to do so, or uses the technologies at a fraction of their capacities. So it cannot be expected, that the traditional sector with its labour-intensive technologies and different forms of production, management and structure could adapt the modern technologies. Japan somehow survived the crisis by modifying the new technology and adapting it to both the modern and traditional sectors, hence improving the existing system of production, modernizing old processes and lessening the gap between the two sectors. Current developing countries are still struggling in this difficult phase of modern and traditional co-existence, and very little adaptation has occurred, Lall (1978_b, p238); as long as this problem as such is not solved, one cannot predict a successful technological transfer.

What the less developed countries need, Ardnt (1975) notes, is not so much transfer of the high technology but adaptation; moreover, a widening of the spectrum of technologies available and in use in the industrial* sector of developing countries. To

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* The transfer of technology has been mainly related to the transference of industrial technology, only recently is the transfer of agricultural technology receiving consideration and debates, see the IMCC (1977) (International Minerals and Chemical Corporation) on the transfer of farming technology where it is realized that the solution to the agricultural problems is to produce the food where it is needed, and that it is going to call for a

do so, they need technological knowhow, it should be remembered that it is increasingly difficult for developing nations at the moment to adapt and learn the new technologies because of the widening technological gap between the industrialized and the developing worlds, whereas in Japan's period of transfer, the gap was not so large which made learning, adaptation and modification easier. Therefore, one may adapt the method used by Japan and modify it to suit the conditions of the actual developing economies. This process will obviously require a large amount of investment, effort and flexibility, because of the delicate nature of the problem the appropriateness of the technologies transferred will be discussed in section 5 of this chapter where it is intended to raise the problem of technological knowhow required for the adoption of foreign technology and possibly for its modification.

3.7 Knowhow Transfer.

The most important part of technology transfers is the transmission of knowhow through education and training combined with practical experience. There exist several means for the transmission of knowhow, formal local training programmes, training programmes abroad, in-plant courses, on-the-job training, education abroad, circulation of books and periodicals, etc. Vaizey (1969) suggests that job-oriented training programmes and on-the-job training are the most efficient means. Education abroad has often been criticized as impractical to the actual needs of developing nations, Young (1966). In general, failure to transfer satisfactorily

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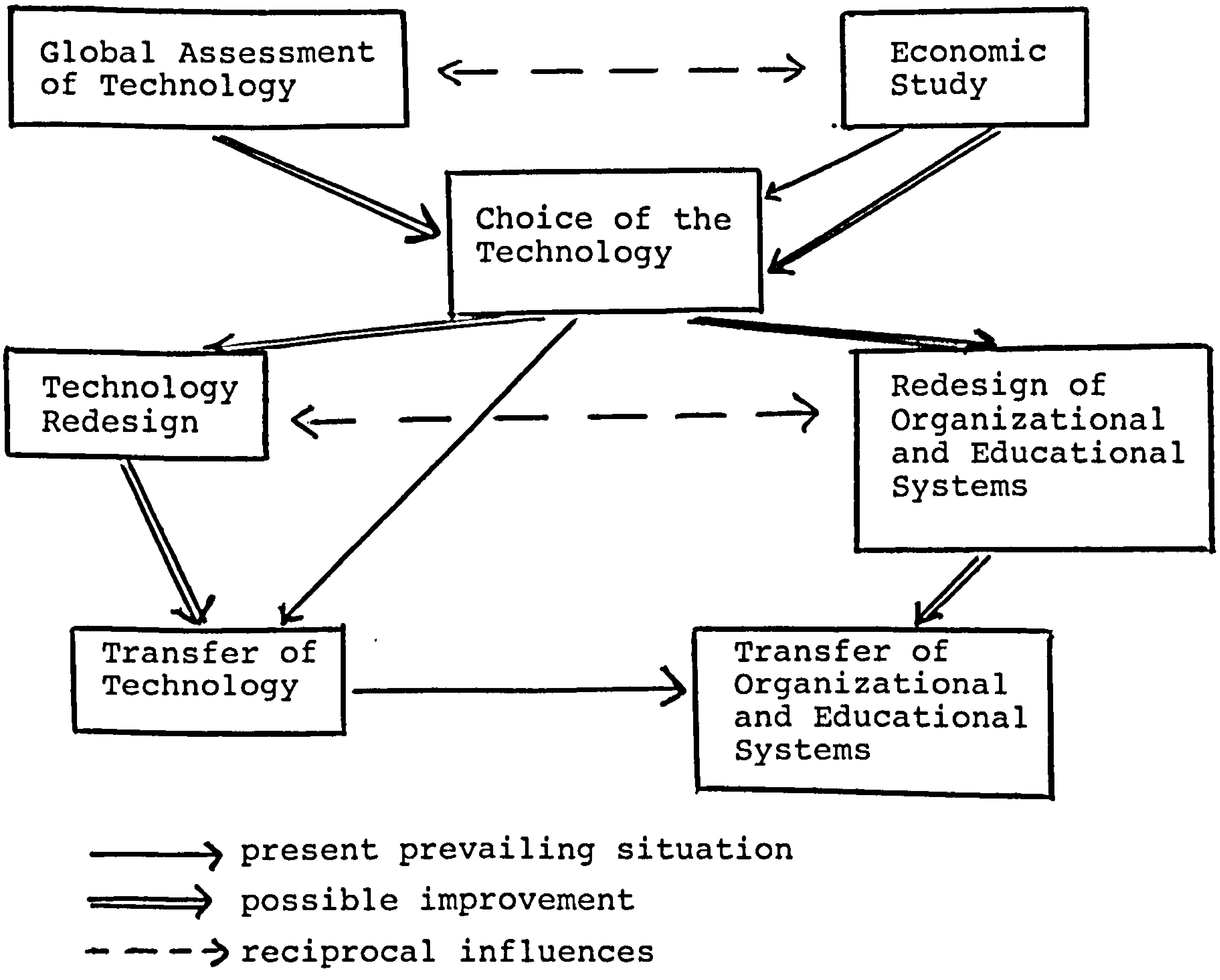
* massive transfer of modern farming technology to the small farmers in developing countries.

orily the knowledge required for the absorption of technology has led to the failure of technological transfer; a relevant study by Peterlongo (1977) is worth mentioning at this point; it consists of coordinating the transfer of educational systems with the transfer of technology. The usual path followed to accomplish both transfers can be described as: economic study - choice of the technology - transfer of the technology then transfer of organizational and training systems. This simple uncoordinated pattern has created serious difficulties to the recipient country. Improvement of this pattern is suggested by Peterlongo and is presented in figure 1.2.

Fig. 1.2 SCHEME OF THE TECHNOLOGY TRANSFER PROCESS.



Source: Peterlongo (1977, p174).

From these considerations, there appears two new aspects, which are the redesign of technology and the redesign of educational transfer. The redesign of technology is very similar to the approach of modification of technology used in the 1870's for the silk industry and then in the 1950's for the other industries in Japan; this phase requires an enormous contribution of the country receiving the technology, which should dedicate more resources and more time for the forecasting and planning of industrial development. The competence and abilities of the country of origin are obviously very important and are required in this phase. The concept of redesigning the organizational as well as the educational and training systems correspondingly to the redesign of technology allows the receiving country to take into account the requirements and the general situation of the country, and therefore, of being able to assimilate and adapt the technology. The two activities of redesign should be performed contemporaneously and not, as often happens at present, sequentially. The aim is to obtain reciprocal influences in order to benefit from both aspects of the transfer. The phases of redesign in order to modify the technologies and education transferred will direct the training and educational systems towards the proper use of technology. Although the costs involved for these operations are high, this approach will not only compensate, in the long run, the allocated resources but also, it will ensure a well-planned, and successful technological transfer. Peterlongo (1977, p178) concludes his paper with the following original idea, which may be related to technological transfer, to some extent; he says:

> "The suggestions here proposed could perhaps improve the present situation. They are based on resources, such as creativity and reflection, which by their nature are much more evenly distributed among the nations than capitals and raw materials."

The modernization theorists, see Rostow (1960) will certainly not agree with the above statement, they stipulate that third world countries are "backward", "late-starters" and lack the attributes of modernity, as Fitzgerald (1981) reports. One should therefore not restrict his views when looking at developed and developing nations and at their technological differences, as knowledge exists everywhere, what is lacking is enhancement and encouragement for the use of knowledge to profitable ends.

3.8. Aid and Technical Assistance.

The study of technological transfer would be incomplete if the aspect of aid and technical assistance is not raised. As mentioned above the success of growth programmes depends on imports of machinery and equipment with the related technological knowhow, the ability to import such goods is subject to the availability of adequate supplies of foreign exchange, which are often lacking in most developing economies, this affects the supplies of aid, credits and technical assistance tied to equipment and technology by some organizations from industrialized nations. See OCDE (1982, annex 1) for a large treatment on aid agreements. Technical assistance programmes were aimed at eliminating assistance and putting recipient countries on a self-sustaining basis, Ziribn (1975,p135) notes, about twenty five years experience in this field have demonstrated that the objective was clearly utopian. Official technical assistance programmes consist mainly of transfer of experts, scholarships and other forms of training, which usually involve only the transmission of diffuse knowledge and the skills to operate, but not captive knowledge, which provides the capacity to reproduce the technology, see Ardnt (1975) for a discussion on diffuse and captive knowledge. Often the experts render a service, if they have to solve a problem by applying their skills, but they would not be transferring knowledge. If aid and technical assistance are always done in this way, despite the fact that they are aimed at other ends, then one should not question why there is growing dependence despite increased amounts of technical assistance.

Aid often tends to frustrate the receiving poor nations, which tend to focus on this one factor and makes it easy for the leaders to blame inadequate growth rates to the policies of developed nations, it may then be a detrimental factor, to the process of establishing a modern industrialized economy as Wall (1968, p167) argues, he criticizes UNCTAD for concentrating on this one factor to divert attention from more important prerequisites of development. Also, the many studies and reports dealing with external aid and American technical assistance are variously interpreted, one of the main idea stemming from these studies is summarized by Ohlin (1970, p29) who writes:

> "Hopes and assumptions about the relationship between aid, development, political stability and world peace are rarely spelled out, but it was recognized that, in the end, an aid programme must serve the interests of American national security in a broad sense."

The statement above clearly shows that organisations supplying aid are mainly aiding themselves, in fact, Ziribn (1975, p134) attributes foreign aid policies to two objectives, to develop the production of necessary raw materials in the recipient country and to ensure a market for the donors' industrial products. He attributes the factors affecting the failure of foreign aid to:

i) technical assistance programmes not stemming from the needs of the receiving countries, but are formulated according to the offers of the providers;

ii) it is often managed independently from other channels of transfer, and often there is no coordination between technical co-operation and other forms of aid, such as capital assistance;

iii) it is also due to administrative problems mainly related to the absence of managerial staff to solve organizational problems.

The developing economies can benefit from external aid, if they can affect the actions taken by international organizations. Then bargaining capacity on raw material products, on which rich countries depend greatly, will be able to strengthen their position. Also, official technical assistance will play an important role only if it is channelled toward the creation and strengthening of the educational, scientific and technological infrastructure. However, aid and technical assistance should not be viewed as an indispensable asset of technology transfer, countries with minimum resources can achieve growth without relying on aid.

3.9 Recent Approaches to the Transfer of Technology.

In the late 1970's, United States (U.S.) corporations, which constitute the main element of transfer, particularly in foreign direct investment, begun to depart from the traditional approach of managing their technological assets (this aspect is discussed in part 4 of this chapter); they increasingly prefer the sale of industrial technology to foreign enterprises without owning or controlling them. The technology sold in these cases is highly sophisticated (mainly related to computer, aircraft, automotives consumer electronics and chemical engineering industries) and is aimed at assuming rapid and efficient implantation of an internationally competitive productive capability; it is often referred to as "technology sharing", Baranson (1979, pll).

The new approach is a result of evolutionary trends in the world economy, which have changed the corporations viewpoints about technology transfer and have altered the bargaining position of the purchasers. Many factors, evolving from both the U.S. corporations and developing economies, have contributed to this evolution, Baranson (1979, pll)presents them as follows:

1) The demands of newly industrializing nations for technology sharing and access to world markets;

2) The intensified political risks and economic uncertainties of overseas capital investments in plant and equipment.

3) The shifting emphasis in certain firms from production to marketing and research and development (R and D) functions.

4) The intensified competition from foreign enterprises as suppliers of industrial technology.

5) The escalation of R and D and capital investment costs connected with the proliferation of world involvements and the ever-increasing sophistication of product systems.

The above considerations show that newly industrializing countries are increasingly becoming aware of their bargaining power, which allows them to share the technology, and not depend on the providers, as there are high costs involved. This awareness also stems from the U.S. multinationals which are encountering increasing competition from other foreign technology such as Japanese, Western Europe and the Soviet Union. This competition means that the share of American business does not hold the same bargaining power in entering foreign markets or in withholding its technology, towards both advanced and less advanced economies as it previously did. Graham (1982, p67).

The new approach of sharing technology poses the problem of retaining core technology (the part that represents the company's competitive aspect) as a protection against future competition. For the developing economies, it implies profound changes in management, manufacturing and technical methods, as the technology involved in this kind of contract is highly sophisticated. Whether these objectives will be achieved, it will depend greatly on how both parts react to the transfer agreement, in particular whether the transferor will actually provide the ability to design and engineer the industrial system and whether the transferee will acquire these abilities. The main advantage tied to this approach is that increasingly the technological transfer becomes an asset of pure exchange between the two parts, and not, as is usually the case, an asset providing a superior bargaining position to the transferors, as Baranson (1979, p Xi) puts it:

> "The combined result of these trends has been to move segments of the U.S. corporate world into what may be termed "commonwealth" arrangements with "sovereign" enterprise affiliates - and away from traditional "empire" relationships with owned and controlled subsidiaries."

This type of transfer will obviously benefit, if performed successfully, only those nations capable of paying the high cost. Examples of industrial transfer to some developing countries are reported in table 1.3. They are constituted from tables 7.2, 7.4, and 7.6. from Baranson. This table reports the policies and objectives of both transferor and transferee.

3.10 Industrial Forecasting Related to Technology Transfer.

Similarly, in considering certain criteria for forecasting industrial activities, related to technology transfer, OCDE (1982, pp 190-212) presents information on the industrial activities which are likely to show high rates of development up to 1990 in the following developing economies:

1) ASIA: Taiwan, South Korea, Indonesia, Saudi Arabia;

2) LATIN AMERICA: Brazil, Argentina, Mexico;

3) AFRICA: Algeria, Nigeria.

The selection of these countries was based on the following criteria:

a) The importance of industrial production and industrial potential measured by the size and growth of population and GDP, the share of the industrial sector, energy consumption per head and level of education.

b) The intensity of economic relations between these countries and OCDE (organization for economic co-operation and development) countries measured by imports, exports and direct investment.

c) Growth dynamics such as industrialization policies, raw materials resources, trade intensification and the market system.

The industrialization process of different industrial branches were analysed for each country for the period 1970 to 1977, and qualitative predictions have been made for the 1980's. Also brief summaries are given on:

i) prospects for the industrialization process in each country;
ii) main elements of industrial policy;
iii) technological potential;
iv) and characteristics of exports.

The table provided by OCDE (1982) are reported for each country in tables 1.1 to 1.9, appendix 1. These tables allow the reader to get an insight into the policies of technological potential and technological transfer of those developing economies likely to generate economic growth due to technology transfer.

Table 1.3. Case Summaries and Overview of Policy Implications.

Case Studies	Technology Transferred	Corporate Considerations	Purchaser Considerations	Policy Implications
Piper Aircraft - Embraer (Brazil)/ licensing agreement	Production technology for light civil aircraft	Need to maintain technological lead and production competitiveness against future Brazilian export capabilities.	- Piper preempted from export by Brazilian import restrictions. - Brazilian government interest in developing national design and production capabilities.	U.S. Economy Prospect foreign associate may become low-cost producer of product. Newly industrializing Nation (NIN): Opportunity for NIN enterprise to enter into world market on competitive basis - including upgrading of industrial design and engineering capabilities.

Table 1.3. Case Summaries and Overview of Policy Implications. (continued)

Case Studies	Technology Transferred	Corporate Considerations	Purchaser Considerations	Policy Implications
GTEI-SONELEC (ALGERIA)/ Turnkey contract	Plant construction, manufacturing technology (fully integrated from raw material to radio and T.V.) and training of full range of managers and technicians.	opportunity to earn substantial return on technology assets without capital resource commitment	oil revenues permitted government to finance industrial facility. Want self-sufficient operational and design engineering to compete in world market.	newly industrializing nation (NIN). -Management service contracts provide opportunity for NIN firms to develop an internationally competitive industry, including training of vital technical and managerial personnel.

Table 1.3. Case Summaries and Overview of Policy Implications. continued.

Case Studies	Technology Transferred	Corporate Considerations	Purchaser Considerations	Policy Implications
Fluor - IRAN and SAUDI ARABIA/ Turnkey contracts	Engineering and construction of chemical and petroleum processing facilities, with a strong emphasis on efficient and rapid installation (Saudi Arabia - a natural gas collection plant; Iran - a series of refineries.	Process and plant engineering firm's basic interest in maximising returns from sale of design and engineering services anywhere in the world (over half of $10 million in contracts overseas) -In order to maintain commercial and technological lead in world, firm must improve its competitiveness by constantly upgrading its efficiency in project management.	Saudi Arabia anxious to expand its domestic processing of oil and natural gaz resources. -Strong drive in Iran to develop local expertise in project management.	Potential threat comes from internationally competitive facilities producing for world markets. -Safety and energy conservation regulations can have important impact on relative competitiveness of U.S. industry. Newly industrializing nations (NIN). NIN enterprises can negotiate contracts that move beyond turnkey operations into self-sustaining engineering capabilities.

4- THE ROLE OF THE MULTINATIONAL ENTERPRISES IN TECHNOLOGY TRANSFER.

The multinationals are the most usual suppliers of technology to developing countries. In this section, two related aspects of the multinationals' activities will be examined, these are:

i) their willingness to engage in various forms of operations in developing economies, and

ii) the exploitation of their managerial and technological capabilities.

A multinational corporation is defined as "one which commits financial, technological, managerial and human resources to a foreign operation through direct investment and which attempts to maximize global profit through centralized control and co-ordination," Okada (1983, p116).

The multinationals are considered as the prime agents of technology transfer, they are mainly American-owned, and they carry out about eighty percent of technological transfers, especially through direct foreign investment (in either wholly or partially controlled subsidiaries). Delorme (1982, p90) classifies the characteristics of these firms in the following:

i) they have the ability to operate globally and to survey the inputs and outputs of their technical field;

ii) they have the ability to organise this field by rationalising their subsidiaries' production worldwide;

iii) they have the ability to take maximum advantage of favourable wage conditions and of the probable opening up of potential markets by worldwide relocation operations.

They are then mainly seen as global maximers of profit in locating their R and D activities and transferring technology internationally, as Hirshey and Caves (1981, p128) put it. The main criticism, as has been pointed out by Wilkins (1974) is that they engage in transfer rather than in true diffusion of technology.

The main reasons pushing the multinationals to operate in developing countries, are due to conditions in both countries. First, the product cycle theory of Vernon (1971), which integrates the theory of international trade with the theory of direct investment, shows that the expansion of the product which benefits the multinationals necessitates the latter to produce abroad (and particularly in developing countries) as a move against potential competitors. Vernon's findings may be explained by the 2,904 subsidiaries of which sixty five percent had been set up by acquisitions rather than by new investments by the end of the 1960's, as Lall (1978_b, p230) reports. These acquisitions are due to the immense financial and other resources that put local competitors in a difficult position which leads the multinationals to buy them at ridiculous prices. Second, the entrepreneurs in developing countries desirous of acquiring foreign technology, lack the technical knowledge and therefore have to undertake negotiations with foreign companies, which are often multinationals and have experience in international licensing. Unido (1973, p16).

The circumstances in which the multinational firms will supply the technology and their decision processes have already been the subject of considerable studies, see Stopford and Wells

(1972) in particular. Helleiner (1975, p86) notes that these preferences mainly depend upon tax structure (tariff structure, profits taxes, taxes on royalties and other international transactions), legal provisions and restrictions of various kinds (related to capital repatriation, foreign exchange control etc.) and other factors such as their size, the nature of the technology and the country of origin.

When comparing the productivity of a multinational operating in a developing economy, or a domestic enterprise, Lall (1978_b, p218) asks the following questions:

a) would the local enterprises have been set up in the absence of multinationals' investments;

b) did they gain or lose by having the multinationals as major customers;

c) is the host economy capable of creating the same linkages at lesser cost, by replacing a multinational by a local firm;

d) are the linked local enterprises desirable from the social point of view ;

e) whether negative linkages were created by stifling potential local investment.

These questions arise from the impact itself that a multinational enterprise has on the economy of the recipient country. The relationships that it has with local suppliers or purchasers constitute a powerful mechanism for stimulating or retarding idustrial growth. Other effects resulting from the multinationals' operations may concern the performance of the economy as a whole, in particular, they may affect the profitability and growth of indigenous firms as well as alter financing, marketing, technological and managerial operations of the sectors they enter.

In general, the literature suggests that there exists a vast potential for linkages with domestic producers, who may manufacture components or whole products for foreign firms or for the multinationals' affiliates in developing countries. Moreover, it has been reported by Lall (1978_b, p232) that the multinationals are fairly profitable in the less developed countries and that on average they perform better than local firms.

A major element of great interest in the study of multinational enterprises is the appropriateness of the transferred technology. Although this aspect is mainly discussed in the next section, some considerations are raised here.

The adaptability of the multinationals' technologies have been an area of great interest and controversy, the main questions involved with this point are put forward by Lall (1978_b, p237), these are:

a) whether the technologies used by the multinational corporations are adaptable to low-wage, labour abundant conditions in less developed countries;

b) whether they do in fact adapt the technologies they transfer;

c) whether they adapt better or worse than local firms.

Studies suggest that technologies used by the multinational firm are, in some cases, adapted to the local environment and objectives, and in other cases they are not, UN (1974, p2), however, it is often argued that there is no adaptation, in the sense of alterations to the low-wage conditions of developing economies, see Stewart (1974) in particular. The main consequence of non-adaptation is the non-absorption of low-wage workers, which affects heavily the unemployment problem in these countries, and which allows more advantage for the multinationals' affiliates, as they avoid the expensive adaptation costs to suit the relatively small markets and to absorb employment. It would, however, be interesting to see whether the adaptation of technologies by the multinationals would, in the long run, benefit both parties, as these operations may encourage more contracts and projects.

When studying the multinational enterprises, one notices the steady shift from earlier focus on international capital flows and the direct investment package to the unpackaging of direct foreign investment, that is, capital technology, marketing, management, etc. Non attention is being focussed on the international market for technology, which proves to be complex and highly imperfect. In fact most criticism is related to the high cost involved as mentioned earlier, also the "package" nature of transfer tends to create and increase dependence.

Such dependence tends to be frustrating no matter how the multinational enterprise behaves and no matter what the regulations are by the host country. The power of the enterprise to take actions in relation to production, employment and exportation, and to affect the diversion of local activities, may harm the interests of the developing economy. The frustration is reinforced as the costs and benefits associated with the presence of multinationals are difficult to quantify as they involve social costs. UN (1974, p1) attributes these costs to the difficulty in evaluating the cost of certain types of imported goods and services, to social costs related to the restrictive business practices they create, there may be loss when parent firms cause a displacement or unemployment of local resources, such as savings,entrepreneurs and skilled labour. Other costs may be political, in the sense that the multinational firm's operations may have an impact on internal and international relations in turning the economy to foreign firms.

These few remarks show how difficult it is to deal with the phenomenon of technology transfer, which is further complicated by the differing characters of the parties concerned, two firms and two states, each of whom has its own policy, as Delorme (1982, p91) puts it. With regard to the firms' policy, the multinational has a rigid and institutionalized organisation, which may not be flexible in certain circumstances.

As the cost is difficult to determine, one therefore ignores whether an alternative source could provide the same services at a lesser cost and with less dependence; all too often the alternative source is not available and the multinationals remain the main suppliers. In this case the acceptance of the "package" of capital, technology and management embodied in the multinational enterprise may still be an attractive source of technology for some developing countries. In some other cases, alternative types of sources, or some non-traditional arrangements with the multinationals, which do not involve proprietary rights, may be obtained and may, as is often argued, see UN (1974, p2) and Baranson (1979), appear to be both feasible and more socially profitable than direct foreign investment of the traditional form. Furthermore, it seems that these new arrangements lend themselves to a more systematic and quantitative analysis.

5. THE CHOICE OF TECHNOLOGY.

The issue of technological transfer to developing countries is very much linked with the choice of techniques imported. increasingly, many economists and policy makers place some of the blame for the failure of industrial development on the technology imported from the advanced countries.

Many developing countries are experiencing a serious and increasing rate of unemployment which is said to be due to the capital-intensive techniques used. The recipient firms* are accused of selecting manufacturing processes that do not combine capital and labour according to their availability in the country. Some studies have shown that the impact of the kind of technology used is extremely significant, for instance, Wells (1973) shows that in several industries in Indonesia, intermediate technologies in use in some plants use twice as many workers as an automated plant.

A large amount of research, has therefore, concentrated in finding out the factors that influence the selection of technologies for the developing economies. It is argued that both government policies in these countries as well as the behaviour of the suppliers of technology (which are basically the multinationals)

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* These could be either foreign (wholly or partially owned subsidiaries) or domestic enterprises.

are responsible for the choice of capital intensive techniques.

Two criteria are usually distinguished, price and brand-name, both resulting from the competitive position of the firm. Wells found that whether the company is foreign owned or domestic, it is more likely to import a capital intensive technology if it is competing primarily on brand-name basis than it would if it was competing primarily on price. When the company is subject to a strong price competition, its aim may be to choose a technology that minimizes the costs, that is choosing a more or less labour intensive technology.

The managers of both the foreign owned or domestic firm seem to respond to certain factors that lead them to prefer a more capital intensive technology to a labour intensive alternative. The manager is influenced by the problem of managing a larger number of workers associated with the labour intensive technologies; Wells notes that generally, they prefer to design the plant on a small labour force basis to avoid this problem, despite the low cost of a labour intensive plant.

The managers are also influenced by engineers, who play an important role in the design of manufacturing plants. It is argued, see Pack (1972) that engineers, often prefer sophisticated and so-called modern equipment to the old design machineries associated with labour intensive techniques.

Furthermore, the managers are greatly influenced by the high degree of risk and uncertainty that may be encountered when the plant design is of a labour intensive technology type. Wells finds there are two kinds of insurance against risks that can be offered by a capital intensive plant. First, in a capital intensive plant, the manager is more able to respond to inexpected fluctuations in demand or in production levels; and second, the perception of capital intensive plant itself is designed to allow the manager to reduce the risks facing future liquidity problems, such as shortage of working capital etc.

Just as there are factors affecting the selection of capital intensive techniques, there are also other forces that constrain this choice. Some research suggests that the scale of the plants in developing countries may be the most important constraint, for example, Yeoman (1968) suggests that generally the pieces of capital intensive equipment not only come in discontinuous units, but also some parts may operate at only a fraction of their capacities, as a result of being originally designed for large scale sophisticated plants. Therefore, this factor may have been the major element constraining the multinationals to transfer a highly capital intensive technology.

Other constraining factors may be due to the difficulty to find spare parts for sophisticated equipment in developing countries, as well as the scarcity of skilled repairmen. In addition, the above research suggests that labour laws have served as restrictions to the automation of plants, as they are based on employing more workers, as was pointed out by Wells.

One may summarize from the above discussion that basically, the choice of capital intensive techniques is related to management, engineering and maximization of profit elements, it seems that the socio-economic factors within which the plants operate are ignored.

The choice of capital intensive techniques has received considerable criticism, Malmgren (1971, p66) notes that the choice of heavy capital investment techniques is mainly based on the assumption that if something works for an advanced country, it must also work for a developing country; it is often wasteful, he continues to argue, it wastes job opportunities and capital, which is extremely scarce. On the other hand, Bhattasharya (1976) argues that the use of Western technologies, resulted in a continuous deterioration of their trade position, mainly causing a redistribution of world income in favour of developed nations. The following table (1.4) shows the increase in net transfers of income from developing to developed countries during the years 1963-1973.

Table 1.4. Estimated Transfer of Income (U.S. $ Million)

Year	From developing market economies to developed economies.	From developed market economy to developing economies.	Net transfers from developing to developed economies.
1963	230.4	227.7	+2.7
1964	505.4	747.9	-242.5
1965	809.3	521.8	+287.5
1966	1477.0	1123.2	+353.8
1967	1514.0	881.4	+632.6
1968	1347.6	974.4	+373.2
1969	2994.4	2174.4	+820.0
1970	5948.6	3615.3	+2333.3
1971	9101.0	7147.2	+1953.8
1972	15762.0	10854.4	+4917.6
1973	41428.8	33426.8	+8002.0

Source: Bhattasharya (1976, p318).

Similarly, Kim (1975) remarks that exports from industries using labour intensive techniques have been gradually decreasing since the developing countries have intensified their imports of technology, this not only implies that the modern imported technologies have killed off the existing technologies, but also that there was no successful co-ordination between the traditional and modern sectors. Basing his analysis on the findings of another study, he classifies capital intensive and labour intensive techniques for Korea in the following, this classification helps to distinguish between the existing techniques. See table 1.5.

Table 1.5: Capital Intensive and Labour Intensive Industries.

Capital intensive industries	Labour intensive industries
Chemical fertilizers	Non-electrical machinery
Petroleum products	Lumber and plywood
Glass and stone products	Rubber products
Basic chemicals	Miscellaneous manufacturing
Paper products	Fishery
Other chemical products	Coal
Steel products	Finished textile products
Electrical machinery	Other minerals
Fibre spinning	Leather and leather products
Printing and publishing	Beverages
Coal products	Wood products and furniture
Textile fabrics	Processed foods
Iron and steel	Tobacco
Transport equipment	Other agriculture
Non-ferrous metal products	Rice, barley and wheat
Finished metal products	Forestry

Source: Kim. N.W. (1975, p208).

. It is revealed that 82.3 percent of exports from those industries were labour intensive industrial products in 1962; the figure fell to 74.4 percent in 1966; to 71.5 in 1971 and is at present still continuously falling.

The increasing pressure of unemployment and related socio-economic problems in the developing economies has given urgency to the long-lasting discussion of labour absorption in manufacturing industries. Forsyth and Solomon (1977) note that the outstripping rate of output-growth and that of job-creation has led to a search for possible reasons for the failure of industrialization to absorb the labour force, and attention is increasingly focused on the technology in use which is frequently capital intensive and does not suit the local factor supply conditions. Hence / there is a great deal of interest in developing policies to encourage firms in labour-surplus countries to select or develop more labour-intensive processes. It is often argued, see Bhattacharya for instance, that there are strong economic reasons for the introduction of more appropriate technology in the third world countries, because it is labour intensive, cheap, simple to absorb and is not so dependent on the availability of foreign exchange and skills.

Shumacher (1979,p175) known as the father of appropriate technology, criticizes the industrial estates set up in rural areas, where sophisticated equipment is often standing idle because of lack of organization, raw material supplies, transport, etc., and proposes a more appropriate technology for developing countries in the following;

"If we define the level of technology in terms of 'equipment

> cost per workplace', we can call the indigenous technology of a typical developing country - symbolically speaking - a £1-technology, while that of the developed countries could be called a £1,000-technology. The gap between these two technologies is so enormous that a transition from the one to the other is simply impossible. In fact, the current attempt of the developing countries to infiltrate the £1,000-technology into their economies inevitably kills off the £1-technology at an alarming rate, destroying traditional workplaces much faster than modern workplaces can be created, and thus leaves the poor in a more desperate and helpless position than ever before. If effective help is to be brought to those who need it most, a technology is required which would range in some intermediate position between the £1-technology and the £1,000-technology. Let us call it - again symbolically speaking - a £100-technology."

The main characteristic of this technology is its capacity to fit in the relatively unsophisticated environment, it is based on the optimal use of locally available natural resources, and is above all designed to serve the human person instead of making him the slave of machines, as both Shumacher and Bhattacharya remark.

However, since the new theory of intermediate technology was raised, a number of objections have been made by those who relate economics to growth of output only, for instance, Kaldor (1965) quoted by both Shumacher and Bhattacharya, claims that research has shown that the most modern machinery produces more output than a more labour intensive technology, and that the choice of capital intensive technology will increase the proportion of income going to profits and decrease the proportion going to wages, he says:

> "If we can employ only a limited number of people in wage labour, then let us employ them in the most productive way, so that they make the biggest possible contribution to the national output, because that will also give the quickest rate of economic growth. You should not go deliberately out of your way to reduce productivity in order to reduce the amount of capital per worker. This seems to me nonsense because you may find that by increasing capital per worker threefold you increase the output per worker twentyfold. There is no question from every point of view of the superiority of the latest and more capitalistic technologies."

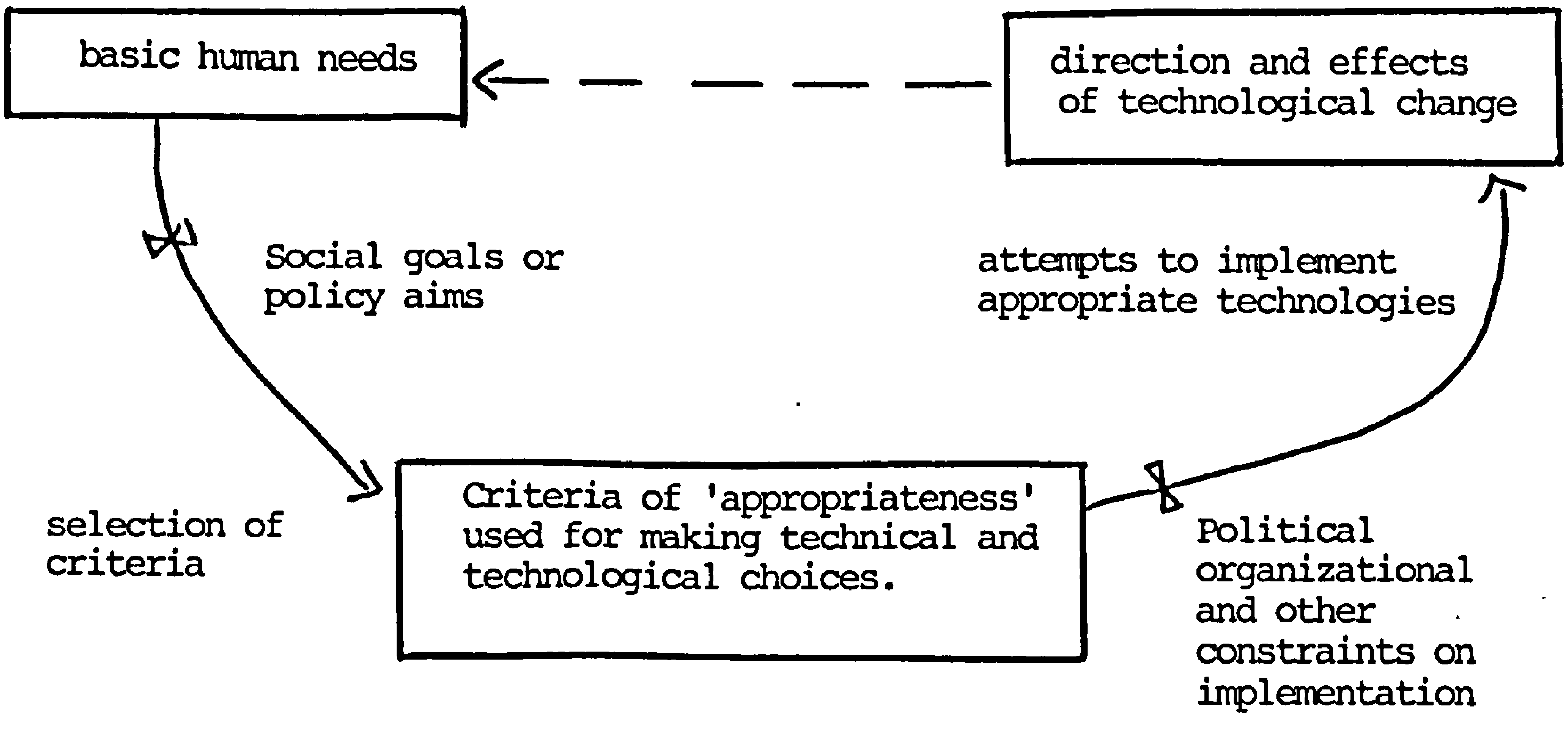
One may find the arguments above attractive in a purely profitable sense, for a handful of people that control the production, but what about its attractiveness when it comes to dealing with organizing a whole society and trying to make a more even distribution of income, so that most people benefit from the resources and therefore unemployment which creates social tensions is lessened. In addition, Bhattacharya recalls a study of India and Japan that he made earlier, and he notes that the amount of profit per unit of capital was no smaller with the less capital intensive methods.

In order to function effectively, the small rural industries, which supposedly use a more appropriate technology, will have to co-ordinate effectively their activities with the already existing modern sector, these organizations seem to have been developed in China. The Chinese approach to appropriate technology has been oriented to the most immediate needs, that is, food, shelter, employment and the achievement of a more egalitarian society. Bhattacharya.

A practical approach to intermediate technology has also been experienced in the early development of Japanese economy, Otsuka (1982) notes that the modified machines were easy to use and cheap to purchase, and were able to bridge the gap between the modern and traditional sectors.

In their study on appropriate technology, Thomas and Lockett (1977, p25) effect a link between basic social needs and the choice of technology; they propose the following diagram (Fig.1.3)

Fig. 1.3. Appropriateness as the Link Between Basic Social Needs and Directing Technology.



The basis of their argument is that the appropriateness of technology cannot be used for making technical choice without taking a wider social and political context into account.

In general, there are those who argue that intermediate technology should be used simultaneously with the sophisticated technology, as was mentioned earlier, and those who support the idea of creating a capital goods sector within the developing economy to produce appropriate technology for the entire economy; in fact, Pack and Zodaro (1969) argue that the less developed countries should produce their own machinery, copying initially the earlier more labour-intensive designs of Western countries. This will allow them to direct both the direction and speed of technical change, and will leave them unaffected by the capital intensive bias of the West. The main conclusion drawn for this copying of technology is that in the long-run, economic aspirations of developing countries will depend largely on the successful adoption of a domestic capital goods industry.

However, it is argued that the ability to develop its own technology depends on the way the technology was previously imported, Stewart (1979, p42) notes that firms that received their technology on license contracts were not able to develop their own technologies, due to the clauses of the contracts, whereas those that acquired technology by direct means were generally expected to be able to generate new technology; symbolically speaking, ninety seven percent of firms that licensed their technology said they would be unable to develop their own technology, and seventy three percent of firms which acquired technology by other means said they would be able to develop their own technology.

The need to develop appropriate technology in developing countries is stressed increasingly, Stewart (1974, p97) gives the following arguments for such development, first, the learning effects would be generated within the developing nations, second, the links between entrepreneurs between developing countries will be easier to maintain, and thirdly, the costs and availabilities will be incorporated in the design of the new technologies.

A study related with actual existing trade and economic relations between the developed and the developing worlds, stipulate that it is difficult to develop efficient appropriate technologies in the current environment and that there are no incentives towards their development, as far as the multinationals are concerned. The main constraining factor is the heavy protection and monopolistic or oligopolistic position typically enjoyed by the multinational firms in the less developed countries, which removes pressure upon it to adopt efficient labour intensive technologies. Furthermore, their existence as such will directly or indirectly affect the policies of developing countries which are increasingly dependent on the technologies and know how.

The arguments of Shumacher and those who support the development of appropriate technologies, seem to avoid the real environmental sphere where economy operates, they have not taken the constraints of developing such technology, rather they seem to take the developing economy as an isolated cell and propose more efficient methods than the existing ones, and in general, one does not know how to go about first taking away the existing industry and at which rate it should be replaced, it is the whole capitalist methods of production, embodied in the techniques that should be questioned. Although these newly proposed methods appear attractive, there remains a widely shared scepticism as to whether it could actually be realized, despite all sorts of pressures. Furthermore, one may wonder what will happen to this technology in an era where the computer is making the breakthrough in its technological domain.

Despite the existence of some appropriate technologies in the fields of agriculture, manufacturing industry and construction in certain areas, it is recognised that developing economies will remain dependent on the imports of technology for some time.

6. CONCLUSION.

The transfer of technology is a necessary part of the learning process, either by providing an essential input into the learning process or by permitting the economy to bypass the long process of reinventing a technology. The preceding literature examined the terms and conditions of transfer and has identified the problems encountered. The issues covered are relevant in the sense that one could see the changing pattern of transfer. In particular, the developing countries are becoming increasingly aware of their bargaining power, and the suppliers of technology, the multinationals more specifically, are confronted by an increasingly competitive environment, which may result in an alteration of their terms of trade in favour of developing economies.

CHAPTER THREE

IDENTIFICATION OF AN INDEX MEASURING INTEGRATION OF TECHNOLOGY AND FORMULATION OF AN ECONOMETRIC MODEL

CHAPTER 3

1. INTRODUCTION

Most of the literature on the transfer of technology bases its analysis on the nature of technology to be transferred, this is referred to as intermediate and advanced technology, and on the role of the multinationals as they represent the main body of transfer.

Most of the review, as was seen in chapter 2, treats the problem theoretically, these approaches appear to be missing the realistic environment within which technological transfer operates.

In the present thesis, a complementary analysis is attempted, which consists of a statistical investigation of economic and social indicators of a large number of developing countries in relation to their assimilation of the technology transferred.

The analysis consists of interpreting the transfer of technology in quantitative terms, and relating it, within a mathematical framework, to economic and social variables.

The objective is to identify the most important variables that affect the integration of technology imported, by the use of multiple regression analysis.

Once those variables are identified, they can be used to explain the differences in the way the developing countries integrate the imported technology, also, they would allow for predicting and forecasting the integration of technology as will be seen later.

2. ESTIMATION OF A MEASURE FOR THE TECHNOLOGICAL TRANSFER, SELECTION OF VARIABLES AND SAMPLE SELECTION

In this section, an attempt to formulate an index of measurement of the transfer of technology is made in order to be able to manipulate it mathematically with the entered variables.

Criteria for the use of growth of Gross Industrial Product (GIP) over imported technology as a percentage of GIP as the measurement index of the integration of technology are defined.

The selection of variables, their definition and calculations are described, as well as the selection of the sample of countries studied.

Data sources are indicated and computer programs have been written to carry out the necessary calculations required.

The period which the study covers is 1970 - 1977.

2.1. Identification of an Index of Measurement for the Transfer of Technology

It is generally agreed that the economic, technological and industrial state of the developing countries exert pressures for imports of capital goods from more advanced economies to develop their manufacturing industries.

In other words, developing countries have to rely on imported capital goods for industrial development.

However, the problem related to the imports of goods is to know whether the economy will be able to utilize these investments in an efficient manner to attain industrial growth.

A large amount of literature has been concerned with the analysis of this point, see in particular Singh (1975) and Stewart (1979).

Most of the analysis is theoretical and, therefore, does not allow for a clear representation of the problem of the transfer of technology.

Kim (1975) suggested two main factors that affect the use of capital goods, these are:

1 - The improvement of managerial skills and administration, and

2 - The availability of skilled workers.

These factors seem obvious. Many suggestions of this sort can be found in the literature or can be thought of. However, the problem does not lie on suggestions about how to improve the technological transfer but on how does the technological transfer operate and what are the determinant factors that hinder or promote it.

The present study is intended to investigate the determining factors and to show how different developing countries integrate the imported technology.

As was seen in the review, the transfer of technology comprises two parts, the transfer of knowledge and skills and the transfer of capital goods. One may use the terms disembodied technology to describe the knowledge that can be productively used and embodied technology to describe the use of capital goods. It is the embodied technology with which one is concerned in the present study, the disembodied technology, which cannot be quantified in order to be used in the present work, is dealt with theoretically in the review of technological transfer and also in the latter part of chapter five.

The analysis of technological transfer in the present study is mainly based on the transfer of capital goods, that are generally produced in a developed nation and bought by a developing nation. The user nation may not possess the knowledge of how the capital goods function, which leads one to suppose that the user nation may economically benefit from the embodied technology or may not use profitably these machineries.

The fact that developing countries have to rely on imported capital goods for industrial development will be used as a hypothesis in this analysis. That is, a developing country is not expected to improve its industrial growth if it does not import capital goods, which consist mainly of machinery and equipment for the production of manufacture and industry.

Taking this hypothesis along what has been mentioned in the introduction, that is, technology integration is due to the economic and social factors of the countries, it is obvious that political as well as other factors influence strongly the technological transfer, however, for lack of appropriate data, the study is limited to economic and social factors, comments on these uncovered aspects can be found in the last part of the fifth chapter, one may formulate the following relationship, which is, industrial growth is due to a combination of the imports of technology and the socio-economic state of a nation. Also from the first statement made in this section, which is that the economic, industrial and technological state of developing countries exert pressures for imports of capital goods, one could derive the following hypothesis; that is the importation of technology obviously depends on the industrial and technological state of an economy, it could also be added that importation of technology depends not only on governmental decisions and financial state of a country, but also on the socio-economic environment.

The value assumed by important variables is also dependent on the history of the economy, for instance, the growth of industrial production at year t depends not only on the imported technology of year t, but also of years t-1, t-2 etc.... As the imports of technology depend on industrial production, it could be said that it also depends on its growth, which may be expressed in the following way: if last year's growth of industrial production was important, then the industrial product would have accumulated more and, therefore, one may invest more in the transfer of technology. To explain the relationship between growth of gross industrial production and importation of technology, one needs:

1. Measurement of growth in Gross Industrial Product (GIP).
2. Measurement of Imported Technology (IT).
3. Relation between growth in Gross Industrial Product and Imported Technology.
   a) growth of GIP = f(IT$_{(\text{Lagged})}$+ Social and economic indicators).
   b) IT = f(growth of GIP$_{(\text{Lagged})}$ + social and economic indicators).

Where 3a and 3b take the form:

$$\text{growth of } (GIP)_t = a_o\,(IT)_t + a_1(IT)_{t-1}) + b_2\,(IT)_{t-2} + \ldots + f\ (\text{social and economic factors})$$

Also

$$(IT)_t = .b_o\,(\ GIP)_t + b_1(IT)_{t-1} + b_2(IT)_{t-2} + \ldots + f(\text{social and economic factors}).$$

Since both the growth of G.I.P. and I.T. are functions of the same variables, there will be identification problems if both equations are to be estimated simultaneously, it would, therefore, be better and certainly simpler to estimate the relationship between growth of G.I.P./I.T. with the social and economic variables. This ratio will express the integration of technology in developing economies and represents the influence that imported technology has on industrial growth.

The measurement of growth of G.I.P. for the period under study, which is 8 years, (1970 - 1977), is made by using a least square method presented in section 2.1.1.1. As for imported technology, it is not the growth one is concerned with, one needs to know how many imports a country has transferred for the period of 8 years on average.

The problem at hand being to identify the most important factors that hinder or promote the integration or the assimilation of technology, this leads one to consider only the growth of industrial production and the technology imported on average for the same period. The measurement of growth of G.I.P. for the period under study, which is 8 years,(1970 - 1977),is found by using a least square method presented in section 2.1.1.1. As for imported technology, one needs to know how many imports a country has transferred during that same period, so an average of imports over the 8 years is required. It will be shown in section 2.1.2 why the importation of technology is taken as a percentage of G.I.P.

In order to understand the usefulness of this index, one needs to use some representative examples. The growth of Gross Industrial Product divided by the amount of imports gives a figure which is significant in comparative analysis. For instance, if country A's industrial growth is 5% and its imports for the industrial sector are 20%, the value of the integration ratio would be .25,if for the same amount of growth, country B imports 40% for its industrial sector, the ratio would be .12.

These two figures which represent the integration of technology show that countries A and B differ very significantly in their assimilation of technology and, therefore, in their industrial performance. For country B to assimilate as good a technology as country A, it has to have an industrial growth of 10%. It is what makes this difference in integrating technology that is the major issue in this study.

A table comprising the industrial growth, imports of technology as a percentage of Gross Industrial Product and the ratio of technology integration for the 45 countries analysed, is provided to allow the reader to get a grasp of the utility of the ratio of technological integration, see table in Appendix 3 which also contains GIP as a percentage of GDP.

The technology integration ratio appears negative for some countries, these countries are known to have political problems at the period of investigation. It is decided to replace these negative values by a zero,to show that there was no technology integration, as a negative value would not be suitable for the analysis.

It was stated that the present analysis concentrates on the industrial sector only, this is because most of the technology transferred is based on industrial machinery and equipment which are mainly used in industry. Also, this sector represents the predominant area where the technological transfer operates.

Following the hypothesis under which the index of measurement for the transfer of technology performs, a careful examination of the developing countries under study is undertaken. This necessitates the exclusion of those countries that have a comparatively developed industrial sector, such as Brazil and India among others, as will be seen in the section of the countries selection. This measure is not appropriate for this group of countries as they do not depend heavily on imports of technology for their development as others. Also, those countries that hardly have an industrial sector are excluded as they are not so much dependent on technology transfer, these countries live on tourism and agriculture and have a small population (under 1 million) in general. To conform to the hypothesis, rich oil countries are also excluded as their dependence on technology has different forms in the sense that they have enough resources to finance their economy.

Let one first discuss the period over which this study has taken place, before the Gross Industrial Product and imports of technology are defined and calculated.

The period over which this study takes place is eight years from 1970 to 1977. This is due to the data available, also it was intended to analyse the transfer over a period of time as it is difficult to see whether any assimilation of technology has taken place during one year only.

2.1.1. The Gross Industrial Product

As one is concerned with industrial economic growth in this section, an attempt to discuss some theories of economic growth is made in order to see the importance of using this measure of growth in relation to the investments in machinery and equipment.

The economy of a country is characterized by the production of an annual flow of goods and services by firms and enterprises through the combination of land, capital and labour.

Capital consists of those aids to production which have been made by man ex : machinery, equipment and roads. Labour consists of human resources which are partly mental and partly physical, and production is the process of making goods and services which are measured by the Gross Domestic Product (GDP).

The economic growth, or growth of GDP is characterized by the process in which the productive capacity of the different economic sectors is increased over time to raise the income, Todaro (1981).

That is, the growth of domestic product is quantitatively dependent on physical relationships between inputs and outputs, which is due to many causes. Among these are increased flows of labour and capital inputs to the production processes, improvements in their productive quality, advances in the techniques and organization of production and marketing.

This is purely a mechanistic approach to the phenomenon of economic growth. It may indicate what has happened, but not why it happened and consequently be of limited predictive value to the planners of economic development.

Economic analysis has conventionally conceived growth of the gross domestic product as being fundamentally explained either

1) by additions to the stocks of physical assets and human resources or
2) by improvements in the productive quality of these stocks. Elkan (1973) and Meier (1970).

The contribution to domestic production of additional resources is dependent on the available technologies whereas the second possibility, raising the quality of productive resources may be of greater importance as a source of economic growth rather than merely increasing the stocks of resources, what is called replicative capital accumulation, Rosenberg (1971).

However, if any growth existed in a developing country, it would be more likely that it is due to the first factor, that is by addition to the stocks, Myint (1980) as well as Samir Amin (1974) among others demonstrated that economic growth in the third world accords a foremost priority among resource requirements to physical or financial capital.

This view is derived from an explanation of economic growth where the rate of growth of aggregate output depends on the proportion of a country's annual output which is saved (the saving-output ratio) or allocated to uses conventionally classified as investment or capital formation.

The basic notion for accelerated economic growth follows from the process of more saving and investment and less consumption. Thus Lewis (1970) shows how saving is the central problem in the theory of economic growth.

Shultz (1961) resuscitated the notion of human 'capital' as an explanation of economic progress. Following these findings, planned investments in human capital have provided new areas of specialist activity in manpower and educational planning.

So far, a brief review of economic growth has been attempted, emphasizing the concept that economic growth of developing countries is mainly due to the addition of physical capital rather than technological progress which is the case for developed economies.

Many developing countries do invest in capital goods, yet for a major part of these economies, investment in these machineries and equipments does not necessarily promote capital formation, and therefore economic growth, this seems to contradict the classical analysis of economic growth. See table in appendix 3 where many countries which seem to allocate a large proportion of their industrial product to investment in capital goods, have in fact a very low industrial growth.

As will be seen later, emphasis is increasingly made on the socio-economic and political factors of the developing economies, as being the main causes of economic development and hence of technology integration.

It should therefore be emphasized that theories of development economics have been misleading in these major aspects, which are the essence of economic operations, and which should be taken more seriously into the analysis of development economics, if awareness of the realistic problems concerned with technology, its uses and the benefits that can be derived from are of interest.

Let one describe how the calculations of the gross industrial product growth over the period 1970 - 1977 are found.

2.1.1.1 Data and Calculations of Gross Industrial Product.

As described in the world bank tables (1980a) (from where data for the whole analyses were obtained), gross industrial product represents a measure of the output of the following branches:

- mining
- manufacturing
- construction
- electricity - gas and water
- transport and communications which include roads, inland and coastal waterways, sea and air transport, including the construction and maintenance of air-

ports, and government support for operating the railways.

A computer program, based on a method given by the world bank (1980a,p6)was written in order to obtain the growth of gross industrial product. Values for each of the five branches for each year from 1970 to 1977 were computed, the method of least squares regressing the annual values of the variables using the following logarithmic form was used:

$$\log X_t = a + bt + e_t$$

where X_t is the value of variable X (which is gross industrial product) in year t, t is the time measured in years, a and b are the coefficients, and e is the error term. The average annual growth of X is $\{\text{antilog } b\}$ - 1, see Appendix 2.1.1 for the computer program.

Singh (1975) argues that the volume of machinery exports to developing countries in quantitative terms rose from $8 billion in 1960 to $19 billion in 1970, constituting 33.4 percent of all imports by the developing countries in 1970, this is constantly rising.

The increasing rate of demand for capital goods, according to Singh, reflects a stagnation in industrial development. Since during the early and intermediate stages of industrialization, the demand for capital goods usually rises rapidly, tends to stabilize and even declines when the home capital goods production competes in international markets.

This industrial stagnation forces increased dependence on technology,however;the continuing dependence on capital goods imports has significant technological, socio-economic and political implications as was demonstrated in the second chapter.

Having briefly discussed the increasing demand for technological transfer, the next task is to attempt to quantify the technology transferred. It is necessary to stipulate that the amount of technology transferred as such cannot be used for a comparative study, as the countries considered differ in size, in economy, etc.., therefore, the imported technology is computed as a percentage of the gross industrial product, so that only that proportion of technology imported for the industrial sector is considered and is used as a fraction of the industrial product, that is, instead of saying country X imported a certain amount and country Y imported a certain amount of technology in money terms, one says country X imported 10 percent of its gross industrial product, and country Y imported 15 percent of its gross industrial product, this notion of proportion allows for a comparative analysis, whereas the first notion does not make any sense, as one million dollars for example means different things to different countries, it could mean a high proportion for one country and a low proportion of imports for another.

2.1.2 The Imported Technology

The machinery and equipment needed for the production of certain goods is not available in the developing countries, and therefore needs to be transferred or imported from the more developed countries. The capital goods which have to be imported comprise generally two categories:

- mechanical equipment, including transport
- and electrical equipment.

These are discussed in the second chapter when it was shown that the increased tempo of industrialization creates an acceleration in demand for capital goods. However, it would be useful at this stage, to highlight some of the significant trends and implications of such increased demands and consequent increases in imports of machinery and equipment. This emphasis would stress the importance of the hypothesis already outlined for the model, which is developing countries are dependent on the technology transferred for their development and more specifically, for their industrial development.

The data concerned with the imported technology are given and defined by the source of data stated above.

At a first stage, the data is presented then the calculations to obtain the imported technology as a percentage of GIP are made.

2.1.2.1 Data on Imported Technology

1) Imports of machinery and equipment as a percen-

tage of merchandise imports, They include machinery and transport equipment.

2)Merchandise imports, they constitute a component of imports of goods and non-factor services, it is the market value of movable goods the ownership of which changes from a foreigner to a resident.

3)Exports of goods and non factor services,* it comprises the value of goods and non factor services sold to the rest of the world. Included as goods and non factor services are merchandise transport, travel, insurance and other non factor services.

4)Exports of goods and non factor services as a percentage of GDP.

2.1.2.2. Calculations of IT as Percentage of GIP

As data on the variable imported technology as a percentage of GIP is not provided in the data source, some calculations were required, it should be mentioned that the calculations of this variable are subject to the data availability in the data source used and that the person interested in the calculations involved should consult the data source (World Bank 1980a) as it will provide an immediate

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*In order to relate the imported technology to the gross industrial product, this variable is used as it is provided as a percentage of GDP and could be obtained as a percentage of GIP.

understanding of the steps involved. On the other hand, the person interested by the proposed measure of technological transfer may have different source of data which will have to be manipulated otherwise to reach the desired variables. Overall, the calculations of the variables basically depend on how the data is structured, what is provided in values or percentages, and how the available data could be related in order to reach the desired measures. For the present case, the steps followed were:

$$\frac{IT}{GIP} \times 100 = \frac{IT}{MI} \times \frac{MI}{EG} \times \frac{EG}{GIP} \times 100$$

where IT represents the Imported Technology,

GIP the Gross Industrial Product,

MI the Merchandise Imports,

EG the Exports of Goods

and where $\frac{EG}{GIP}$ was obtained by dividing EG as a percentage of GDP by GIP as a percentage of GDP.

The following procedure shows how the ratios above were calculated.

1) Imports of machinery as a percentage of total merchandise imports. The data on this variable was only available for the years 1970 and 1977 and not for each year from 1970 to 1977 as would have been preferred. An average of the two years is calculated. This value represents the imports of machinery as a percentage of total merchandise imports for the period 1970 - 1977.

2)Merchandise imports, and

3)Exports of goods and N.F.S.* will serve as a numerator and denonominator respectively in order to get the merchandise imports as a percentage of exports of goods and N.F.S.

For both these variables, data was provided for every year from 1970 to 1977 (with the exception of few cases where the ratio had to be calculated for the number of years given). The ratio of merchandise imports over exports of goods was calculated by summing the values of the eight years in both numerator and denominator, and multiplied by 100.

4)Gross industrial product as a percentage of GDP. A value for each of the five industrial branches presented above is given as a percentage of GDP at factor cost for the period 1970 to 1977.

In order to get GIP as a percentage of GDP, the five percentages were added and divided by the GDP at market price for the same period.

This division was required, because, as will be seen in the next point, the exports of goods and non factor services are given as a percentage of GDP at market price, and the previous five values of the industrial sector were given as a percentage of GDP at factor cost.

5)Exports of goods as a percentage of GDP (at current market price) having calculated the GIP as a

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*The use of the variable exports of goods as a denominator is arbitrary, one could have used instead the imports of goods (as they are also provided as a percentage of GDP and could be obtained as a percentage of GIP), which leads to the same results.

percentage of GDP at current market price. One needs to divide the value of the exports of goods which is given for the period 1970-77 by the GIP as a percentage of GDP. This gives the exports of goods as a percentage of GIP.

6) The final step which is the calculation of IT as a percentage of GIP consists of the multiplication of the three variables that have been calculated above which are:

- Imports of machinery as a percentage of total merchandise imports.
- Merchandise imports as a percentage of exports of goods and
- Exports of goods as a percentage of gross industrial product

2.2 Relationships between GIP and IT as a percentage of GIP

It is important to note the relationships between these two variables which constitute respectively the numerator and denominator of the ratio used as the integration of technology.

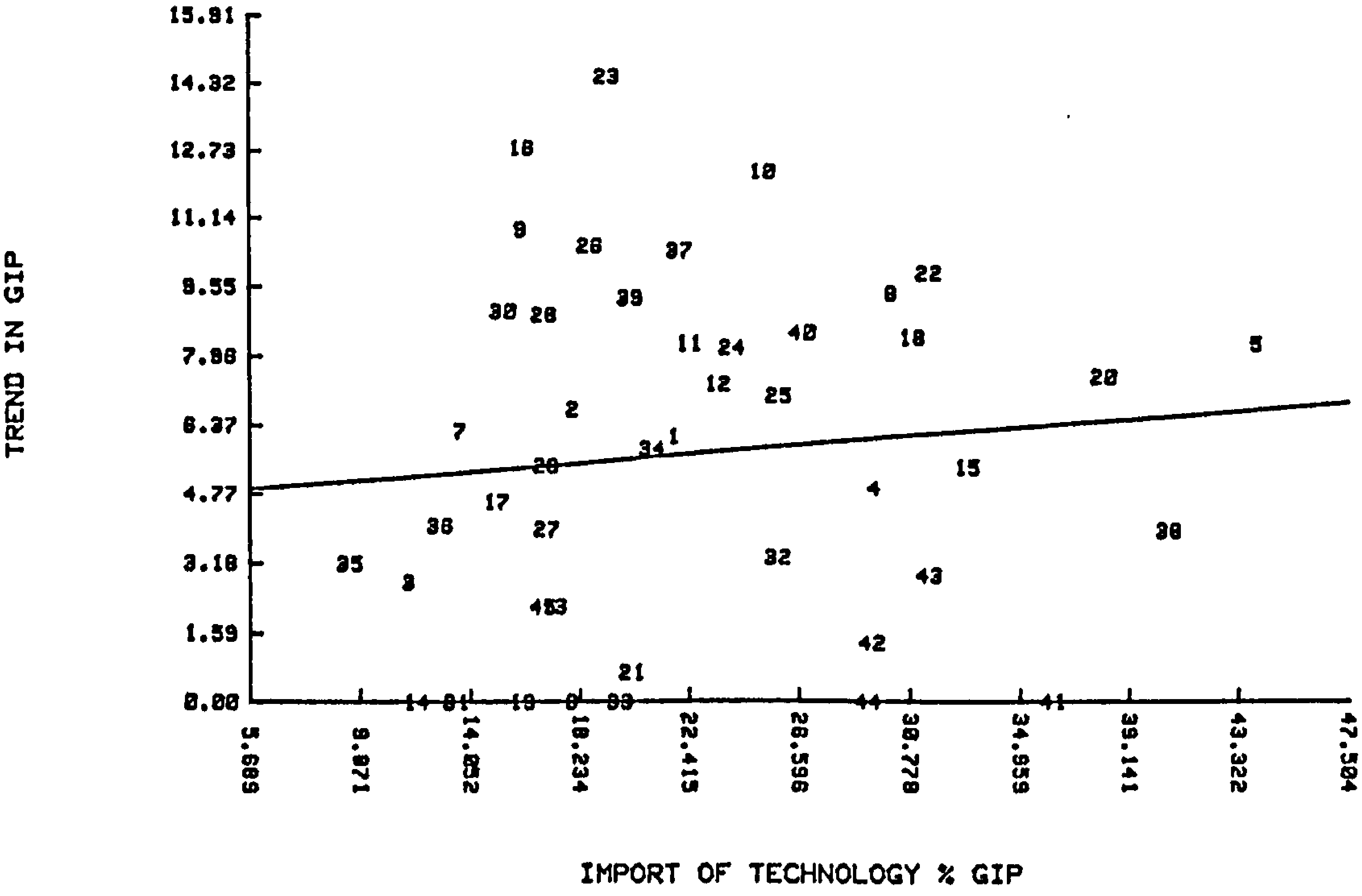
For this purpose, a correlation analysis of the two variables was attempted. A discussion on the technique of correlation analysis is discussed in the second part of this chapter, its main objective is the measure of the degree of association existing between the variables.

The value of r, the coefficient of correlation is

FIGURE 3.1

COMPONENTS OF THE RATIO

CORRELATION COEFFICIENT .10



.10, that is there is only 10 percent association between the two variables giving a value of .01 percent for r^2. The t test, which will be discussed in the second part of this chapter, was applied with 43 degrees of freedom. A correlation coefficient of at least ($r = .33$) would show a significant correlation at the 5 percent level. See fig. 3.1.

This correlation shows that there is a very weak relationship between the imports of technology for the industrial sector and its economic growth. Which seems quite realistic when one looks at the review on the transfer of technology and to the economy of most developing countries.

Having noted that imported technology and industrial growth are not related for the majority of the cases, then one may wonder about the factors which affect industrial growth and therefore technology integration.

The present study is aimed at exploring those factors which are most predominant in this integration of the technological transfer. Once the indicators are identified the economists and policy makers will be able to:

- draw attention to those industrial products that need particular improved technology.
- predict the present as well as future amount of integrated technology for one or many countries.
- it can generally make the planners, economists, researchers and politicians aware of the industrial strengths and weaknesses of a particular nation.

2.3 Selection of Indicators

The choice of the variables in the analysis is based on the fact that technological transfer operates within a socio-economic and political environment. It is nonetheless obvious that the political environment as well as other known or unknown qualitative aspects cannot be considered in the present analysis which is based on purely quantitative measures.

Some relevant variables to this study have been found in the united nations statistical year book (1977) but the presentation of data is so badly presented that they could not be included. For example one may have data of one variable for one or two years for one country, and one or two different years for another, some data exist for some countries but not for all, the sample of countries on which data is available is very small. These variables are: number of scientists, engineers and technologists, scientists and engineers engaged in research, expenditure for research and development per capita, newspapers per thousands, cinema seats per thousands etc.

It is also regrettable that data on valuable indicators such as rate of output per man-hour of labour, use of mechanical power, use of irrigation and fertilizer, administrative organization and efficiency, education and skills in terms of professional and technical personnel as well as many other indicators directly related to technological progress, cannot be found. It is worth mentioning that even the advanced countries which are making unprecedented effort on data collection have not got most of the data mentioned above! Baster (1972 ,p16) The existence of such data would, in principle, improve the quality of information, and thus of analysis and decisions. This study therefore considers the socio-economic environment alone. Many theoretical analyses covering the political aspects of developing countries have been attempted, see Braibanti and Spengler (1961) and Pesmazoglou (1977).

The number of indicators employed in the present study is as large as possible so as to give as accurate an economic and social profile of the countries as possible. These variables will be entered in a multiple regression function, where the ratio of technology integration represents the dependent variable and the entered variables represent the independent variables, the best set of variates indicating statistical significance is retained as the determinant indicators of the technology integration.

The notion of dependence of the technology integration on the social and economic variables shows that the former tends to increase or decrease according to the latter variables, that is, these indicators explain the assimilation of technology transferred.

2.3.1 Previous Analyses on Economic and Social Indicators

It is intended in this section, to define what is meant by indicator and to present a brief review on the use of social and economic variables. It should be mentioned that these economic and social variables are used as indicators of economic development, mainly, as an analogy between technological transfer and economic development is made clear in both this study and the extensive review of the technological transfer. One could conclude that economic and social variables are both indicators of economic growth and technological integration. The originality of this work is that, for the first time a conceptual and straightforward approach is made to the analysis of the technological transfer. It is not only capable to provide the realistic environment of the transfer of technology, which is made clear by the review, but also to provide statistical foundations to show the exploratory abilities as well as the validity of the approach.

An indicator represents some aspect of development such as health, equality, and industrialization. It may be a direct measure of an economic or social variable in the sense that gross national product, for example, measures the output of goods and services, or, more often, an indirect measure of some non-measurable phenomenon. Most of the commonly accepted indicators of levels of living, for instance, are indirect measures of different aspects of welfare. However, opinions differ as to the boundaries of indicators. Drewnowski (1966) argues that indicators should be limited to observable and measurable phenomenon, whereas Adelman and Morris (1967) approach the measurement of institutional phenomena in a more flexible way, an example of one of the indicators they use is political participation.

When an economic and social variable is used as an indicator, it is not an indicator of itself, and it is not an operational definition of what it points to. McGranahan (1972) gives the following example; the temperature given by use of a thermometer is not an indicator of body temperature, it defines body temperature, but is actually an indicator of sickness. Similarly, mortality rate does not simply indicate relative numbers of deaths but may indicate public health levels. The school enrolment ratio is a measure of the amount of school enrolment but it may be used as an indicator of the educational levels of a country. Overall, economic and social indicators are not simply statistics, and statistics are not ipso facto indicators, unless some theory or assumption makes the relation between the measure provided by the variables and the phenomenon which it could indicate. This is at least the argument in borderline.

Indicators may be disaggregated, composite or representative. In the first case, a phenomenon is broken down into a number of components, and indicators are selected to represent these different elements, in the second case a single indicator is constructed by combining a number of indices. In the third case, a representative indicator is selected as a measure of a particular phenomenon on the basis of some criteria such as high correlation with other indicators of the same phenomenon etc. In all these cases the validation of the indicator depends on its accuracy, reliability, and on the consistency of its relation to other indicators.

The uses of indicators are needed for a number of different purposes. They may be used to describe trends and to diagnose a particular situation, they may be used for prediction, and they may be used for planning, both for measuring targets and objectives , Baster (1972).

The specification of the model in which indicators are used can be approached in two ways. One may start from existing collections of data and look for systematic relations between the variables or start with some analytical model in mind, before proceeding to the selection of indicators and the collection of data. Both methods are not unrelated, as they somehow try to identify relationships that can be put into practice.

An increasing amount of effort is being put into the collection of statistical data both at the national and international level. Data of cross-national data and time series going back over a hundred years are being collected by universities and research institutions. Official government series have tended to concentrate on demographic data as well as economic series on trade, production and consumption; information concerning public sectors where government has administrative responsibility are being increasingly recognised as important data, these sectors are: transport, education, housing and health.

For the developed economies, at least, data on political series and social indicators are made. It can be said that at an international level, there is an accumulating wealth of statistical data throwing light on economic, demographic, and to a lesser extent, on social and political indicators. However, in the majority of the less-developed countries, statistical information systems are still in their infancy.

The review mainly consists of a controversial analysis between economic and social indicators, it shows on which areas the policies usually concentrate for development. Some agree that GNP per head is an adequate measure, others argue that emphasis should be put on social indicators.

2.3.1.1 Analysis of Economic Indicators

Since economists have tackled the problem of development of the less developed countries, the principal means for measurements of economic development have been the Gross National Product, its components and their growth.

The national accounts have continued to be the main focus of discussion of growth despite the many problems with national accounting of developing countries, and the GNP per head is widely accepted as the best single indicator of development, both historically and for international comparisons.

The use of national accounting was influenced by Keynesian economics at the time when increasing attention was paid to the developing countries, however, the growth rate of GNP is shown to be a misleading indicator of development in itself by Ahluwalia and Chenery (1974), since it represents mainly the income shares of the rich.

In the next paragraph, emphasis on social variables as economic development indicators, and therefore as adequate means of economic measurement is made.

2.3.1.2 Analysis of Social Indicators

Having seen that economic variables and specifically the growth of GNP per head are the main measurements of development efforts in developing countries, it would be useful to stress, that increasingly development economists have become aware that the growth of income per head or the growth of output are most adequate indicators by themselves.

There has been a growing interest to stress the importance of social indicators as complementary measures of development.

Streeten (1979), in a paper on basic needs emphasizes the need to enquire into the social variables of a developing country, this allows for factors such as poverty and income distribution to be taken into account in economic decisions.

This emphasizes and explains the need for the author to include social indicators in the analysis of the technological transfer. When one deals with the analysis of social indicators, it should be kept in mind that they are constantly made in relation to the technology integration, for example, when one draws on the economics of development and their relations to social aspects, he should concentrate on the fact that economic decisions are made mainly upon economic aspects such as gross national product etc.. and that increasingly, at least one may hope emphasis is made on social aspects as well, it is therefore interesting to see the relevance of social indicators in economic analysis so that when a social indicator is found to explain technology integration, it is immediately related to economic policy and government decisions.

Early thinking on development economics concentrated mainly on purely economic factors, This ideology had controversial issues from what the experience has shown, which makes emphasis on economic indicators still dominating at least for the low income countries, Leipziger and Lewis (1980) show that at lower levels of per capita income, emphasis on growth is necessary for economic development and therefore for progress in basic needs indicators.

These findings appear consistent with the 'Kuznets hypothesis', which shows that income distribution worsens at early stages of growth to improve at later stages, Kuznets (1963), Hicks and Streeten (1979) argue that if concentration is not made on distribution of income, the unequal growth would persist and would be more difficult to alleviate. This view is consistent with the observation of Ahluwalia, Carter and Chenery (1979) who state that in the middle-income countries which tend to have more rapid growth and less equal distributions, emphasis on improved distribution is often more effective in reducing poverty than is accelerated growth.

It is also increasingly recognised that early theories concentrating on huge industrial projects and on economic aspects alone cause social tensions, and therefore slower growth and slower technological advance, and that concern with meeting basic needs such as nutrition, education, health and shelter would improve social conditions and therefore promote economic growth.

The new focus on meeting basic needs requires a set of indicators able to measure deprivation so that the policies can be directed to its alleviation.

A great deal of work has been undertaken by international agencies to compile a set of social indicators, among them the united nations (1977) and the world bank (1980a).

Streeten and Hicks (1979) show certain advantages of the social indicators.

a) first they are concerned with ends as well as means, since they measure the state of the society for example variables such as population per physician or school enrolment rates attempt to capture the inputs that are nearer to the results desired than GNP per head.

b) secondly, social indicators can show more about distribution that GNP per capita does. An increase in literacy reflects also a distributional improvement.

c) thirdly, social indicators are capable of catching the state of the human, social and cultural costs such as diseases, accidents and poverty. In particular, they can register some of the shared global problems such as cultural dependence and pollution.

d) and fourthly, it is widely believed that social indicators present more rigour in inter-country analysis.

With the advantages outlined above, social indicators can reduce the false impression that may be created by pure economic indicators.

It is also mentioned that:

1) Measures such as literacy, access to clean water and primary school enrolment can be used to indicate the percentage of the population having basic needs deficiencies.

2) Measures such as life expectancy, infant mortality and average calorie consumption are less informative of distribution but indicate the degree to

which basic needs have been fulfilled.

3) Measures such as health, education and nutrition are valued in their own right, and also as being the main causes of raising the productivity of the workers.
4) Measures such as doctors or hospital beds per 1000 or enrolment rate in schools may reflect government intentions and efforts to provide public services.

2.3.2 Relationships between Economic and Social Indicators

Because of the importance of the use of social indicators in the present work, it is useful to indicate through past studies the enormous role social indicators play in economic analysis. It is intended to first indicate the relationships between GNP and social indicators in some studies, then to confirm the findings of these studies with the more updated present analysis.

As will be seen later, the results of the present work not only stress the previous findings but also show a coherence of the collection of data and therefore of the analysis as a whole.

Several studies and in particular McGrahanam et al (1972), the united nations (1975) have found high correlation between economic and social indicators. Larson and Wilford (1979) as well as Hicks and Streeten (1979) found non linear relationships between per capita GNP and life expectancy at birth and adult literacy rate.

The correlation analysis undertaken in the present analysis shows the same pattern of correlation found in the cited studies.

The sample consists of 45 developing countries as will be shown later in the sample selection, and the correlation coefficient r^2 is equal to .47 on average for life expectancy and access to water rate with GNP per capita. See figure 3.2, figure 3.3 also figure 3.4, figure 3.5, figure 3.6, and figure 3.7.

It should also be emphasized that the plots of the actual and more updated present analysis (1970-77) follow the same non-linear relationships described by Hicks and Streeten, and Larson and Wilford.

Some illustrative figures comprising correlation between social indicators and GNP per capita, between GNP per capita and other economic indicators, and between social indicators are presented, generally high correlations are recorded between economic indicators and between social indicators.

It is intended to demonstrate the perfect linear correlations between economic indicators and the non-linear relationships existing between social indicators and the main economic indicator. It is also aimed at supporting the logic of statistical analysis, hence allowing for an accurate model of the technological transfer.

Figure 3.2 GNP PER CAPITA AND LIFE EXPECTANCY

CORRELATION COEFFICIENT .63

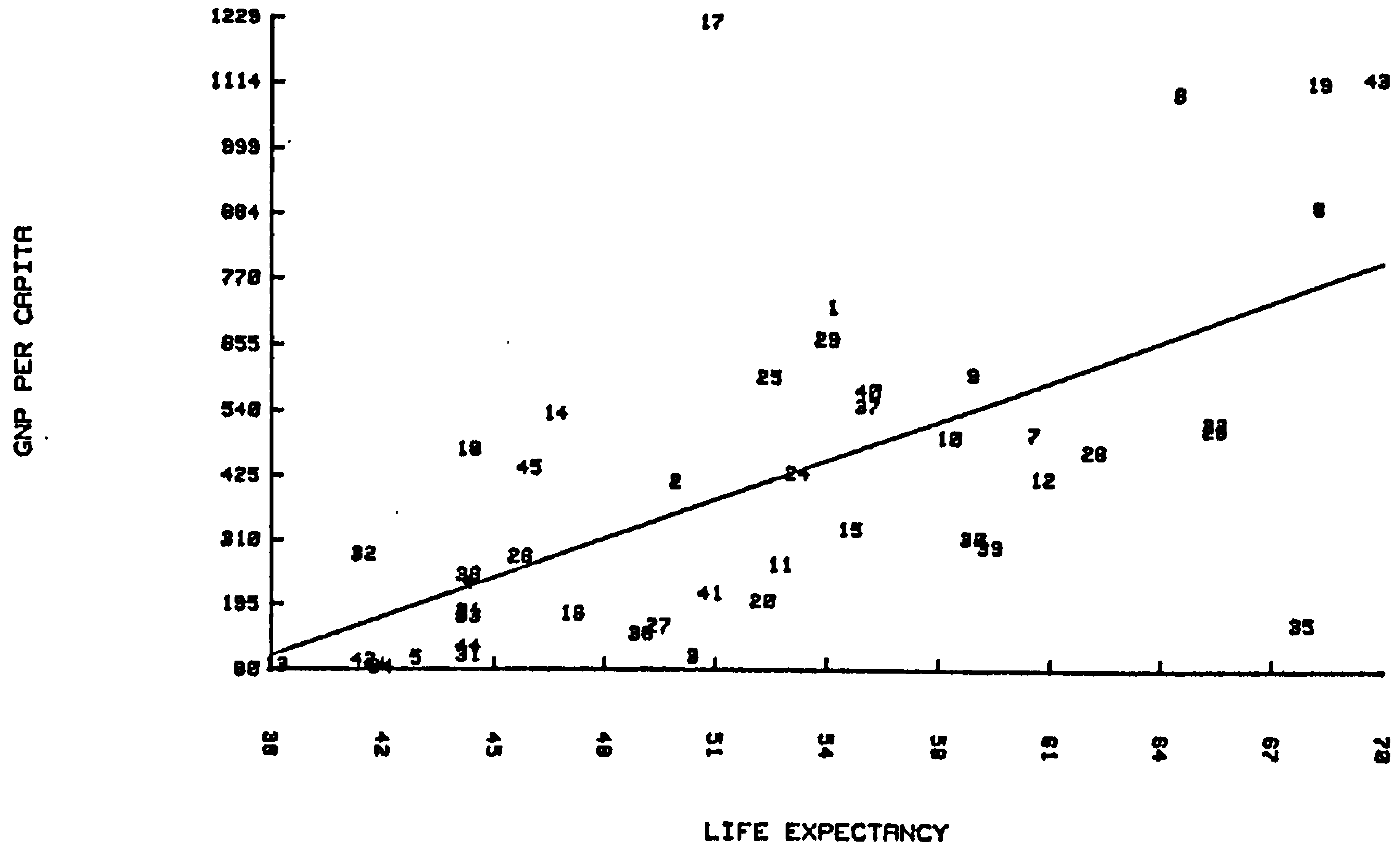


Figure 3.4 ACCESS TO WATER % POP. AND DEATH RATE

CORRELATION COEFFICIENT -.57

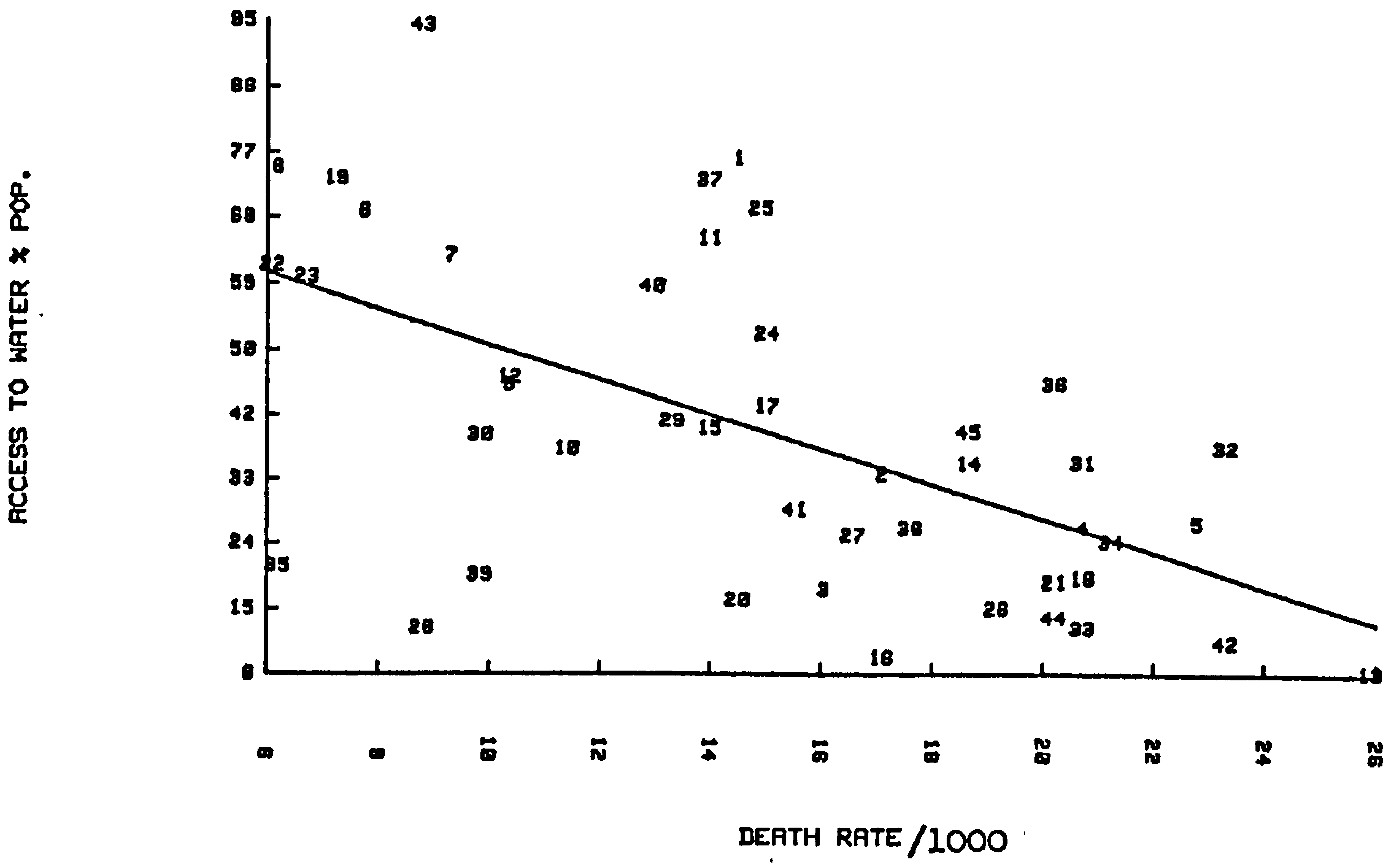


Figure 3.4 GNP PER CAPITA AND ENERGY CONS. PER CAPITA

CORRELATION COEFFICIENT .91

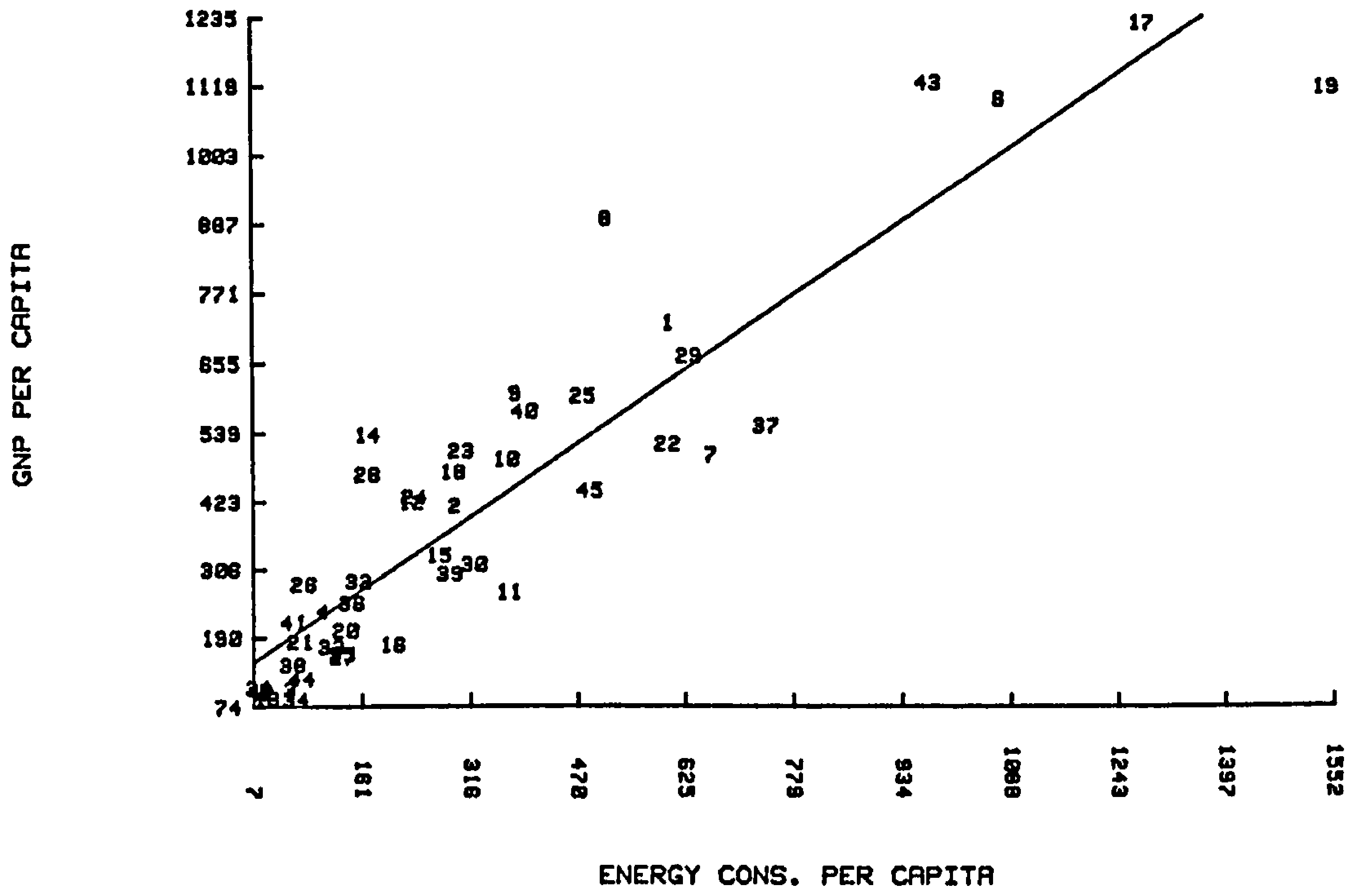
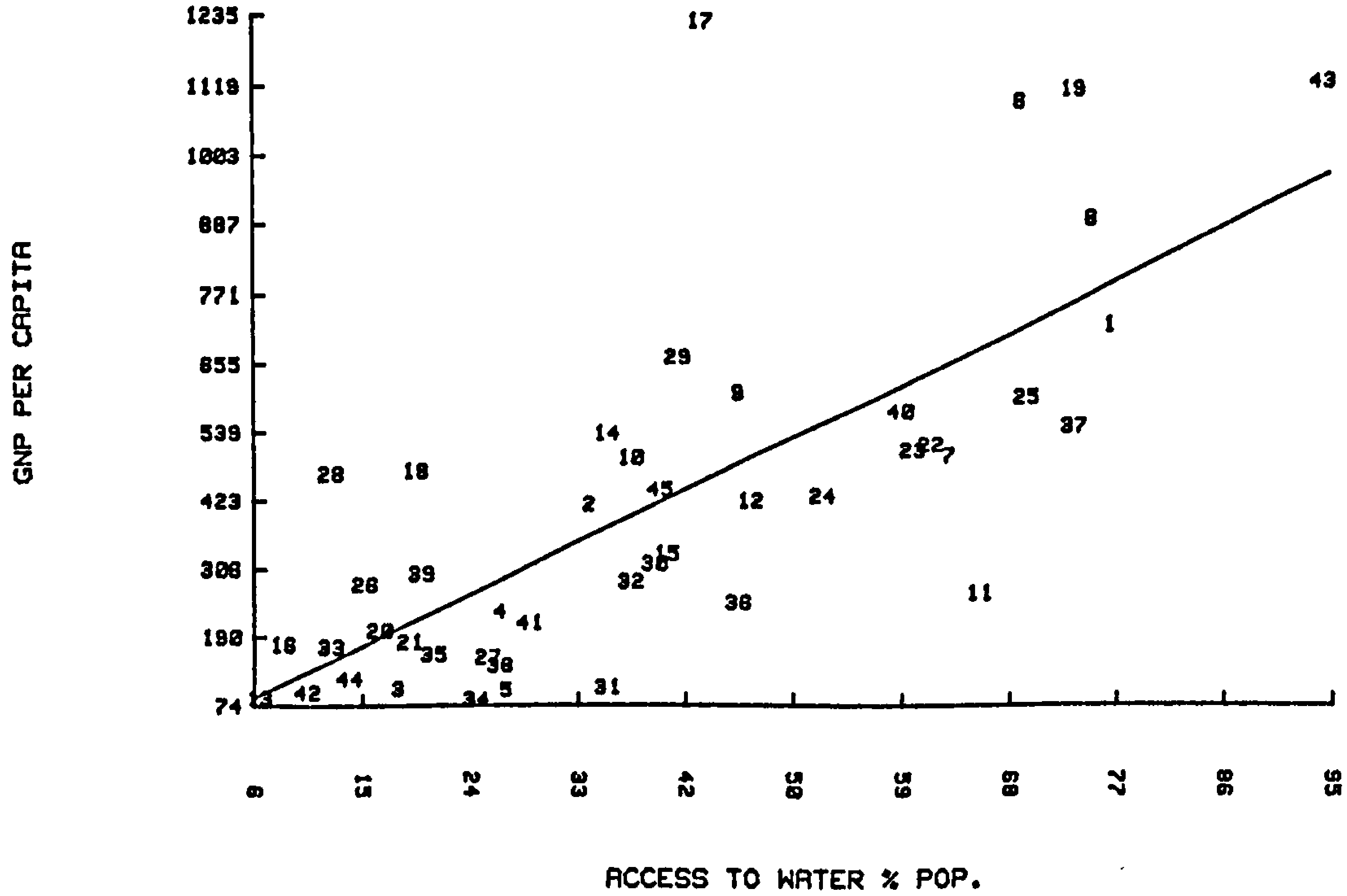


Figure 3.5 GNP PER CAPITA AND ACCESS TO WATER % POP.

CORRELATION COEFFICIENT .74



2.4 The Variables Selection

2.4.1 Introduction

Having stressed the relevance of economic and social indicators for the present analysis, it is now intended to describe the variables included in the model.

The number of variables is 30, it is aimed at producing through the use of multiple regression a linear model. This will be the subject of the next section, a reasonable number of variables to indicate the most important areas where the technological transfer operates.

The data source already mentioned is the world bank (1980a) which provides the most recent available data to date.

The variable education expenditure as a percentage of gross domestic product was not fully provided by this source, and was complemented with data from the United Nations Statistical Yearbook (1977)

As the study takes place over a period of eight years, from 1970 to 1977, and as the data on variables is provided only for 1970 and 1977, an average of the two years is taken in order to get the value of the variable considered for the period (1970-77).

For some countries data on some variables were only available for one of these two years 1970 or 1977, in which case, the value was used to represent the value of the whole period.

For some other countries, data on some variables were not available at all, in this case, among the five methods to estimate missing values, regression method was used, as it is best suited to the study ,see BMDP Computer Programs (1979, p353).

The total number of missing values is 15. There are 10 countries with missing values for different variables.

Some of the variables included in the model are not subject to the world bank's classification, as will be seen in the next paragraph. They were calculated from data of the same source. These additional variables which are mainly macroeconomic are classified with the other variables according to their nature, some calculations are executed by computer and are described. These variables are:

- Gross National Product
- Gross Industrial Product
- Gross National Saving as percentage of GDP
- GIP as a percentage of GDP
- Education expenditure as a percentage of GDP
- Population

2.4.2 Classification of the Variables Included in the Model.

The variables are defined and classified by the world bank. They fall into two groups, economic and social.

This classification gives a vague representation of the variables. It is intended in the next chapter, to group the variables in a more representative number of categories. This is achieved by the statistical use of factor analysis technique.

It is useful to mention at this stage that the objective of classifying the variables under a certain number of categories helps identifying the association between variables. A list of variables can be found in appendix 5.

2.4.2.1 Economic Indicators

Many variables are taken as a percentage of GDP when necessary. This is because they would not allow for a comparative study otherwise. If, for instance, the variable is education expenditure or gross national investment, its interpretation for cross-section analysis is meaningless as it does not represent the proportion corresponding to the economy but merely a value.

Variables such as GNP and population are used in values. This allows to compare between the size of different economies.

The economic variables included are:

1) Gross National Product in $: This is the measure of total domestic and foreign output claimed by the residents of a country. The value has been converted from the national currency into average 1970-77 U.S. dollars. Two stages were involved for the calculation of GNP in $ to cover the period of the study.

i) GNP at current market price had to be added for each of the eight years from 1970-1977.

ii) Then it was divided by the foreign exchange rate in dollars for the eight years.

2) Gross National Product per capita in $: This value constitutes the annual income for each person, and is thus calculated by dividing the GNP in $ by the mean of population for the eight years.

3) Gross Industrial Product in $: This value was calculated in the same manner as the GNP in $ with the difference that only the five industrial branches, already mentioned, were taken.

4) Gross Industrial Product (GIP) as a percentage of GDP. A value of each branch of the industrial sector is given as a percentage of GDP at current factor cost. It had to be divided by GDP at current market price, as the whole analysis is based on current market price values..

5) Gross Domestic Investment (GDI) as a percentage of GDP or Gross domestic capital formation,: it measures the expenditures for the addition of reproducible capital goods to the fixed assets of all the enterprises, private and public and to the government. This category contains all new items produced domestically or purchased from abroad, it also covers expenditures on the improvement of durable goods, purchased land and used equipment, the government outlays for construction and durable goods for military purposes are excluded. This figure is given for the period 1970-77.

6) Gross National Saving (GNS) percentage of GDP: This measure represents the amount of Gross domestic capital formation financed from national output. It is equal to the Gross Domestic Investment plus the net export and services. A value of Gross National Saving as a percentage of Gross Domestic Investment for the period 1970-77, it had to be multiplied by the GDI as a percentage of GDP to get GNS as a percentage of GDP.

7) Education Expenditure as a percentage of GDP: It comprises the management and support of pre-primary, primary, secondary schools and universities and colleges. The expenditure on the general administration, on the regulation of the education system, on research and organisation are included. For many countries, figures were only available for some of the eight years. The values available for the number of years of each country were

divided by the values of GDP at market price for the same number of years, this is in order to find the average value of education expenditure for the period.

8) Industrial Production as a percentage of GDP: This production constitutes the output of the industrial sector which includes mining, construction and public utilities (electricity, gas and water).

9) Production of manufacture as a percentage of GDP: This production comprises chemicals and manufactured goods.

Data for production of manufacture and other industry was combined to constitute the industrial production.

An average* of the values of the two years 1970 and 1977 was made to obtain the approximate value for the period 1970-1977.

10) Agricultural Production as a percentage of GDP: This comprises agriculture, forestry, hunting and fishing.

11) Exports of Manufactured Goods as a percentage of total merchandise exports, this comprises chemicals, manufactured goods, different manufactured articles and commodities.

12) Imports of manufactured goods as a percentage of total merchandise imports: This constitutes the imports of chemicals, manufactured goods, diverse manufactured articles and commodities.

13) Commodity Concentration: This variable is intended to indicate the degree of export specialisation, more precisely, it expresses the current value of the three major commodities in the exports of a country as a percentage of the total current value of merchandise exports.

14) Food consumption per capita: This indicator expresses the net food supplies available per day at the retail level divided by population.

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*The variables that follow have the same available data.

and are calculated by averaging the data on the two years 1970 and 1977. This applies to the social indicators as well.

15) Energy consumption per capita: this variable expresses the annual consumption of commercial energy(coal and lignite, petroleum, natural gas, and hydro, nuclear and geothermal electricity) in kilogram of coal equivalent per capita.

2.4.2.2. Social Indicators.

Although a close relationship between economic and social development is widely recognised, there has been relatively little progress on international scale for the collection and analysis of social indicators, the world bank (1980, p. 13).

The variables on which data was available are:-

16)Population: the population figures which are midyear estimates are added up over the period of eight years, then divided by the number of years.

17) Population density per square kilometer of total land.

18) Urban population as a percentage of total population.

19) Urban population growth rate: this variable is usually defined as the growth of inhabitants of city and towns.

20) Birth rate per thousand: this value represents the number of live births in a year per thousand of midyear population.

21) Death rate per thousand represents the number of deaths

in a year per thousand of midyear population.

22) Life expectancy at birth: this represents the average number of years of life to a newborn child at the time of birth.

23) Population per physician is the total population divided by the number of practicing physicians qualified at university level.

24) Access to water expresses the percentage of total population who have reasonable access to a safe water supply.

25) Adjusted school enrolment ratio comprises the enrolment of all ages in secondary schools as a percentage of the population of secondary school age.

26) Adult literacy rate comprises the number of adults with the ability to read and write expressed as a percentage of the total adult population.

27) Labour force in Agriculture represents the labour force for agricultural activities, including farming, forestry, hunting and fishing as a percentage of the total labour force.

28) Labour force in Industry expresses the number of labour force for industrial activities, including mining, and quarrying, manufacturing, construction, and public utilities (electricity, gas, water and sanitary services).

29) Radio receivers per thousand expresses the number of all types of receivers for radio broadcasts to the general public per thousand of the population.

30) Passenger cars per thousand represents the number of motor cars seating less than eight persons per thousand population.

2.5. The Sample Selection.

In order to obtain a representative model for the population of developing countries as a whole, the aim is to introduce as many developing countries as possible into the analysis.

However some categories of countries have not been included, the reasons given below show their antagonism with the underlined hypothesis.

2.5.1. Countries not included in the Analysis.

1) Oil Exporting Countries.

These countries are characterised by huge surpluses that can finance not only the imports of capital goods and consumer goods but also the imports of manpower required.

Oil production represents the most dominant part in these economies, a good and representative table about sectoral contribution to the economy can be found in Khouja and Sadler (1979, p.87).

Then high dependence on foreign trade and their wealth make their transfer process different from the other developing countries.

According to their GNP per capita, they have been divided into two groups, see world bank Atlas (1980), also world development report (1981).

i) Countries with a GNP/capita between $3,000 and $6999 are Bahrein,and Saudi Arabia.

ii) Those with a GNP/capita of $7000 and over are Kuwait, Libya, Qatar and the United Arab Emirats.

2) Developing countries possessing a comparatively more developed industrial sector.

These countries are characterised by the fact that they produce part of their own machinery and equipment.

They are not so dependent on foreign technology as are most of the other developing countries.

One can recall The Times quoting on the 18th October 1973, p 1, "Like a sleeping giant Brazil is awakening to a period of industrial expansion and development almost unparalleled among countries of the third world."

Within a few years of manufacture, some of these countries competed in international markets by producing and exporting a number of sophisticated machinery products. Singh (1975).

Significant examples are the export of complete cement plants, heavy electrical equipment and boilers from India to other Asian countries. Machine tools and heavy equipment exports from Brazil to other Latin American countries; Flour Milling equipment from Mexico and certain categories of electronic machinery and components from Taiwan, Republic of Korea and Hong Kong to various countries. For more detail see Bhagwatiand Cheh (1972), Frank et al (1975).

These countries are, among others, India, Brazil, Mexico, Argentina, Korea (Republic of), Taiwan and Singapore.

3) Centrally Planned Economies.

The economy of these countries is of protectionist nature and not dualistic, where the private and public sector coexist as for most of the other developing countries.

The imports of their technology is mainly from the advanced centrally planned economies.

The process of their technological transfer is therefore different from the other developing countries as it is based on different aspects.

This category contains, among others, Cuba, Korea, (democratic people's republic of) Mongolia, and Yemen (people's democratic republic of).

4) Countries with a relatively small population.

The criteria for not including these countries in the analysis is that these countries are so small that they mainly live on agriculture and tourism, their industrial sector scarcely exists making it difficult to relate them to other countries for a study on technological transfer.

2.5.2. Countries Included in the Analysis.

Apart from the four categories of countries already described, most of the remaining countries are representative of the hypothesised population of developing countries for the present study.

However, many countries had insufficient data and hence, had to be discarded.

It should be mentioned that the capital deficit oil exporters are represented in this analysis as they have the same characteristics of the oil importing developing countries. They share common interest with the capital-surplus oil exporters in that they try to improve the returns to their oil exports, and with the oil- importing developing countries in having been net importers of capital in recent years and being likely to need foreign capital in the future, see World Development report (1981, p.88), these countries are Algeria, Iran and Nigeria.

The number of countries included in the analysis on which data was available is forty five. A list is provided in Appendix 6.

3. METHODOLOGY

3.1. Formulation of the Model

This part is concerned with the elaboration of an analytical framework which portrays the functional relationships existing between the "technology integration" indicator and its environmental economic and social indicators mentioned above.

The following econometric model defines the underlined relationships:

3.1 $$Y_t = \beta_1 + \beta_2 X_{2t} + \beta_3 X_{3t} + \dots \beta_k X_{kt} + U_t$$

Where Y_t is the index of technology integration for country t, to be explained by k + 1 explanatory variables $X_{2t}, X_{3t}, \dots, X_{Kt}$.

$\beta_1, \beta_2, \dots, \beta_k$ the parameters that tie the dependent (Y) variable and the independent variables (X_j) into equation statement, and that have to be measured by the appropriate econometric technique.

U_t is the stochastic disturbance term, which represents the numerous other factors that affect the integration of technology transfer and that cannot be included.

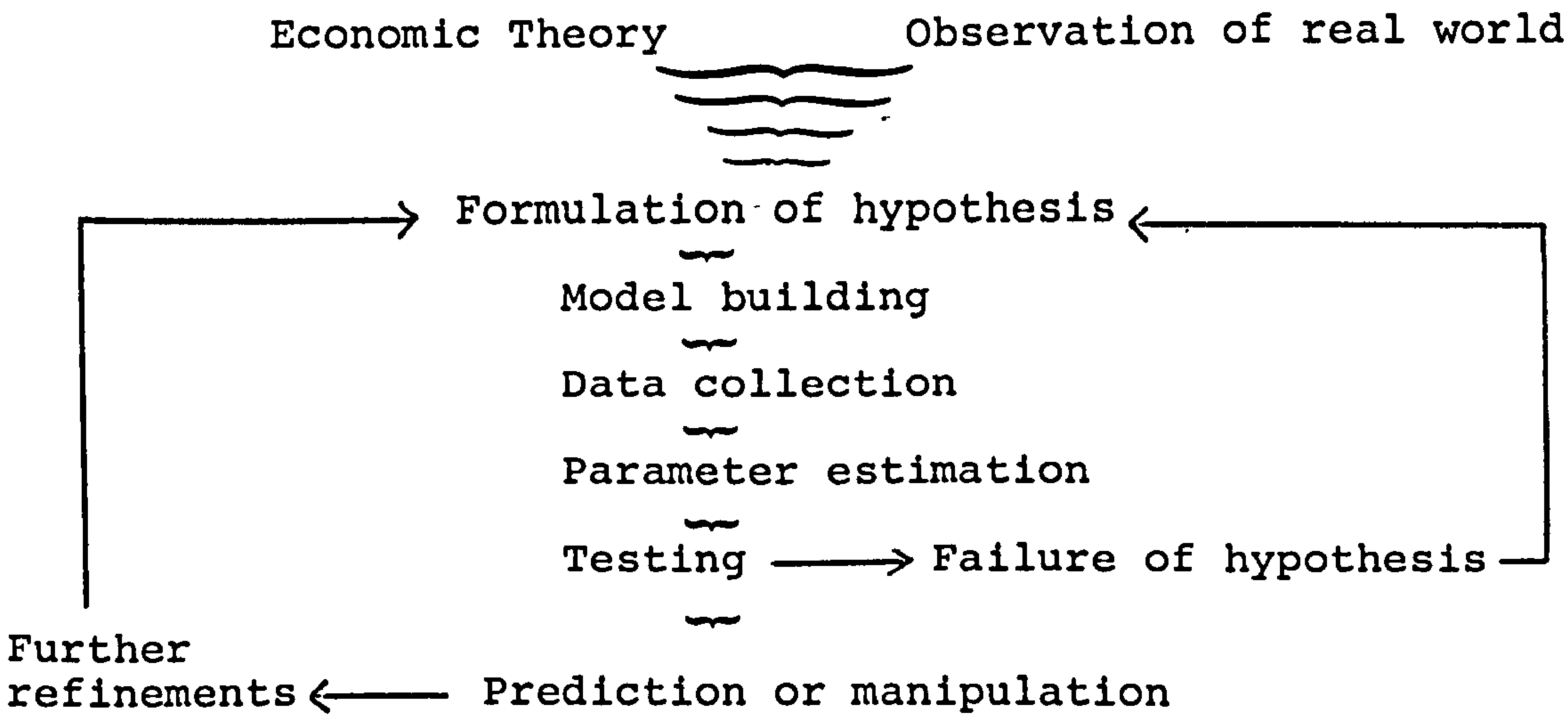
An econometric model can be a single equation or a system of simultaneous equations, depending on the nature of the relationships existing between the variables and on the scope of the study. It should have a priori economic foundation either mathematical or theoretical.

James and Throsby (1980, p272) wrote: "The generation of ideas about how economic systems operate may come from theoretical consideration, from observation of economic behaviour in the real world, or from a combination of these two sources".

With the absence of theoretical economic models related to the technological transfer, the model under investigation is based on observation of economic phenomena based on the literature of the subject, already discussed in chapter 2.

The procedure of the construction of a model, in order to test a theory or to explore a phenomenon may be schematically cally represented as in Fig. 3.1, James and Throsby (1980, p270).

Fig. 3.6. Diagram for Model Construction



The presented model deals with economic relationships and is, therefore, called an econometric model. The term econometrics is formed of two Greek origin words which are economy and measure respectively.

Econometrics may be considered as the integration of economics, mathematics and statistics, as it provides the numerical values for the parameters of economic relationships. For an extensive discussion on econometrics, see Malinvaud (1971), Wonnacott and Wonnacott (1970), Theil (1978), Gujarati (1978), Johnston (1972), Kmenta (1971) and Koutsoyionnis (1981).

The most important characteristic of economic relationship is that they contain a random element which is, however, ignored by economic theory that postulates exact relationships, examples are the production function, the consumption and the demand function among others.

It is quite clear that in the economic environment, many more factors may affect the variable under investigation, such as change in law, migration, an unpredicted war and political problems as well as the changing human behaviour.

The influence of these other factors is taken into account, in econometrics, by the introduction of a random variable, denoted by U, into the economic relationships.

It is the inclusion of this error term that makes econometrics a highly specialised tool of research, which goals are analysing and testing the economic behaviour, in the case of explanatory analysis and of economic theory, in the case of testing the stipulated relationship by providing the numerical estimates of the coefficients and by using the numerical estimates of the coefficients to forecast the future values of economic relationships.

3.1.1. The Nature of the Stochastic Disturbance Term.

The disturbance term U_i is a surrogate for all those variables that collectively affect Y and are omitted from the model for some reasons that will be seen later.

These reasons explain why the multiple regression model, or the econometric model will not include as many variables as possible to attempt to replace the U. These are:

1) Whether it is theory or observation and theoretical analysis about a phenomenon, it is difficult to determine the behaviour of Y completely, as there is always a possibility that one is ignorant or unsure of the other factors affecting Y, which makes U suitable to substitute these unknown variables or these variables on which data is not available, or again, these variables that cannot be quantified, for example, one could introduce some explanatory variables related to the political situation of the countries, which will be of valuable relevance, but which are omitted because of their non availability.

2) The joint influence of the variables omitted by the regression function, are so small and at best nonsystematic

that as a practical matter and for cost consideration it does not pay to introduce them into the model explicitly. However, their combined effect may be treated as a random variable U.

3) Even if one succeeds to introduce all the relevant variables, there is bound to be some randomness in the dependent Y which cannot be explained no matter how one tries hard. The U's may well reflect these randomnesses,

4) Finally, following Razor (1956) "that descriptions be kept as simple as possible until proved inadequate", the regression model should be kept as simple as possible. If four or five variables explain the model adequately, why then introduce more variables. Simple models are appropriate and less costly for decision-making, prediction and forecasting. Needless to say, that important variables should not be excluded just to keep the regression model simple.

The stochastic disturbances U's assume an extremely critical role in regression analysis, which is, in fact, based mainly on the assumptions of these disturbance terms, as will be seen in the following sections.

In this part, the econometric technique used to estimate the parameters for the available statistical data and to test the hypothesis related to the model are discussed along with other aspects of the model which constitute mainly five sections, these are:

1) The multiple linear regression model.

2) The objectives of the model.

3) Specification of the model, involving the determination of the dependent and independent variable, as well as the mathematical form.

4) Estimation of the model, that is the method applied to estimate the parameters and the tests involved for the goodness of fit.

5) Application of computer program in generating statistics.

The other important stages of the model will be the subject of the fifth chapter, they are mainly, the evaluation of the estimates, that is to decide on the basis of certain criteria whether the estimates are satisfactory and reliable and evaluation of the forecasting validity of the model, or to test its application. The econometric tests relating to the assumption of the error term as well as problems related to the independent variables such as multicollinearity and autocorrelation are also analysed in this chapter.

3.1.2. The Regression Equation

The outlined econometric model consists of regressing Y on the X's to determine those explanatory variables that explain the largest variance of the dependent variable and to measure their parameters.

Regression analysis is a branch of statistical theory that is widely used in almost all the scientific disciplines.

In economics it is the basic technique for measuring or estimating relationships among economic variables. As will be seen on the estimation section, the method of least squares will be used to estimate the parameters.

Gujarati (1978) defines it as: "Regression analysis is concerned with the study of the dependence of one variable, the dependent variable, on one or more other variables, the explanatory variables, with a view to estimating and, or predicting the (population) mean or average value of the former in terms of the known or fixed (in repeated sampling) values of the latter".

3.1.2.1. Historical Significance

Regression analysis was the first applied to random samples from approximately normal distributions. The populations sampled were biological characteristics of plants, animals and human beings, which closeness of association was determined by the correlation coefficient.

Only by the late 1920's did some leaders in biological statistics start to do controlled experiments whereby values of one or more variables subject to human control were fixed and only the dependent variable was subject to random variations. It then became clear that the dependent variable and the independent variable could not form a bivariate normal distribution and that the correlation coefficient proved to be less reliable when the X's are fixed.

It was not until 1928 that a distinction between 'correlation models' and 'regression models' came to light with the pioneering work of Fisher, see Fox (1968).

However, this was only relevant to controlled experiments, as economics deal with changing variables, it was not until the 1940's that regression analysis was applied to the special problems of economics.

3.1.2.2. The Purpose of Multiple Regression

When several variables act in common to produce a single result, the interest is to know the separate effect of each variable. This enables one to know the impact and the weight of each variable on the dependent variable.

Multiple regression analysis represents one of the standard methods whereby such attempts are made. The other method being the controlled experiment, which is physically explicit and lies outside the realm of statistics, Kane (1969).

If, for example, one wants to know how the aggregate consumption (c) in a country would respond to changes in price (W) and quantity (Z). The linear model would be of the form:

$$3.2. \qquad C = \alpha + \beta W + YZ$$

The sample estimates a, b and c for α, β and Y would be found by setting the model as:

Table 3.1 ANATOMY OF K - VARIABLES REGRESSION MODEL

Assumed	Observed	Not Observed	Imposed	Computed
True $\beta_o, \beta_1, \beta_2, \ldots\ldots \beta_k$		True $\beta_o \cdots \beta_k$	Some estimating criterion e.g. least sq.	$\beta_o, \beta_1, \ldots\ldots \beta_k$
True U's exist		True U's		Residuals e's
U'shave the following properties:				
(i) $E(u_i) = 0$		$E(u_i)$		$\acute{e}$ = mean of residuals = 0
(ii) $E(u_i^2) = \sigma^2$		$E(u_i^2)$		σ^2 = estimate of σ^2
(iii) $E(u_i u_j) = 0 \quad i \neq J$				
Population of Y for given X's	Y and X's	Y not in the sample		$\hat{Y}_i$
in which $Y = \beta_o + \beta_i X_{ii} + \beta_2 X_{2i} + \ldots \beta_k X_{ki} + U_{ki}$	given sample			

Adapted from S. SALAVANIS (1959)

3.3. $\Delta C = a + b\Delta W + CYZ$

Where the change on C is seen as dependent on the change in W and Z.

In economics,physical experiments to record the variations in all relevant variables are not possible and, therefore, the powerful technique of regression analysis is used to identify the effect of change, table 3.1 contains a schematic representation of the method.

Chenery and Syrquin (1980), Shourie (1972) as well as Beenstock (1980) among a number of economic analyses using multiple regression analysis, enquire into a number of economic and social indicators in order to identify and explain the phenomenon under study.

Multiple regression analysis is the generally preferred technique for those studies concerned with explanatory analyses and predictive objective.

3.2. Objectives of the Model

Having defined the first objective of the present study in the first part, which is the identification of an index measuring the integration of technology, let one outline the objectives of the proposed econometric model.

As was mentioned above, most of the work done on technological transfer is theoretical, this is mainly due to the complexity of the problem of technological transfer as such and to the nature of the problem, as was seen in chapter 2, different countries are ruled by different cultures, traditions and, therefore, by different values, it is also, however, and most importantly, due to the political complexity and economic environment within which the transfer of technology operates.

Therefore, the need to test the theoretical literature may lead one to question about the main indicators of the technological transfer, and urged the author to proceed to the present quantitative investigation.

The determination of the significant variables leads to a further question which is: can one predict the rate of technology integration for other countries not considered in the analysis or for other periods of time?

This is precisely what the present model is aimed at, let one summarize the main objectives:

i) This model is aimed at determining the variables that have the largest influence on the integration of technology of developing countries. As will be seen later, the method used in this research employs "subsets regression" programme from BMD (1979) whereby the computer is let to choose, among a number of specified variables N, different sets of 1 to N variables, then it chooses the most statistically significant set as best subset of variables explaining Y, which is the dependent variable.

ii) Once the significant indicators are identified and the parameters are measured, the researcher, the policy-maker or the economist can predict the rate of technology integration for other developing countries not included in the analysis because of lack of data, or for a different period of time and can forecast the future integration of technology for one or many countries.

iii) The numerical estimates obtained of the coefficient of the economic relationships existing between the variables may be used for decision making; that is if water supply appears to be a relevant indicator then emphasis on this aspect can be made. Working with the model, the policy-maker or the analyst can see that an improvement in water supply to the population will have a direct effect on the integration of technology. For a discussion on forecasting, see Leser (1966).

For a model to be reliable, it should have some desirable properties, which are:

i) Theoretical plausibility, the model should describe adequately the economic phenomenon to which it relates.

ii) Explanatory ability, that is, it should be able to explain the observations of the actual world.

iii) Accuracy in the estimation of its parameters.

3.3. Specification of the Model

The specification of the model requires the determination of dependent and explanatory variables and the mathematical form that relates these variables, let one illustrate each aspect in turn.

3.3.1. Dependent and Explanatory Variables

On the basis of the literature on the transfer of technology, the variable that indicates the integration of technology is seen as dependent on the environmental factors which have been defined and listed in part 1, this leads to the construction of the model whereby "integration of technology" or Y constitute the dependent variable and the entered variables or X's constitute the independent or explanatory variables.

In the literature the terms dependent variable and explanatory variables are described in various terms. A list to represent these terms is suitable, it is represented as follows:- see Gujarati (1978, p17).

Dependent variable	Explanatory variable
↓↑	↓↑
Explained variable	Independent variable
↓↑	↓↑
Predictand	Predictor
↓↑	↓↑
Regressand	Regressor
↓↑	↓↑
Response	Stimulus

3.3.2. Mathematical Form of the Model

The assumed dependency of integration of technology upon the other factors can be written as:

3.4. $Y = f(X_1, X_2, X_3 \ldots\ldots X_k)$

Where the notation f can be translated as "depends on", or is a "function of".

This statement merely shows a general dependence of Y on the X's, it does not tell the way Y depends on the X's, therefore, a form to this relationship should be specified.

It is assumed that the relationship is linear and can be approximated by the multiple regression model of the form:

3.5. $Y_t = \beta_o + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots\ldots + \beta_k X_{kt} + U_t$

The choice of the linear form is based on four points.

1) The scope of the study is aimed at identifying a set of explanatory variables which shows that the analysis is mainly explanatory and the linear form represents the adequate form for the purpose of the analysis.

2) It often happens that the analytic nature of the relations between the dependent and the explanatory variables are not always known a priori, therefore, regard for simplicity and for want of precise theoretical knowledge of the nature of dependence makes a linear form preferable to other mathematical expressions. Malinvaud (1978) and Blalock (1972) make a good attempt on this point.

3) Also most of the economic phenomenon have been modelled on the basis of the general linear model. Dhrymes(1978)

4) Some of the data was plotted on two-dimensional diagrams, taking two variables at a time, the dependent and some of the explanatory variables. The examination of some scatters threw some light on the form of the function and helped in deciding upon the choice of the linear form, other logarithmic and exponential forms have been tried but have not been appropriate.

3.3.3. Constituents of the Model

The elements constituting the model are variables and parameters.

3.3.3.1.Distinction between variables and parameters.

The variables are economic or social quantities.free to take any possible value, and the parameters are constants which are presumed to have fixed numerical values in any observation. In the linear function already stated, Y and the X's are the variables, and the β's are the parameters.

The parameters indicate the model's structure or the hypothesized relations among the variables through the equation statement.

The parameters of the present function, are of behavioural type as they consist of showing how the dependent variable or the criterion behave according to the explanatory variables, other types of parameters can be found in

Fox (1968, p.83) and in Rowan (1968).

3.3.3.2. Distinction between variables.

Models in general try to explain how certain the quantities represented by the variables are determined.

The variables are classified in two groups according to whether they determine the model or whether they are determined by the model, they are:

1) the exogenous variables, which represent the outside force that characterise the external environment, and which act upon the dependent variable through the properties of the model, these are the independent variables.

2) the endogenous variables, which are determined within the model and are characterised of being defined by the relations of the model and the values of the exogenous variable, these are the dependent variables, Kane (1969) gives a thorough discussion on these types of variables, also Koutsoyiannis (1981) and Malinvaud (1978).

It should be noted that the present model is represented by a single equation and therefore it contains only one endogenous variable.

3.3.4. Regression and Causation

Although regression analysis deals with the dependence of one variable on other variables, it does not necessarily imply causation. Kendall and Stuart (1961) wrote "A statistical relationship, however strong and however suggestive, can never establish causal connection: our ideas of causation must come from outside statistics, ultimately from some theory or other".

Theoretically and practically, the integration of technology is the result of a combination of environmental variables, which stipulate the one way relationship causality, that is the independent variables X's act on Y.

The principle of causality is important in the sense that reliable results can be obtained by the regression methods only if the cause effect relationships is correctly specified, this requires that the explanatory variables are able to accurately predict the response and control it.

Causality can be described as the unidirectional lines of influence on the endogenous variables provoked by the exogenous variables, see Kane (1969), Wonnacott and Wonnacott (1970).

3.4. Estimation of the Model

To estimate the parameter of the model, that is to obtain numerical estimates of the coefficients, one requires the knowledge of various econometric methods as well as their assumptions.

The gathering of statistical observations on the variables included in the model as well as the sample of countries analysed and the period over which the present study takes place are clearly stated in part 1 of this chapter.

The present section is concerned with the choice of the appropriate technique to estimate the parameters of the present model.

The outlined econometric model consists of regressing Y on the X's to determine those X's that explain the largest variance in Y.

The model being a simple phenomenon, satisfactorily approximated with a single equation, therefore the method of least squares is chosen for its considerable advantages. The popularity of ordinary least squares is attributable to its low computational costs, its intuitive plausibility, and its support by a broad body of statistical inference. The method of least squares can be employed on at least three separate conceptual levels. It can be applied mechanically, merely as a means of curve fitting. Second, it provides a vehicle for hypothesis testing. Thirdly, and most importantly, it provides an environment in which statistical theory, the theory of the specified discipline and data may be brought together to increase our understanding of complex physical and social phenomena. Belsley et al (1980).

The analysis of equation 3.5. requires the estimation of the coefficients $\beta_1, \beta_2 \cdots \beta_k$ one needs observations on X, Y and U, however U is not observed like the other explanätory variables, and therefore in order to estimate the outlined model some assumptions should be made about the shape of the distribution of each U, its mean, variance and covariance with other U's.

These assumptions being related to the true, but unobservable values of U_t.

3.4.1. Assumptions of the linear regression model

As stated above, the linear regression model is based on certain assumptions, most of them refer to the random variable U, others to the relationships between U and the explanatory variables and the rest to the relationship between the explanatory variables.

The assumptions are classified under stochastic assumptions and others.

3.4.1.1. Stochastic assumptions of the least squares method

These assumptions are crucial for the estimates of parameters that are to be calculated by the method of least squares, the latter being the most commonly used technique is especially adaptable to the stochastic nature of economic phenomena.

Assumption 1. Randomness of U.

The value which U_t may take in any observation depends on chance. Each value has a probability assumed by U.

Assumption 2. Zero mean of U. For each value of X, U assumes various values so that their mean is equal to zero, $E(U) = 0$, for a profound discussion on this, see Koutsoyiannis(1981, p56).

Assumption 3. Homoscedasticity.

The variance of U_t about its mean is constant for all values of X, that is it has the same variance for all X values, this property, equality of variance is called homoscedasticity.

For further discussion on this point, see Malinvaud (1978 p:84), also Goldfeld and Quandt (1965).

Assumption 4.Nonautocorrelation of the U_s.

The values of U_t corresponding to X_t are independent from the values of any other U_j corresponding to X_j. That is knowing the error associated with one observation would tell one nothing about error in another. This implies that Y_t and Y_j are also unrelated.

Assumption 5. Normality of U.

The errors U have a normal or Laplace-Gauss distribution. Under this assumption, together with the precedent one, U_t and U_j, as well as Y_t and Y_j $(t \neq j)$ are not only uncorrelated, but independent, see Lindeman (1980, p 16,p95).

Assumption 6 Independence of U_t and X_t

The random error is not correlated with the explanatory variables, that is the U_s and the X_s do not tend to vary together, and their covariance is Zero.

$$\text{cov}(XU) = E\left\{ \{X_t - E(X_t)\} \{U_t - E(U_t)\} \right\} = 0$$

Assumption 7 No errors of measurement in the X_s

The disturbance term U is supposed to absorb the influence of omitted variables and the errors of measurement in the Y_s which leaves the variables error-free.

3.4.1.2. Other Assumptions of Ordinary Least Squares.

Assumption 8. The explanatory variables are not perfectly linearly correlated ($rx_ix_k \neq 1$).

The regressors are assumed not to be highly correlated, therefore they are not multicollinear, this term is used to denote the presence of linear relationship.

Assumption 9. The economic variables should be correctly aggregated.

This point has already been discussed in the specification of the model, whereby values such as the Gross industrial product comprised many components that had to be aggregated.

Assumption 10. The estimated relationship is identified.

It is assumed that the relationship whose coefficients are to be estimated has a unique mathematical form. This assumption is important in the sense that one has to be certain of the reliability of the coefficients.

Assumption 11. The specification of the relationship is correct.

It is assumed that no specification errors have been committed in determining the explanatory variables, that is all important regressors have been included, and that the mathematical form of the model is correct.

3.4.2. The Least Squares Estimators.

An estimate is the value of an estimator calculated from any set of data. The problem here is to find estimators for the unknown parameters β_s which are simply procedures for making guesses about the unknown parameters on the basis of the known sample of Y and the Xs.

One denotes therefore, the estimates of the parameters by b_1, b_2,... b_k in order to estimate the value of Y_t by $\hat{Y}_t = b_1+b_2X_{t2}+ \ldots b_kX_{tk} + U_t$.

The difference between the observed and the predicted values of Y for each observation is called the residual for the t^th^ observation and is the vertical distance between the actual observation Y_t and the estimated plane, the residual is denoted by U_t.

The method of least squares determines the estimators b_k under the criterion of minimizing the sum of squared errors. For an extensive discussion on the review of the method of least squares, a good attempt on the theoretical aspect of the least squares method can be found in Hanushek and Jackson (1977,p.29.)

One wants to minimize

$$3.6. \quad \sum_{t=1}^{T} e_t^2 = \sum_{t=1}^{T} (Y_t - \hat{Y}_t)^2$$

With the least squares criterion,(had it not been for the stochastic element U, the least square method is not to be used, as the relationships are deterministic and the number of equations corresponding to the observations could be solved simultaneously in order to determine the βs.) a minimum deviation between the Y and the $\hat{Y}$ can be easily found. Also under the assumptions mentioned above the estimates can be shown to have desirable statistical properties, which will be discussed later.

Before proceeding, it is worth noting some characteristics of the coefficients that are to be estimated by the least squares method.

The βs are constant for the whole population, they do not change for different cases, moreover, they represent the independent effect of each independent variable on the criterion, thus, as was said above, β_2 for example is the amount of change in Y that corresponds to a unit change in X_2, the other variables being held constant.

One shall procede to the development of the coefficients estimators using the standard scalar notations first, then the normal equations derived are developed in matrix notations.

As was stated above, in order to determine the coefficients estimators, the least squares method is used to minimize the sum of squares residuals (SSE) where

$$3.7. \quad SSE = \sum_{t=1}^{T} e_t^2 = \sum_{t=1}^{T} (Y_t - \hat{Y}_t)^2 = \sum_{t=1}^{T} (Y_t - b_1 - \sum_{k=2}^{K} b_k X_{tk})^2$$

In minimizing SSE, the coefficients estimates, the b_k become the variables that must be adjusted to find the minimum, and the values for Y and the X_k as well as their covariances are treated as constants.

A number of b_k could be used as estimates of the β_k, to obtain the best possible estimates, calculus is used according to the least squares criterion to minimize SSE in respect to b_k.

Let one set the first partial derivative of SSE with respect to each b_k equal to zero, to get the minimum value of SSE, that is:

3.8. $$\frac{\partial SSE}{\partial b_k} \doteq 0$$

this yields K linear equations which can be solved for the K unknowns b_1, b_2, ... b_k.

The derivation (2) can be elaborated to

3.9. $$\frac{\partial SSE}{\partial b_k} = \frac{\partial(\Sigma e_t^2)}{\partial b_k} = \sum_{t=1}^{T} (\frac{\partial e_t^2}{\partial b_k})$$

giving

3.10 $$\frac{\partial(e_t^2)}{\partial b_k} = \frac{\partial(e_t^2)}{\partial e_t} \cdot \frac{de_t}{db_k} = 2e_t \frac{de_t}{db_k}$$

For k=1, the derivative is:

3.11 $$2e_t \frac{de_t}{db_1} = 2e_t(-1) = -2(Y_t - b_1 - \sum_{i=2}^{K} b_i X_{ti})$$

to have

$$3.12 \qquad \frac{\partial SSE}{\partial b_1} = \frac{\partial \Sigma e_t^2}{\partial b_1} = -2\Sigma(Y_t - b_1 - \sum_{i=2}^{K} b_i X_{ti})$$

For k=i to K, The derivative is

$$3.13 \qquad 2e_t \frac{de_t}{db_k} = 2e_t(-X_{tk}) = -2(Y_t - \hat{Y}_t)(X_{tk})$$

by substituting $\hat{Y}_t$, one gets:-

$$3.14 \quad -2\ (Y_t - \hat{Y}_t)(X_{tk}) = -2(Y_t - b_1 - \sum_{i=2}^{K} b_i X_{ti})(X_{tk})$$

and developing

$$3.15 \qquad \frac{\partial SSE}{\partial b_k} = -2 \sum_{t=1}^{T} [(Y_t - b_1 - \sum_{i=2}^{K} b_i X_{ti})(X_{tk})]$$

$$= -2(\Sigma Y_t X_{tk} - b_1 \Sigma X_{tk} - \sum_{i=2}^{K} b_i \Sigma X_{ti} X_{tk})$$

In order to estimate the b_k by minimizing the sum of squared residuals, one needs to solve the following K simultaneous equations for the K unknown parameters, by setting the derivatives equal to zero, one gets from b_1 to b_k:

$$\frac{\partial SSE}{\partial b_1} = -2(\sum_{t=1}^{T} Y_t - \sum_{t=1}^{T} b_1 - b_2 \sum_{t=1}^{T} X_{t2} - \ldots - b_k \sum_{t=1}^{T} X_{tk} - \ldots - b_k \sum_{t=1}^{T} X_{tk}) = 0$$

$$3.16 \quad \frac{\partial SSE}{\partial b_3} = -2(\sum_{t=1}^{T} Y_t X_{t3} - b_1 \Sigma X_{t2} - \ldots - b_k \sum_{t=1}^{T} X_{tk} X_{t3} - \ldots - b_K \sum_{t=1}^{T} X_{tK} X_{t3}) = 0$$

$$\frac{\partial SSE}{\partial b_k} = -2(\sum_{t=1}^{T} Y_t X_{tk} - b_1 \Sigma X_{tk} - \ldots - b_k \sum_{t=1}^{T} X_{tk} X_{tK} - \ldots - b_k \Sigma X_{tK}^2) = 0$$

giving the following normal equations:

For b_1,

$$3.17 \qquad \sum_{t=1}^{T} Y_t = Tb_1 + b_2 \sum_{t=1}^{T} X_{t2} + \ldots b_k \sum_{t=1}^{T} X_{tk} + \ldots + b_k \sum_{t=1}^{T} X_{tk}$$

and for b_2 to b_k,

$$3.18 \qquad \sum_{t=1}^{T} Y_t X_{tk} = b_1 \Sigma X_{tk} + b_2 \Sigma X_{t2} X_{tk} + \ldots b_k \Sigma X_{tk}^2 + \ldots + b_K \Sigma X_{tK} X_{tk}.$$

To solve these equations, the problem is put into matrix notation. See Appendix 11 for matrix algebra.

The multiple regression model can be expressed in matrix form as

$$Y = X\beta + U$$

that is

$$X = \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_t \\ \vdots \\ Y_T \end{bmatrix} \qquad \beta = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_k \\ \vdots \\ \beta_K \end{bmatrix} \qquad U = \begin{bmatrix} U_1 \\ U_2 \\ \vdots \\ U_t \\ \vdots \\ U_T \end{bmatrix} \qquad X = \begin{bmatrix} 1 & X_{12} & \cdot\ \cdot & X_{1k} \cdot\cdot & X_{1K} \\ 1 & X_{22} & \cdot\ \cdot & X_{2k} & X_{2K} \\ \vdots & \cdot\ \cdot & \cdot\ \cdot & \cdot & \\ 1 & X_{t2} & & X_{tk} & X_{tK} \\ \vdots & & & \vdots & \\ 1 & X_{T2} & & X_{Tk} \cdot & \cdot X_{TK} \end{bmatrix}$$

Where Y is a column vector, X is a TXK matrix, β a column vector of the true coefficients and U a vector of the true disturbance term, the row of one's has been included in the X matrix to allow for its estimation.

The estimated equation for the T observation in matrix form is

$$3.19 \qquad Y = Xb + e$$

Where b is the vector of the estimates of the true coefficients and e the vector of the observed residuals.

In order to obtain estimates for b_k as well as informations about the distributions from which the b's are drawn, so that inferences about the true parameters, the β's are drawn, one uses the same principle, that is the least squares criterion of minimizing the sum of squares.

3.20 $$SSE = \sum_{t=1}^{T} e_t^2 = e'e = (Y-Xb)'(Y-Xb)$$
$$= X'Y - 2b'X'Y + b'X'Xb$$

because $Y'Xb = b'X'Y$

by setting the derivative of $e'e$ with respect to each b_k equal to zero, one gets

3.21 $$\frac{\partial e'e}{\partial b} =-2X'Y + 2X'Xb = 0$$

where $X'Xb = X'Y$

It is necessary to recall at this point assumption 8 which stipulates the rank of X equal to k, implying $T \geq K$ and a non-linearity between the explanatory variables, it is only when this condition holds, that $(X'X)^{-1}$ exists and allows for estimates of b, equation 3.21 can be written

3.22 $$b = (X'X)^{-1} X'Y$$

which represents the set of equations whose solution for vector b yields the minimum sum of squared errors.

3.4.2.1. Properties of Least Squares

Carl Friedrich Gauss, the originator of the approach, has shown that under certain assumptions the least squares method produces estimators which are linear, unbiased and have minimum variance.

Statistical methods main task is concerned with the estimation of parameters of some population distribution and with their test of hypothesis. Generally an estimator on the basis of sample information is developed to allow for guesses about the true population. It is, therefore, important to understand the properties of the estimators used.

The properties of the least squares estimators are based on the fact that the estimators themselves are random variables, distributed about some mean with a given variance. They are random variables because of the error term that exists in the observed values of Y.

The most important distributional parameters are the mean and variance of the estimators, under the assumptions outlined, the least squares estimators are considered as the best linear unbiased estimators (BLUE), their two properties, unbiasedness and minimum variance will be seen in turn.

Let one first state that the mean and variance of the estimated coefficients are bound by substituting the true population model in 3.22 giving:

3.23 $$b = (X'X)^{-1} X'(X.\beta + U) = \beta + (X'X)^{-1} X'U$$

this development is based on the assumption that the X's are fixed for repeated trials.

1) Unbiasedness

The means of the coefficients are the first parameters that describe their distribution, by taking the expected values of equation 3.23, one has:

3.24 $$E(b) = E(\beta) + E \left\{ (X'X)^{-1} X'U \right\}$$

since the β's and the X's are assumed to be fixed.

3.25 $$E(b) = \beta + (X'X)^{-1} X'E(U)$$

and recalling assumption 2, that the means of the errors are equal to zero, one can write

$$E(b) = \beta$$

that is the mean estimate of b tends to equal the true and unknown population values of β showing that the least squares estimators are unbiased.

The quantity $E(b - \beta)$ is the sampling error and is called the bias of an estimator, an estimator is said to be unbiased when $E(b) = \beta$ or $E(b) - \beta = 0$, that is when the distribution of b is centred on the true value of the parameter, the estimator is unbiased.

2) Minimum Variance

The estimators in any sample, generally do not equal the true values exactly, it is necessary to look at their variance, when the variance is small, one can think of a high probability that the estimate is close to the true parameter.

Under assumption 5, stating the normal distribution of the error term, the variance of the estimator for each parameter can be written as $E\left\{ \{b - \beta\} \{b - \beta\}' \right\}$ giving a matrix which represents the variance of the b's on the main diagonal and the covariance between any two coefficients on the off-diagonal.

According to equation 3.23, one can write

$$3.26 \qquad b - \beta = (X'X)^{-1} X'U$$

to have, by replacing

$$3.27 \qquad (b - \beta)(b - \beta)' = (X'X)^{-1} X'U.U'X (X'X)^{-1}$$

before taking the expected value of this expression, assumption 3 and 4 are to be considered at this stage, that is each U is drawn from a distribution with the same variance (σ^2) and that each U is independent of another U.

The variance of the estimator can be written

$$3.28 \quad E\left\{(b-\beta)\ (b-\beta')\right\} = (X'X)^{-1}X'E(UU')X(X'X)^{-1}$$
$$= \sigma^2(X'X)^{-1}$$

Given that the X's are fixed, that $E(UU') = \sigma^2 I$ that $XI = X$ and that σ^2 is a scalar. For a further discussion on this point, see Hanusek and Jackson, 1978, p119.

This expression means that a certain coefficient equals a certain diagonal element of $(X'X)^{-1}$ times the variance of the true error terms, by substituting b by another estimator, say $\hat{b}$, one can find that the variance of $\hat{b}$ is superior to the variance of b, therefore showing that the least squares estimates have minimum variance among all estimators.

Having discussed the method to estimate the parameters of the regression model, it is now intended to discuss the statistics produced by the computer, the higher order econometric tests about the assumptions of the linear regression model will be discussed in the fifth chapter.

These statistics can be grouped under three major headings:

1) General Statistics
2) Correlation-Regression Statistics
3) Measures Employed in Statistical Inference

3.5 Statistical Tests and Significance

3.5.1 General Statistics

Of the many general statistics generated by the computer are the arithmetic mean and the standard deviation.

The value of the arithmetic mean is found by adding the values of the variables of the observations and dividing by the number of variables in the observations.

It has the following properties:

i) The algebraic sum of the deviations of the values from the mean equals zero.

ii) An algebraic relationship exists between the mean and the values of the variables.

iii) The sum of the squared deviations is less taken around the mean than around any other value.

A measure of the amount of variation is called a measure of dispersion of the many measures available, the variance and its square root, the standard deviation, are the most important, it indicates the minimum deviation from the mean and is expressed as:

3.29 $$S = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n}}$$

The standard deviation and the mean provide some insight into the characteristics of population from which data are gathered.

3.5.2 Correlation-Regression Statistics

Before considering the measure of goodness of fit, let one consider the precision of the least squares estimates which is measured by their standard error.

It is evident that the least-squares estimates are a function of the sample data, but since the data are likely to change from sample to sample, the estimates will change as well. Therefore, a measure of "reliability" or "precision" of the estimates β's is needed. This is measured by the standard error, given the Gaussian assumptions, the standard error of estimates can be obtained as follows:

3.30 $$\sqrt{Var(\beta)} = \sqrt{\frac{\Sigma(Y-\hat{Y})^2/(N-2)}{\Sigma(X-\overline{X})^2}} = \sqrt{\frac{SS_{reg}/(N-2)}{SS_x}}$$

The standard error of estimates can be regarded as a standard deviation, the latter measuring the deviation around the mean and the former around the regression values $\hat{Y}_i$.

It is the standard error which enables one to draw inferences about the population parameters, for a detailed discussion on this point, see Gujarati (1978) and Theil (1978).

A problem closely related to that of estimation of the regression coefficients is the overall goodness of fit of the sample regression. The goodness of fit is measured by the coefficient of determination r^2, which represents the proportion of the variation in the dependent variable that is explained by the regression model, for the two variable model, r^2 is equal to

$$3.31 \qquad r^2 = \frac{\Sigma(\hat{Y}_i - \bar{Y})^2}{\Sigma(Y_i - \bar{Y})^2} = \beta_1^2 \left(\frac{Sx^2}{Sy^2}\right).$$

the multiple coefficient of determination indicates the amount of variation explained by the independent variables jointly and the strength of the relationships.

The formula of the multiple correlation is obtained by letting one of the independent variables do all the explaining it can before another one is permitted to explain what it can of the remaining unexplained variation and so on.

$$3.32 \qquad R^2 = \frac{\text{Variation in Y explained by the combined linear influence of the independent variables}}{\text{Total variation in Y}}$$

that is, following the deviation of r^2 in (1) for a three variable case,

$$3.33 \qquad R^2 = \frac{\hat{\beta}_{12.3} \Sigma\, y_i x_{2i} + \hat{\beta}_{13.2}\, \Sigma\, y_i x_{3i}}{\Sigma y_i^2}$$

R^2 indicates the proportion of the total variance accounted for by the linear relationship between Y and the X's, it ranges from 0 to 1 and an increasing number of X's in a regression cannot reduce the value of R, therefore an increase in R by the addition of variables does not insure its significance.

Although conceptually very much different from the regression coefficients r^2 (for the two variables and R^2 (for more than one independent variable), r and R are the measures of degree of association between two variables (r) and between Y and all the explanatory variables (R).

r can be computed either from

$$3.34 \qquad r = \pm\sqrt{r^2}$$

or from its definition

$$3.35 \qquad r = \frac{\Sigma x_i y_i}{\sqrt{(\Sigma x_i^2)(\Sigma y_i)^2}} = \frac{N\Sigma X_i Y_i - (\Sigma X_i)(\Sigma Y_i)}{\sqrt{[N\Sigma X_i^2 - (\Sigma X_i^2)][N\Sigma Y_i^2 - (\Sigma Y_i)^2]}}$$

In using a coefficient of correlation, some caution must be exercised in that: i) variation in either the dependent or independent variable may be caused by variation in another variable, ii) the correlation of the two variables may be due to an unknown factor affecting each in the same or opposite ways, iii) the causal relationship between the two variables may be the result of interdependent relationships and iv) the correlation may be due to chance, that is, there is always a possibility that another sample may give significantly different results.

The coefficient of correlation r has the properties of: i) being positive or negative, depending on the sign of the numerator which accounts for the covariation of the two variables, ii) it lies between - 1 and 1, iii) it is a measure of linear association or linear dependence only, it has no meaning for describing non-linear relations and, (iv) although it is a measure of linear association, it does not necessarily imply any cause and effect relationships.

The three or more variable analog of r, denoted by R, which is the coefficient of multiple correlation, differs with r only in the fact that it is always taken to be positive, it is equal to the square of R^2.

$$3.36 \qquad R = \sqrt{\frac{\text{explained variation}}{\text{total variation}}} = \sqrt{\frac{\hat{Y} - \bar{Y}}{Y - \bar{Y}}}$$

However, in practice R is of little importance, the more meaningful quantity is attributed to R^2.

It would be relevant to mention at this stage, the difference between correlation and regression. Correlation analysis measures the strength or degree of linear association between two or more variables, whereas in Regression analysis the interest is not primarily focussed on this measure, instead it is focussed on the estimate or prediction of the average value of one variable on the basis of the fixed values of other variables.

In correlation analysis, any two variables are treated systematically whereas in regression analysis the dependent and independent variables are treated in an asymetric manner the dependent variable is assumed to be random or stochastic, that is, it has a probability distribution, the independent variables are assumed to have fixed values.

It is important to note that the explanatory variables may be stochastic, but for the sake of regression analysis, their values are assumed to be fixed for repeated sampling, which make them nonstochastic.

3.5.2.1. Partial Correlation

The correlation coefficient between two variables may not reveal the true relationship because of the influence of a third variable. It would be necessary to eliminate the effect of this third variable in order to assess the relationship between the first two variables. Let one make use of the multiple regression model to obtain measures of the degree of relationships between a dependent variable Y and any of the independent variables X_1 and X_2.

In order to do this, a way is to be found such that changes in the third variable X_2 will not affect the correlation of Y and X_1.

This is achieved by regressing Y on X_2 and X_1 on X_2 whereby the influence of the third variable X_3 is eliminated.

The two regression equations are:

3.37 $$Y = a_o + a_1X_2 + V_1$$

3.38 $$X_1 = b_o + b_1X_2 + V_2$$

where V_1 and V_2 are random variables satisfying the least squares assumptions already outlined.

The partial correlation between Y and X_1, with X_2 held constant, can be defined as the correlation between the residuals of the regressions of Y and X_2 and X_1 on X_2, it is merely the product - moment correlation between the derived variables $Y - \hat{Y}$ and $X_1 - \hat{X}_1$, usually denoted by $r_{y1.2}$ for a thorough discussion on partial correlation see Blalock (1972) and Lindeman (1980).

The computation of the partial correlation coefficient is used as a function of the bivariate product moment correlation between the three variables considered, the formula may be written by substituting Y, X_1 and X_2 for 1,2,and 3.

3.39 $$r_{12.3} = \frac{r_{12} - r_{12}r_{23}}{\sqrt{(1-r^2_{12})}\sqrt{(1-r^2_{23})}}$$

When many variables are involved, adjustment for all the control variables is done simultaneously to get a partial correlation for any number.

3.40 $$r_{12.345} = \frac{r_{12.34} - (r_{15.34})(r_{25.34})}{\sqrt{1-r^2_{15.34}}\ \sqrt{1-r^2_{25.34}}}$$

3.5.2.2.Relationships between partial and multiple correlation

To see the relationship between multiple and partial correlation coefficients, one can interpret the partial $r^2_{13.2}$ in relation to R^2 .

3.41 $$r^2_{13.2} = \frac{R^2_{1.23} - r^2_{12}}{1- r^2_{12}}$$

The effect of variable 2 has been taken out of the multiple correlation to get the correlation between 1 and 3, with 2 held constant.

The variation unexplained by 2 and 3 can be found by using the partial correlation of 3.

3.42 $$1 - R^2_{1.23} = (1-r^2_{12})(1-r^2_{13,2})$$

The multiple correlation coefficient can similarly be computed in terms of the correlation coefficient.

3.43 $$R^2_{1.23} = \frac{r^2_{12} + r^2_{13} - 2r_{12}r_{13}r_{23}}{1-r^2_{23}}$$

3.5.3. Inferential Statistics

3.5.3.1. Test of significance for the sample Correlation coefficient and regression coefficients.

The correlation coefficient r has been derived as an estimate of the true correlation coefficient which measures the degree of relationship of the variables under consideration.

However, r being a sample estimate only, its statistical reliability must be tested by conducting a test of significance, which requires the knowledge of the sampling distribution of r.

The sampling distribution of r is symmetric and follows a normal distribution with a mean equal to zero and a standard deviation equal to $\sqrt{(1-r^2)/(n-2)}$, if the true correlation coefficient denoted by ρ is equal to zero.

In order to establish the significance or non-significance of the sample estimate r one applies the student's t test which value is estimated from the sample correlation coefficient r by:

$$3.44 \qquad t = \frac{r}{\sigma_r} = \frac{r}{\sqrt{(1-r^2)/(n-2)}} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

this test will enable one to establish whether the computed correlation coefficient r is statistically significant, for a more detailed discussion on the student's t distribution see Koutsoyiannis (1981,p547).

3.5.3.2. The overall test for goodness of fit of the regression equation.

The overall test uses statistical inference to test the null hypothesis that the multiple correlation is zero in the population from which the sample was drawn. The test statistic employed for the overall test is the F ratio which is a weighted measure of the relationship between the explained and the unexplained variation. Each variance is weighted by the inverse of its degrees of freedom. The explained variance has one degree of freedom since it is based upon the deviations of the Y_i values from its mean $\bar{Y}$. The unexplained variance has (n-k-1) degrees of freedom, where n is the total number of observations, and k the number of variables in the regression. As it is based upon the deviations of the n values from Y_i. Stating the F ratio then in algebraic terms:

$\Sigma(Y_i-\bar{Y})^2$ = total variance

$\Sigma(\hat{Y} - \bar{Y})^2$ = explained variance

$\Sigma(Y_i-\hat{Y})^2$ = unexplained variance

Where Y_i represents the actual values, $\bar{Y}$ the mean, and $\hat{Y}$ the estimated values of Y_i. Also:

$$3.45 \qquad r^2 = \frac{\text{explained variance}}{\text{total variance}} = SS_{reg}$$

$$3.46 \qquad 1-r^2 = \frac{\text{unexplained variance}}{\text{total variance}} = SS_{res}$$

From these components, an F ratio can be computed by using the formula

$$3.47 \qquad F = \frac{SSE/k}{SSR/N-k-1} = \frac{(N-k-1)R^2_{y.1...k}}{k(1-R^2_{y.1...k})}$$

The partition of the total variation shows the effect of the correlation, if R is large, most of the variance in the total variation can be attributed to the information contributed by the regression function. If, on the other hand, R is small, little information is contributed by the variables and the variation must be explained by other means.

To determine if the ratio is significant, reference may be made to the F distribution tables, to test the null hypothesis at the α level (.05,.01 or .001), that the population multiple coefficient of determination equals zero, the value of F is compared with the value $F_{1-\alpha}$ with k and N-k.1 degrees of freedom.

The term. number of degrees of freedom means, the total number of observations in the sample, that is N, less the number of independent restrictions put on the regression.

To obtain the estimate of the parameters β_1,β_2 and β_3 for example, will put three constraints on the analysis of residuals.

3.5.3.3. Test for a specific regression coefficient.

The overall null hypothesis, $H_0:\rho_{y.1..k}= 0$, ρ being the population correlation coefficient, is equivalent to the null hypothesis that k number of regression coefficients are equal to zero in the population, $H_0: \beta_1 = \beta_2 = .. \beta_k = 0$.

Therefore, if the overall null hypothesis is rejected, one may conclude that one or more of the population regression coefficients has an absolute value greater than zero. As the overall test does not indicate which β_i value is non zero, an additional test for specific regression coefficients is required.

Such tests may be used to decide whether some variables can be deleted from the regression function or to decide on the confidence that can be attributed to the sign of the regression coefficient.

The student's t test is used to test the significance of a regression coefficient, its formula is given by:

3.48 $$t = \frac{b_1 - \beta_1}{SE(b_1)}$$

Where β_1 is the true parameter, b_1 the parameter estimate and $SE(b_1)$, the standard error of the estimate.

If the computed t value exceeds the critical t value at the chosen level of significance, one may reject the null hypothesis that the coefficient is equal to zero.

4. CONCLUSION.

This chapter dealt with the identification of an index representing the integration of technology as well as a formulation of a model explaining the rate of this integration. The next chapter deals with the analysis of variables presented in this chapter.

CHAPTER FOUR

ANALYSIS OF VARIABLES

CHAPTER 4

1. INTRODUCTION

In this chapter it is intended to present a framework for classifying the economic and social variables as they relate to the countries' characteristics, such a framework makes it easier to adopt a systematic approach to the analysis of socio-economic indicators of technological transfer, as it provides greater insights into the similarities of the variables and indicates their hierarchical relationships.

Surprisingly little work has been done towards producing a theory of socio-economic variables analysis which 1) identifies the linkages between variables, and 2) explains how these various variables interrelate to clarify a profile of the countries' characteristics.

The proposed analysis is aimed at reaching these two objectives which satisfy in their turn the purposes below:

a) The aim of the model of this thesis discussed in Chapter 3 is to select those most important variables that possibly explain to what is technological transfer mostly related.

The grouping or classification of variables in this chapter provides information on their functional similarities, which allows further knowledge on the interrelation between the variables. This assists the regression model in the choice of variables; that is, a variable can be selected or rejected by the analyst on the ground of the dimension it explains, if, for instance two selected variables by the regression model are known to explain the same dimension by the use of the technique in this chapter, then one of the variables should be discarded and only one would be used, see Shen (1977, p.416).

Therefore, with the present categoric framework of the classified variables as well as their importance, the researcher can test whether his regression model has selected the appropriate variables. Also he is more aware of the validity and importance of the variables and has a more defined idea of what they represent, and how they relate to each other.

Most important of all, once the variables or indicators are identified by the regression model, the grouping helps locate the indicators that are from the same or from a different category from the ones retained. This is of relevant importance in the sense that application of the model could be performed for cases in which data on that variable is unknown, which cannot be achieved by regression analysis or other techniques, it should therefore, be stressed that the classification of variables is a complementary analysis of exploratory ability to multiple regression analysis model.

b) The present classification analysis is important in its own right as it proposes a framework to the analyst or researcher who can adopt a comprehensive approach to the analysis of socio-economic variables.

Furthermore, the usefulness of this analysis can be more appreciated when one knows that many variables can be similar in construction while they may not be similar in terms of measuring the same characteristics.

The method used to determine the empirically based groupings of variables is factor analysis. This technique accounts for the covariance or correlations of the numerous observed variables in terms of a small number of hypothetical components or factors.

2. FACTOR ANALYSIS AND THE VARIABLES CLASSIFICATION

Correlation analysis in the third chapter served as a preliminary basis for the analysis of variables, a further analysis based on the method of factor analysis is attempted to provide another criteria for the classification of the employed set of variables into groups. This method is applied to the 30 economic and social indicators of the 45 developing countries during the period 1970 to 1977. The selection of variables as well as the sample selection are discussed in the preceeding chapter.

In order to interpret cross sectional analysis as indications of historical transformations, one may conceive successive points along the statistical fit as successive levels of socio-economic state of a typical developing country. More specifically, an n-dimensional space corresponding to each country is determined by a set of n variables related to the country's stage of social and economic development. The method of factor analysis fitted to these points in the m-dimensional space of common factors yields a representation of the average relationship among the several factors for the countries in the sample.

It is intended in this part to discuss the method of factor analysis and to comment on the results in the next part.

The use of cross section analysis to obtain insight into the phenomenon of economic structure of developing countries is necessary and requires justification.

2 - 1 On Factor Analysis

The technique of factor analysis originated with the work of psychologists such as Spearman and Thurstone, see Harman (1970), and was primarily concerned with mathematical models for the explanation of psychological theories of human ability and behaviour.

Vincent (1953) made an early attempt at a general review based on the historical development of factor analysis; a mathematical treatment of the technique can be found in Harman (1970), Lawley and Maxwell (1971) and Cooley and Lohnes (1962) among others; a less mathematical description that may serve as an introduction to the topic may be found in Comrey (1973).

Factor analysis is a branch of multivariate analysis, concerned with the internal relationships of a number of variables, it enables one to see whether some underlying pattern of relationships exist such that the data may be condensed to a smaller set of factors, hence the information provided about the individual observations by the total number of variables originally employed can be obtained from these fewer factors.

An example whereby a factor of "bigness" could be used to account for the correlation between height and weight is given by Comrey (1973, p.6) where both height and weight would substantially be correlated with a factor called "bigness", the correlation of the two variables would be accounted for by the fact that they both share a relationship to the factor.

Harman (1970, p.7) gives a broad classification of disciplines in which factor analysis is being increasingly used, apart from psychology, these fields are as varied as sociology,geography, meteorology, medicine, business, international relations and economics, among many others.

An example of the use of factor analysis in economics, Gilbert (1980) and among others, Tinter (1965, chapter 6) has suggested that with the application of factor analysis one may answer questions such as: what proportion of the total variation of the various quantities produced in the different industries is accounted for by an index of industrial output.

Particular reference should be made to Adelman and Morris (1965 and 1971) where factor analysis was used to study the interaction of economic and noneconomic forces in development, it was basically one of the first development economics studies to use factor analysis and involved one economic variable which is GNP per capita and a broad selection of indicators of the social and political structure of seventy four less developed countries. According to the dimensions they explained the non economic indicators were analysed in conjunction with the economic indicator to conclude that the purely economic performance of a community is strongly conditioned by the social and political setting in which economic operations take place.

The brief enumeration of the fields in which factor analysis is increasingly being used shows the popularity and power of this technique. Its use by researchers or investigators is in part due to the following reasons among others.

1. Factor Analysis as a Descriptive Device.

One may have measurements on a number of variables for certain observations and would be interested to know about the factors that can be used to explain the intercorrelations among these variables. It can be simple to interpret the values for each true variable individually, but when they all vary together, they may give a confusing picture. If the small number of factors that are used to explain a large part of the variance can be linked with some meaningful concepts, then factor analysis can act as a powerful descriptive and explorative device in explaining the difference between observations.

2. Factor Analysis as a Ranking Device.

An economist may be faced with the situation where he has a large number of socio-economic variables that he considers are related to a factor of success of a developing country, and that he wants to rank the countries from the most successful to the least successful, without being prepared to consider any variable to be a more important indication of the success than any other. He therefore must take some weighted index of all these variables in such a way as to form an index that distinguishes the countries to the greatest extent possible, that is the index must have a maximum variance, the index having the desired property is precisely the first factor as will be shown later, Rayner (1970) comments on this point, see also Tinter (1965).

3. Factor Analysis as a Tool for Further Analysis.

As was stated earlier, this technique can be used in order to perform further statistical analysis such as regression analysis or discriminant analysis, when the number of variables under study is large, it is often convenient to reduce the original number of explanatory variables to a smaller set, which are preferably independent, and which together explain a large proportion of the variance.

4. Factor Analysis as a Testing Device.

One may wish to test a theory about the nature and number of factor constructs needed to account for the variable he is studying, or wish to test previous findings, using a new sample from the same population or from another.

One may briefly conclude that the main objective of factor analysis is to provide a relatively small number of factors or components that will serve as satisfactory substitutes for a larger number of variables. These factors are even considered as more important than the original variables, as Comrey (1973,p.6) argues:

> "These factor constructs themselves are variables that may prove to be more useful than the original variables from which they were derived."

2.2 The Factor Models.

The analysis of the structure of correlation matrices from which the factors are derived, can be achieved by two models. The principal component analysis, initially proposed by Pearson in 1901, and developed by Hotelling in the 1930's and the classical factor analysis model which originated with the work of Spearman in 1904.

The object of both methods is to transform linearly a set of k observed variables X_1, X_2, X_k, in order to produce a new set of k standardised variables z called factors. However, as put forward by Harman (1970, P.14) there exists a distinction between the two objectives, namely that principal component analysis is used to extract the maximum variance and factor analysis is used to "best" reproduce the observed correlations.

The model for component analysis is:

$$(4.1) \qquad Z_j = a_{j1}F_1 + a_{j2}F_2 + \dots + a_{jn}F_n \quad (j = 1,2,\dots n)$$

where each of the n observed variables is described linearly in terms of n new uncorrelated factors F_1, F_2, ..., F_n. Even though this model is exact from the mathematical and statistical point of view, is straightforward and has no assumptions involved, it has the disadvantage of extracting n components corresponding to n variables, which forces the researcher to stipulate only a small number of factors that account for most of the variance, therefore to reproduce the correlations among all variables would require all components. However, this model is widely used as its weakness is overcome by specifying the number of factors to be extracted, using some criteria, see Lindeman et al (1980, p262); its use is frequent in disciplines which have some apriori knowledge of the number of factors, or more precisely dimensions that account for most of the variance of the observed data.

Hence, the model used in the present analysis is the classical factor analysis which extracts a small number of factors by the process itself; this may be put in the form:

$$(4.2) \qquad Z_j = a_{j1}F_1 + a_{j2}F_2 + \dots + a_{jm}F_m + a_{ju}U_j$$

$$(j = 1,2,\dots\dots, n)$$

where Z_j is a standardized variable i.e. $Z_j = (X_j - \bar{X}) / S_j$, linearly described in terms of m factors considerably smaller than n common factors and a unique factor. The common factors account for the correlations among the variables, the unique factor accounts for the remaining variance of variable j.

The model (4-2) can be written for the value of variable j for individual k as follows:

$$(4.3) \quad Z_{jk} = a_{j1}F_1k + a_{j2}F_{2k} + \dots + a_{jm}F_{mk} + a_{ju}U_{jk}$$

or

$$(4.4) \quad Z_{jk} = \sum_{p=1}^{m} a_{jp}F_{pk} + a_{ju}U_{jk} \qquad \begin{matrix}(k = 1,2,\dots, N)\\(j = 1,2,\dots, N)\end{matrix}$$

where

F_{pk} is the value of a common factor p on observation k

a_{jp} is a factor loading for variable j on factor p

d_j is a factor loading for variable j on factor U

and U_{jk} is the unique factor for observation k on variable j.

Each A value is a numerical constant called factor loading, that is found by the process of factor analysis itself. It falls between -1 and 1, and represents the extent to which variable j is related to factor p, or more precisely it shows the weight attributed to that variable on the factors.

The F scores for observation k on factor p may be computed as part of factor analysis. This represents the score of factor p on all variables, once the dimension of the factor is specified, the factor scores could be used as new variables, therefore m number of factors could be used instead of n number of variables $(m < n)$

Since F and U are standard variables, it can be assumed that they have zero means and unit variance. Also, the n unique factors are supposed to be independent of each other and independent of the m common factors.

The problem of factor analysis is to estimate the nm loadings that is the a's, whether the principal component analysis or the basic factor analysis model is used, the procedure is the same; it involves three stages, firstly the preparation of the correlation matrix, secondly the extraction of the factors which can be achieved by various methods for the classical factor analysis model and thirdly, the rotation of the factors which also could be performed by many methods. Once the factors are rotated, then a meaningful interpretation of the dimensions they represent is attempted.

2.2.1 Preparation of the Correlation Matrix

In this section, the variables are standardized and their correlations are used for the calculations of the factor loadings. See Appendix 11 for some matrix algebra.

Equation (4.3) may be represented in shematic matrix form for all values of j and i simultaneously, that is, for all data variables and all observations in fig. (4.1).

The shematic matrix equation in fig. (4.1) may be represented by the following matrix equation:

(4.8) $$Z = A_u F_u$$

FIG. (4-1) SHEMATIC MATRIX NOTATION FOR ALL VALUES OF j AND i

$$
\underset{Z}{\begin{array}{c|ccccc}
\multicolumn{6}{c}{\text{OBSERVATIONS}} \\
 & 1 & 2 & 3 & \ldots & N \\
\hline
1 & z_{11} & z_{12} & z_{13}\ldots & & z_{1n} \\
2 & z_{21} & z_{22} & z_{23}\ldots & & z_{2n} \\
3 & z_{31} & z_{32} & z_{33}\ldots & & z_{3n} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
n & z_{n1} & z_{n2} & z_{n3}\ldots & & z_{nN}
\end{array}}_{\text{VARIABLES}}
=
\underset{A_u}{\begin{array}{c|ccccc|ccccc}
\multicolumn{6}{c}{\text{FACTORS}} & \multicolumn{5}{c}{} \\
 & 1 & 2 & 3 & \ldots & m & 1 & 2 & 3 & \ldots & n \\
\hline
1 & a_{1n} & a_{12} & a_{13}\ldots & & a_{1m} & a_{1u} & & & & 0 \\
2 & a_{21} & a_{22} & a_{23}\ldots & & a_{2m} & & a_{2u} & & & \\
3 & a_{31} & a_{32} & a_{33}\ldots & & a_{3m} & & & a_{3u} & & \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & & 0 & & \ddots & \\
n & a_{n1} & a_{n2} & a_{n3}\ldots & & a_{nm} & & & & & a_{nu}
\end{array}}_{\text{VARIABLES}}
\times
\underset{F_u}{\begin{array}{c|ccccc}
\multicolumn{6}{c}{\text{OBSERVATIONS}} \\
 & 1 & 2 & 3 & \ldots & N \\
\hline
1 & F_{11} & F_{12} & F_{13} & \ldots & F_{1N} \\
2 & F_{21} & F_{22} & F_{23} & \ldots & F_{2N} \\
3 & F_{31} & F_{32} & F_{33} & \ldots & F_{3N} \\
\vdots & \vdots & & & & \\
m & F_{m1} & F_{m2} & F_{m3} & \ldots & F_{mN} \\
\hline
1 & U_{11} & U_{12} & U_{13} & \ldots & U_{1N} \\
2 & U_{21} & U_{22} & U_{23} & \ldots & U2N \\
3 & U_{31} & U_{32} & U_{33} & \ldots & U_{3N} \\
\vdots & \vdots & & & & \\
n & U_{n1} & U_{n2} & U_{n3} & \ldots & U_{nN}
\end{array}}_{\text{FACTORS}}
$$

which shows that, by multiplying A_u by F_u, the model (4.3) is represented for all observations and for all variables, therefore, to reproduce the score on variable i for observation k would involve the multiplication of the i^{th} row of matrix A by the kth column of matrix F_u which gives:

$$(4.9) \qquad Z_{ik} = A_{i1}F_{1k} + a_{i2}F_{2k} + \ldots\ldots + a_{im}F_{mk} + a_{iu}U_{ik}$$

The formula for the correlation coefficient in standard form is:

$$(4.10) \quad r_{ji} = S_{ji}/S_jS_i = \sum_{k=1}^{N} x_{jk}x_{ik}/\sqrt{\sum_{k=1}^{N} x_{jk}^2 = \sum_{k=1}^{N} x_{ik}^2} = \sum_{k=1}^{N} Z_{jk}Z_{ik}/N$$

where

$$x_{jk} = X_{jk} - \overline{X}_j \quad , \quad x_{ik} = X_{ik} - \overline{X}_i$$

and

$$Z_{jk} = X_{jk} - \overline{X}_j \;/\sqrt{\sum_{k=1}^{N} x_{jk}^2}$$

The correlation between a pair of data variables j and i could be obtained by multiplying equation (4.9) by (4.3) summing both sides over k from 1 to N observations and dividing both sides by N; thus equation (4.10) becomes:

$$(4.11) \quad r_{ij} = \frac{\Sigma Z_{ik} Z_{jk}}{N} = a_{i1}\, a_{j1}\, (\frac{\Sigma F^2_{1k}}{N})$$

$$+ a_{i2} a_{j2} (\frac{\Sigma F^2_{2k}}{N}) + \ldots + a_{im} a_{jm} (\frac{\Sigma F^2_{mk}}{N})$$

$$+ 2a_{i1}\, a_{j1}\, [\frac{\Sigma F_{1k} F_{2k}}{N}] + \ldots + 2a_{(m-1)i} a_{mj} [\frac{\Sigma F_{(m-1)k} F_{mk}}{N}]$$

$$+ a_{i1} a_{ju} [\frac{\Sigma F_{1k} U_{jk}}{N}] + \ldots + a_{im} a_{ju} [\frac{\Sigma F_{mk} U_{jk}}{N}]$$

$$+ a_{j1} a_{iu} [\frac{\Sigma F_{1k} U_{ik}}{N}] + \ldots + a_{jm} a_{iu} [\frac{\Sigma F_{mk} U_{ik}}{N}]$$

$$+ a_{iu}\, a_{ju} [\frac{\Sigma U_{ik} U_{jk}}{N}].$$

where the sums without indicated index are on k from 1 to N. The formula for the variance or the squared deviation of a set of standardised variables is:

$$(4.12) \quad \sigma^2_i = \frac{\Sigma Z^2_k}{N} = 1.0$$

In the orthogonal factor analytic model being considered, the factors are assumed uncorrelated with each other, therefore the terms in brackets which represent the correlation between the factors in equation (4.11) are equal to zero, furthermore, the terms in parentheses represent variances like (4.12) and hence are all equal to 1.0; therefore, the correlation between any two standardised variables is reproduced from the factor pattern (4.3) by the simplification of (4.11) to get:

$$(4.13) \quad r_{ij} = a_{i1}a_{j1} + a_{i2}a_{j2} + \ldots\ldots + a_{im}a_{jm}$$

$$(i \neq j;\ i,j=1,2\ldots,n)$$

The development above merely states that the correlation between any pair of variables is the sum of the products of their factor loadings in the common factors; this statement has been called "the fundamental factor theorem" by Thurstone,

Equation (4.13) may be put in the following matrix form:

$$(4.14) \quad R = AA'$$

From equations (4.13) and (4.14) it is apparent that only the common factors determine the off diagonal elements of R, that is for which i and j are different for an element r_{ij} of R. However, for the diagonal elements, the r_{ij} values for which i=j, the unique factor does not make a contribution in the correlation matrix, in other words, for the diagonal terms the row by column multiplication gives terms like those in (4.12), that is:

$$(4.15) \quad \sum_{k=1}^{u} Z^2_{jk} = S_j = a^2_{j1} + \ldots.. + a^2_{jm} + a^2_{ju} = 1$$

which represents the variance of any variable, and may be divided up as follows:

$$(4.16) \quad 1 = h^2_j + u^2_j$$

where

$$(4.17) \quad h^2_j + a^2_{j1.} + a^2_{j2} + \ldots.. + a^2_{jm}$$

and

$$(4.18) \quad u^2_j = S^2_j + e^2_j$$

h^2_j is the communality of variable j which represents the proportion of the total variance of a variable due to common factors, and is equal to the sum of squares of the loadings of variable j on the common factors, U^2_j is the uniqueness of variable j, which represents the proportion of the total variance that is accounted for by the specific and error factors to that variable, it should be noted that the term $a_{ju}U_j$ in model (4.2) could be decomposed into $a_{js}S_j$ and $a_{je}E_j$, to represent the loadings of each variable on its specific and error factors. The reliability of a variable can be found by adding the proportion of variance due to the specific factor to the communality, excluding the error variance, the reliability of variable j is:

$$(4.19) \quad r_{tt_j} = h_j^2 + S_j^2$$

Having shown how the factor loadings could be obtained from the correlation matrix, according to the principle of factor analysis, the concept of factor extraction will now be introduced.

2.2.2 Factor Extraction

2.2.2.1 Methods of Factor Extraction

The process of factor extraction starts with a matrix of correlations between data variables and ends up with a matrix of factor loadings A in order to reproduce the correlation matrix R when A is multiplied by its transpose A'. Many methods have been developed for this purpose; the computer package SPSS (1976) contains five methods of which two are the most general. The methods of extraction are mainly differentiated by the procedure used to determine the diagonal of the correlation matrix. Thus, if 1's are put in the diagonal of the correlation matrix R, the extracted matrix of factor loadings A is obtained such that AA' reproduces exactly R, this process requires an A matrix the same size as R, which extracts as many factors in A as there are variables in R, generally only the first factors are kept to account for most of the variance of the variables, in this case all the factors are common in that the specific and error variance are absorbed by the common factors, this first method labelled as PA1 by the SPSS is referred to as the principal component method which was discussed earlier.

The second method which goal is to reproduce the R matrix with an A matrix containing as few factors as possible is called the principal factor method and labelled PA2 in the SPSS.

This method allows for some discrepancies between the computed data correlations and the reproduced correlations which are the AA′. To allow for error, communality estimates are put in the diagonal of the correlation matrix R to derive m factors substantially smaller than n variables.

This is the method used in the current analysis in that it possesses the advantage discussed above and it is the only one provided by the available computer package besides the method of principal components and three other methods, Rao, Alpha and Image which are relatively new and are still subject to debate; other methods such as the maximum likelihood, centroid and Minres are not available in the computer package used.

Today, the principal factor method of extraction is the most widely used in that it handles most of the factoring needs of the user as argued by Comrey (1973, p15), Harman (1970, p135) and S P S S (1976, p480).

2.2.2.2 The Principal Factor Solution

This method of factoring is the application of the method of principal components to the reduced correlation matrix, that is, with communalities instead of the ones in the principal diagonal. It was first adapted to the classical factor analysis model by Thomson (1934) as stated by Harman (1970).

The squared multiple correlation between one variable and the rest of the variables is used as initial estimates of the communalities, then an iteration procedure is used to improve the estimates of the communality.

From the classical factor analysis model (4.2) the common factor coefficients are determined by:

$$(4.20) \quad Z_j = a_{j1}F_1 + a_{j2}F_2 + \ldots. + a_{jm}F_m \qquad (j = 1,2,\ldots.,n)$$

where the unique factor $a_{ju}F_u$ has been omitted. Knowing that a^2_{jp} from (4.17) indicates the contribution of the factor F_p to the communality of Z_j, the principal factor method is aimed at selecting the first factor coefficients such as to make the sum of the contributions of that factor to the total communality a maximum. The sum of the first coefficients for all variables represents the proportion of the total variance accounted for by the first factor; it is called eigenvalue and may be written as:

$$(4.21) \quad V_1 = a^2_{11} + a^2_{21} + \ldots. + a^2_{n1}$$

in which the coefficients a_{j1} (j=1 to n variables) must be chosen such that U_1 is a maximum under the conditions of equation (4.13); that is:

$$(4.22) \qquad r_{ij} = \sum_{p=1}^{m} a_{ip}a_{jp} \qquad (i,j = 1,2,\ldots.,n)$$

where $r_{ij} = r_{ji}$ and r_{jj} is the communality h_j^2 of the standardised variable Z_j. Equation (4.22) implies that the observed correlations may be replaced by the reproduced correlations to assume no residual. In order to maximise V_1 which is a function of n variables a_{j1} under the $\frac{1}{2}n(n+1)$ conditions of (4.22) among all the coefficients a_{jp}, that is:

$$(4.23) \qquad 2T = V_1 - \sum_{i,j=1}^{n} \mu_{ij}r_{ij} = V_1 - \sum_{i,j=1}^{n} \sum_{p=1}^{m} \mu_{ij}a_{ip}a_{jp}$$

where $\mu_{ij} = \mu_{ji}$ are the Lagrange multipliers. The partial derivation of (4.23) with respect to a_{ji} is set to zero

$$(4.24) \qquad \frac{\partial T}{\partial a_{ji}} = a_{ji} - \sum_{i=1}^{n} \mu_{ji}a_{i1} = 0$$

Similarly, the partial derivative in respect to any other coefficient a_{jp} ($p \neq 1$) is set equal to zero to give:

$$(4.25) \qquad \frac{\partial T}{\partial a_{jp}} = - \sum_{i=1}^{n} \mu_{ji}a_{ip} = 0$$

Equations (4.24) and (4.25) may be combined as follows:

$$(4.26) \qquad \frac{\partial T}{\partial a_{jp}} = \partial_{1p}a_{j1} - \sum_{i=1}^{n} \mu_{ji}a_{ip} = 0 \qquad (p=1,2,\ldots.,m)$$

where the Kronecker $\partial_{np}=1$ if p=n and $\partial_{1p}=0$ if p≠1. Multiplying (4.26) by a_{j1} and summing with respect to j gives:

$$(4.27) \quad \partial_{1p} \sum_{j=1}^{n} a_{j1}^{2} - \sum_{j=1}^{n} \sum_{i=1}^{n} \mu_{ji} a_{ji} a_{ip} = 0$$

According to (4.24) the expression $\sum_{j=1}^{n} \mu_{ji} a_{ji}$ is equal to a_{j1}, setting $\sum_{j=1}^{n} a_{j1}^{2} = \lambda_{1}$, equation (4.27) may be written as follows:

$$(4.28) \quad \partial_{1p} \lambda_{1} - \sum_{i=1}^{n} a_{i1} a_{ip} = 0$$

Multiplying (4.28) by a_{jp} and summing for p, this equation becomes

$$(4.29) \quad a_{j1} \lambda_{1} - \sum_{i=1}^{n} a_{i1} \left(\sum_{p=1}^{m} a_{jp} a_{ip} \right) = 0$$

or, applying the conditions (4.22),

$$(4.30) \quad \sum_{i=1}^{n} r_{ji} a_{i1} - \lambda_{1} a_{j1} = 0$$

expression (4.30) may be represented for the m following equations, for each value of j as:

$$(4.31) \quad \begin{aligned} (h_1^2-\lambda)a_{11} + r_{12}a_{21} + \dots + r_{1n}a_{n1} &= 0 \\ r_{21}a_{11} + (h_2^2-\lambda)a_{21} + \dots + r_{2n}a_{n1} &= 0 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots & \\ r_{n1}a_{11} + r_{n2}a_{21} + \dots + (h_n^2-\lambda)a_{n1} &= 0 \end{aligned}$$

In order to solve these n homogeneous equations, a necessary condition is the vanishing of the a_{j1} coefficients such that:

$$(4.32) \quad \begin{vmatrix} (h_1^2-\lambda) & r_{12} & r_{13} & \cdots\cdots & r_{1n} \\ r_{21} & (h_2^2-\lambda) & r_{23} & \cdots\cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & r_{n3} & & (h_n^2-\lambda) \end{vmatrix} = 0$$

which is known as the characteristic equation. Some of the important properties of this equation are that all roots are real and that a q-fold multiple root substituted for λ in (4.32) would reduce the rank of the determinant to (n-q). A set of homogeneous linear equations of rank (n-1) is obtained when a simple root of (4.32) is substituted for λ in (4.31), this set of equations has a family of solutions which are proportional to one particular solution. It follows that the factor of proportionality is:

$$(4.33) \qquad \lambda_1 = \sum_{j=1}^{n} a_{j1}^2$$

which shows that λ_n is V_1, and that V_1 is equal to one of the roots of the characteristic equation, more precisely, the largest root λ_1. Therefore, the factor loadings or coefficients a_{jn} may be obtained by substituting the largest root λ_1 of (4.32) in (4.31) in this set of equations, to each eigenvalue correspond a vector (a set of α's) called eigenvector.

To satisfy the relation (4.21), these values are divided by the square root of the sum of their squares and multiplied by $\sqrt{\lambda_n}$ to get:

$$(4.34) \quad a_{j1} = \alpha_{j1}\sqrt{\lambda_1} \,/\, \sqrt{(\alpha_{11}^2 + \alpha_{21}^2 + \ldots. + \alpha_{n1}^2)} \quad (j=1 \text{ to } n)$$

which are the coefficients or factor loadings on F_n in the factor pattern (4.20). The roots (λ's) are referred to as eigenvalues.

The first factor may be defined as the best linear relations exhibited in the data, the second factor should account for the maximum variance of the residual communality; to do this, its contribution is removed to find the first factor residual correlations, as the process continues until (m-1) factors are removed, the residual correlation of r_{ij} with S factors removed may be written $s^{r}ij$, the first factor residual is then:

$$(4.35) \quad 1^{r}ij = r_{ij} - a_{i1}a_{j1} = a_{i2}a_{j2} + a_{i3}a_{j3} + \ldots. + a_{im}a_{jm}$$

or more generally, using the R matrix (4.14), the residual matrix after extraction of factor 1 is:

$$(4.36) \quad R_1 = R - A_1A_1'$$

where A_1 represents the first factor vectors $a_{11}, a_{21}, \ldots, a_{m1}$. Then in order to extract the coefficients of the second factor F_2, it is necessary to maximize:

$$(4.37) \quad V_2 = a_{12}^2 + a_{22}^2 + \ldots + a_{n2}^2$$

which represents the sum of the contributions of the second factor to the residual communality.

Once the factors needed to account for the correlations in the R matrix have been extracted, an initial unrotated matrix is provided, see Table 4.1.

The first factor in this table is the largest in the sense that the sum of squares of the factor loadings or eigenvalue on the first column is the largest (12.27) that is explaining 40% of the total variance. The following factors become progressively smaller with the last one being only (.58), that is explaining about 2% of the variance, see table 4.1. The last column contains the communalities which represent the extent to which the variables overlap with the factors, that is they give the proportion of variance accounted for by the factors, the nearer the communality to 1, the more it indicates that the variable overlaps perfectly with the factors in what it measures. If, on the contrary, the communality of a variable is near to zero, then it would not share anything in common with any of the five factors. When $0<h^2<1$ it indicates partial overlapping between the variable and the factors.

Although this table gives an acceptable factor solution, the factors represented in an unrotated factor matrix are rarely useful. This is because the factor extraction is designed to extract as much variance as possible with each successive factor, which results in a sharp decrease in factor size from the first to the last factor.

These unrotated factors tend to be highly complex to interpret as they relate to many of the variables rather than to just a few. For instance,the first factor in table 4.1 has appreciable loadings for most of the variables. The second factor has loadings of some importance with about half the variables. Seven variables are somehow related to the third factor, then three and two variables have significant loadings on the fourth and fifth factors respectively. Therefore, the unrotated factor matrix is transformed into a new matrix that is mathematically equivalent to the original matrix but which represents factors that are much more useful for scientific purposes than the unrotated factor matrix in the sense that each factor is made to overlap with as many of the data variables as possible. This process is called factor rotation, it consists of rotating the original factor matrix into another form so that each factor tends to receive substantial contributions from as many of the data variables as possible, this provides an easier measurement and, therefore, facilitates interpretation.

TABLE 4-1 UNROTATED MATRIX OF LOADINGS FOR ALL COUNTRIES

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	COMMUNALITY
Population	- .10002	.38839	.64222	-.22676	-.09808	.04950	.63679
Per Capita GNP	.87090	.16553	.18025	.06924	.33980	-.00543	.93865
Gross National Product (in $)	.28881	.74480	-.54940	.16068	.16215	.01728	.99239
Gross Industrial Product (GIP)	.29827	.79227	-.40901	-.08499	.19590	.00010	.92955
Gross Domestic Investment	.24684	.56043	.37143	.06851	-.55828	-.02974	.83022
Gross National Saving	.23935	.58403	.01221	.28566	-.24990	-.13723	.56142
GIP as % GDP	.57804	.50333	.04447	-.09742	-.11444	.03978	.61362
Education Expenditure	.32483	.14457	.38890	.06822	-.10729	.04019	.29544
Agricultural Production	- .77689	-.26154	-.38602	.15126	.16382	-.03332	.87179
Production on Manufacture	.74732	-.26148	-.06470	-.10975	-.04659	-.02558	.64592
Industrial Production	.27707	.81716	.23033	.02429	-.11237	-.00403	.81081
Exports of Manufactured Goods	.14604	-.21663	.03292	-.51646	-.18170	.27114	.44260
Import of Manufactured Goods	- .38291	-.02189	.05551	.33952	.20619	.45386	.51396
Commodity Concentration	- .07146	.29283	-.08916	.68031	.28421	.06196	.64625
Per Capita Food Consumption	.64059	-.07973	.03008	-.25105	.21233	-.08493	.53295
Per Capita Energy Consumption	.84970	.22703	.14979	.00396	.25828	-.09688	.87207
Urban Population Growth	- .61279	.23033	.26316	.25733	.08914	-.04916	.57440
Population Density	.20873	-.21474	-.25383	.27544	-.23131	.00150	.28349
Urban Popul. as % of Total	.85747	-.03444	.17140	-.05649	.16793	.07049	.80218
Birth Rate	- .74582	.37153	.30116	-.06171	-.00736	.26830	.86083
Death Rate	- .81597	.25514	.22992	-.26080	.29498	-.02422	.93939
Life Expectancy	.84468	-.32461	-.15778	.23765	-.21983	-.03299	.94964
Population per Physician	- .66062	.01395	.02375	-.01326	.18660	-.29816	.56107
Access to Water	.76821	-.10884	.29194	.07448	.12676	.05726	.71212
Adjusted School Enrol. Ratio	.86088	-.15069	-.16708	.07545	-.01114	-.09274	.80616
Adult Literacy Rate	.73732	-.19521	-.36077	.27212	-.15320	.09074	.81766
Labour Force in Agriculture % Tot.	- .93777	.04868	.08799	-.02330	-.05908	-.13844	.91272
Labour Force in Industry % of Tot.	.86122	.02723	-.08145	-.10300	.09231	.16953	.79695
Radio Rec. per Thousand	.74454	-.03055	.17133	-.00814	.15811	-.00126	.60969
Passenger Cars per Thousand	.80733	-.14641	.24787	-.03426	.15702	-.13264	.77808
Eigenvalue	12.27	3.79	2.12	1.50	1.25	.58	
Percentage of Variance = 69	40%	12%	7%	5%	4%	1.9%	

2.2.3 Factor Rotation

The rotational process in factor analysis involves finding a transformation matrix so that when it is multiplied by the initial unrotated matrix it produces a new set of factor constructs that mathematically accounts equally well for the data as the initial factor loadings.

There exists a number of factor rotation methods of which the basis has been expressed by Thurstone's concept of simple structure for the case of orthogonal factors. His criteria for the transformation matrix is that only one factor should contribute substantially to variable j while the other factors should not contribute at all. The conditions are; see Harman (1970, p98).

1) Each row of the factor matrix should have at least one zero.
2) If there are m common factors, each column should have at least m zeros.
3) For every pair of columns, there should be several variables with elements equal to zero in one column, but not in the other.
4) For every pair of columns of the factor matrix, a large proportion of the variables should have elements equal to zero in both columns when there are four or more common factors.
5) For every pair of columns, there should be only a small number of variables with elements not equal to zero in both columns.

The several analytical procedures that were developed independently, based on the conditions above may be conveniently put in the following matrix rotation:

(4.38) $B = AT$

in which

$A = (a_{jp})$ initial factor matrix $(j=1 \text{ to } n)$
$(p=1 \text{ to } m)$

(4.39) $B = (b_{jp})$ final factor matrix

$T = (t_{qp})$ orthogonal transformation matrix

When A is carried into the rotated factor matrix B by the orthogonal transformation T, the communality of any variable remains constant, that is:

(4.40) $$\sum_{p=1}^{m} b^2_{jp} = \sum_{p=1}^{m} a^2_{jp} = h^2_j \qquad (j = 1,2,\ldots.,n)$$

The first methods of rotation were mainly graphical and required a large amount of labour and experience for their operations; the development of more objective methods began in the 1950's, it has been greatly aided by the increasing availability of computers, Darton (1980) makes an attempt of reviewing the different methods of rotation.

The two best known methods for rotating the initial factor matrix are the quartimax and varimax methods, a number of other procedures and criteria have been suggested to obtain orthogonal rotated solutions, among them the transvarimax methods. For a discussion of these methods see Mulaik (1972, Chapter 10.) The other methods of factoring are called oblique in which two factors can be notated through different angles so that the rotated factors are correlated.

Quartimax method is aimed at simplifying the rows of the factor matrix, the essential idea underlying this approach is to rotate in such a way that each variable would have a major loading in one and only one factor; in practice, this ideal can only be approximated by this method. However, experience with the quartimax approach has shown that it tends to give a general factor to which virtually all the variables are substantially correlated, this undesirable property of the quartimax approach and the later appearance of the varimax method has led to the preference of the later approach by most analysts as shown by Lindeman (1980,p272) , Comrey (1973,p173) Cooley and Lohnes (1962,p162) and Harman (1970,p311).

The varimax criterion of rotation is a development of Kaiser (1958) and it involves the simplification of columns rather than of rows of the factor matrix, that is, it maximizes the variance of the squared factor loadings by columns, thus, on any given factor the desired pattern is to have some high loadings, lots of low loadings and a few intermediate sized loadings. This type of solution offers an easier interpretability as the variables with high loadings are similar to the factor. However, even-though this method does not suffer from the tendency to give a general factor, Cattell (1966) states that it still does not pull enough variance away from the largest extracted factor; see Lawley and Maxwell (1971, p75).

The varimax method of rotation is used in the present analysis, it has provided some significant solutions which will be discussed in the next part; it is first intended to outline briefly the method.

In the notation of (4.39) the object of the varimax method is to determine the orthogonal transformation T which will carry the initial factor matrix A into a new factor matrix B for which the variance of squared factor loadings of columns is a maximum.

Following the development of Kaiser, the simplicity of a factor P is defined as the variance of its squared loadings,

$$(4.41) \qquad S_p^2 = \frac{1}{n} \sum_{j=1}^{n} (b_{jp}^2)^2 - \frac{1}{n^2} \left(\sum_{j=1}^{n} b_{jp}^2 \right)^2 \qquad (p=1,2,\ldots\ldots,m)$$

The criterion of maximum simplicity of a complete factor matrix is defined as the maximization of the sum of these simplicities of the individual factors, that is:

$$(4.42) \qquad S^2 = \sum_{p=1}^{m} S_p^2 = \frac{1}{n} \sum_{p=1}^{m} \sum_{j=1}^{n} b_{jp}^4 - \frac{1}{n^2} \sum_{p=1}^{m} \left(\sum_{j=1}^{n} b_{jp}^2 \right)^2$$

When the variance is at a maximum, the factor has the greatest simplicity in the sense that its loadings (the b's) tend towards the unity of zero. The maximization of (4.42) has been called the "raw" varimax criterion by Kaiser, this is because of the existence of a bias that is attributed to the different weights which are attached to the variables by the size of their communalities, each variable contributes to (4.42) by the square of its communality as may be seen from (4.40). Therefore, the greater the communality of a variable, the more it influences the rotation. This problem led Kaiser to modify his original approach (4.42) by weighting the variables equally. This is accomplished by extending the vectors that represent the variables to unit length in the common factor space, carrying out the rotations, then bringing them to their original length. Therefore, the improved factor loadings matrix requires the maximization of the function.

$$V = n \sum_{p=1}^{m} \sum_{j=1}^{n} (b_{jp}/h_j)^4 - \sum_{p=1}^{m} (\sum_{j=1}^{n} b_{jp}^2/h_j^2)^2$$

The computing procedure for this solution consists of rotating two factors at a time until the value of V no longer increases (Kaiser, 1958).

The final rotated matrix is found by using Kaiser's varimax method, denoted by PA2 in the SPSS Computer package by Nie et al (1976, p480), it is now necessary to identify the underlying dimensions that each factor represents.

3 THE FACTOR ANALYSIS: RESULTS AND INTERPRETATION

The major task of factor analysis is to interpret what each of the factors represents in terms of the original data. It is therefore necessary to examine the loadings of the individual variables on each factor, so that one can identify the communality and hence meaning in those variables. This process consists of trying to identify the nature of a factor, Comrey (1973,p224) cites some conditions which facilitate this process;

1) The higher the factor loadings the greater is the degree of overlapping true variance between the data variable and the factor and the more the factor is similar to the data variable.
2) If a complex data variable has a substantial loading on a given factor, it becomes difficult to determine the factor from this information alone.
3) The greater the number of variables with a substantial loading on the factor, the easier it is to isolate what the factor represents.

A question that often arises is that of how high the correlation between a data variable and a factor must be in order to be significant for interpretive purposes. Guilford (1965,p442) suggests that a factor loading of .90 would indicate a total overlap in true variance between the data variable and the factor. Comrey (1973 , p225) states that a commonly used cutoff level for factor loading is .30, a squared value $(.30)^2$ gives (.09) which indicates that a correlation of .30 between a data variable and a factor has less than 10 percent of its variance in common with the factor.

Besides these statements, several tests have been suggested to assess the significance of the loadings, see Koutsoyiannis, (1981, p421) for a discussion on these tests. For the present analysis, the Burt-Banks test is used as this formula has the advantage over the others, of taking into account the number of variables and the order of extraction of factors. This test is based on the standard error of the loadings; to do this they suggest an adjustment to the standard error of the correlation coefficient which can be obtained from table in appendix 9. This table is reproduced from Child (1970, p 95). The standard error of the loadings can be obtained using the formula:

$$S(L_{mj}) = \{S(rx_i x_j)\} \sqrt{\frac{k}{k+1-m}} \qquad (i,j=1,2,\ldots,k)$$

where k is the number of X's in the set, and m is the order of factors extracted, that is 1st, 2nd factor, etc.

What magnitude should loadings (L_i) have in order to reach significance in the 3rd factor can be found by substituting in the Burt-Banks formula; the standard error of $rx_i x_j$ is found from the table referred to above, equal to 0.37 (for N = 45) at the 1 percent level of significance, thus:

$$S(L_i) = .37 \sqrt{\frac{30}{30+1-3}} = .38$$

That is for any loading (L_i) to satisfy the 1 percent level of significance in factor 3, its value must be at least equal to .38. The test applied to the 6 factors gave the following minimum values for the loadings to be significant.

FACTORS	SIGNIFICANT LOADINGS
Factor 1	.37
Factor 2	.37
Factor 3	.39
Factor 4	.39
Factor 5	.39
Factor 6	.40

Each variable may be assigned to that factor with which is shows the closest linear relationship, when a variable loads significantly in two or more factors, an example is the variable "urban population growth", it is generally assigned to the factor with which it has the closest affinity, then it may be used for the explanation of the other factors with which it has lesser linear relationship but significant enough to share in the contribution of that dimension. In fact, these variables are attributed special importance as they measure more than one dimension.

The results of the rotated factor matrix are presented in table 4.2 in which the variables are grouped according to the factor with which they have more affinity, the highest loading are boxed in order to distinguish them more easily. The interpretation of factor loadings may more easily be made in terms of the squares of the coefficients in the factor matrix. Each $(a_{ip})^2$ represents the proportion of the total unit variance of variable i which is explained by factor p, after allowing for the contributions of the other factors. From the first row, it can be seen that 8.4 percent of intercountry variations in population are explained by factor 1, an additional 0.8 percent by factor 2, another 0.15 percent by factor 3, 52 percent by factor 4, 1.25 percent by factor 5 and 0.28 percent by the last factor. The sum of these squared loadings are indicated by the communality given in the right hand column as was already shown, the communality indicates the proportion of the total unit variance explained by all the common factors and is thus anologous to R^2 in multiple regression analysis. The communality of population for instance is:

$$(.29)^2 + (.09)^2 + (.04)^2 + (.72)^2 + (.11)^2 + (.05)^2 = .62$$

That is to say 62 percent of intercountry variations in population are associated with the six common factors extracted from the thirty economic and social variables incorporated in the analysis. It is interesting to note that the communality in both tables 4-1 and 4-2 are the same. This indicates the mathematical equivalence of the initial unrotated matrix and the final matrix for describing the original correlation matrix.

Another important characteristic about the matrix of loadings is that the last row of table 4-2 which represents the eigenvalues of the factors, described earlier, are different from the ones in table 4-1. They indicate a different proportion of the total variance explained, more precisely, the large variance explained by the first factor is, in some ways, spread to the remaining factors, even though the degree of variance extraction still remains from largest to lowest, these values were not provided by the computer output and had to be calculated apart, each eigenvalue in the sum of squares of the factor loadings of each variable on that factor, therefore one may see in table 4-2 that 27.3 percent of the total explained variance is accounted for by factor 1, then 14.3 percent by factor 2, 10 percent by factor 3, 9.6 percent by factor 4 5.3 percent by factor 5. and only a small proportion of 2.6 percent by the last factor.

As stated above, the interpretation of the matrix of factor loadings consists of identifying the dimensions expressed by the factors by giving a reasonable explanation of their underlying forces. The factors may represent a variable as such, or indeed an integrated system which underlies the process of economic organisations in developing countries. Thurstone (1961,p61) who pioneered the use of factor analysis in psychology may be quoted to express this point:

> " The derived variables are of scientific interest only insofar as they represent processes or parameters that involve the fundamental concepts of the science involved."

To determine the factors from the functional relationships of the variables, it is necessary first to know what the variables to be related are, also it should be realised that all possible sets of variables may not be equally good for expressing a particular phenomenon: to quote Comrey (1973,p228)

> " Some sets may be more parsimonious than others. Some sets may be more easily integrated into unifying theoretical superstructures. Some sets of variables may have greater heuristic value than others. "

In the sections below, the factors which are specified in the results of the present statistical analysis are identified.

3.1. The First Factor

No.	Variables	Factor 1
1	Per Capita GNP	.92
2	Agricultural Production	- .67
3	Per Capita Food Consumption	.66
4	Per Capita Energy Consumption	.85
5	Urban Popl. as % of total Popl.	.84
6	Population per Physician	- .45
7	Access to Water	.77
8	Percentage of Labour Force in Agric.	- .78
9	Percentage of Labour Force in Indus.	.74
10	Radio Receivers per Thousand	.73
11	Passenger cars per Thousand	.81

One of the ideas that emerges from the constituents above is that this first factor has a tendency to group the consumption variables negatively with variables related to agriculture.

TABLE 4-2 ROTATED FACTOR MATRIX FOR ALL COUNTRIES

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
X1 Population	-.28951	.08964	-.03935	.72648	-.11295	-.05354
X2 GNP/Capita	.92161	.13143	.19503	.12421	.13622	.00035
X3 GNP in $	.16640	.00159	.17036	.96156	.09875	-.03649
X4 GIP in $	.21931	-.06689	.25484	.88164	.18602	-.01222
X5 GD Investment	.01182	.02927	.90672	.02841	-.03804	-.06952
X6 GN Saving	.03430	.12782	.60521	.27706	.30908	-.07298
X7 GIP as % GDP	.43171	.09240	.52187	.37377	-.06828	-.04459
X8 Education Exp.	.31162	-.00707	.41118	-.16601	-.00643	.04019
X9 Agric. Prod.	-.67515	-.10624	-.59130	-.01095	.21793	.08623
X10 Prod. of Manufacture	.59452	.45839	-.00791	-.01536	-.23522	-.16346
X11 Industrial Prod.	.21297	-.20942	.74557	.37798	.15050	.01440
X12 Exp. of Manuf. Goods	.10348	.02529	-.04283	-.02408	-.65391	.03529
X13 Imp. of Manuf. Goods	-.22323	-.13672	-.14495	-.11247	.21831	.60342
X14 Commodity Concentration	-.01719	.04808	.04981	.12471	.71732	.33325
X15 Food Consumption/Capita	.66458	.11006	-.04680	.09360	-.17640	-.19260
X16 Energy Consumption/Capita	.85899	.12174	.25234	.17800	.10434	-.11463
X17 Urban Pop. Growth	-.42466	-.44641	.10118	-.16116	.37096	.14479
X18 Popl. Density	-.02856	.52508	-.02929	-.04127	.06681	-.00145
X19 Urban Popl. as % of Total	.84405	.23720	.14845	.00989	-.10641	-.00651
X20 Birth Rate	-.53643	-.64272	.19654	-.02312	.00944	.34747
X21 Death Rate	-.45197	-.84356	-.13143	.01429	.04843	.06074
X22 Life Expectancy	.53410	.79731	.07912	-.09277	-.04032	-.11041
X23 Popl./ Phys.	-.45553	-.44535	-.24840	-.08026	.23636	-.17665
X24 Access to Water	.77167	.23367	.17615	-.17193	-.02450	.02917
X25 Adjusted School Ratio	.65573	.57763	.04357	.09530	-.02854	-.17528
X26 Adult Literacy Rate	.41938	.78962	.01218	.13014	.01650	.03030
X27 Labour Force in Agric. % of Tot.	-.78239	-.49780	-.11686	-.15878	.11218	-.03650
X28 Labour Force in Indus. % of Tot.	.74792	.36561	.11445	.23262	-.18641	.04395
X29 Radio Receivers/1000	.73946	.20195	.13556	-.02066	-.03284	-.04718
X30 Percentage Cars/1000	.81377	.21739	.10682	-.14531	-.04414	-.18473
Eigenvalue	8.18	4.29	2.99	2.88	1.59	.80
% of Total Variance = 69	27.3	14.3	10	9.6	5.3	2.6

The consumption indicators which are: per capita gross national product, per capita food consumption, per capita energy consumption, access to water, radio receivers per thousand and passenger cars per thousand. One may include the variable population per physician as well in this set, as health in a way is paid for, and seen within a nation, it could be said that the more the population is able to use the health service, the more there are physicians. The negative sign of this variable in this factor tends to approve its association with the consumption variables, that is, the more a society has a per capita GNP, the less it has population per physician.

The above consumption variables are positively related to two other important variables of rather similar nature which are: urban population as a percentage of total population and percentage of labour force in industry. These relationships may well explain a logical economic circuit, that is the labour force in industry tends to be mainly concentrated in urban areas in which the population tends to be more consumer oriented than the population is in rural areas.

This line of reasoning seems even more convincing when one analyses this set of variates with the two remaining variables. These are agricultural production and percentage of labour force in agriculture and they are negatively related to the indicators mentioned above.

This factor clearly shows a process of economic development whereby higher per capita Gross National Product as well as other consumer indicators are mainly characteristic of urban populations where industrial activities exist.

3.2 The Second Factor

No.	Variables	Factor 2
1	Production of Manufacture	.45
2	Urban Population Growth	-.44
3	Population Density	.52
4	Birth Rate	-.64
5	Death Rate	-.84
6	Life Expectancy	.79
7	Adjusted School Enr. Ratio	.57
8	Adult Literacy Rate	.78
9	Labour Force in Agric.	-.49

This factor seems to be dominated by demographic variables in which birth rate and death rate are opposed to life expectancy. These relationships could explain that the higher the life expectancy of a society, the lower its birth and death rates are. Variables indicating education which are adjusted school enrollment ratio and adult literacy rate are of the same positive sign as the variable production of manufacture. The positive relation between these three variables could well explain that an educated population is mainly concentrated in areas where the production of manufacture takes place.
The variable population density is related positively to these four variables which shows that densely populated areas are those where production of manufacture exist along with a higher proportion of educated people. In a study concerned with the relevance of density and country size effects in trade and development, Keesing and Sherk (1971) using trade models based on regression analysis found that densely populated countries were expected to demonstrate a systematic comparative

advantage in manufactures as against agricultural products. Their findings depend on high positive correlations, for any large sample of countries, between population density and the combined availability of mineral wealth, arable land and other economically useful endowments from nature. Furthermore, they found clear evidence of country size and density effects, showing that densely populated countries trade more of their output internationally, leading to greater exports and imports per head, because of these trade capacities they continue to argue, these countries are more able to concentrate on the imports of capital goods (this relationship is emphasized by a previous finding of Chenery (1960) and therefore confirm the idea stated above, that is, densely populated countries could be expected to specialize in manufacture and lightly populated countries in primary products. One may question at this stage whether population density does have an effect in the process of technological transfer as it seems so related to the imports of capital goods, according to Keesing and Sherk (1971). The fact that the variables population density and production of manufacture are grouped in one factor, in this analysis,and positively related could well approve the previous findings mentioned above. Furthermore in a recent study on the relationship between population density and infrastructure Frederiksen (1981) employing cross province regressions for the Philippines found that there is a strong positive effect of population density on infrastructure; no further theoretical explanations are given, but one may group these results with the previous ones showing that densely populated areas are more expected to specialize in manufacture and hence have a higher infrastructure basically because of the close relationships between these two economic branches.

Eventhough the variable percentage of labour force in agriculture is a major component of the first factor, it is also considered as an important component of this factor. This variable may be said to be an important indicator as it contributes to the measurement of more than one dimension, see Comrey (1973). Its opposing sign to the variables indicating education and to those of production of manufacture and population density may show that when a country has less labour force employed in agriculture, it is expected to have a larger industrial sector, sustainable urbanization depends on lowering the agricultural share of the work force as Lipton (1980) put it, higher rate of education and population density may be characteristics of this type of country. In the brilliant and original work of Adelman and Morris (1971) mentioned earlier in this chapter, the first factor is partly explained by the fact that the growth of cities promotes both the specialization of economic activities and the spread of communication and education. Hence these modernising influences tend to favour family limitation which reduce fertility rates. This factor in the present analysis seems to confirm Adelman and Morris's findings.

The relationships between the variables up to this stage show that the constituents gathered in this factor follow a logical and regular pattern of reasoning, mainly differentiating agricultural and more or less industrial developing countries on the basis of some related economic, demographic and educational variables. The meaning of the economic process expressed by this second factor becomes even more interesting to investigate when the last variable which is urban population growth is analysed along the set. This variable is negatively related to most of the variates that show that a country is more industrialized, the urbanization phenomenon is a problem of developing countries in general, and particularly to countries that have a large proportion of traditional agricultural societies. As this aspect is greatly related to the technology employed, as will be seen later, it is analysed in greater depth.

Generally, urban population growth is due to population growth in the cities and to rural migration, following Keyfitz argument (1977,p152), supposing that a country is three-quarter rural with a three percent natural increase both in the city and in the countryside, that each year half of the rural natural increase moves to the city, then the one percent of the rural population that goes to the city constitutes three percent of the city population. When this is added to the two percent urban natural increase, it results in a five percent total urban increase; these estimations are not far from the rate at which the cities of Asia, Africa and Latin America have been growing. The preindustrial areas could hardly maintain three percent of their populations in cities, yet by 1970 twenty five percent of the population of developing countries was urban. The rate of rural urban migration is usually said to be determined by a number of major variables, Namely:

1. The failure of the rural sector to provide employment opportunities, as a consequence of low productivity. The traditional rural sector, engaged in peasant agriculture uses mainly labour intensive techniques of production, that is a large amount of labour is used against a relatively small amount of capital, even though highly labour intensive techniques are used, there remains a relatively abundant labour force as the excess of labour does not add much to the productivity at a certain level; see Lewis (1954).
2. The differentials in expected real earnings as between rural and urban areas; earnings of modern sector workers are often three or four times as the average small farmer income which is an important incentive to migrate as Turnham and Jaeger (1969,p 36-38) and Todaro (1969, p144) among others have shown.

The job seekers in town and cities face problems of unemployment as the formal urban sectors of industry generally fail to grow sufficiently fast to absorb the increasing number of available labour as put forward by Harris and Todaro (1968). This economic system is indeed shown by the empirical analysis of variables presented in this study. The opposing relation between urban population growth and production of manufacture may show the existing distortions between the rural and urban sector which have been subjects of great concern to economists of development.This factor has raised the question within the economics of development, and has surely contributed to the theoretical foundations concerned with technological transfer as will be seen later; this is why the problems of urban population growth, and particularly of rural-urban migration are analysed in great depth in this section.

The failure of the urban sector to provide employment opportunities is due to two main groups of reasons:

a) Those relating to the product mix in the modern sector and the resultant choice of techniques.

b) Those connected with government policies in the fields of industrial promotion and income distributions.

The points related to each group will be seen in turn in order to provide a clear understanding of this important aspect that, clearly is able to give some insights within the problem of the transfer of technology.

a 1) In order to produce modern products, characteristic of the urban sector, modern methods of production are required. Only capital-intensive methods requiring sophisticated machinery are available to developing countries, through the transfer of technology from the developed countries where virtually all industrial research and development work takes place, see Seers and Joy (1971) and Kuznets (1979), some further references are also given in the preceeding chapter. There is as was already shown, little incentive for machine tool industries in the advanced countries to develop, produce and market a more appropriate machinery for the developing countries only.

a 2) The fact that developing countries have no choice of technology is emphasized by the fact that they cannot compete if outdated technology is used.

a 3) Therefore, low income countries have no alternative but to prefer capital intensive techniques in a new manufacturing processes, despite the fact that modern technology has been developed in high income countries for their own needs, requirements and necessities.

This first group of reasons affecting the urban sector in its incapacity to absorb the new comers, clearly shows that the choice of technology, or in other works the transfer of technology is somewhat responsible for the urban crises. Again one may ask at this stage whether the second factor in the present analysis by grouping these variables does not demonstrate a process of technological transfer.

There is a cause to each consequence, and this may well show that the second group of reasons that hinder the creation of employment is a cause of the first group, that is, even if technology conducive to the creation of employment opportunities exists, government policies currently appear to encourage the adoption of capital intensive techniques.

b 1) Preference for capital intensity is often said to be the result of the scarcity of managerial and other skilled labour, therefore there is a possibility to substitute physical capital for human capital. The lack of skilled labour may in turn, be the result of inadequate or inappropriate government education and training policies, see Johnston (1981).

b 2) Fiscal policies aimed at encouraging investment such as investment grants and accelerated depreciation allowances are capital based.

As a result of these two major factors, it seems realistic as Shumacher(1971) argues, that the competitive power of large urban capital-intensive enterprises kills off traditional economic activities in the countryside, encouraging therefore the rural population to migrate which increases the pressures on the physical structures of the urban areas, and hence promotes the urban crises which in turn aggravates further the problem of migration.

These pressures may represent the other category of factors that discourage urban population growth, in particular housing and transport, the world bank (1972) thoroughly discusses these problems and infra-structure itself, a place which might be re-designed for a population of 200 per square mile at one time will have to squeeze 1500 persons per square mile when urban growth grows at a rate it has been doing for these two decades; the result is packing on urban land and emptying the rural land, therefore distorting the distribution of the population on the available land as Keyfitz (1977) emphasizes, then a problem of density arises.

Urban population growth which is a characteristic of agricultural societies does in fact hinder the well functioning of the urban economic sector, it should be remembered that population density as such, should not be mistaken for increasing urban cities, which is another problem as the additional porportion of population per square mile becomes not only unrelated to the arable land and resources as a result of overurbanization but also to the technology used in the urban sector.

The grouping of variables in this factor has enabled the author to look at a deep economic problem of great concern in the present thesis, as it is related to a major area concerned with the causes of the success or failure of technological transfer. However, this is an area or research that is on the frontier of economics, as Johnston (1981,p386) states.

"the important and certainly interesting problems of this area extend beyond the boundaries of economics as conventionally defined, this leaves many questions unanswered and not conceptualized satisfactorily."

3.3 The Third Factor

No.	Variables	Factor IV
1	Gross Domestic Investment	.90
2	Gross National Saving	.60
3	Gross Industrial Product as percentage of GNP	.52
4	Agricultural Production	- .59
5	Industrial Production	.74

The close relationship between investment and saving is well known in economics, the grouping of these two variables in this factor confirms the theory, and shows the steadiness of the data collected as well as the regular pattern of the sample of countries under study. The close positive relationship between investment and saving as well as industrial production and the gross industrial product to a certain extent tends to show that, among the countries studied those countries that have higher gross domestic investment, and therefore savings, tend to have a relatively greater industrial production. The dimension expressed by this factor is very relevant to the present study, in order to get some insight into these relationships, the notion of investment and saving had to be seen more deeply.

"The final output produced by an economy is not restricted to the output of goods and services that are used up in the accounting period which is a year, but it includes also the output of goods and services which may be used over the years, the use of this final output, which is desired as a means of adding to the economy's wealth is known as investment."
Beckerman (1968,p50)

Investment is therefore that part of the current output of goods and services devoted to adding to the stock of capital and thus to raising the future potential of a community, it is mainly referred to as capital formation.

The computations of gross domestic investment consist of subtracting the private and general government consumption from the gross domestic product and adding the difference between exports and imports, that is

$$I = GDP - C + X - M$$

where I represents the gross domestic investment, C the private and government consumption, X the exports and M the imports, see the world tables (1980) from which data is taken from, also Beckerman (1968,P62). It is well known that investment provides a major force to the process of economic growth, Agarwala and Singh (1969,p7) argue that some of the most intractable problems which developing countries have to encounter is reaching a take off point with capital formation, they include in their book important contributions which deal with questions relating to the acceleration of investment in developing countries.

Saving is the difference between income and consumption, also the following relationship show how saving and investment are so related, see Wai (1972,p6).

$$I - S = X - M$$

Where I is the investment, S saving, X and M as defined above. These relationships are namely based on trade. Chenery and Eckstein (1970) argue that an increase in exports is accompanied by a rise in the savings ratio since it permits a larger volume of investment. See Bhagwati (1978) for an excellent treatment of the relations between trade and saving as well as investment. On the other hand, Streeten (1969) shows the repercussions that investment and savings have on economic growth when their level of equilibrium differ, that is, when investment exceeds saving and when saving exceeds investment, etc., he emphasizes the responsibility of government to maintain an aggregate equilibrium between investment and saving in developing countries. In emphasizing the need to accumulate capital from domestic sources, Lewis's (1970, p 224-25) famous statement is:

> "The central problem in the theory of economic growth is to understand the process by which a community is converted from being a five percent saver to a twelve percent saver - with all the changes in attitudes, in institutions and in techniques which accompany this conversion."

Even though the savings rate is regarded as a key performance indicator by development economists, the formulation of policies designed to increase the savings propensity has suffered from a limited knowledge of the nature of the savings function in developing countries as Wai (1972 , p4) Mikesell and Zinser (1973,p.1) point out, a number of alternative savings hypotheses derived mainly from the literature relating to developed countries have been formulated, but the lack of reliable data has made it difficult to test these hypotheses, it would be interesting to review the hypotheses regarding national saving related to developing countries. There are, in the economic literature, two broad views expressed about the determinants of national savings, one view which stresses interest or the rate of return on savings originates from the classical and neo-classical schools, whereas the other which stresses income stems from Keynes and other modern economists such as Modigliani and Friedman.

The interest rate theories are based on the fact that the higher rate of interest will increase the amount of savings, as interest is the payment for the use of funds and the like, in turn the demand for funds is decided by the expected return on an investment, which let the interest rate determined by the equilibrium point between savings and investments, the rate of interest is determined by six sets of equations, see Fisher (1954,p505) namely, two opportunity principles which represent investment opportunities, two impatience principles and two market principles, that is supply and demand for funds, he also points out that the rate of interest depends upon very unstable influences, which involve not only strictly economic considerations. Wai (1972,p74) shows that in developing economics the demand and supply of loanable funds are influenced by interest rates, which makes the supply of savings also influenced by interest rates. However, he agrees that changes in interest rate may not cause the supply of national savings to increase in developing countries, giving five reasons related to the economic and social structure of these economics.

The Keynesian theory, based on underemployment equilibrium made saving a function of income and income a function of investment as opposed to the classical view of saving as a determinant of investment, he critisizes the classical theory by putting forward that the level of income must be the factor which brings the amount saved to equality with the amount invested, Keynes (1965, p107-10), he listed eight main motives that lead individuals to save, namely, precaution, foresight, calculation, independence, improvement, enterprise, pride and avarice, four other factors, are listed for governments, which are enterprise, liquidity, improvement and prudence.

The Keynesian savings function, in its most commonly used form is linear with a constant marginal propensity to save,

$$S = a_o + a_n Y_\partial$$

where S is gross domestic saving, Y_∂ is gross national product and a_n is the constant marginal propensity to save, it is assumed that $a_o < o$ and $o < a_n < 1$ such that as the level of income rises the average propensity to save will also increase.

Studies by Chenery and Eckstein (1970) and Mikesell and Zinser (1973), applying the keynesian savings function to Latin American countries, found that keynesian approach does not hold for developing economies.

Other variants of the influence of income on savings were developed, for example Friedman (1957) established a permanent income hypothesis, in its most simple form, the linear equation is:

$$S_t = a_o + a_1 Y_{pt} + a_2 Y_{Tt}$$

where Y_{pt} is permanent income and Y_{Tt} is transitory income in Year T. Empirical studies for the developing countries support the permanent income hypothesis, see Mikesell and Zinser. Another approach by Modigliani-Brumberg-Ando (1963) is based on life cycle hypothesis, they postulate that individuals adopt a planning horizon for their life time consumption, based on their hypothesis, Leff (1969) regressed the gross savings ratio $L_n(S/Y)$, and per capita saving, L_n (S/Population) on the following independent variables: per capita income L_n (Y/Pop); the rate of increase in per capita income ∂; the percentage of the population age 14 or less, LN (D_1); the percentage of the population age 65 or older L_n (D_2) and the total dependency ratio $(D_1 + D_2)$, L_nD_3. The analysis was based on both developing and developed countries to conclude that the high birth rates are among the important factors in accounting for the great disparities in saving rates between developed and developing countries, and that unless birth rates are reduced, there are no prospects for increased savings. This well known study of savings is probably the most related to the problems of developing countries, in the sense that it classified some of the aspects related to savings. Another equally important study related to capital inflows in developing countries is made by Rahman (1968), where he finds that an increase in foreign funds causes a relaxation of government saving and therefore reduces the average national saving rate. This aspect is of particular importance for developing countries that are dependent on foreign aid, in particular it may make governments conscious that contrary to the principle that foreign aid or capital imports are expected to supplement and even induce domestic saving and capital formation, it may hinder the nation's national savings and thus capital formation.

3.4 The Fourth Factor

No.	Variables	Factor III
1	Population	.72
2	Gross National Product	.96
3	Gross Industrial Product	.88

Often population size and gross national product size are used as measures of country size. In his attempt to provide empirical evidence on the nature of the relationship between country size and rate of economic growth and levels of economic development, Khalaf (1980) uses multiple correlation analyses with two explanatory variables in which level of economic development and economic growth are the dependent variables; country size, measured in terms of population and gross national product and dependence on trade are the two independent variables. There are no generally agreed upon measures of country size, [illegible] Belassa (1969) used population size and/or usable land areas, had this last variable been used in the present analysis, it would have been, most probably included with this set of variables, which tend to show a dimension of country size. Other variables such as percentage of labour force in industry and gross industrial product as a percentage of gross national product as well as per capita energy consumption and industrial production load over 30 which may help giving some further insight to this factor. The positive relation between all these variables suggests that the higher the rate of gross national product, the more population, industrial production and per capita energy consumption are likely to exist together; this is in a way what Keesings and Sherk analysis (1971) suggests.

3.5 The Fifth Factor

No.	Variables	Factor V
1	Exports of manufactured goods	- .65
2	Commodity concentration	.71

Commodity concentration was defined in the preceeding chapter as the percentage contribution of the three major commodoties in total exports. This factor which accounts for five percent of the total variance seems to suggest that countries that have higher exports of natural products such as cocoa, copper, jute, coffee or rice, have a tendency to export less of their manufactured foods. This may, by the same token, suggest that countries that have a high rate, of natural products are less expected to specialize in the production of manufacture. A further development of this aspect of exports may give a clearer insight to the understanding of the opposing relationships of the variables constituting this factor.

It is well recognised, among those who are working actively in economic development, that the growth of exports is an essential element of development programmes, trade provides the necessary links with the world efficiency, technology and administrative standards, and exports particularly provide the necessary volume of resources needed to finance the requirements of import and debt repayments as well as increasing the flow and assimilation of technical and managerial know-how. The question of whether exports promote growth or growth promotes export is a controversy which has fascinated many economists, see for a simple treatment of the problem, Kindleberger (1962), some believe that exports grow only when the products perform to the world standard, others believe that exports are encouraged by world demand, thereby, stimulating the domestic economies to grow faster. There was no question in the 19th Century that trade was an engine to growth, it was a "means whereby a vigorous process of economic growth came to be transmitted from the center to the outlying areas of the world." as Nurkse (1959, p 14) stated. There is, therefore, no doubt that developing economies depend heavily on exports at these early stages of development, however, these countries face increasing problems of exports. Nearly one half of their exports are primary products and only thirteen percent of manufactured products, see united nations (1970, p58) also Klein (1974) found that the trade position of developing countries under study export more of their primary products and raw materials than manufacture. Even the newly industrializing countries such as Taiwan, Mexico and India have very limited exports of manufactured good, Franko (1981) shows that the advanced OECD countries have a total penetration of not more than two percent of their gross domestic product by the newly industrializing countries export of manufacturers; he presents an interesting and illustrative table taken from different sources of statistics.

It is often argued, see Malmgren (1971,p9) that while exports of developing countries rise as world trade and general world economic activity develops, they do not rise as fast as the exports of the rich countries, their share in world trade has been continuously falling from thirty one percent in 1950 to eighteen percent in 1968, whereas, the developed economics share rose from sixty percent to seventy percent in the same period. This shows that even commodity concentration is threatened today, one of the factors affecting the reduction of exports is the difficulty to penetrate the markets of the developed countries because of the measurers taken such as displacing natural commodities like cotton, nylon and polyester, by developing the agricultural sector and by using sophisticated industrialization which requires fewer raw materials per unit of highly technological output. Maizels (1971) argues that the import restrictions of the developed countries act both to limit the rate of industrial growth and to reduce the real income of the industrial countries themselves, since the consumed home produced goods are more costly. The exports of basic manufactured consumer products face intense competition to enter the developed country markets. Nurkse (1959,p26) seems to see the problem in a much wider perspective, he says:

> "In a world which (outside the Soviet area) over nine-tenths of the manufacturing and over four-fifths of the total productive activity are concentrated in the advanced industrial countries, the ideas of symmetry, reciprocity, and mutual dependence which we associate with the traditional theory of international trade are of rather questionable relevance to trade relations between the center and the periphery. "

The problem of exports of developing economics can be looked at by a different approach, Devries (1967) in an excellent analysis based on government policies, shows how exports may differ from one country to another. A distinction between inward policy which tends to steer new investments towards manufacturing and away from agriculture, and outward policy, which consist of avoiding heavy industrialization at the expense of agriculture and other primary products, placing a greater importance on exports. He finds that countries with inward orientations are experiencing a rapid increase in exports of manufactures, and a reduction in primary exports, whereas countries with outward policy tend to experience a higher rate of primary products. These findings clearly contribute to a great degree to the understanding of the opposing relations between commodity concentration and exports of manufactured products.

3.6 The Sixth Factor

No.	Variable	Factor VI
1	Imports of manufactured goods	.60

It seems clear that this factor presents some diffulties for its understanding, as it only comprises one variable. Even though the other variables load insignificantly in this factor, it would be helpful to look at the signs of these variables and especially those that load at least more than .10 in order to try to understand the dimension that this factor explains. This variable is generally related negatively to investment and saving, to production of manufacture, to education and to consumption variables, with the exception of per capita gross national product, it is related positively with agricultural production, birth rate and commodity concentration variables. The relation of imports of manufactured goods with the other variables seems to suggest that countries characterized with agricultural production, with higher rates of birth and higher exports of raw materials, tend to import more manufactured products.

Imports of developing countries in general have been increasing, as early as 1913, the total imports represented 1.9 billion dollars, it increased to 11.2 billion dollars in 1955, it would have obviously been more interesting if more up to date values could be included to see the pattern of change in imports, even though most of the literature on trade suggests a constant increase in total imports of the developing areas. In these periods manufactures represented the main boost in imports, they increased from forty seven percent of total imports to sixty one percent. Maizels (1971, p66). After 1955 there was a shift from imports in manufacture to capital goods, machinery and transport equipment represented the largest and fastest growing category of goods exported from industrial countries to the third world, it accounted for one third in 1955 and forty three percent in 1969, the manufactures which knew a sharp rise during earlier periods, declined from one quarter of the total in 1955 to less than one fifth in 1969. Wightman (1971, p3). This shift in imports may be explained by the rapid growth in demand for capital investment goods at the early stages of industrialization which tends to favour these imports as well as chemicals, lubricants and other essential raw materials, rather than manufactured consumer goods.

For the purpose of the present analysis, a distinction between developing countries that embarked in industrialization and those that have less developed their industrial sector has to be made, this is in order to know which are the areas that import more manufactured products and which import less. In a table based on the composition of imports of third world countries by area, Unctad (1968) reports the following. For Africa, the imports of manufactured consumer goods represent 28.8 percent of the total imports in the period 1956-1960 and

26.5 percent in the period 1961-1965, Asia's imports were 22.6 and 21.1 and Latin America's were 17.7 and 16.8 respectively. Even though all three continents knew a decrease in these imports, Africa's imports of manufactured goods are the highest, with as much as 10 percent more than Latin America and 5.4 percent more than Asia. Asia represents the second continent in manufactured products imports, and Latin America the third and last.

It is well known that among these three continents, Africa is mostly constituted of agricultural societies, Asia has relatively less agricultural countries and the majority of Latin American countries have a developed industrial sector. Therefore, one may conclude that agricultural societies tend to import relatively more manufactured consumer goods than more industrial developing societies. Maizels (1971) in his excellent historic analysis of trade makes it clear that there is a shift in imports at different economic levels. These theoretical and statistical findings contribute immensely to the understanding of the relationship of the imports of manufactured goods variable and the others. In turn, the relationships found in this factor contribute to the understanding of the notion of trade and seems to complete the theoretical analysis made on trade for developing countries bringing more up to date results.

3.7. Differences in the Relationships of Variables in Low and Middle Income Countries.

In this section, factor analysis is applied to two sub-samples, middle income and low income countries, the separation between the two groups is based on a criteria used by the world bank (1980a) p.18.), that is countries with a per capita GNP lower than £360 constitute the low income group for which the number of observations is 23, and countries with higher per capita GNP than £360 constitute the middle income group, for which the number of observations is 22.

This analysis may provide a test of the validity of the overall analysis, also it may give some further insights into the differences of the characteristics of the low and middle income countries. Table 2.3 contains the results for the middle income countries and Table 2.4 contains the results for the low income countries. The significance of the loadings at the one percent level for the middle income group is .53 for factor 1, .53 for factor 2, .54 for factor 3, .55 for factor 4, .56 for factor 5 and .58 for factor 6.

Similarly the significance of loadings at the one per cent level for the low income group is .53 for factor 1, .53 for factor 2, .54 for factor 3, .55 for factor 4, .56 for factor 5 and .58 for factor 6.

TABLE 4 - 3 ROTATED FACTOR MATRIX FOR 22 MIDDLE INCOME COUNTRIES

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
X1	Population	-.12172	.86778	.03613	.12831	-.08538	-.07231
X2	GNP/cap.	.47988	.38047	.64963	-.15227	-.13385	.09620
X3	Gross National Product	.01404	.96241	.22958	.11061	.01186	-.11034
X4	Gross Industrial Product	.01872	.91353	.27984	.20503	.05851	-.11582
X5	Gross Domestic Investment	-.25639	.03116	.10077	.87348	.03963	.18046
X6	Gross National Saving	-.14172	.33262	.12798	.85229	.12261	-.14057
X7	GIP as % GDP	-.01619	.23637	.59750	.14597	.12052	-.18953
X8	Education Expenditure	-.15855	-.08487	.11137	.08868	.06486	.46527
X9	Agricultural Production	-.12575	-.03682	-.78788	-.23255	.20965	-.12334
X10	Production of Manufacture	.63524	-.14811	.20355	-.40478	-.20281	-.06269
X11	Industrial Production	-.25575	.33362	.58109	.61127	.01416	-.13329
X12	Export of Manufactured Goods	.24124	-.15450	-.24155	-.13365	-.13978	.65098
X13	Import of Manufactured Goods	-.05203	-.05834	-.13288	.01187	.71603	.12837
X14	Commodity Concentration	-.28931	.19705	.09172	.06154	.56717	-.27450
X15	Food Consumption/cap.	.42368	.22594	.19206	-.17940	-.53764	.13133
X16	Energy Consumption/cap.	.40295	.34721	.74764	-.02883	-.09857	.14749
X17	Urban Population Growth	-.71170	.08904	-.00831	.22350	.15506	-.15554
X18	Population Density	.35831	-.29643	-.04310	.15046	.28515	-.04540
X19	Urban Population as % of Total	.54201	.16148	.29250	-.31991	-.24335	.16186
X20	Birth Rate	-.84691	.07454	-.14549	.17818	.25709	.03534
X21	Death Rate	-.92388	.15778	.10099	-.08473	.11046	.04658
X22	Life Expectancy	.93463	-.21540	.00824	.02402	-.18386	.09479
X23	Population per Physician	-.77281	-.08632	.01920	.08202	-.08413	-.00473
X24	Access to Water	.54421	-.03310	.34012	.05623	-.07151	.53046
X25	Adjusted School Enrolment Ratio	.67517	.06542	.41139	-.27540	-.02017	.18037
X26	Adult Literacy Rate	.87143	-.20495	.11792	-.24484	.02674	-.21174
X27	Labour Force in Agriculture (% total)	-.88019	-.13545	-.24581	.12365	.11928	-.18629
X28	Labour Force in Industry (% total)	.75626	.31748	.24199	-.10534	-.07289	.10443
X29	Radio Receivers per Thousand	.48443	.08863	.30268	-.07465	-.07432	.39910
X30	Passenger Cars per Thousand	.51642	-.16774	.56034	-.12836	-.32138	.23314

TABLE 4 - 4 ROTATED FACTOR MATRIX FOR 23 LOW INCOME COUNTRIES

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
X1	Population	.12321	-.06303	.89496	-.03047	.19853	.00866
X2	GNP/cap.	.23202	.72483	.26380	.15942	-.04261	.07958
X3	Gross National Product	.18417	.12585	.96933	.06319	.09031	.03214
X4	Gross Industrial Product	.14500	.08604	.97442	.16338	.06433	-.02415
X5	Gross Domestic Investment	.08620	.10771	.24944	.70593	-.10252	.40592
X6	Gross National Saving	.23686	-.02178	.34986	.15119	-.21853	-.02348
X7	GIP as % GDP	.11703	.17800	.53051	.63613	.27513	.33206
X8	Education Expenditure	-.03685	.18894	-.07822	.74228	-.07255	-.08341
X9	Agricultural Production	-.11058	-.35219	-.02773	-.65424	-.29875	-.47494
X10	Production of Manufacture	.44563	.57211	.11565	-.06358	.02919	.55986
X11	Industrial Production	-.18867	-.16012	.45187	.71593	.29653	-.09330
X12	Export of Manufactured Goods	-.00302	.02631	-.04481	-.03448	.54018	.48461
X13	Import of Manufactured Goods	-.38001	-.06357	-.14615	-.16949	-.12275	-.48539
X14	Commodity Concentration	.14512	-.03987	.09271	-.07763	-.11146	-.79797
X15	Food Consumption/cap.	.02931	.65689	-.09437	.17800	.36876	-.09413
X16	Energy Consumption/cap.	.41117	.68768	.27739	.12907	.12248	.34341
X17	Urban Population Growth	-.31189	-.21550	-.35427	-.10276	-.33100	-.37159
X18	Population Density	.68715	-.11975	.18907	-.16060	.11105	.03158
X19	Urban Population as % of Total	.20078	.50574	.03916	.30882	.57250	.18744
X20	Birth Rate	-.77394	-.15905	-.04630	.02097	-.16145	-.05976
X21	Death Rate	-.90997	-.26564	-.10502	-.07250	-.03758	-.03481
X22	Life Expectancy	.94741	.21409	.02503	.03531	.02285	.02898
X23	Population per Physician	-.40931	-.55496	-.05520	-.19920	-.30548	-.01473
X24	Access to Water	.08443	.74384	-.15067	-.19166	.09641	.06327
X25	Adjusted School Enrolment Ratio	.83971	.28109	.10308	.02973	.25859	.19851
X26	Adult Literacy Rate	.75505	.20763	.39646	.10154	-.04773	-.10268
X27	Labour Force in Agriculture (% total)	-.53855	-.22368	-.39757	-.04351	-.64999	-.07835
X28	Labour Force in Industry (% total)	.30197	.18461	.27741	.04369	.79203	.15515
X29	Radio Receivers per Thousand	.09527	.80234	.10398	.22548	-.00141	.07798
X30	Passenger Cars per Thousand	.31346	.38711	-.20475	.30824	.06363	.37145

3-7-1 The Middle Income Countries

It can be seen that the general dimensions displayed by the factors for this group of countries parallel in important respects those for the entire sample. The variables constituting the second factor in the previous analysis are grouped in the first factor for this group, which may demonstrate that priority is given to production of manufacture and education, similarly size variables seem to be given greater importance as they constitute the second factor and therefore explain a larger proportion of the variance as they did for the whole sample, consumer variables are given less weight in this group as they constitute the third factor only, investment, saving as well as industrial production are found in the fourth factor, the fifth factor groups positively import of manufacture as well as export of basic raw materials, which may signify that middle income countries tend to have a relatively developed trade, exports of manufacture which constitutes the sixth factor is positively related to consumer variables such as access to water, which may explain that this group of countries has more access to consumer goods and also tends to export manufactured goods.

While displaying the same pattern of dimensions as the overall analysis, the middle income countries seem to give priority for variables directly concerned with economic activities such as production of manufacture and education.

3-7-2 The Low Income Countries

Variables related to education and to population seem to be given greater importance in this group of countries as they constitute the first factor, production of manufacture is related to consumer variables in the second factor, size indicators are distinctly shown in the third factor and investment is positively related to industrial production and negatively related to agricultural production in the fourth factor, the fifth factor groups negatively labour force in Agriculture to labour force in Industry, and the sixth factor which constitutes trade variables tends to show that the low income countries tend to experience less trade than the middle income countries.

Even though, production of manufacture is related to consumer variables rather than production of agriculture, for this group of countries, the direction of relationships remains the same. The rest of the factors are also very similar to the overall analysis with the exception of the sixth factor which groups all trade variables.

3-8 Regional Differences in the Relationship of the Socio-economic Variables.

Another way to test the validity of the relationship displayed in the general analysis is the consistency with which it appears in subsamples of the larger population analysed, see Adelman and Morris (1971) who used a similar test of validity. It is also hoped that this classification provides a further understanding into the characteristics of the different regions. The sample is divided into 24 African countries 13 Latin American countries and 8 Asian countries. Table 4.5 contains the results of the African countries, table 4-6 contains the results of the Latin American countries and table 4-7 the results of the Asian countries.

The significance of loadings at the 1 percent level for the African countries is .48 for factor 1, .48 for factor 2, .49 for factor 3, .50 for factor 4, .51 for factor 5, .52 for factor 6. For the Latin American countries it is .71 for factor 1, .72 for factor 11, .73 for factor 3, .74 for factor 4, .76 for factor 5, and .77 for factor 6. For the Asian countries it is .71 for factor 1, .72 for factor 2, .73 for factor 3, .74 for factor 4, .76 for factor 5, and .77 for factor 6. The samples of Latin American and Asian countries may be biased as the number of observations are relatively low. Therefore the characteristics outlined may be more valid had the samples been larger.

3-8-1 African Countries

When the order of factors is considered, these countries show more similarity to the overall analysis than the middle and low income groups. The first factor contains in addition imports of manufactured goods to emphasize what has been said earlier, that is the more urbanized and consumer society is, the less it imports manufactured goods, the second factor displays the relations that have been found in the third factor for the overall analysis and in the fourth factor the middle and low income groups, namely those between investment and industrial production, most indicators related to population and education are found in the third factor, these relations were also characteristics of the low income countries, size variables are clearly shown in the fourth factor, the fifth factor seems redundant as it exposes some consumer variables which does not give much information and the sixth factor groups trade variables showing that African countries are not exporters of manufactured goods.

3-8-2 Latin American Countries

The same variables constituting the first factor in the middle income group are also found in the first factor for these countries. Production of agriculture is negatively related to industrial production in the second factor, size variables are also clearly shown in the third factor, Investment and Savings are found with a negative sign in the fourth factor, Imports of manufacture constitute the fifth factor and exports of manufacture are positively related to a consumer variable in the sixth factor.

3-8-3 Asian Countries

This group of countries differs from the others in that it does not have a dimension of country size, most consumer variables are found in the first factor as for the overall analysis, here again agricultural production is negatively related to these variables. The second factor shows some relations between urban population growth, labour force in agriculture and industry with consumer indicators. An interesting characteristic of the Asian countries is displayed in the third factor, that is these countries tend to have high birth and death rates and lower education, production of agriculture is negatively related to some consumer variables in the fourth factor, another interesting feature is displayed in factor five which shows that these countries are characterized by a lower rate of production of manufacture together with a lower rate of exports of manufacture, imports of manufactured goods is shown in the sixth factor with a negative sign which may also demonstrate that these countries tend to import less manufactured goods.

TABLE 4 - 5 ROTATED FACTOR MATRIX FOR 24 AFRICAN COUNTRIES

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
X1	Population	-.14323	.00619	.04250	.93292	.04488	.02103
X2	GNP/cap.	.74065	.42717	.20208	.06248	.15259	.17383
X3	Gross National Product	.24531	.15815	.00310	.94973	.10822	.07797
X4	Gross Industrial Product	.24121	.28328	-.01251	.89676	.01034	.17235
X5	Gross Domestic Investment	.39501	.71795	-.12796	.15419	.02391	.04037
X6	Gross National Saving	.39987	.45968	.08980	.16061	-.00512	.36363
X7	GIP as % GDP	-.08398	.78199	.21257	.19912	.15747	-.21326
X8	Education Expenditure	.20853	.63790	.05387	-.01293	.41294	-.26539
X9	Agricultural Production	-.42210	-.79176	.00728	.03226	-.14596	.27837
X10	Production of Manufacture	.48241	.12366	.23241	.02444	.29943	-.28505
X11	Industrial Production	.18608	.84206	-.01196	.29960	-.16978	.15070
X12	Export of Manufactured Goods	.00630	.10483	.05835	-.07205	.02809	-.53991
X13	Import of Manufactured Goods	-.51848	-.34247	.00922	-.10624	-.13386	.48401
X14	Commodity Concentration	.00955	.06754	.17990	.17635	-.09135	.68808
X15	Food Consumption /cap.	.32914	-.00978	.24448	.12914	.66307	-.34211
X16	Energy Consumption/cap.	.72489	.52990	.12054	.02109	.24396	.05348
X17	Urban Population Growth	-.21340	-.13332	-.52760	-.13253	.00119	.54509
X18	Population Density	.08356	-.08059	.77317	-.09710	.07948	.14630
X19	Urban Population as % of Total	.69817	.51610	.21701	.06960	.08372	-.19334
X20	Birth Rate	-.44037	.05211	-.62395	.17499	-.31952	.19694
X21	Death Rate	-.53264	-.15179	-.54066	-.01024	-.54310	-.07109
X22	Life Expectancy	.57716	.12645	.54668	-.00739	.47271	.07703
X23	Population per Physician	-.39348	-.30325	-.16616	-.08478	-.56486	.06763
X24	Access to Water	.83717	.13969	.24939	.03822	.18290	-.02371
X25	Adjusted School Enrolment Ratio	.58901	.08680	.57568	.01993	.35145	-.16860
X26	Adult Literacy Rate	.14618	.18337	.63598	.28426	.49897	.22033
X27	Labour Force in Agriculture (% total)	-.66625	-.33636	-.57388	-.26200	-.05884	.11652
X28	Labour Force in Industry (% total)	.51558	.26985	.62510	.28746	-.02233	-.36080
X29	Radio Receivers per Thousand	.85108	.12544	.13934	.22459	.18564	-.05868
X30	Passenger Cars per Thousand	.54044	.57171	.29895	-.23189	.28607	-.04687

TABLE 4 - 6 ROTATED FACTOR MATRIX FOR 13 LATIN AMERICAN COUNTRIES

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
X1	Population	-.02230	-.03571	.92183	-.06146	-.06252	-.04576
X2	GNP/cap.	.75414	.44501	-.01310	.39778	-.01656	.13124
X3	Gross National Product	.15264	.09044	.94394	.25748	-.06514	-.09191
X4	Gross Industrial Product	.20430	.16854	.91443	.28152	-.06694	-.08945
X5	Gross Domestic Investment	-.25534	.00316	-.34789	-.79556	.14427	-.03339
X6	Gross National Saving	-.17872	-.03499	-.03945	-.91930	-.02652	-.03106
X7	GIP as % GDP	.15699	.91023	-.02666	-.19246	.01186	.12774
X8	Education Expenditure	.11462	.23708	.16247	.08519	.58119	.01522
X9	Agricultural Production	-.38910	-.78591	-.01758	-.37258	.04510	-.12258
X10	Production of Manufacture	.61421	-.00239	.17349	.51366	-.35166	.37007
X11	Industrial Production	-.02696	.90246	.00188	-.03840	.28552	-.30883
X12	Export of Manufactured Goods	.38618	-.53367	-.34314	.05498	.06827	.57638
X13	Import of Manufactured Goods	-.40781	-.29578	-.20781	-.16681	.55198	.39893
X14	Commodity Concentration	-.39200	-.17368	.58228	-.08864	.07709	.25883
X15	Food Consumption/cap.	.69290	.06514	-.24540	.39484	-.49808	-.08311
X16	Energy Consumption/cap.	.61785	.62848	.13193	.30401	.16993	.03800
X17	Urban Population Growth	-.62967	-.00456	.15146	-.27797	.16196	-.17488
X18	Population Density	.19698	.10661	-.24640	-.14113	.77746	.08688
X19	Urban Population as % of Total	.54955	.08227	.46941	.49791	-.30830	.28014
X20	Birth Rate	-.86715	-.16358	-.24624	-.27361	.15024	-.13067
X21	Death Rate	-.89703	.13065	-.08388	.06615	-.19069	.12686
X22	Life Expectancy	.97061	-.01231	-.10797	.04410	.12325	.02949
X23	Population per Physician	-.32795	-.04143	-.09594	-.05376	.77813	-.14029
X24	Access to Water	.56361	.24726	.05703	.28135	.04247	.62915
X25	Adjusted School Enrolment Ratio	.71962	.61522	.07480	.19118	-.01129	.13374
X26	Adult Literacy Rate	.94075	.06303	.16187	.10688	-.12991	-.13642
X27	Labour Force in Agriculture (% total)	-.83564	-.26998	-.22403	-.28144	.09704	-.25106
X28	Labour Force in Industry (% total)	.73534	.41109	.12420	.06789	-.26310	.09116
X29	Radio Receivers per Thousand	.58871	.28861	-.07409	.05446	.05198	.26971
X30	Passenger Cars per Thousand	.78142	.34409	-.16943	.29224	.00493	.30418

TABLE 4 - 7 ROTATED FACTOR MATRIX FOR 8 ASIAN COUNTRIES

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
X1	Population	.15544	-.56232	.49666	-.33053	-.00251	.45366
X2	GNP/cap.	.80301	.46579	.09029	.31064	.08367	-.13828
X3	Gross National Product	.93943	.02142	.30541	-.11464	.07046	.09059
X4	Gross Industrial Product	.94340	.19161	.22700	-.07687	.14104	.01457
X5	Gross Domestic Investment	.60882	.02447	-.19315	.67558	-.29869	-.06220
X6	Gross National Saving	.95211	.10657	-.13191	.16790	.04641	-.16464
X7	GIP as % GDP	.93355	.18186	-.01225	.24076	-.03616	.16229
X8	Education Expenditure	-.05700	.18358	-.02359	.92677	.18837	.09703
X9	Agricultural Production	-.66912	-.37478	.07531	-.57139	.23253	.11927
X10	Production of Manufacture	.14432	-.08572	-.49679	.02303	-.67840	-.15133
X11	Industrial Production	.92983	.19314	.20517	-.01385	.20355	.11097
X12	Export of Manufactured Goods	-.31087	.23218	.22586	.04045	-.79908	.25210
X13	Import of Manufactured Goods	-.03595	.00159	.60509	-.05553	.35494	-.59710
X14	Commodity Concentration	.17269	.31357	-.14946	.12790	.87048	-.05547
X15	Food Consumption/cap.	.49031	.76413	.14400	.33424	.09747	-.05700
X16	Energy Consumption/cap.	.74402	.46895	.11208	.44632	.08628	-.08441
X17	Urban Population Growth	.32779	.82368	.13911	.39709	.10020	.02045
X18	Population Density	-.26532	-.09395	-.82115	-.31452	-.11497	.28844
X19	Urban Population as % of Total	.29481	.78111	.05702	.46583	-.02819	-.02062
X20	Birth Rate	.09154	.26760	.75905	.33760	-.37334	-.01339
X21	Death Rate	.03505	.10929	.98418	-.05661	.06733	.07275
X22	Life Expectancy	-.16129	.02216	-.96487	-.11726	-.01238	-.02203
X23	Population per Physician	-.01317	-.69939	.29715	-.14599	.44424	.37155
X24	Access to Water	.10086	.57053	-.04677	.75443	-.19853	-.06499
X25	Adjusted School Enrolment Ratio	.11969	.37775	-.78766	.25954	.06035	.03657
X26	Adult Literacy Rate	-.03104	-.48524	-.67330	-.02823	.26663	-.32350
X27	Labour Force in Agriculture (% total)	-.25309	-.85537	.03575	-.04757	-.17246	-.14120
X28	Labour Force in Industry (% total)	.36771	.88719	.23926	.09038	.04265	-.02040
X29	Radio Receivers per Thousand	.36752	.31224	.05784	.83038	.07467	-.09952
X30	Passenger Cars per Thousand	.79660	.40561	-.36645	.21775	-.03886	-.07116

4. SUMMARY AND CONCLUSIONS

This Analysis provided an understanding of the relationships existing between the variables under study. The allocation of some variables to one factor and of some other variables to another factor permitted an understanding of the relationships of the variables with the factors, thereby explaining economic and social structures of developing countries. The analysis based on the review of variables such as investment, saving, urban population growth and trade provided a deep understanding of the economic and social problems which are often related to the technological transfer. Out of the 30 variables under study, 6 dimensions accounting for 69 percent of the total variance were found to express the main areas of interest, this grouping may help to choose the variables for regression analysis in the next chapter, so that the variables express different dimensions.

The regional and income studies clearly support the findings of the overall analysis, together by giving the characteristics related to each group of countries, these subsample studies establish the validity of the results.

CHAPTER FIVE

RESULTS ANALYSIS AND THEORETICAL INTERPRETATION

Chapter 5

1. Introduction

Having estimated the parameters, the reliability of these estimates are assessed; econometric tests are applied first in order to judge the "goodness" of these estimates. These tests provide evidence regarding the validity or the violation of the assumptions of the linear regression model; statistical tests based on the coefficient of multiple determination (R^2), the standard errors of the estimates and the related t and F statistics are also used. These tests are valid only if the assumptions of least squares, already described in Chapter 3, are satisfied. Finally the results are tested within their theoretical perspectives, i.e. the relationships between the independent variables and the dependent variable are analysed by taking into consideration the theories and literature covering these aspects.

The first part of this chapter describes the methods used for obtaining the results; the second part describes the statistical and econometric analysis used with descriptions of some of the diagnostic techniques used for the examination of residuals. A preliminary analysis of the results, econometric tests and criteria and statistical analysis is also given. The third part discusses the economic criteria employed in determining whether the variables are compatible with the theory and other results in the published literature. Finally, the last part presents a discussion of complementary factors that may affect technological integration and that could not be incorporated in the analysis because of their unquantifiable nature.

2. Methods for Selecting Variables

There are a number of methods used to select the appropriate variables for multiple regression analysis; detailed descriptions are given in Draper and Smith (1980) and Thompson (1978).

The choice of the method used in this analysis is based on the objective of the study; as discussed earlier, the aim is to determine among a certain number of variables available those which are most significant and can best explain the assimilation of the technology being transferred.

"All possible subsets regression" is the regression method that satisfies most of the requirements of the present study. It consists of computing different sets of variables, and identifying subsets as first best, second best etc., to provide a wide range of alternatives to the researcher. This program is contained in The Biomedical Computer programs, BMD (1979) and is called P9R. It will be seen later that "all possible subsets regression" provides information mainly on the different combinations of the variables. Hence, when the set is identified, one can proceed to another method of selection called "stepwise" labelled P2R, contained in the computer suite of programs BMD. This method has the advantage of giving complementary information as to how the set of variables chosen was obtained i.e the order in which variables enter the equation, also a considerable statistical output is provided by this program. The method "all possible subsets regression" is discussed first; the "stepwise method" is then discussed.

2.1. All Possible Subsets Regression

The procedure used by the BMD programs is based on Furnival and Wilson's algorithm (1974), which estimates regression equations for "best" subsets of predictor variables.

Furnival and Wilson use a "leaps and bounds method" which computes only significant subsets. The above authors demonstrate the method with illustrative trees showing how the important combinations are kept, and use particular criteria for selecting the subset considered best.

A specified number of best subsets (up to ten) is identified for a specified number of k exploratory variables, i.e. ten best subsets of 1 explanatory variable are identified, then ten best subsets of 2,3, etc., explanatory variables are selected. Thus, not only the best, but also the second best, third best, etc., subsets are identified to provide feasible alternatives for the researcher.

Best is defined in terms of one of the three following criteria:

a) The sample multiple coefficient of determination or R - squared.

b) The adjusted R - squared which is defined as

5 - 1 $$R^2 - p\ (1 - R^2)/N - P$$

Where p is the number of variables included in the regression and N the number of observations.

c) The Cp statistic of Mallows which is based on the standardized total squared error, its estimate is given by

$$Cp = \frac{RSSp}{\hat{\sigma}^2} - (N - 2p) \tag{5 - 2}$$

RSSp is the residual sum of squares for the particular p variables, p is the number of variables in the regression and $\hat{\sigma}$ is an estimate of σ, which is the residual mean square from the complete regression.

For a full discussion on the criteria, see Garside (1965). This gives a procedure for comparing all subsets in a multiple regression analysis thereby giving the best subset of a certain size in terms of the minimum residual sum of squares. Hocking and Leslie (1967) used the Cp statistic of Mallows as a basic criterion for comparing regression subsets, their article reviews the method and gives examples. See also Furnival (1971). Hocking (1972) discusses the validity of the criteria used for the selection of variables and similarities existing between them.

One of the three criteria has to be specified in the program for the choice of the best subset. If, for example, the R - squared criterion is used, the best subset then is the one with maximum R - squared.

In the present analysis, the Cp statistic of Mallows is used because this is the one most commonly used and preferred by other researchers. Mallows has shown that regressions with small bias have small Cp's; that is the subset for which the residual sum of squares is a minimum, and hence subsets with minimal Cp are considered best.

The printout of the program BMD gives the above three statistics, the regression coefficients together with the t statistics for the five best subsets. This program carries out an extensive analysis of the residuals, it computes the residual, predicted residual, standardized residual as well as the Mahalanobis and Cook's distances which will be discussed in part 2; it also provides graphical output of the standardized residual, its normal probability, as well as other plots between variables or variables and residuals.

The main drawbacks to this method is that it tends to provide equations with too many predictors, also, if too small a value of k is chosen, an important choice might not be included and information as to how the various subsets were obtained are then not available. Therefore, as suggested by Draper and Smith (1980, p 305) this method can be carried out in conjunction with the stepwise method, which complements the first method.

2.2 The Stepwise Regression Procedure

This method introduces significant predictor variables into regression one by one (forward stepping) and removes any variable which subsequently become insignificant (backward stepping), until an equilibrium point is reached such that either the introduction of a further variable does not lead to a significant decrease in the residual sum of squares or the exclusion of any one of the variables does not lead to a significant increase in the residual sum of squares. For a detailed discussion of the method one can refer to Thompson (1978).

3 STATISTICAL AND ECONOMETRIC ANALYSIS

It is intended to analyse the results in their statistical and econometric perspectives, the next section deals with the economic implications of the variables and suggests complementary qualitative variables that affect technological transfer.

3 - 1 Diagnostic Techniques for the Examination of Regression Residuals.

It is intended to discuss the diagnostic techniques related to major problems in regression analysis such as detection of outliers*, which is a basic problem in the sense that individual or groups of cases can be influential and yet go undetected during the usual analysis of residuals; this is discussed in section 3 - 3. Outliers as well as additional methodologies to isolate such outlying cases are defined below.

3 - 1 - 1 Outliers

Traditionally, most of the investigations which used multiple linear regression models has centered on the study of

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* It will be seen that the diagnostic techniques used to detect outliers provide at the same time information on inhomogeneity of variance, normally called heteroscedasticity, and curvilinear relationships, if present; these are discussed in subsection 3-1-1-1.

the presence, strength and form of relationships between the variables. It is, however, increasingly recognised that least squares regression computations can be strongly influenced by a few cases, which makes the model reflect unusual features of those cases rather than the overall relationship between the response and independent variables. It is of interest, therefore, for an analyst to be able to determine influential cases and make decisions based upon statistical and theoretical criteria concerning their usefulness for a problem at hand.

A case is judged influential if important features of the analysis are altered substantially when it is deleted from the data, Draper and Smith (1980, p 152) define this phenomenon as:-

> "An Outlier among residuals is one that is far greater than the rest in absolute value and perhaps lies three or four standard deviations or further from the mean of the residuals."

Thus an outlier can be termed as a peculiarity that may indicate that a data point is not typical of the rest of the data. Its peculiarity may be due to a difference between its characteristics and those of the data or simply to causes such as errors in recording the observation.

The general rule is to remove the corresponding observation(s) from the data, after which the data is reanalysed. However, the rejection of outliers should be based on careful examinations, sometimes the outlier is providing information in an area where the ability to take observations is limited. See Cook and Weisberg (1980).

The following techniques are used to aid in the systematic location of data points that are either unusual or inordinately influential.

3-1-1-1. Use of Residuals and Partial Residual Plots.

The plotting of residuals versus the independent variables has been recommended by several authors, the best known being Draper and Smith (1980), these plots help to detect outliers, to assess the presence or absence of inhomogeneity of variance and to determine if a transformation of one or more variables is needed.

Larsen and McCleary (1972) proposed a new method using partial residual plots, these provide the same information described above plus an ability to assess the importance of the i^{th} independent variable, in terms of predicting power for the dependent variable, in the presence of the other independent variables, as well as assessing the importance of nonlinearity, if it exists it enables one to choose transformations required more precisely. That is, in addition to the informations provided by the usual residual plot on deviations from linearity, the partial residual plot shows the extent of the deviation from linearity and the extent and direction of linearity.

The partial residual of a variable is computed from the multiple regression model $Y = X\beta+\varepsilon$ and the fitted model $\hat{Y} = X\hat{\beta}$. As commonly defined residuals are $r = Y-X\hat{\beta}$. let X_i be the i^{th} column of X, then the i^{th} partial residual vector is

$$5\text{-}3 \quad r_i^* = r + X_i\hat{\beta}_i = Y - \sum_{j\neq i} X_j\hat{\beta}_j$$

3-1-1-2 Cook's Distance

It has been suggested that the estimated variances of the residuals contain relevant information beyond that provided by residual plots or studentized residual, thus Behnken and Draper (1972) statement:

> "A wide variation in the variance of the residuals reflects a peculiarity of the X matrix, namely a nonhomogeneous spacing of the observations and will thus often direct attention to data deficiencies."

A measure which may detect this problem is proposed by Cook (1977) who suggests that the influence of the i^{th} data point be measured by the distance

$$5\text{-}4 \qquad D_i = \frac{(\hat{\beta}_{(-i)} - \hat{\beta})'X'X(\hat{\beta}_{(-i)} - \hat{\beta})}{ps^2}$$

Where X is n x p, $\beta_{(-i)}$ is the least squares estimator obtained after the i^{th} data point has been omitted, β is the usual least squares estimator and s^2 is $R'R/(n-p)$. When D_i which provides a measure of the distance between $\beta_{(-i)}$ and β_i is compared to $F(p, n-p, 1-\alpha)$ for selected α, a large D_i denotes an influential i^{th} observation. When this measure is written in its equivalent form, it combines information from the studentized residuals (the residual divided by its standard error) and the variances of the residuals and predicted residuals.

5-5 $$D_i = \left(\frac{e_i}{s(1- r_{ii})^{\frac{1}{2}}} \right)^2 \left(\frac{r_{ii}}{1 - r_{ii}} \right) \frac{1}{p}$$

Where e_i is the i^{th} residual when full data is used, s^2 is the estimate of the variance $V(Y_i = \sigma^2)$ provided by the residual mean square when full data is used, and r_{ii} is the i^{th} diagonal entry of the matrix $R = X(X'X)^{-1}X'$. The first term is the studentized residual and the second is the ratio of the variance of the i^{th} predicted value and the variance of the i^{th} residual. A large D_i denotes an influential i^{th} observation. See also Cook and Weisberg (1980) and Draper and Smith (1980) for further discussions.

3-1-1-3 Mahalanobis Distance

This statistic basically measures the distance between the outlier and the mean of the population. See BMDP programs (1979,
et. al
p 804) and Belsley and Kuh (1980) for further discussion.

3-2 Preliminary Analysis

In running all possible subset regression for the 30 variables of the 45 developing countries (described in the third chapter), the following set of explanatory variables was found significant in explaining 57% of the total variance of the dependent variable, which is technology integration, the regression equation and variable definitions are

$$5\text{-}6 \quad IT_i = \beta_1 + \beta_2 POP_i + \beta_3 GDI_i + \beta_4 IP_i + \beta_5 ALR_i + \varepsilon_i$$

where

IT_i(X31)= The average ratio of technology integration for country i over the period 1970 - 1977.

POP_i(X1)= The average population over the period 1970 - 1977.

GDI_i(X5)= The average gross domestic investment as a percentage of gross domestic product over the period 1970 - 1977.

IP_i(X11)= The average industrial production as a percentage of gross domestic product over the period 1970 - 1977.

ALR_i(X26)=Adult literacy rate, it represents the average percentage of literate population aged 15 and over, for the period 1970 - 1977.

A full list of variables and countries are given in the appendix.

The ordinary least squares estimates are

$$5\text{-}7 \quad IT = -19.47 + .00042\ PoP + 1.81GDI - 1.01\ IP + .29\ ALR$$

$$(7.85) \quad (.000096) \quad (.41) \quad (.34) \quad (.082)$$

$$t = (-2.48) \quad (4.43) \quad (4.42) \quad (-2.93) \quad (3.60)$$

$$R^2 = .57$$

Where the figures in the first set of parentheses are the estimated standard errors and those in the second set are the t statistic for each coefficient. The amount of variation explained by the four independent variables is relatively high (57 percent) and shows that R^2 is significant, the standard errors of the estimates as well as the t test are also statistically significant. However, where extensive residual analysis is performed and Cook's and Mahalanobis' statistics are considered, three of these variables raise some problems by either violating the statistical and econometric assumptions, or by recording wrong signs, which possibly contradict the theory of economic reasoning. The maximum value (22.30) of Mahalanobis distance occurred among cases for Indonesia, also the maximum value of Cook's distance (.28) occurred for the same case.

The variables are analysed in turn below.

3.2.1. Industrial Production

This variable appears with a wrong sign which shows inconsistent theoretical results. An initial residual plot can be carried out in order to obtain an insight into the extent and direction of linearity as well as detecting outliers. This figure displays deviation from linearity caused by six cases which are: Algeria (1), Iran (17), Zambia (45), Sierra Leone(33), Zaire (44) and Jamaica (19), the figures in parentheses represent the numbers to which they refer in the plot, see fig. 5-1.

It was found that because the mining sector is included in industrial production, these countries tend to show a high level of industrial production compared to the rest of the sample, which tend to have a less important mining sector; the main reason apparently that these countries are out of range or outliers is that they have a low ratio of technology integration and produces the negative sign of this variable. This further indicates that countries that have a relatively high mining sector are not necessarily integrating better than those with a low mining sector technology. A correlation coefficient plot between the dependent variable and this variable and which demonstates the relationships between them is presented in Fig.1. Appendix 10 . The mining percentage of industrial production is presented in Appendix 7.

A significant increase, from 5 to 36 percent in the correlation coefficient is obtained when these countries are not included; however, as these countries are mainly outliers for this variable only and as the following analysis will select new variables where these countries seem to follow the general pattern, they are retained in the analysis.

3-2-2- Gross Domestic Investment

The partial residual plot for this variable tends to show a curvilinear relationship when analysed with the presence of the other three retained variables. A clearly distinct outlier is also present in this plot. See Fig. 5-2. A correlation plot was made between the dependent variable and gross domestic investment in order to see where the outlier lies in the diagram. The outlier is Algeria labelled 1, see fig. 2, Appendix 10. This variable is also no longer selected by the final regression runs.

3-2-3 Population

A partial residual plot was performed to test the validity of including this variable; it was found that one country, Indonesia, is an outlier, see fig. 5-3 and affecting the regression estimates by increasing the correlation between the two variables, from 23 percent, when this country is excluded from the analysis, to 42 percent, when it is included. When Indonesia is removed from the analysis, the variable population appears rarely in the regrèssion subsets whereas when this country is included, this variable appears in all subsets.

Apart from the fact that this country has a much larger population than the others in the sample, it also shows that contrary to the other countries, it records a high technology integration for generally low consumption, infrastructure and education variables; there are no clear reasons why this country has shown a high technology integration despite its generally low economic and social state, it would be interesting to investigate in greater detail, the only conclusions that can be drawn at present when one examines the various correlation plots (16) in which this country is present, see figures 1,2,3,4 and 5, Appendix 10 , is that, besides the characteristics mentioned above, it has a low production of manufacture (about 9 percent of the GDP), a relatively high industrial production (about 17 percent of GDP); it is also characterized by a high agricultural sector (about 40 percent of GDP), and a low urban population growth, when compared with the rest of the sample. This last indicator possibly shows that because consumer variables are very low, people tend to stay in agricultural areas where production is important, therefore leaving the industrial and manufacturing sectors free from over supply of agricultural labour. Eventhough this country may provide some supplementary information regarding technology integration, it is found to be the only case in the whole set of 45 countries to have the above characteristics; further Cook's and Mahalanobis' distances are the largest values obtained. For these reasons it was decided to discard this case from the analysis.

The regression results after removing this case are as follows:

$$\text{5-8} \quad IT = 9.39 + 1.08\ GDI - .48\ IMG + .48\ ALR - .90\ PC$$

$$(16.07) \quad (.3099) \quad (.3201) \quad (.0956) \quad (.2563)$$

$$t = (.58) \quad (3.50) \quad (-1.51) \quad (5.04) \quad (-3.53)$$

$$R^2 = .51$$

The new variables entered are:

IMG = The average imports of manufactured goods as a percentage of total merchandise imports over the period 1970 - 1977.

PC = The average passenger cars per thousand population over the period 1970 - 1977.

To comment briefly on the results, the four indicators explain a significant part of the total variance of the dependent variable, β_2(IMG) has a small t statistic and an insignificant standard error; the rest of the parameters are statistically significant, however, a major problem is created by b_5 (PC) which has a negative sign and contradicts economic reasoning. The inconsistency shown by this indicator is that the fewer passenger cars per thousand population the greater the technology integration present. The same analysis as for the variable industrial production was performed, see fig. 5-4, and it was found that basically three Latin American countries were falsifying the results by causing the negative relation of 8 percent between the ratio technology integration and this variable. These countries are Chile (6), Jamaica (19) and Uruquay (43). Also the largest value of Mahalanobis distance (18.02) occurred for Uruguay and the largest value of Cook's distance (23) occurred for Chile. The problem that these cases create is that they are characterized by a relatively high rate of consumption, education as well as infrastructure and yet have a very low rate of technology integration. See figures 6,7,8 and 9, Appendix 10.

This could be explained by the political phases these countries went through. Chile and Uruguay are still governed by military regimes; the reason why these countries have a high consumption and infrastructure indicators is they both had democratic regimes which may have contributed to the development of their economies before the military coup d'etats took place in the 1970's. Jamaica also had a more or less stable economy until the 1970's when the country experienced conditions of near civil war.

As purely political factors seem to affect these economies, it would appear necessary to discard them from the analysis as they would then constitute special cases of developing countries, and would not contribute to the understanding of technological transfer, in the context of this study. In order to include these countries, it would be necessary to introduce political indicators which could be quantified and included in the analysis. When the above three countries are discarded, together with Indonesia, most discrepancies such as wrong signs and biased variables disappear. Regression subsets obtained without these countries gave the following explanatory variables as the best subset explaining 65 percent of the total variance of the dependent variable. Correlation tables for both 45 and 41 countries are reported in Appendix 8.

The results are:

5-9 $$IT = 39.34 - .92\ IMG + .054\ PD + .40\ ALR + .055\ RR.$$

$$(11.54)\quad (.2686)\quad (.0263)\quad (.0849)\quad (.0299)$$

$$t = (3.41)\quad (-3.45)\quad (2.07)\quad (4.80)\quad (1.87)$$

$$R^2 = .65$$

The new variables entered are:

PD = The average of population density per square kilometer over the period 1970 - 1977.

RR = The average of radio receivers per thousand population over the period 1970 - 1977.

To comment briefly on the results, all parameters are statistically significant, with the exception of b_5 (RR) which has a small t statistic, R^2 is high enough to be significant and the variables have correct signs. However, when one looks at the results of factor analysis in the preceeding chapter, one finds that population density and adult literacy rate are constituents of the same factor as was previously discussed, if two or more variables selected by the regression model are known to express the same dimension, only one of these variables should be kept in the analysis. The variable accordingly rejected was population density. Other reasons that contributed to the exclusion of this variable, was that when partial plot was performed, see fig. 5- 5, one country, Mauritius (23), appeared as an outlier and increased the positive correlation, also the observations were condensed on the left part of the plot showing heteroscedasticity. This will be discussed further in the next section. Mahalanobis and Cook's distances for this country, Mauritius (23) also had the largest values, (24.10) and (.82) respectively, this further shows that this case is definitely an outlier and would affect the results of the variable population density if retained.

When this variable is removed from the analysis, the best

Fig. 5.3 PARTIAL RESIDUAL PLOT

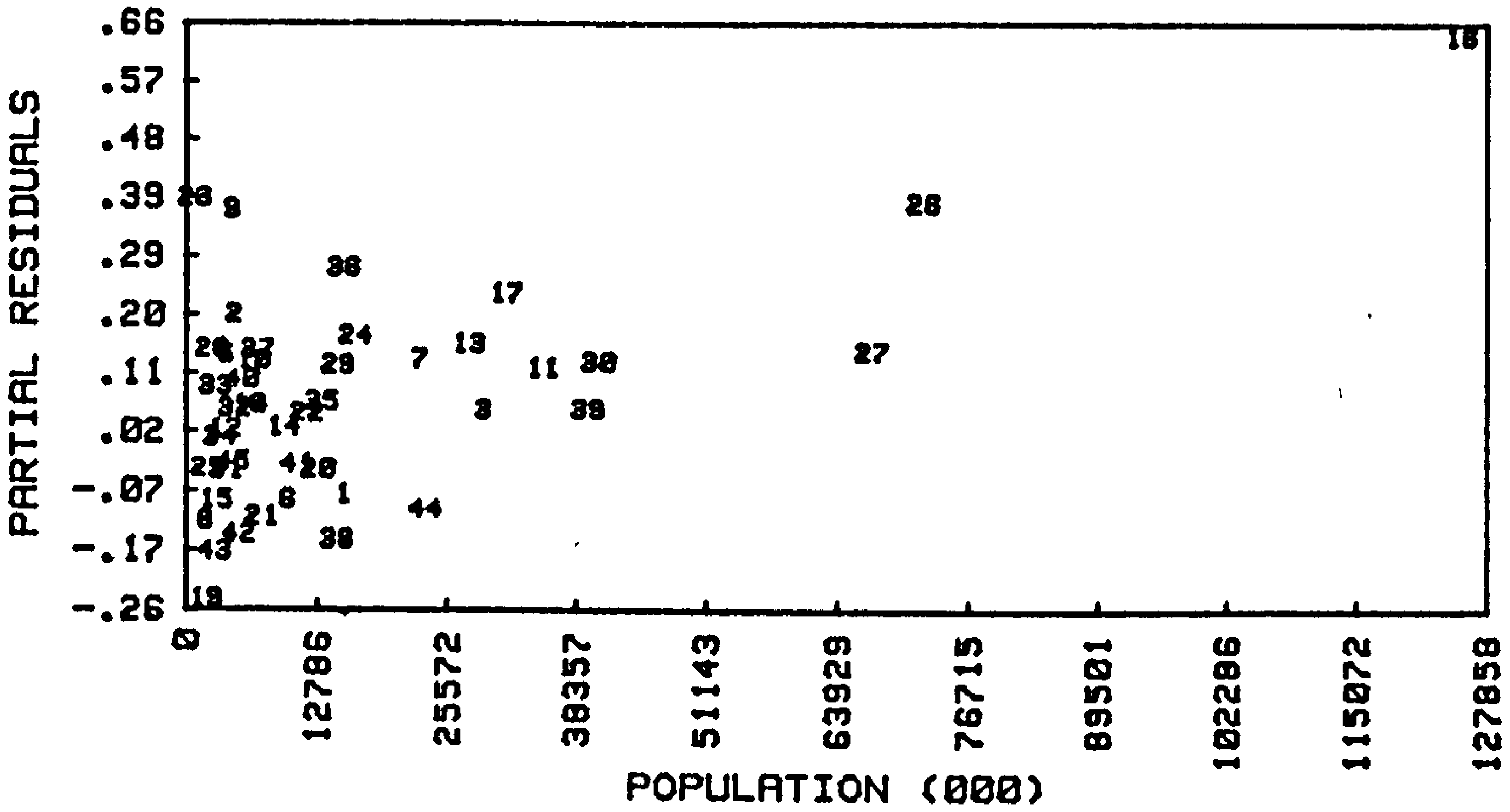


Fig. 5.2 PARTIAL RESIDUAL PLOT

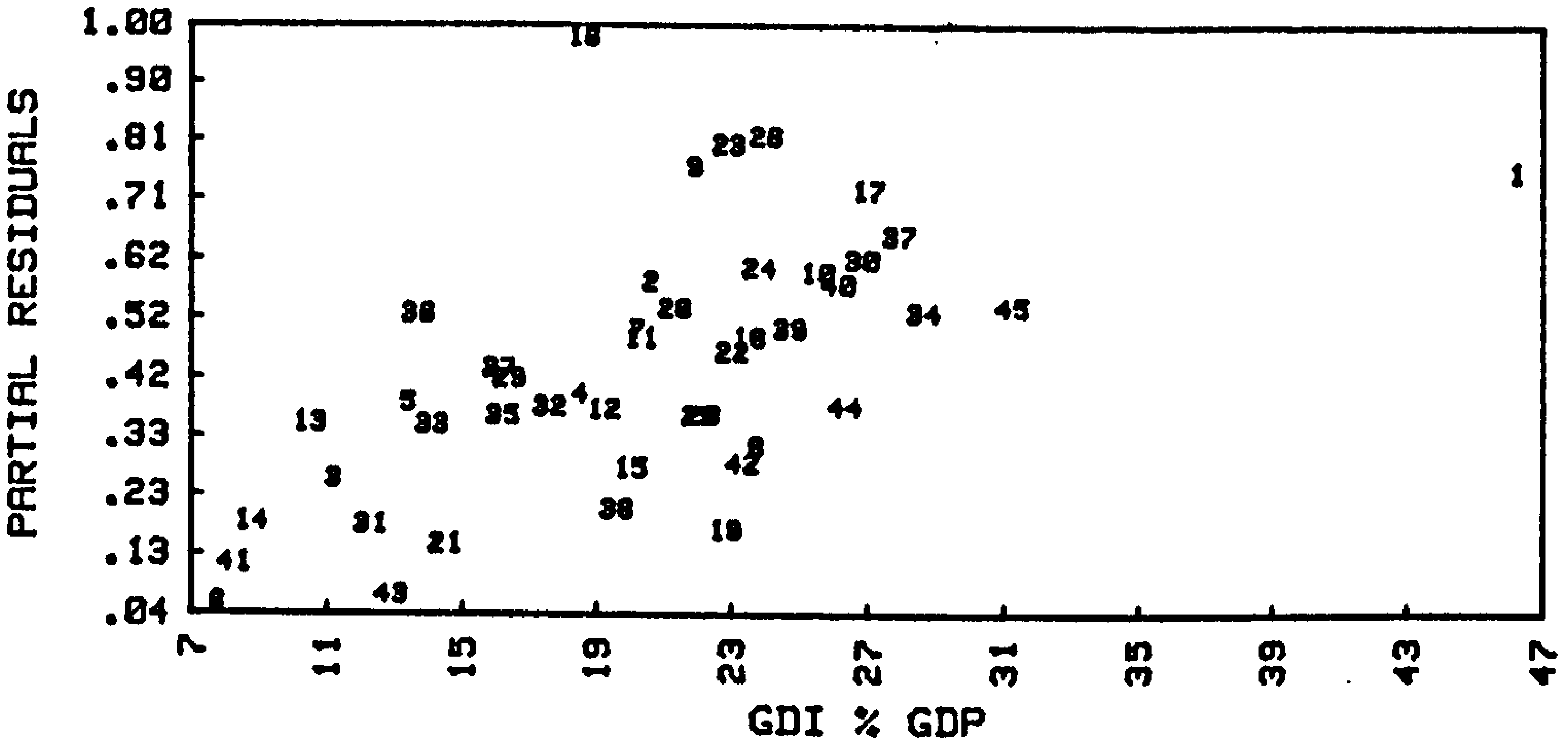


Fig. 5.1 PARTIAL RESIDUAL PLOT

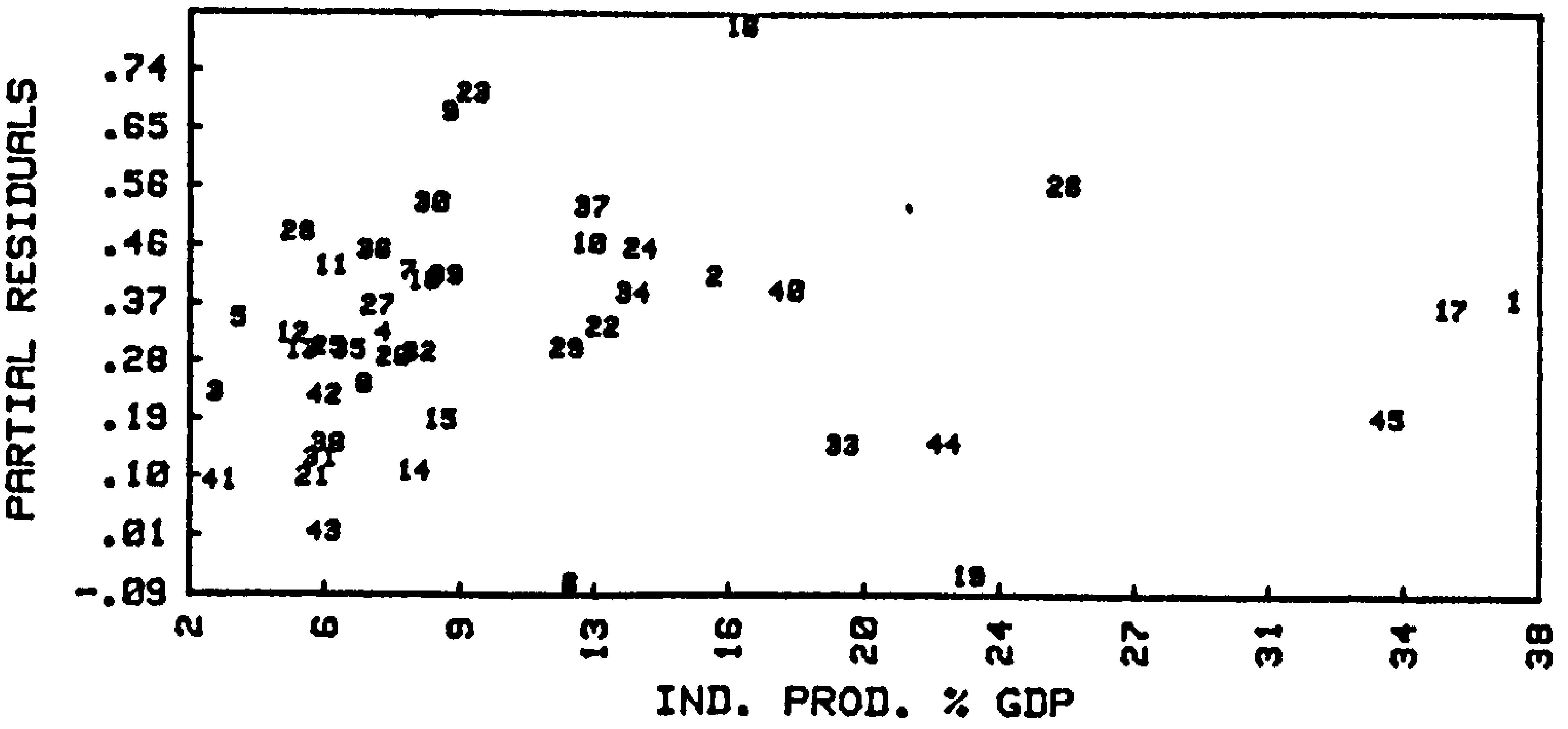


Fig. 5.4 PARTIAL RESIDUAL PLOT

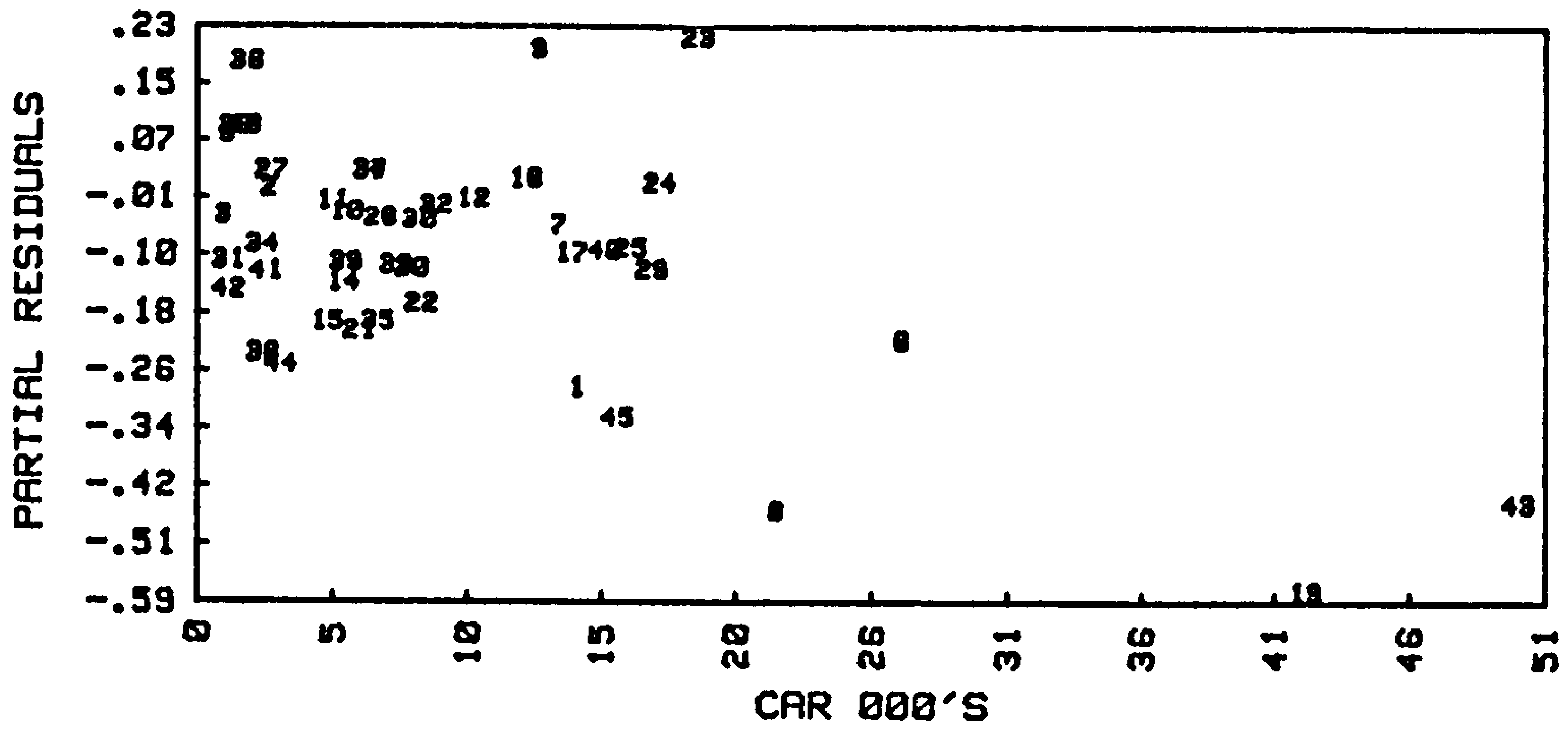
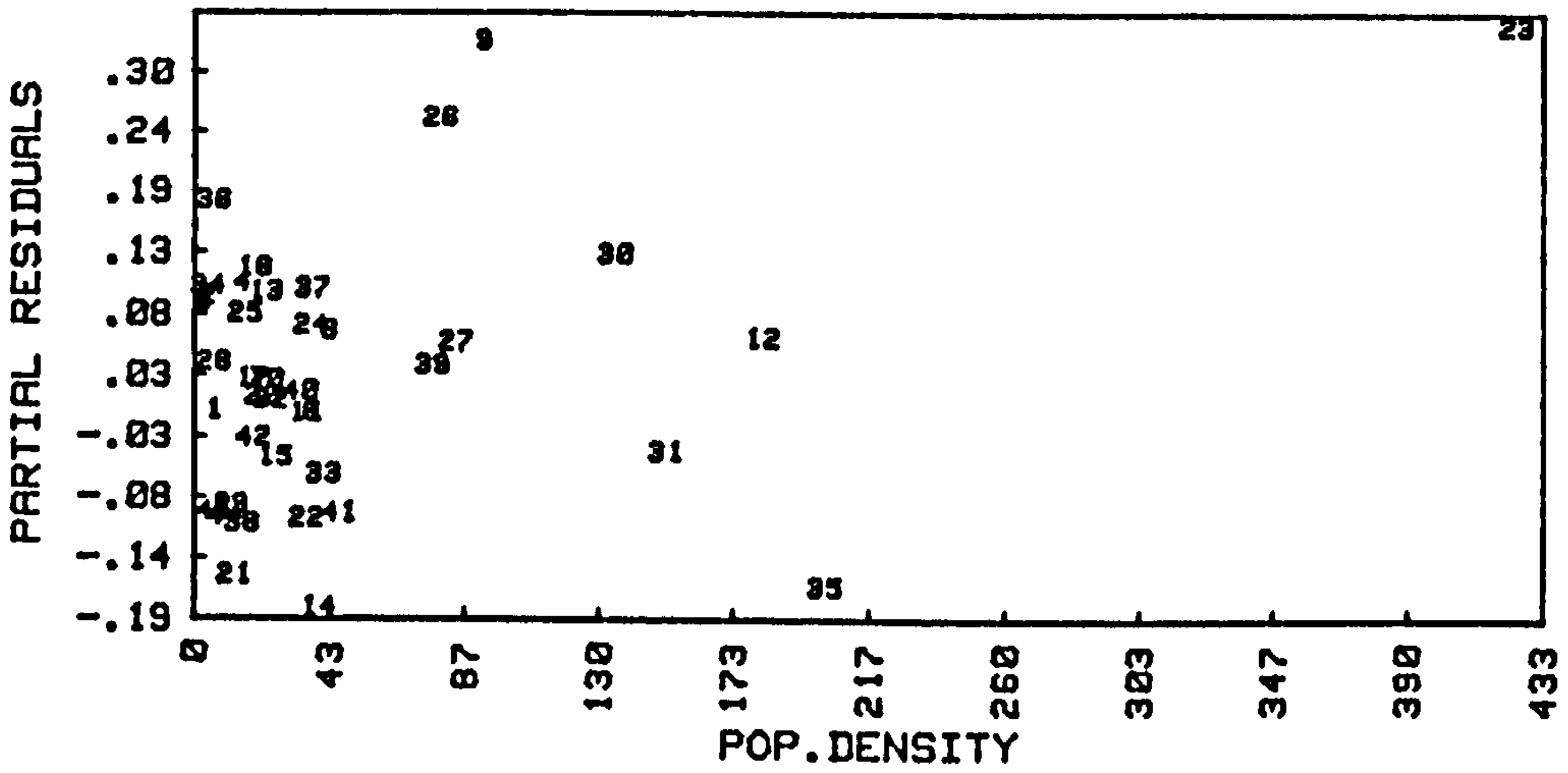


Fig. 5.5 PARTIAL RESIDUAL PLOT



subset comprises three variables explaining 61 percent* of the total variance of the dependent variable technology integration.

The final results are then:

5-10

$$
\begin{array}{lllll}
IT = & 38.825 & - .9098IMG & + .4740\ ALR & + .0523\ RR \\
 & (12.048) & (.2802) & (.0821) & (.0311) \\
t = & (3.22) & (-3.25) & (5.77) & (1.68) \\
R^2 = .61 & & & \bar{R}^2 = .58 &
\end{array}
$$

The variablesbeing

IT : Ratio of technology integration

IMG : Imports of manufactured goods

ALR : Adult literacy rate

RR : Radio receivers per thousand

$\bar{R}^2$ is the adjusted squared multiple correlation

Because of the low values of the coefficients, the value of the dependent variable was arbitrarily multiplied by 100. The results are reported in matrix-form in the following:

---

* When Indonesia is kept in the analysis R^2 drops from 61 level to 55 which shows the drop in significance caused by including one outlier.

- Problem in matrix notation

$$
\underset{(41\times1)}{\underset{Y}{\left|\begin{array}{r}
.278\\ .375\\ .235\\ .165\\ .187\\ .456\\ .311\\ .680\\ .483\\ .366\\ .310\\ .127\\ 0.000\\ .163\\ .304\\ .270\\ .196\\ .034.\\ .311\\ .748\\ .338\\ .272\\ .562\\ .233\\ .528\\ .320\\ .587\\ 0.000\\ .128\\ 0.000\\ .276\\ .335\\ .313\\ .469\\ .095\\ .459\\ .317\\ 0.000\\ .046\\ 0.000\\ .130
\end{array}\right|}}
=
\underset{(41\times4)}{\underset{X}{\left|\begin{array}{crrr}
1 & 37.200 & 30.500 & 198.000\\
1 & 39.800 & 51.500 & 78.000\\
1 & 54.800 & 67.000 & 18.500\\
1 & 44.500 & 12.000 & 48.000\\
1 & 38.000 & 11.000 & 16.500\\
1 & 36.400 & 77.000 & 112.000\\
1 & 51.250 & 83.000 & 73.000\\
1 & 36.500 & 67.100 & 39.000\\
1 & 40.700 & 70.950 & 279.000\\
1 & 29.650 & 44.000 & 135.000\\
1 & 56.300 & 61.000 & 232.000\\
1 & 43.500 & 8.000 & 6.500\\
1 & 41.450 & 30.000 & 92.500\\
1 & 48.200 & 57.000 & 55.500\\
1 & 41.800 & 44.000 & 171.000\\
1 & 39.350 & 20.000 & 68.500\\
1 & 39.750 & 35.000 & 38.000\\
1 & 47.500 & 44.500 & 96.000\\
1 & 30.250 & 57.500 & 118.000\\
1 & 40.900 & 80.000 & 113.500\\
1 & 28.950 & 24.500 & 76.000\\
1 & 49.550 & 55.000 & 57.500\\
1 & 42.000 & 66.400 & 51.000\\
1 & 33.200 & 20.500 & 15.000\\
1 & 28.700 & 79.500 & 69.500\\
1 & 37.800 & 72.000 & 132.500\\
1 & 33.200 & 84.500 & 41.500\\
1 & 48.700 & 23.000 & 12.000\\
1 & 37.600 & 10.000 & 69.000\\
1 & 43.400 & 15.000 & 19.000\\
1 & 37.300 & 27.500 & 19.500\\
1 & 25.100 & 77.850 & 38.000\\
1 & 40.800 & 17.500 & 79.000\\
1 & 36.950 & 46.500 & 224.000\\
1 & 42.200 & 47.000 & 15.000\\
1 & 38.400 & 80.500 & 104.500\\
1 & 33.400 & 39.500 & 109.000\\
1 & 48.550 & 35.000 & 21.000\\
1 & 37.400 & 5.300 & 16.500\\
1 & 40.800 & 14.000 & 52.500\\
1 & 38.100 & 43.150 & 19.000
\end{array}\right|}}
\times
\underset{(4\times1)}{\underset{B}{\left|\begin{array}{c}
B1\\ B2\\ B3\\ B4
\end{array}\right|}}
+
\underset{(41\times1)}{\underset{U}{\left|\begin{array}{c}
U\ 1\\ U\ 2\\ U\ 3\\ U\ 4\\ U\ 5\\ U\ 6\\ U\ 7\\ U\ 8\\ U\ 9\\ U10\\ U11\\ U12\\ U13\\ U14\\ U15\\ U16\\ U17\\ U18\\ U19\\ U20\\ U21\\ U22\\ U23\\ U24\\ U25\\ U26\\ U27\\ U28\\ U29\\ U30\\ U31\\ U32\\ U33\\ U34\\ U35\\ U36\\ U37\\ U38\\ U39\\ U40\\ U41
\end{array}\right|}}
$$

- From the preceeding data, one obtains the following matrices and results

```
X'X MATRIX


 |   410.000E-01   163.990E+01   183.995E+01   322.950E+01  |
 |   163.990E+01   675.153E+02   734.449E+02   128.869E+03  |
 |   183.995E+01   734.449E+02   107.459E+03   165.586E+03  |
 |   322.950E+01   128.869E+03   165.586E+03   426.950E+03  |
```

```
Inv(X'X) MATRIX


 |   961.869E-03  -209.723E-04  -168.655E-05  -291.387E-06  |
 |  -209.723E-04   520.229E-06   260.770E-08   601.139E-09  |
 |  -168.655E-05   260.770E-08   446.253E-07  -533.705E-08  |
 |  -291.387E-06   601.139E-09  -533.705E-08   643.473E-08  |
```

```
X'Y MATRIX


 |    11407.000E-03  |
 |    43788.515E-02  |
 |    64210.590E-02  |
 |    10895.290E-01  |
```

```
B = Inv(X'X).X'Y


 |    38817.528E-05  |
 |   -91007.228E-07  |
 |    47426.526E-07  |
 |    52325.295E-08  |
```

3-3 Econometric Analysis

The statistical criteria used to assess the reliability of the parameter estimates are valid only if the assumption of the linear regression model stated in the third chapter are satisfied. Therefore, in order to consider the importance attached to R^2, the standard error and the t and F statistics, one should ensure that the basic assumptions of least squares are satisfied. If these assumptions are violated, the estimates obtained may not possess their properties and the statistics used may become unreliable criteria.

The econometric analysis involving the examination of the regression residuals, the e's, which are defined as the n differences $e_i = y_i - \hat{y}_i$, $(i = 1,2,...n)$; where y_i is an observation and $\hat{y}_i$ is the corresponding fitted value obtained by use of the fitted regression model. The e's are therefore the differences between what is actually observed and what is predicted by the regression function, that is, the amount which the regression function has not been able to explain. Thus one may think of the e's as the observed errors. When performing regression analysis, certain assumptions were made about the errors, see section 3-4-1-1 in Chapter 3, yet one or more of the ordinary least squares assumptions concerning the errors or disturbances may not be valid, that is, they may be non normal or heteroscedastic, the exogenous variables may be stochastic or multicollinear, the functional form of the relationship may be wrongly specified, one may also find that relevant exogenous variables have been omitted, or irrelevant variables included. These specification errors have clear consequences with regard to the least squares estimates of the coefficients and of the variances. A number of tests are available to discern a specification error, these will be discussed in turn along with the diagnostic techniques in section 3-1 on the analysis of the final regression results of this study.

3-3-1 The Assumption of Randomness of u

This assumes that u can take various values in a chance way; that is for each value of x, u can assume positive, negative or zero values. The term u is introduced in the model in order to take into account the effects of errors such as errors of measurement, of the mathematical form of the model, errors of the omitted variables as well as errors inherent in human behaviour. For u to be random, the omitted variables should be numerous, individually unimportant and change in different directions so that their effect on the dependent variable is unpredictable. If important variables are excluded, the values of u will not show a random pattern as they will reflect mainly the movements of these variables. Also the errors of measurement should be random, that is they should not exhibit a systematic pattern, see Koutsoyiannis (1981, p 179).

Since there is no test for the assumption of randomness of the u's, as they are not observable, and their estimates, the e's, are obtained with the assumption of randomness. The researcher should attempt to justify this assumption on a priori grounds, by making sure that the conditions stated above are fulfilled. It is, however generally recognised that important variables are omitted in practice, either because of their non availability or to avoid multicollinearity. This point, which is related to the assumptions of the disturbance variable u, will be dealt with further in the conclusion.

3-3-2 The Assumption of Zero Mean of u

This assumes that each u_i, corresponding to x_i, may take values which have a zero mean. This assumption is imposed on the estimation procedure because of the stochastic nature of economic relationships, as the estimates could not be obtained by the common rules of mathematics. With this assumption, the expected mean value of Y can be written

5-11 $$E(Y) = (b_o + b_1X_1) + E(u).$$
$$= b_o + b_1X_1$$

Which can be estimated by the rules of mathematics. Geometrically, this assumption implies that the observations of X and Y are scattered randomly around the estimated line which is $(\hat{Y} = \hat{b}_o + \hat{b}_1X)$, and which is a good approximation of the true line $E(Y) = b_o + b_1X$ under the assumption of Zero mean of u if the fitted model is $E(Y) = \beta_o + \beta_1X_1 + \ldots + \beta_kX_k$, the equation can be written, see Draper and Smith (1980, p 143),

$$-2\Sigma(Y_i - b_o - b_1X_{1i} - \ldots\ldots - b_kX_{ki}) = 0$$

where i is equal to 1 to n. This reduces to

5-12 $$\Sigma(Y_i - \hat{Y}_i) = 0$$

Thus

5-13 $$\Sigma e_i = \frac{\Sigma e_i}{n} = 0$$

Eventhough there is no specific test for this assumption, as E(u) = 0 is set for the estimation procedure and the u's are not observable, one may attempt to draw a histogram of the observed residuals in order to see if the mean is approximately around zero. The studentized residuals are used instead of the simple residuals, which is obtained from

5-14 $$e_i^* = \frac{e_i}{s(i)\ \sqrt{1-h_i}}$$

where e_i is the observed residuals, S(i) is the standard deviation of X, and h_i is equal to the number of explanatory variables over the number of observations, that is $h_i = p/n$. The studentized residual is preferred because of a number of practical situations, see Belsey et al (1980, p 20), in particular e_i^* is distributed closely to the t-distribution with n-p-1 degrees of freedom, thus if the Gaussian assumption holds, one can readily assess the significance of any studentized residual

The histogram of the studentized residuals is computed using the computer package BMD presented below.

Fig 5-6 Histogram of Studentized Residuals

```
-2.0   1 *
-1.8   1 *
-1.6   1 *
-1.4   0
-1.2   5 *****
-1.0   1 *
 -.8   2 **
 -.6   2 **
 -.4   3 ***
 -.2   8 ********
 0.0   1 *
  .2   3 ***
  .4   2 **
  .6   5 *****
  .8   2 **
 1.0   0
 1.2   0
 1.4   1 *
 1.6   0
 1.8   1 *
 2.0   0
 2.2   0
 2.4   2 **
```

While this histogram exhibits slight irregularity, it does not appear abnormal and the mean value is situated approximately around zero. This histogram can also be used to investigate the normality assumption.

3-3-3 The Assumption of Constant Variance or Homoscedasticity

One of the major assumptions of the classical linear regression model is that the variance of each disturbance term u_i, corresponding to X_i, is some constant number equal to σ^2. that is

5-15 $$\mathrm{Var}(u) = E(u_i^2) = \sigma^2 \quad (i = 1,2,\ldots,N).$$

This means that the variation of each u_i around its zero mean does not depend on the values of X, in other words, the variance of each u_i remains the same irrespective of whether the explanatory variables have small or large values. Homoscedasticity as well as heteroscedasticity are shown diagrammatically for the two-variable regression model in Appendix 14. Where it could be seen that increasing or decreasing dispersion of the observations from the line show inhomogeneous variance or heteroscedasticity.

The assumption of constant variance of the disturbance term may be expected not to hold in many econometric applications, see for example, the saving function which throws a greater variability in the saving behaviour of high income families than that of the low-income families, Goldberger (1964, p231).

There are many reasons to expect the variance of u to vary over time or to vary with the explanatory variable, in fact, as mentioned by Gujarati (1978, p 196), the problem of heteroscedasticity is likely to be more common in cross-sectional than time-series data, as in the former case one deals with members of a population at a certain time, such as firms, countries, consumers etc., which may be classified under small, medium or large sizes whereas in the latter case, one generally collects the data for the same entity over a period of time, which may exhibit a smaller variance among the u's.

As u expresses the influence of the omitted variable as well as the errors of measurement of the dependent variable, one of the reasons to expect the variance of u to vary with X may be that where Y increases, the errors of measurement tend to increase, as it becomes more difficult to check the consistency and reliability of the data. Also, part of the omitted variables tend to change in the same direction with X, causing an increase of the variation of the observations from the regression line. As there are reasons to believe that the assumption of homoscedasticity may be isolated in practice, it is important to examine the consequences of heteroscedasticity on the parameters estimates.

If the assumption of homoscedasticity of the disturbance term is not fulfilled, the OLS estimates are still unbiased and consistent but they are no longer efficient, that is, in repeated sampling the OLS estimators are on the average equal to their true population values, and as the sample size increases, they tend to converge to their true values. However, even with the indefinite increase of sample size, their variances are no longer minimum. Also, as the variance of the prediction of Y for a given value of X includes the variances of u and of the parameters estimates, which are not minimal due to heteroscedasticity, the prediction based on the estimates $\hat{b}$'s would have a high variance and would not be efficient. See Gujarati's (1978, p 199) and Koutsoyiannis (1980, p 184).

3-3-3-1 Graphical Methods to Detect Heteroscedasticity.

These methods consist of plotting the residuals, or the squared residuals against the estimated values $\hat{Y}_i$, against the independent variables X_{ji}, for j = 1,2,... k, or plotting the partial residuals of the i^{th} variable against the explanatory variables. This is in order to find out whether the residuals exhibit a certain pattern with the X's or with the fitted values $\hat{Y}$, that is to assess the presence or absence of inhomogeneity of variance. In this study the e's are plotted against each of the three retained explanatory variables, then the i^{th} partial residual, already described in section 3-1-1-1 of this chapter, is plotted against the values of the i^{th} variable, the uses of these plots being to detect outliers and assess the presence or absence of inhomogeneity of variance. It should be added that the partial residual plot, while displaying in addition the extent of deviation from linearity caused by outliers, inhomogeneity of variance or curvilinear relationships, shows whether the relationships between the dependent variable and each of the explanatory variables is negatively or positively linear, which may complement the information on homogeneity of variance as well as the true relationship when the effect of the other variables is excluded.

Figures 5-7 and 5-8 appear to indicate that the assumption of constant variance is not violated with respect to the variables imports of manufactured goods and adult literacy rate. Figure 5-9 shows constant variance up to a certain point when some observations tend to appear as outliers, but it does not display any evidence of the variance increasing or decreasing with respect to the variable radio receivers per thousand population, therefore one cannot conclude that the assumption of constant variance is violated. The partial residual plot, Figures 5-10, 5-11, 5-12, demonstrate these same results, in addition they give a pictorial representation of each variable's effect on the dependent variable, see Larsen and McCleary (1972, p 786), Y corrected for the

Fig. 5.7 RESIDUAL PLOT

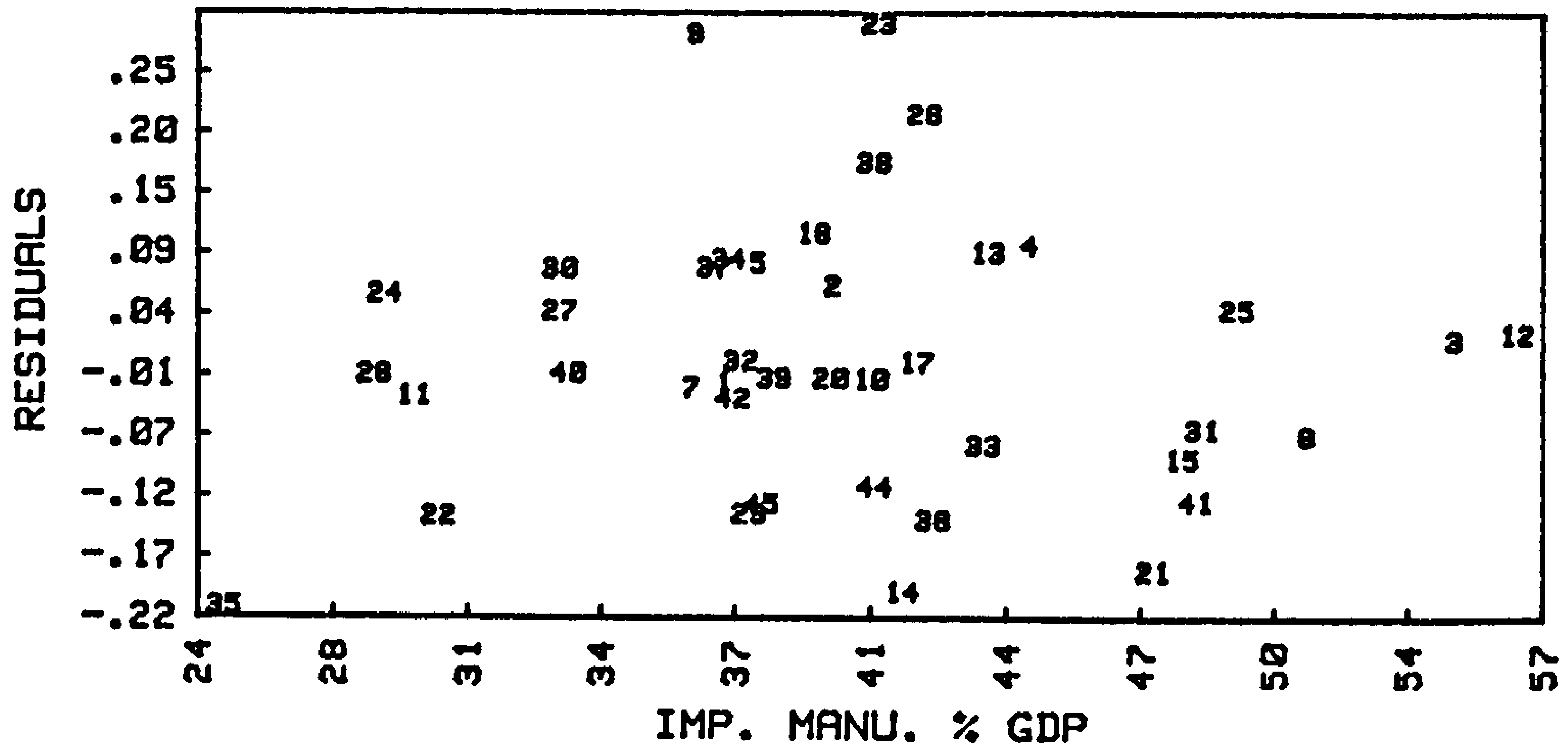


Fig. 5.8 RESIDUAL PLOT

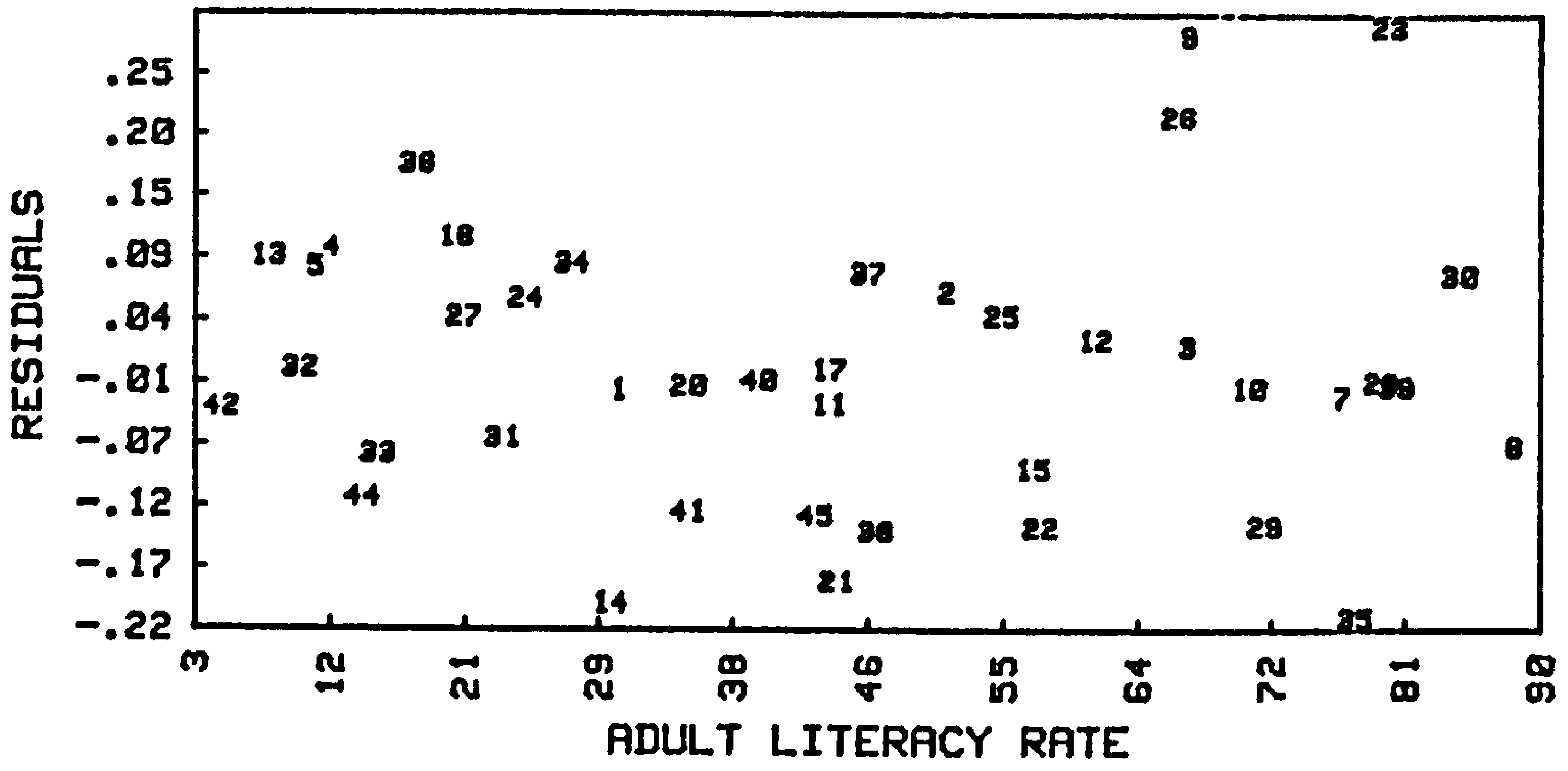


Fig. 5.9 RESIDUAL PLOT

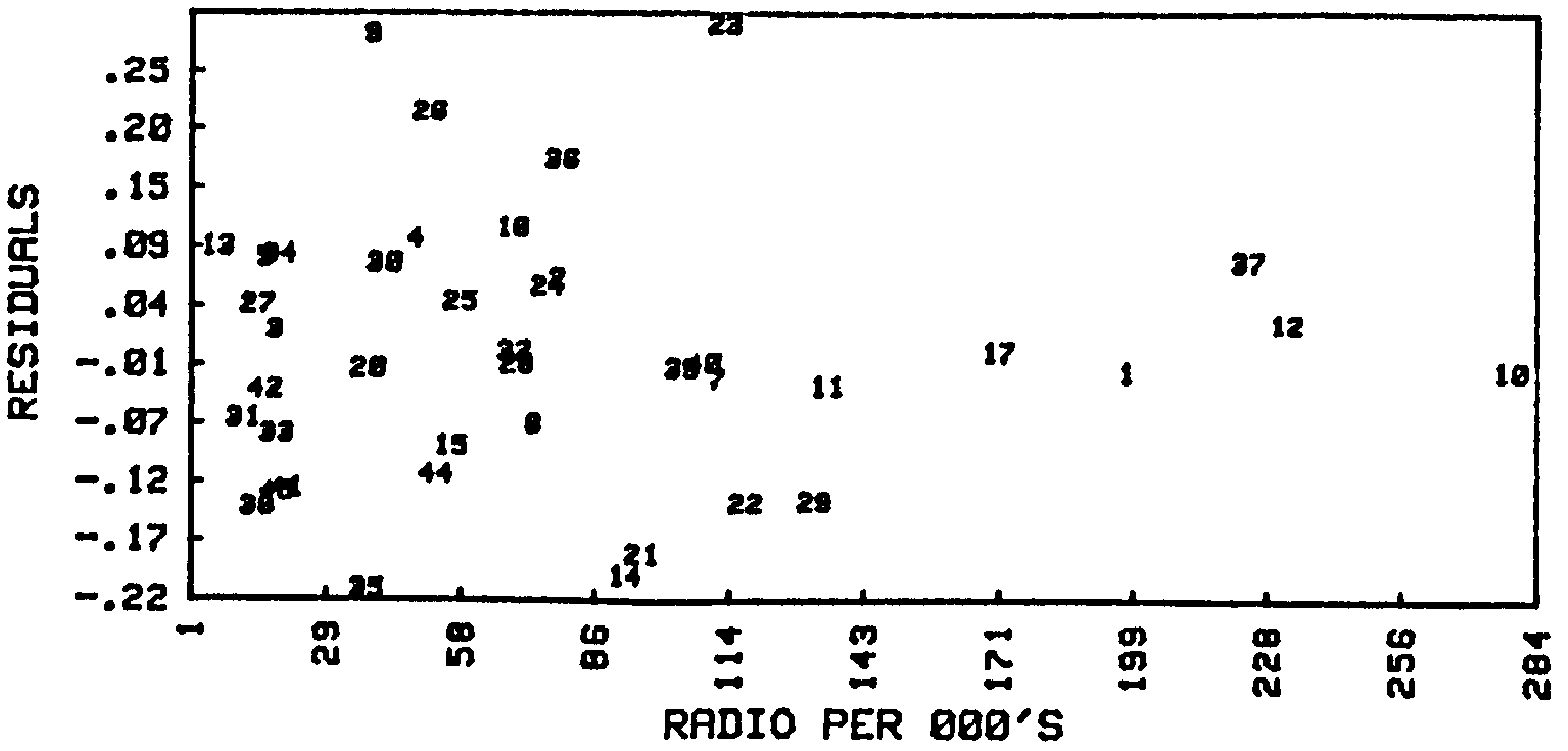


Fig. 5.10 PARTIAL RESIDUAL PLOT

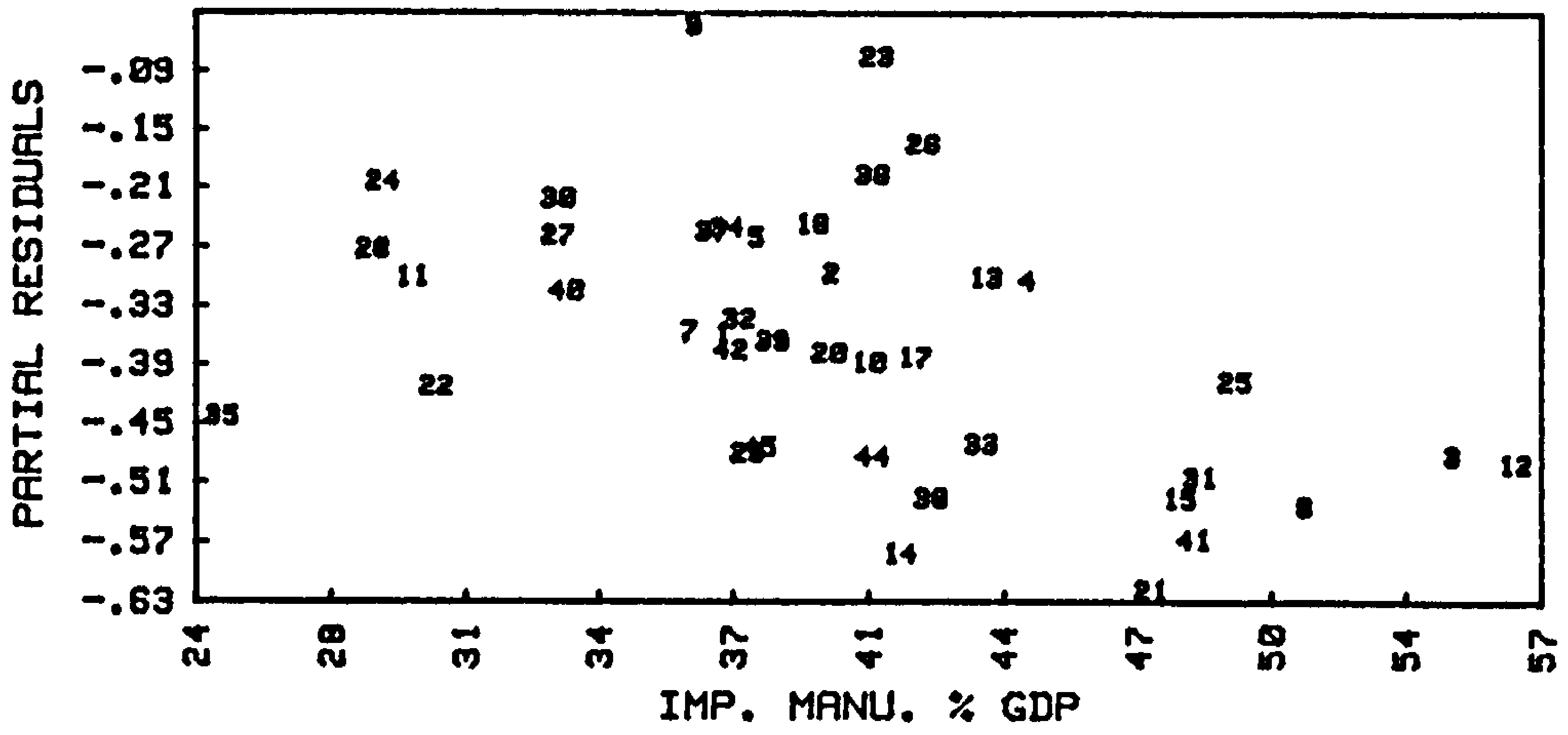


Fig. 5.11 PARTIAL RESIDUAL PLOT

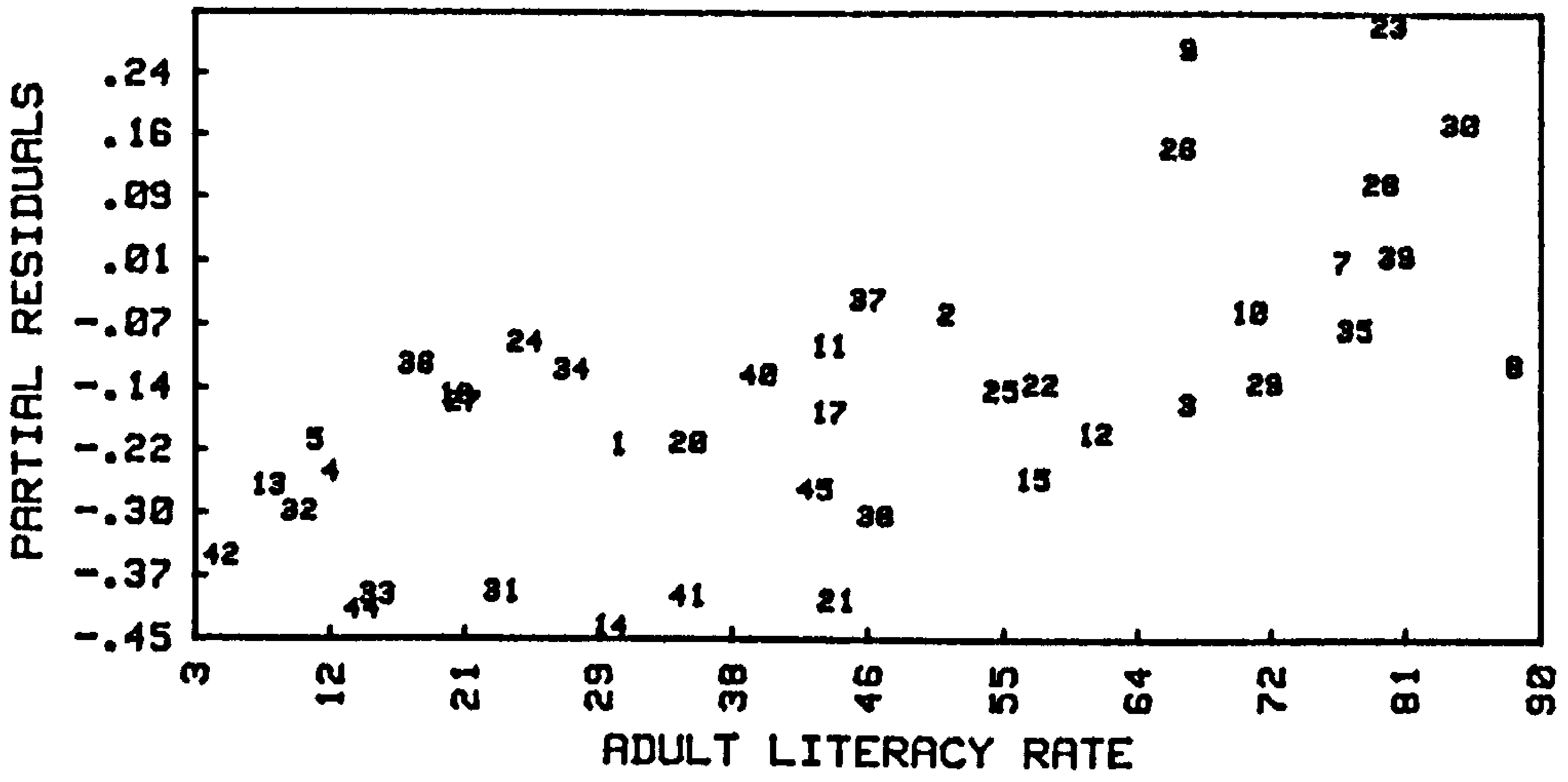
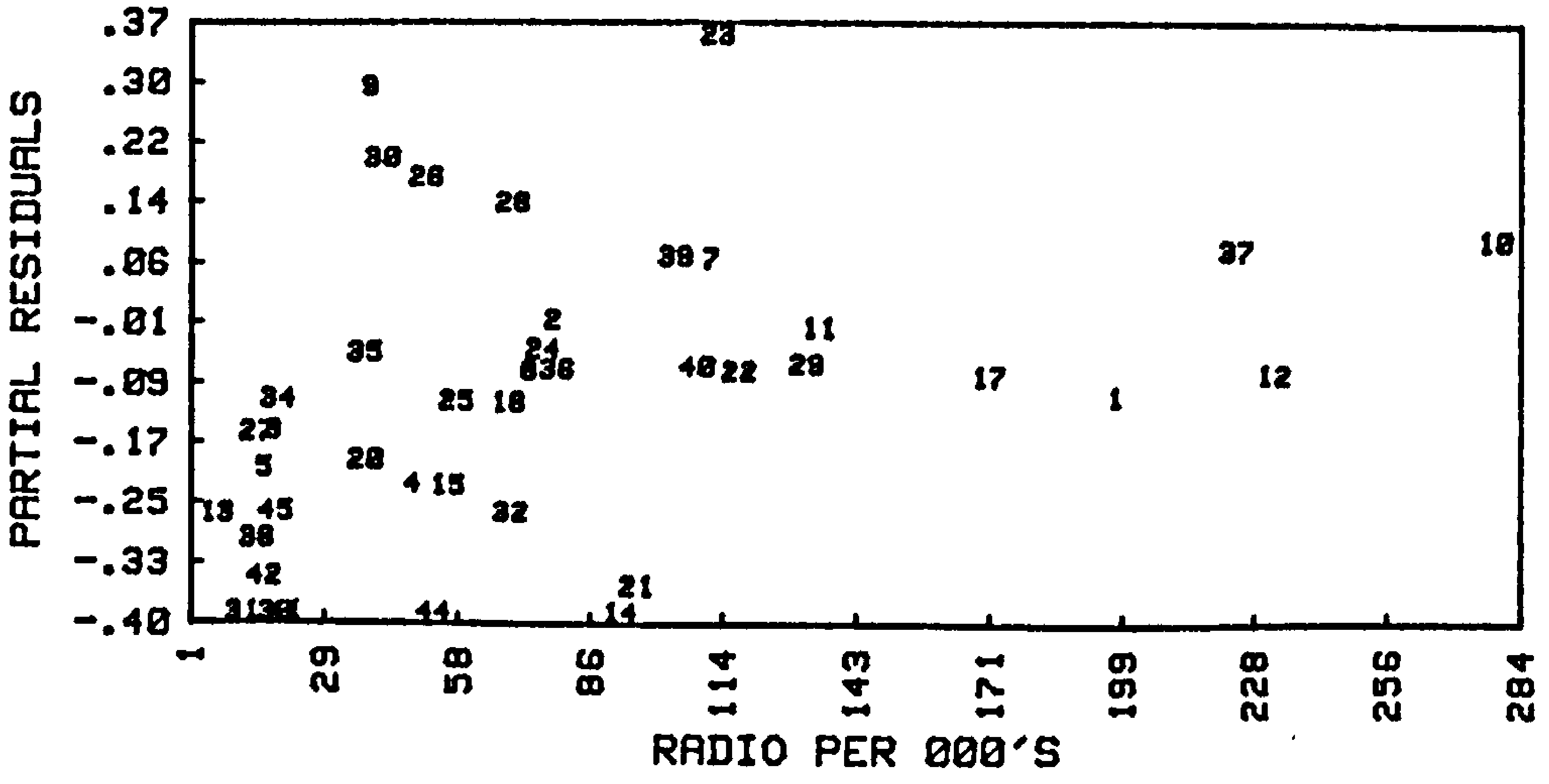


Fig. 5.12 PARTIAL RESIDUAL PLOT



variables adult literacy rate and radio receivers has a definite negative correlation with the variable imports of manufactured goods, see fig. 5-10 (This variable is negatively related to the dependent variable, see fig. 10, APPENDIX 10).The dependent variable corrected for the first and third variable has a definite positive correlation with adult literacy rate, Fig 5-11. Finally, the dependent variable corrected for the first two variables has only a very slight positive correlation with the variable, radio receivers. Fig 5 - 12.

The assumption of homoscedasticity can also be tested by various tests amongst which the Spearman rank- correlation is the simplest.

3-3-3-2 The Spearman Rank-Correlation Test for Homoscedasticity.

This test may be applied to any sample size and consists of ordering the residuals, without their sign and the X values in ascending or descending order and computing the rank correlation coefficient which is

$$5\text{-}16 \qquad r'_{e.x_i} = 1 - \frac{6\Sigma D_i^2}{n(n^2-1)}$$

(see Koutsoyiannis (1980, p185) also SPSS (1976)).

D_i is the difference between the ranks of corresponding pairs of X and e, and n is the number of observations. The rank correlation coefficient is computed between e and each one of the explanatory variables using the statistical package for the social sciences (SPSS). A high rank correlation coefficient suggests the presence of inhomogeneity of variance or heteroscedasticity. The rank correlation coefficient between the residuals and X26 (adult literacy rate) is .0328, with X13 (imports of manufactured goods) it is .1111, and with X29 (radio receivers per thousand) it is -.2022. As these coefficients are low, one may argue that the assumption of constant variance is not violated in the present analysis.

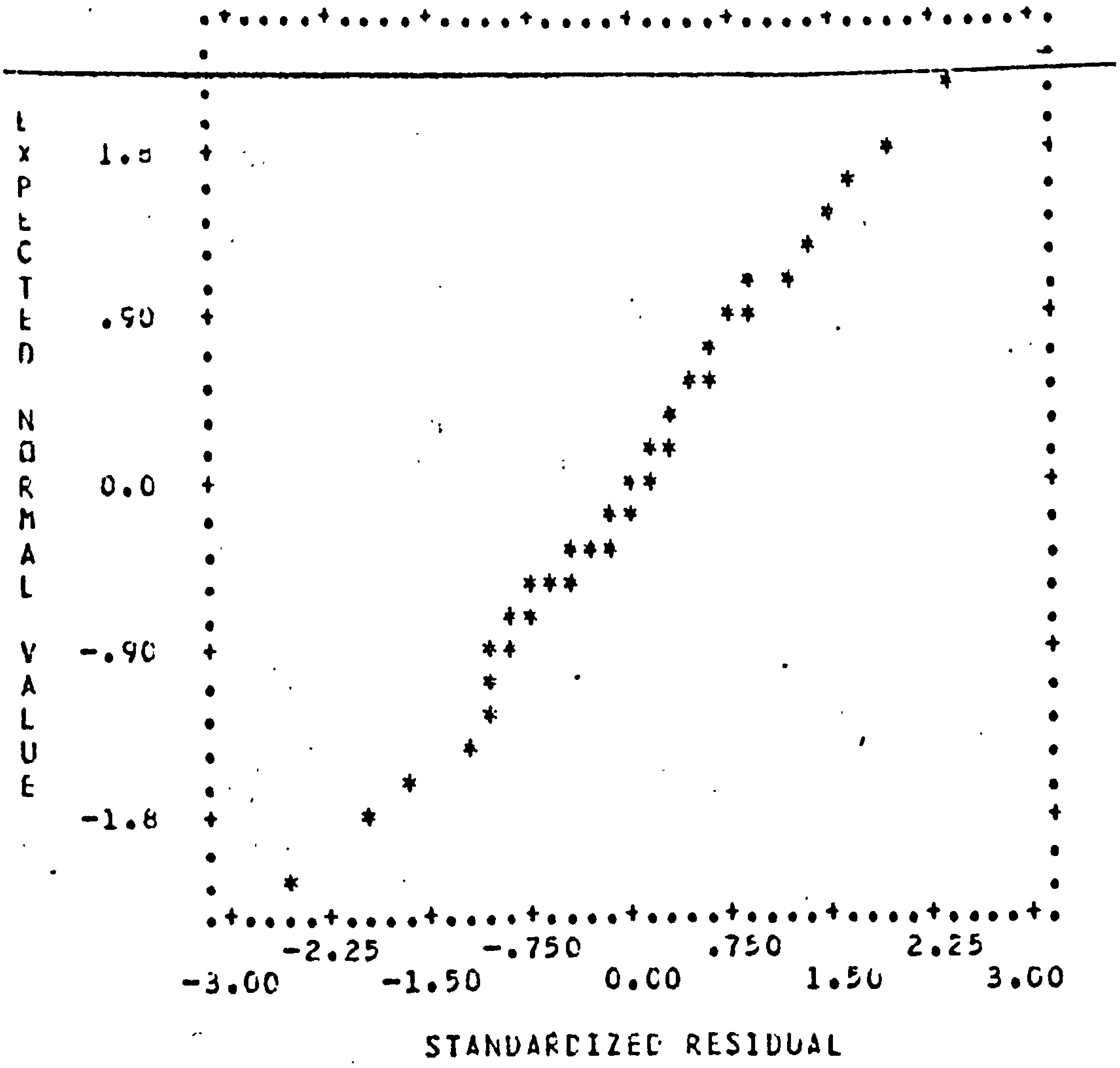
3-3-4 The Assumption of Normality of the u's.

As one is concerned not only with the estimation of the parameters but also with influence, the normality assumption of the errors is also an important characteristic of the OLS estimators, as one may make inference only when the population from which the sample is drawn is normal. The assumption of normality is necessary for conducting the t and F statistics for the parameters estimates if this assumption is violated, the estimates are still unbiased and best but one cannot assess their statistical reliability as the tests will not be applicable. The normality assumption means that the errors that have small values have a higher probability to be observed than those that have large values; in other words the extreme values of the disturbance term are more unlikely the more extreme they become. Koutsoyiannis (1980, p196).

Eventhough the e's, which are the estimates of the true errors, the u's do not always reflect the true distribution of the u's, one may attempt to plot the e's in a normal probability plot in order to see whether the residuals follow a normal distribution.

This plot is performed by the BMD package, which displays the standardized residuals (the residuals divided by the standard error) as abscissa and the expected normal value as y coordinates. When this is done the residuals appear to follow the normal distribution without displaying outlying cases, see fig. 5-13.

Fig 5 - 13 Normal probability plot for standardized residuals



3-3-5 The Assumption of Multicollinearity

Eventhough multicollinearity tends to be a common problem in time series data, it is also prevalent in cross-section data, as most economic and social variables can be highly intercorrelated; some of the relationships between the indicators in the present study are examined in the third chapter. The term multicollinearity is used to represent the presence of linear relationships between independent variables. If these variables are multicollinear, that is correlated to a certain degree, the parameter estimates become unreliable as the effects of one of these variables may be attributed to the other(s),and therefore one cannot determine the influence of these indicators on the dependent variable. However the exact effects of collinearity have not been established theoretically and some arguments may be gathered to illustrate this. Fox (1968) showed that increasing multicollinearity affects the values of the parameters; it is often argued that even small intercorrelations between variables may lead to non-significance of the parameters due to the increase in the standard errors. On the other hand, Klein (1962) argues that collinearity becomes a serious problem only when the correlation between two explanatory variables ($r^2_{x_i x_j}$) is higher than the overall multiple correlation coefficient (R^2) which measures the strength of dependence of Y on the X's. With collinearity present in all analysis, one runs the danger of misspecifying the model, as one of the collinear variables, generally with a large standard error may be rejected, yet it could still be an important explanatory variable.

It is therefore necessary to test whether multicollinearity is present in an analysis. There are two main tests developed for the detection of multicollinearity, the Frisch method (1934) which take into account the R^2 and studies the effects of each new variable on the basis of the values and standard errors of the parameter estimates of the first variable(s), and the Farrar-Glauber test (1967) which takes into account mainly the simple or partial correlation coefficient. Eventhough the Frisch approach is found to be a more appropriate test for multicollinearity, it is preferred to use the Farrar-Glauber test, as Frisch's method seems more intuitive and time consuming. The Farrar-Glauber test is a set of three tests of which the first is the most important as it is concerned with the detection of multicollinearity in a function; the last two tests are used to locate which variables are multicollinear and which cause the multicollinearity. Therefore, one may not use the second and third test if multicollinearity is not detected by the first test, which simplifies the procedure of testing. The Farrar-Glauber test is first described.

3-3-5-1 The Farrar-Glauber test for Multicollinearity.

This test is based firstly on the use of a chi-square (χ^2) to test the presence as well as the extent of multicollinearity in a function comprising several explanatory variables. The hypothesis being tested is that the X's are orthogonal, that is $r_{x_i x_j} = 0$. The variables are standardized for standard deviation and sample size; for instance the standardized value of the t^{th} observation of the i^{th} variable is

5-17 $$\frac{(X_{it} - \bar{X}_i)}{\sqrt{n}\ (Sx_i)}$$

Where Sx_i is the standard deviation of X equal to

5-18 $$S_{x_i} = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n}} = \sqrt{\frac{\Sigma x_i^2}{n}}$$

In matrix terms, this is equivalent to dividing each element of the determinant by the square root of the sums of squared deviations of the variables of the element. In the two variable model, the determinant of the X's is

$$\begin{vmatrix} \Sigma x_1^2 & \Sigma x_1 x_2 \\ \Sigma x_1 x_2 & \Sigma x_2^2 \end{vmatrix}$$

where Σx_1^2 is equal to $\Sigma(X_i - \bar{X}_i)^2$ and $\Sigma x_1 x_2$ is equal to $\Sigma\ (X_1 - \bar{X}_1)^2\ (X_2 - \bar{X}_2)^2$; that is they represent the deviations from the means.

The standardized form of this determinant is therefore:

$$\begin{vmatrix} \dfrac{\Sigma x_1^2}{(\sqrt{\Sigma x_1^2})^2} & \dfrac{\Sigma x_1 x_2}{\sqrt{\Sigma x_1^2}\ \sqrt{\Sigma x_2^2}} \\ \dfrac{\Sigma x_1 x_2}{\sqrt{\Sigma x_1^2}\ \sqrt{\Sigma x_2^2}} & \dfrac{\Sigma x_2^2}{(\sqrt{\Sigma x_2^2})^2} \end{vmatrix}$$

The elements of this determinant may be written in a different form where the diagonal elements are equal to 1 ($rx_i x_i = 1$) and the off-diagonal elements are the simple correlation coefficients among the explanatory variables.

i.e.

$$\begin{vmatrix} 1 & r_{x_1x_2} \\ r_{x_1x_2} & 1 \end{vmatrix}$$

The actual form of the determinant can demonstrate either the extreme cases of orthogonality for perfect multicollinearity when the determinant takes the form

$$\begin{vmatrix} 1 & r_{x_1x_2} \\ r_{x_1x_2} & 1 \end{vmatrix} = \begin{vmatrix} 1 & 1 \\ 1 & 1 \end{vmatrix} = 0$$

or where the variables are orthogonal and the determinant becomes

$$\begin{vmatrix} 1 & r_{x_1x_2} \\ r_{x_1x_2} & 1 \end{vmatrix} = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1$$

From these statements, it follows that if the value of the standardized determinant lies between 0 and 1, there exists some degree of multicollinearity in the function. Thus in order to detect the strength of multicollinearity, Farrar and Glauber suggest an x^2 test given by

5-19 $$^*x^2 = -[n-1-\frac{1}{6}(2k+5)]\ \log_e \begin{bmatrix}\text{Value of the} \\ \text{standardized} \\ \text{determinant}\end{bmatrix}$$

where $^*x^2$ is the observed value of x^2, computed from the sample, n is the size of the sample and k the number of explanatory variables. $*x^2$ can be shown to follow x^2 distribution with $v = \frac{1}{2}k(k-1)$. The basic hypotheses are, H_o; the are orthogonal, H_i; the are not orthogonal.

The value $*x^2$ is then compared to the theoretical value of x^2, which may be obtained from the x^2 table at the chosen level of significance with $v = \frac{1}{2}\, k(k-1)$ degrees of freedom.

The second step to this test is an F test for the location of multicollinearity which consists of computing the multiple correlation coefficients among the explanatory variables, that is $R^2 x_i . x_2\ x_3\ ..x_k$, and testing the statistical significance of these coefficients with an F test. The observed F* for each coefficient is computed as follows

5-20 $$F^* = \frac{(R^2_{x_i . x_1\ x_2 .... x_k})/(k-1)}{(1-\ R^2_{x_i . x_1\ x_2\ x_3 ... x_k})/(n-k)}$$

The observed F* value can then be compared to the theoretical F value from the F table, with $V_1=(k-1)$ and $V_2=(n-k)$ degrees of freedom, at the chosen level of significance. Then the conclusions are made as usual, that is if $F^*>F$, one accepts that the variable X_i is multicollinear, and not if otherwise.

The third step of the Farrar-Glauber test is a t test to detect the variables that cause multicollinearity. This consists of computing the partial correlation coefficients among the explanatory variables and testing their statistical significance with the t statistic, the partial correlation coefficients having been already defined in section 3-5-2-1 of chapter 3. Their significance is tested by computing for each coefficient the t* statistic which is

5-21 $$t^* = \frac{(r_{x_i x_j x_1 \; x_2 \ldots . x_k})\sqrt{n-k}}{\sqrt{1-r^2_{x_i \; x_j . x_1 \; x_2 \ldots . x_k}}}$$

where $r_{x_i x_j}$ is the partial correlation coefficient between x_i and x_j. The observed t* is compared to the theoretical t value from the student's t table, see table in Appendix 12 with v=(n-k) degrees of freedom, at the chosen level of significance. If t*>t, one accepts that the partial correlation coefficient between the two observed variables is significant and concludes that they are the causes of multicollinearity in the function. If t*<t one accepts that the two variables considered are not causing multicollinearity.

3-3-5-2 Results of the Test on Multicollinearity.

For the present analysis, the first test proposed by Farrar and Glauber has been used to detect if multicollinearity is present. The observed $*X^2$ value being 4.037 is inferior to the theoretical value of X^2 which is 6.25 at 10 percent significance level, with 3 degrees of freedom, therefore one may accept the assumption of orthogonality; that is one accepts that there is no significant multicollinearity in the function. Thus the second and third steps of this test are not required.

3-4 Statistical Analysis

The statistical criteria used in assessing the reliability of the parameters estimates are the coefficient of multiple determination or R^2, the standard error of estimates and the related t and F statistics.

3-4-1 The Test of the Goodness of fit with R^2

In the presentation of regression analysis results, one of the most quoted statistics is the coefficient of determination, R^2, which indicates the "goodness of fit". The importance of this is often over-emphasized at the expense of other equally important indicators. A clear limitation on its usefulness is that a high value of R^2 can be obtained even when the estimated equation is poorly specified in the sense that some coefficients may not be significant.

A test for R^2 the coefficient of determination is first discussed.

R^2 may be described as a measure of the strength of the stochastic relationship between Y and the X_i's. The relationship is said to be strong if the conditional expectation of Y is such that $E(Y/X_1, \ldots X_k)$ alters substantially as the X_i's take different values.

In the present study, the three independent variables explain 61 percent of the variation in Y, the amount of variation explained is quite high for cross-section analyses, Belsley and Kuh (1980, p 40) argue that an R^2 of .33 was not uncharacteristically low for the 5 variables saving function of the cross-country analysis they attempted.

One needs to test the null hypothesis that the multiple coefficient of determination or R^2 is zero in the population from which the sample was drawn; the F test, which is described in chapter 3 is used for this purpose. It should be recalled that the total sum of squares (SST) or the total explained variance ie equal to the explained sum of squares (SSE) and residual sum of squares (SSR) that is

$$SST = SSE + SSR$$

or

5-22 $$\Sigma y_i^2 = \Sigma y_i^2 + \Sigma e_i^2$$

$$= \hat{\beta}_1^2 \quad \Sigma x_{i_1}^2 + \hat{\beta}_2 \quad \Sigma x_{i_2}^2 \quad \ldots\ldots + \Sigma e_i^2$$

The sum of squares and their associated degrees of freedom are arranged in the standard form of the analysis of variance table below.

Table 5-1 Analysis of Variance

Source of variation	Sum of Squares	F	Mean sum of squares
Due to regression(SSE)	8835,2727	3 (k)	2945,0909
Due to residuals (SSR)	5584,0375	37 (N-k-1)	150,9199
SST	14419,3102	40 (N-1)	

Using formula F described in chapter 3, one obtains

5-23 $$F = \frac{2945091}{150,9199} = 19.51$$

The critical F value for 3 and 37 degrees of freedom at

α= 0.001 equals 6.60.

The computed F exceeds this critical value by a large margin; it is accordingly highly significant as the probability of having an R^2 equal to zero is less than one in a thousand. Therefore, one rejects the null hypothesis that R^2 is equal to zero.

An important property of R^2 is that it is a nondecreasing function of the number of explanatory variables in the model; as the number of explanatory variables increases, R^2 almost invariably increases also, this being so, in comparing two or more regression models with the same dependent variable, with different numbers of X variables, one should be aware when choosing the model with the highest R^2. Therefore, to minimise the inherent bias in R^2, one employs the so-called "adjusted R^2"; the term adjusted means adjusted for the degrees of freedom associated with the sums of squares entering into R^2. That is

$$5\text{-}24 \quad \bar{R}^2 = 1 - \frac{\Sigma e_i^2/(N-k)}{\Sigma Y_i^2/(N-1)} = 1 - (1-R^2)\,\frac{N-1}{N-k}$$

The following table is constructed from the computer print-outs, see Appendix 13

Table 5-2 Table of R^2 adjusted R and variables

R^2	Adjusted R^2	Variables
.4717	.4582	X26
.5833	.5613	X26, X13
.6127	.5813	X26, X13, X29
.6261	.5846	X26, X13, X29, X6

It can be seen from this table that up to 3 variables the adjusted R^2 increases which shows significance up to this level the entry of the fourth variable which is gross national saving hardly varies the adjusted R^2 which shows that it is superfluous for the present model. The adjusted R^2 for the first 3 variables shows that after taking into account the degrees of freedom, X_{26}, X_{13}, and X_{29} still explain 58 percent of the variation in Y.

One should be aware of choosing a model that gives the highest "adjusted R^2", in regression analysis; the objective is not to obtain a high "adjusted R^2" but rather to obtain dependable estimates of the true population regression coefficients and draw statistical inferences about them. Furthermore, it is not unusual in practice, to have a high "adjusted R^2" with insignificant regression coefficients. Therefore, one should be more aware of the theoretical relevance of the explanatory variables in relation to the dependent variable and their statistical significance.

3-4-2-1 The Standard Error Test

The statistical reliability of $\beta_1, \beta_2, \beta_3$, β_4 should be listed since they are the sample estimates of the true parameters b_1, b_2, b_3 and b_4. This is in order to measure the size of the sampling error and determine the degree of confidence in the validity of the estimates.

There are several tests for this purpose, for this analysis, the standard error test will be used, as it is the most popular in applied econometric research. This test helps decide whether the estimates $\beta_1, \beta_2, \beta_3$ and β_4 are significantly different from zero, in other words, whether the sample from which they have been estimated may be drawn from a population whose true parameters are zero.

Table 5 - 3 : The Standard Error of Estimate

Variable name	Regression Coefficient	Standard Error
Intercept	$\beta_1 = 38.82$	12.04
X 13	$\beta_2 = - .9098$	.2802
X 26	$\beta_3 = .4740$	.0821
X 29	$\beta_4 = .0523$	.0311

The standard errors of the parameters $\beta_1, \beta_2, \beta_3$, and β_4 are less than half the numerical values of their parameter estimates, which shows that the estimates are statistically significant. Therefore one rejects the null hypothesis that the parameters are equal to zero.

The acceptance or rejection of the null hypothesis has a definite economic meaning, namely that rejection of the null hypothesis that b_1, b_2, b_3 and $b_4 = 0$ implies that the explanatory variables to which these estimates relate do influence the dependent variable and should be kept in the function, since the conducted standard error test provided evidence that changes in the X's will definitely affect Y; put simply there is a relationship between Y and the three explanatory variables.

These statements are accompanied by the level of significance tested with the student's t test.

3-4-2-2- The Student's t test.

Given the stochastic assumptions about the values of u, the estimates are normally distributed and hence one may apply the t test. It can be stated that the t test which is the standard normal distribution (or Gauss Normal Curve) is applicable only if the true population variance is known, irrespective of the sample size, or providing the size of the sample is sufficiently large, in which case the sample estimate of the variance is a satisfactory approximation of the unknown population variance.

Having rejected the null hypothesis that the parameters are equal to zero, one may test their level of significance using the student's t test. Generally a test of significance is a procedure by which sample results are used to verify the truth or falsity of a null hypothesis; the test of significance is based on a test statistic or estimator and the sampling distribution of such a statistic under the null hypothesis. The acceptance or rejection of the null hypothesis is made on the basis of the value of the test statistic obtained from the sample data. The formula for transformed β's in a t distribution are given in (3-48).

The following table is obtained from the computer printouts, see Appendix 13.

Table 5-4 : The t-Statistic

Variable	Regression Coefficient	T-Statistic	2 tail Sigma
Intercept	38.82	3.22	.003
X 13	- .9098	-3.25	.002
X 26	.4740	5.77	.000
X 29	.0523	1.68	.102
t_α=0.05		-2.021 & 2.021	

In Econometrics, it is customary to choose the two-tail critical region and to test at the 5 percent level. Each tail will correspond to half the chosen level of significance. With (n-2) degrees of freedom the critical values of t are formed from the t table.

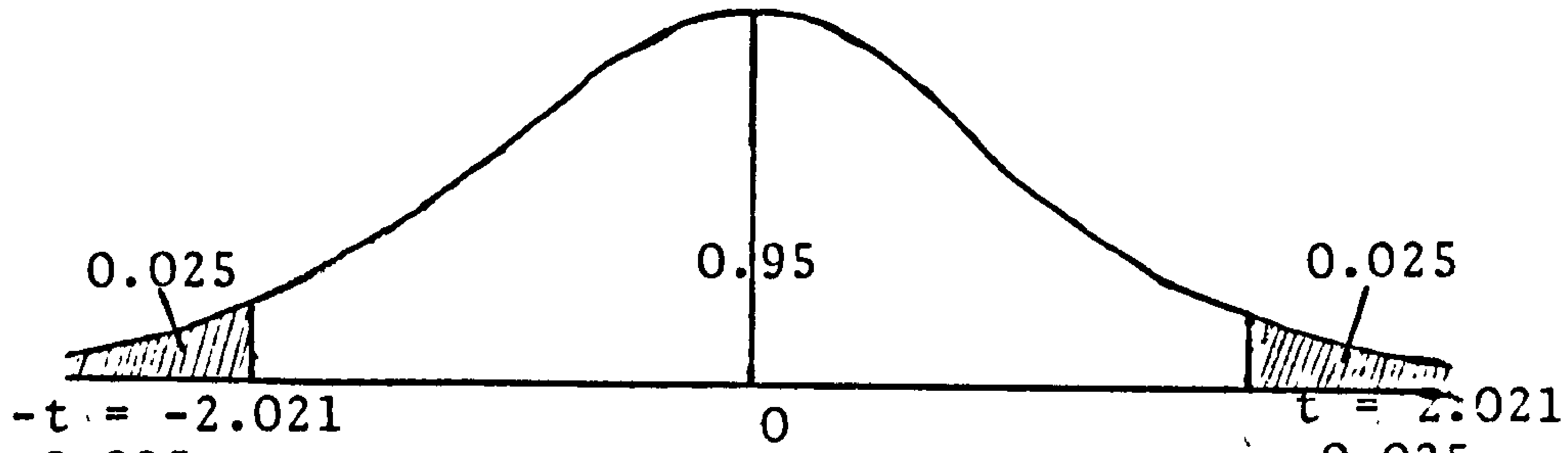
$$t_1 = -2.021 \text{ and } t_2 = 2.021$$

Thus the acceptance region is

$$-2.021 \leqslant t \leqslant 2.021$$

The acceptance and critical regions for 40 degrees of freedom are shown in figure 5-14

Fig. 5-14 The 95 percent confidence interval for t(40 dF)



The t statistics of the 4 parameters reported in table 5-4 fall outside the acceptance region which is $-2.021 \leqslant t \leqslant 2.021$, therefore one rejects the null hypothesis and concludes that the regression coefficients are significantly different from zero. This test suggests that there is at most 5 percent probability that the values of the β's be insignificant. The two-tail sigma test in table 5-4 provides the confidence level for each coefficient.

3-4-2-3 Confidence Intervals for the True Parameters

Rejection of the null hypothesis does not mean that the estimates are the correct estimates of the true population parameters, therefore, one needs to define how close the true parameters are to their respective estimates, this leads one to construct confidence intervals for the true parameters, so that one can establish limiting values around the estimates within which the true parameters are expected to lie with a certain "degree of confidence."

This degree is selected by choosing a probability which is referred to as the confidence level. Usually the 95 percent confidence level is used, which means that the confidence limits computed from the sample would include the true population parameter in 95 percent of the cases.

Using the t statistic, the confidence interval of b_i is

$$b_i = \beta_i \pm t_{0.025} \; (S\beta_i)$$

Where b_i is the i^{th} true parameter, β_i the i^{th} parameter estimate and $S\beta_i$, the i^{th} standard error, further details can be found in Gujarati (1978).

The 95 percent confidence interval for b_i is

$$\beta_i - t_{0.025}(S\beta_i) < b_i < \beta_i + t_{0.025}\ (S\beta_i)$$

Recalling the regression function with the standard errors in parentheses, one gets

$$\text{5-25} \qquad \underset{(12.04)}{Y = 38.82} - \underset{(.2802)}{.9098\ X_{13}} + \underset{(.0821)}{.4740\ X_{26}} + \underset{(.0311)}{.0523\ X_{29}} + u$$

With n - k degrees of freedom, that is (41-2) for each parameter, the value of $t_{0.025}$ from the t table is ± 2.021, hence the 95 percent confidence interval for the parameters is:

i) for b_1

$$b_1 = 38.82 \pm (2.021)\ (12.04) = 38.82 \pm 24.33$$

ii) for b_2

$$b_2 = -.9098 \pm (2.021)\ (.2822) = -.9098 \pm .5703$$

iii) for b_3

$$b_3 = .4740 \pm (2.021)\ (.0821) = .4740 \pm .16.59$$

iv) for b_4

$$b_4 = .0523 \pm (2.021)\ (.0311) = .0523 \pm .0628$$

From the above statements, one can conclude that the intercept b_1 will lie between 14.49 and 63.15, similarly the true parameter b_2 will lie between -1.48 and -.339, b_3 between .308 and .639, and finally b_4 will lie between -.010 and .1151. This means that if 100 samples of size 41 are selected and 100 confidence intervals like $\hat{\beta}_k \pm t_{0.025} Se(\hat{\beta}_k)$ are constructed, where k represents the k^{th} parameter estimate, one would expect that 95 percent of the samples contain the true parameter β_k.

3-4-2-4 Testing the Incremental Contribution of each explanatory Variable.

On the basis of separate t tests for the parameter estimates, one knows from table 4-2-4 that the coefficients of X_2, X_3 and X_4 are statistically significant. Also, the F test given in (5-23) shows significance of the regression function itself. But how does one know that each of the three variables is required in the model. In empirical investigations, one may not be completely sure whether it is worth adding one or more explanatory variables to the model, therefore one must test the contribution of each variable.

Let one first regress Y on X_{26} and assess its significance, then add X_{13} and X_{29}, one by one, in order to test their respective contributions. The order in which the three variables are entered can be reversed, but for simplicity, one introduces the variables correspondingly to the order in which they have been entered in the regression function; see the computer outputs in Appendix IV-4.

The regression of Y (Integration of technology) on X_{26} (Adult literacy rate) is

5-26 $Y = \beta_1 + \beta_2 X_{26}$

$Y = 4.35 + .52X_{26}$

$t = (.96) \quad (5.90)$

$r^2 = .47$

From the above results, it can be seen that the estimated t value of β_2 being equal to 5.90 is highly significant at the 5 percent confidence level with N-2 degrees of freedom, therefore X_{26} significantly affects Y.

The following Analysis of variance (AOV) table allows for the calculation of the F ratio of / the first variable. The F ratio is calculated in order to examine its relationship with the t statistic, when there is one degree of freedom; also the incremental contribution of the additional variables is tested with the F ratio.

Table 5-5 AOV Table for Regression

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares
SSE (due to X_{26})	6801,6414	1	6801,6414
SSR (residual)	7617,6688	39	195,3248
Total	14419,3103	40	

Under the assumptions that the disturbances u_i are normally distributed and the null hypothesis that $\beta_2 = 0$, one gets:

5-27 $$F = \frac{6801.641}{195.3248} = 34.82$$

which follows the F distribution with 1 and 39 degrees of freedom and shows high significance; it can be noted that $t^2 = F$.

When X_{13} (Imports of manufactured goods) is added to the model, the regression function becomes

5-28 $$Y = 41.19 + .51\ X_{26} - .91\ X_{13}$$

Similarly, when X_{29} (Radio receivers per thousand) is entered, the regression function becomes

5-29 $$Y = 38.82 + .47\ X_{26} - .90\ X_{13} + .05\ X_{29}$$

What is then the incremental contribution of X_{13} knowing that X_{26} is significantly related to Y, if the contribution of X_{13} is found relevant to the model, what is then the incremental contribution of X_{29} provided X_{26} and X_{13} are already computed in the regression function, are these contributions statistically significant and what is the criteria for their inclusion ?

These questions can be answered by The Analysis of Variance (AOV) table for assessing the incremental contribution of explanatory variables, the following table is constituted from the basic references already referred to, see in particular Gujarati (1978, p 134).

5-6- AOV Table for Assessing the Incremental Contribution of the Variables

Source of Variation	Sums of Squares	F	Mean Sum of Squares
ESS due to X_{26}	$Q_1 = \beta_2^2 \Sigma x^2_{26}$	1	$\frac{Q_n}{1}$
ESS due to the addition of X_{13}	$Q_2 = Q_3 - Q_1$	1	$\frac{Q_2}{1}$
ESS due to X_{26} and X_{13}	$Q_3 = \beta_2 \Sigma y_i x^2_{26i} + \beta_3 \Sigma y_i x_{13i}$	2	$\frac{Q_3}{2}$
RSS for X_{26} and X_{13}	$Q_4 = Q_5 - Q_3$	N-3	$\frac{Q_4}{N-3}$
Total Variation of X_{26} and X_{13}	$Q_5 = \Sigma y^2_i$	N-1	
ESS due to the addition of X_{29}	$Q_6 = Q_7 - Q_3$	2	$\frac{Q_6}{2}$
ESS due to X_{26} X_{13} and X_{29}	$Q_7 = \beta_e \Sigma y_i x_{26i} + + \beta_3 \Sigma y_i x_{13i} + \beta_4 \Sigma y_i x_{29i}$	3	$\frac{Q_7}{2}$
RSS (for X_{26}, X_{13} & X_{29})	$Q_8 = Q_9 - Q_7$	N-4	$\frac{Q_9}{N-4}$
Total variation of X_{26}, X_{13} & X_{29}	$Q_9 = \Sigma y^2_i$	N-1	

Using the results of the computer outputs from Appendix one can replace the sum of squares and the mean sum of squares by their corresponding quantities, Q_1, Q_3 and Q_7 being given, the quantities to calculate are therefore Q_2 and Q_6 as well as part of the mean sum of squares. Following the steps given in the preceding table, one gets:

Table 5-7 AOV Table to Assess the Contribution of X_{13} and X_{29}

Source of variation	SS	dF	MSS
ESS due X_{26}	6801.6414	1	6801.6414
ESS due to the addition of X_{13}	1408.4343	1	1408.4343
ESS due to X_{26} and X_{13}	8410.0757	2	4205.0378
RSS for X_{26} and X_{13}	6009.2345	38	158.1377
Total variation due to X_{26} & X_{13}	14419.3102	40	360.4827
ESS due to the addition of X_{29}	435.197	2	217.5985
ESS due X_{26},X_{13} and X_{29}	8835.2727	3	2945.0909
RSS for X_{26},X_{13} and X_{29}	5584.0375	37	150.9199
Total variation due to X_{26},X_{13} and X_{29}	14419.3102	40	360.4827

The incremental contribution of X_{13} to the regression already comprising X_{26} can be assessed by the following F ratio, using the values of table 5-7.

5-30 $$F_1 = \frac{Q_2/dF}{Q_4/dF} = \frac{1408.4343}{158.1377} = 8.90$$

The value of F with 1 and 38 degrees of freedom, at the 1 percent level is 7.31, it is obvious that the observed F value for the incremental contribution of the explanatory variable X_{13} is significant at the 1 percent level of significance; that is the addition of X_{13} to the regression model significantly reduces the variation due to residuals (RSS), hence increasing the R^2 value. Therefore X_{13} should be added to the model.

Similarly, the incremental contribution of X_{29} to the regression model already comprising X_{26} and X_{13} can be assessed by the following F value

5-31 $$F_2 = \frac{Q_6/dF}{Q_8/dF} = \frac{217.5985}{150.9199} = 1.44$$

Consulting the F table already referred to, with 1 and 37 degrees of freedom, the F value at the 10 percent level is equal to 2.84. The observed F value being 1.44, it can be concluded that the contribution of X_{29} is not particularly important.

4 THEORETICAL INTERPRETATION OF THE RESULTS

Having discussed the results in their statistical and econometric perspectives, one will now deal with their economic implications. As was already mentioned the three main indicators found in this analysis to explain the variation in the process of technology integration are adult literacy rate, imports of manufactured foods and radio receivers.

It is not surprising that a variable related to education has been entered as a first important indicator of technological integration in the regression equation. The following discussion will attempt to show the relevance of this variable in relation to the economics of development in general and to the problems of assimilating the transferred technology in particular. The other two variables will be considered later.

4-1 Adult Literacy Rate

This variable expresses the number of adults with the ability to read and write as a percentage of the total adult population aged 15 and over. It basically indicates the educational level of a country. It is selected as the first variable entering the regression function and is positively related to the dependent variable integration of technology, explaining 47 percent of its total variance.

In the variables analysis in the preceeding chapter, this variable was a constituent of the second factor, together with other social and economic variables which were significant in explaining a good proportion of the total variables variance.

When one is dealing with the analysis of technological transfer, one is not only interested in the general educational level of societies but mainly with the technological education. However, more often than not, when the term education is used in development economics, it usually denotes general as well as technological education, thus the definition of Murthy and Ranganath (1977, p145) is of interest:

> "Education is a process by which society preserves its cultural heritage and pattern, and perhaps provides for improvement of that pattern. Technological education which is a part of education is concerned with maintaining and improving technological services to the society."

Why is education such a determinant factor of technological transfer? There is evidence (World Bank 1980$_b$,p44) that education increases the productivity of workers, as educated workers are more achievement-oriented, more self-reliant, more adaptive to new situations and more trainable. This implies that education has a direct positive effect on the uses of machinery as well as on their productivity. It is however well known that developing countries have considerably expanded their rate of education during the last twenty years with a slightly less than expected improvement in their economies. It may be useful to report some figures, from 1960 to 1975, the enrolment of primary school children increased from 46.8 percent to 61.8, and university level enrolment increased from 2.6 million in 1960 to 12.5 million in 1976. UN (1974$_b$,p59). Yet, the increase in education did not seem to solve development problems as was naively thought by the politicians and economists of that time, who implied that educational growth would not only contribute to economic development but would also equalize opportunities and income distributions between social classes and develop a more employable labour force, see Carnoy (1982) as well as D'Aeth (1975,p9).

It should be noted that the great expansion of education in the sixties did not reduce illiteracy, which is, as usual, more widespread in rural areas and among women, in fact forty percent of rural females in Latin America are illiterate, Jallade (1978, p62), the world bank sector policy paper (1980, p59) show that despite the expansion in education facilities, one third of the children of primary school age are not enrolled in school. This may be explained by the fact that population increases have been greater than educational growth. Also as some sociologists see it, the core of the problem is that in most developing economies, education is class based and class reproductive, and tied to a social division of labour which is characteristic of the capitalist development process, Carnoy (1977). This may explain why income distribution became more unequal, as Adelman and Morris (1973) show it, unemployment increased and poverty is no longer characteristic of rural areas, but has been transferred to urban areas as well, and above all there is no integration of 'know-how' and technologies. One may question whether the present educational system of these countries is not one of the major factors affecting the economic growth in general and the technological integration in particular.

Most developing economies tended to take the shortest and most expensive route in order to develop economically, namely the building of a so-called "modern" sector requiring high capital investments, where the production techniques were characterized by technologists transferred from technically advanced countries; these technologies are mainly capital-intensive and labour-saving. The educational systems were therefore geared to respond to the development strategy, that is by producing highly skilled manpower that only secondary and higher education could provide. Although these programmes have contributed to some extent to the economy, they have nevertheless created a number of negative consequences, which should be considered seriously by economists and planners.

Jallade (1978, pp69-71) in a study on education for Latin American countries, gives some reasons of the failure of the present educational system and its consequences on the general economic and social health of these countries. He first suggests that continuing expansion of secondary and higher education is less and less in line with the needs of the economy, as it is increasingly difficult for educated people to find jobs. Secondly because of the importance accorded to higher education, primary and adult education, as well as vocational training for small-scale industries are neglected, and thirdly, education in rural areas is neglected at the expense of orientating education towards the urban industrial sector. This policy will continue to maintain the dualism between the modern and the traditional sectors and adds to the already existing problems of unemployment. One of the world bank studies (1974) puts the problems created by this educational approach in simpler terms:

> "Central to this new approach is the widespread inability of the modern sector of developing economies to make full use of the resources available to it - above all, human resources. A number of countries, therefore, are considering a strategy based on a broader deployment of scarce capital throughout the economy, and a fuller use of available human resources. Translated into development objectives, this means that the creation of productive employment is being recognised as an economic goal as important as the growth rate of GDP."

Another preeminant factor which should have been emphasized in Jallade's paper is that developing societies, which are still non-industrial do not have a satisfactory system of technical education, moreover, the situation is getting even more complicated when these countries have to continuously adapt to the increasingly sophisticated technologies of the developed countries. It is also widely recognised that the educational system in most developing countries is weak and do not provide critical and scientific thinking, and lacks practical experience. Young (1966) in studying the methodological aspects of management education in developing countries notes that the education received by students in local universities is essentially classical, designed to serve another purpose. Often, students who have university degrees seem unable to see the relationship between what they have mastered and how they can apply it in everyday work. Similarly, in their study of one case of developing countries, India, Murthy and Ranganath found that despite the great expansion in the number of technical institutions and the number of students, the structure of technical education was characterized by serious weaknesses and lack of effective co-ordination. They propose further points where they show that engineering and technological manpower in some developing countries represent only a fraction of total manpower, which may show that even those countries that had some potential in manpower in the early 1960's were not as yet prepared for technological advances and innovations. A table based on their analysis is presented below, it is however realised that data is not up to date, but this point seems relevant to the argument made, also one may at least see the problem in its historical perspective.

Table 5-8 Scientific and Technological Manpower in Different Countries.

Country (1)	Year (2)	Total Manpower (3)	Engineers and technologists (4)	Ratio 3/4 (5)
India	1965	561,000	95,000	5.90
U.S.A.	1963	1,272,000	925,600	1.37
U.K.	1965	211,231	120,912	1.75
U.S.S.R.	1965	2,735,500	1,630,800	1.68
Argentina	1965	101,003	20,000	5.05
Philippines	1965	85,883	21,170	4.05

The high ratios of total technical and scientific manpower to engineers and technologists in India, Argentina and the Philippines show that the number of engineers and technologists employed in the economy as a proportion of the total manpower is very small compared to those employed in developed economies. It seems that the more industrial a society gets the more engineers and technologists are needed. It would be extremely useful to compare these data with more recent ones for the same countries, as this not only enables one to compare the present ratio of developing economies with the first ones, which may give a great deal of information concerned with technological education and its uses in the economy, but also one may see the extent of the gap in the production and use of technological education between the developed and developing countries. There is evidence from a study made on Zaire recently by Siggel (1983, p98) that the educational system has produced far too many academics in the social sciences and far too few technicians, business administrators and engineers.

It may be concluded that the present educational process has not enabled the developing societies to operate in a harmonious socio-economic and political environment which provides them with the facilities and incentives to adapt the transferred know how and technologies to their needs as well as innovate and create their own technologies.

The arguments concerned with education in developing economies may well clarify the economic and social crisis they are experiencing; the positive relationship between education and technological integration may well find its explanation within these arguments, as despite the complexities and inadequacies of the present educational system, the economy is certainly better off with an increasing rate of any education, even if it is not optimally appropriate, rather than little or decreasing education. The present discussion was intended to clarify the concepts behind education in developing economies, its problems and its relationships with the adoption of technology. Although the educational system attracted sharp critics, it is recognised that the more educated societies are more able to adapt and change; this is clearly emphasised by the present study, which is based on realistic data and situations.

4.2 Imports of Manufactured Goods.

The negative relationship between this indicator and the dependent variable integration of technology shows that the less a country imports manufactured goods the more it tends to integrate the imported technology. This variable explains 11 percent of the variation in technology integration. In order to see the implications of these relationships, one should review as well as analyse the patterns of imports of manufactured goods in some cases of developing countries and their influence on the economy.

Protection of the domestic industries and the encouragement of import situations* as well as the possible gains and losses from trade restrictions have played an important part in the recent literature on international trade and economic development.

Over the past two decades, import substitution in both domestic agriculture and industry have been the basic development

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* import substitution is the replacement of imports by domestic production. Morley and Smith (1971,p123).

policies of most developing nations. These policies may be adopted under different circumstances. As a desire to restructure foreign exchange difficulties, often inherited from a colonial past, as a means of initiating structural change and development, or simply as a result of gradual industrialization as for the case of Brazil. The main objective being to reduce the increasing reliance on the foreign trade sector as well as a means of economic development. One may quote some points relevant to the different causes of implementing import substitution in developing countries. In a study of trade protection in Pakistan, Lewis and Guinsinger (1968, p1173) explain how the country adopted import substitution policies after having experienced catastrophic balance of payments problems in the 1950's.

> "At that time a severe balance-of-payments crisis developed, and a rigid system of quantitative import restrictions was adopted. The terms of trade shifted sharply against the domestic agricultural sector, while the manufacturing sector was heavily protected, not only by the tariff structure but also, and primarily, by the system of quantitative restrictions. The industrial policy was one of manufacturing domestically almost anything that physically could be produced internally. The policy of banning imports once domestic producers said that they could supply all domestic requirements was a dominant part of the protective system."

Brazil, amongst other more industrial developing countries experienced a different motivation for the use of import substitution, one may quote Morley and Smith (1971, p121)

> "With the new industrialization of the 1950's and 1960's, Brazil turned explicitly to a 'strategy' of growth based upon policy-induced import substitution in industry."

They argue that there are two different strategies of import substitution, forced import substitution, that is with protection of the industry and natural import shares as a result of economic growth in a country, as growth improves the competitive power of domestic products. The latter strategy is mainly developed by Maizels (1971) in his historic work on world trade, where he implies that primary-producing countries may follow the trade path of the industrial countries which experienced a natural reduction of imports of manufactured goods as a result of increasing industrialization. He emphasizes though that much caution is needed before drawing conclusions from the analogy.

In Pakistan, Brazil, Sri-lanka and Ghana, countries on which information could be found, import substitution seemed to bring relief to the economy, despite well known difficulties. There were substantial changes in the composition of imports and exports, showing a sharp fall in manufactured goods imported and a rise in the imports of machinery and equipment.

In Pakistan domestic production in most manufacturing industries rose more rapidly than imports and import substitution was a major source of growth in most industries. The growth was due to the incentives provided by import licensing and tariff decisions and to the fact that consumer-goods industries had a domestic raw-material base than did most intermediate and capital goods industries. On the other hand, the exports of some raw materials such as jute and cotton fell by half over a period of ten years, while new manufacturing exports and a few new primary exports rose substantially.

Similarly, Brazil's strategy of industrialization through import substitution was highly successful. One result of its development policies was a strong association between sectoral rates of import substitution and growth after adopting the latter policies. However Brazil's industry rested heavily upon foreign firms, which counted for at least 53 percent of import substitution and 40 percent of growth. The main factors explaining the pattern of foreign penetration are technology and brand-name advantages as well as the lack of experience of Brazilian firms in some sophisticated plants such as drugs and cosmetics. This resulted in domestic production by foreign firms with the exception of government enterprises, which are usually inefficient for new products.

Athukoralage (1981) reports that despite the lack of careful planning and defined priorities, the industrial sector as well as the agricultural sector of Sri-lanka indicated an above average growth, which was particularly prominent in manufacturing and agriculture based on import substituting activities. The abrupt reduction in imports of a wide range of manufactured consumer goods created for the first time, a well protected and attractive market for the domestic manufacturer of similar goods; besides both the private and the public sectors were promoted and encouraged by government.

The implications of import substitution policies for Ghana are discussed by Steel (1972). This country experienced great difficulties during the early stages of implementation; the main problems were caused by the accelerating rate of government and current expenditure which pushed the country to turn to foreign suppliers in order to finance the projects. The repayment periods were relatively short, which did not allow the investments to pay for themselves. The debt burden, therefore, brought Ghana to a virtually financial collapse with great balance of payments difficulties. The foreign exchange debt increased the pressure to restrict imports, other than capital goods, by tariff measures, with low duties on capital goods (two percent), nine percent for inputs into production of intermediate and capital goods. The consumer goods branches had higher tariff rates, sixteen percent for consumer goods industries, twenty five percent for consumer durables, fifty five percent for consumer non-durables and as much as one hundred and twenty eight percent for luxury goods. It is argued that this is the type of structure generally associated with import substitution policies resulting from balance of payment difficulties.

The low tariffs on manufactured goods stimulated rapid expansion of the manufacturing capacity, a slow and clear trend toward substituting domestic production for imports was recorded.

The main problems encountered in countries adopting restrictions of manufactured goods imports are the restriction of consumption in order to shift from private to public sector and to protect domestic production. Other factors could be attributed to the dominance of corruption and personal favour for the allocation of licence allocation decisions rather than by evaluation of economic productivity; also it often happens that the system uses contradictory measures such as permitting imports of goods to satisfy the demand while these goods are, or could be, produced domestically; this runs counter to import substitution policies and discourages internal production. A problem often encountered in developing economies fostering import substitution is that the prices of so-called luxuries increase at an exaggerated rate. Seers (1972,p26), for instance remarks that while prices of food and clothing may be comparable between poor and rich countries, prices of refrigerators, radios, cars etc., are above absurdity.

Krueger (1979) attempts to establish the differences between commercial policies chosen by a developing country and their impact on the rate of economic growth. The trade policies are grouped within two categories, import substitution policies for the protection of domestic production and export promotion, mainly based on traditional exports.

She shows that export promotion policies are more beneficial to growth performance than import substitution policies. The main criticisms of the latter are that domestic markets are extremely small in most developing countries. Attempts to replace imports result in the construction of plants requiring and encouraging capital intensive activities, which operate inefficiently while the activities of the former policy tend to operate with small size plants, which generally do not require capital intensive means of production.* Also the system of licensing and control,

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* This is clearly an issue of technological transfer itself based on the choice of capital intensive technologies and labour intensive technologies.

often related to import substitution entails delays, other costs and bureaucratic regulations. It is also argued that import substitution retards the growth of exports, this does not seem to fit in with the practical findings of Athukoralage who shows that for Sri-lanka, despite the import control regime and the numerous detrimental consequences on the resource allocation of the economy; it provided a strong stimulus for basic structural changes in the traditional export economy. It seems that the weaknesses of protecting the internal economy by reducing imports of manufactured goods are well recognised in the literature on trade, which is often based on a quantitative and realistic analysis of the economies. However, it is also recognised that criticisms of import substitutions are more attributable to the environment and the conditions in which these policies operate. For instance, Steel shows that Ghana developed rapidly foreign exchange problems and economic stagnation at a certain stage of implementation because of a 'big push' on all fronts for production. This study shows that import substitution would have been more successful in utilizing resources more efficiently and in laying a gradual foundation for sustained economic growth. Krueger (1979, p 291) recognises that the failure of import substitution did not result from the choice of trade policy, but that it was mainly due to the excesses of the particular ways in which import substitution policies were administered, that is the excesses of the ways in which domestic production was encouraged.

It was shown that despite the weaknesses of this strategy, or rather, of its imperfect use, that it was beneficial for Brazil Pakistan, Sri-lanka and even Ghana, which experienced a replacement of imports by domestic products only at a later stage of implementation.

It is, therefore, well substantiated that import substitution policies are profitable to the economy in the sense that developing countries decide to reduce their overwhelming dependence on imported manufactured goods from the economically developed nations as well as acquiring the confidence of satisfying their own needs; thereby encouraging their own economic development. The relationship between the variable imports of manufactured goods and integration of technology may well be explained within these perspectives. In particular an increase of machinery imports accompanied by a decrease of manufactured goods imports is more likely to lay a foundation for economic prosperity and prepare a general industrial atmosphere for a perceptive environment. The problems encountered by countries adopting import substitution policies would gradually improve the experience of policy makers as well as that of managers, technicians and engineers for a preparation of a more profitable use of foreign technology; that is a better integration of technology.

If these measures (despite their problems) are not undertaken a developing economy may find itself encouraged by the international market to concentrate on the exports of raw commodities and of traditional products, and remain dependent on the foreign market for the imports of manufactured goods for the increasing and more sophisticated demand of the nation. This trade policy obviously reinforces the traditional note of dependent economies, which does not stimulate the developing economies in creating their own industry. Besides, reference to the analysis of the variable which constituted the seventh factor in the third chapter, makes it clear that traditional or agricultural societies tend to import more manufactured consumer goods than more industrially based developing societies. The main conclusion drawn was that there is a shift in imports of manufactured goods at different economic levels.

4.3 Radio Receivers.

There is a positive relationship between this indicator and the dependent variable integration of technology, this shows that a greater availability of a certain type of consumer goods affects the attitudes and motivations of the population, which in turn affects the productivity and therefore technological integration. This indicator explains two percent of the variation in technology integration. As this variable is basically a social indicator, it is proposed to comment about the usefulness as well as the recent and increasing importance given to the inclusion of social indicators in econometric models. The main emphasis is to show the advantages this consumption variable has over the usual consumption indicator GNP per capita.

In the analysis of variables in the fourth chapter, this variable was found in the first factor related to other consumer factors such as passenger cars, per capita food and energy consumption, per capita GNP, etc., the variables in this factor were highly significant in explaining the whole set of variables variance.

The measurement of economic improvement has generally focussed on the growth of GNP per head. Economists have nevertheless become aware that income growth by itself is not an adequate indicator of the economic and social situation of a developing economy. This is mainly because GNP per capita fails to consider the equal or unequal distribution of welfare per capita GNP may grow considerably and poverty, unemployment as well as inequality may be growing at the same time, which results in a worse situation as noted by Seers (1972). Seers' main intention was to show that economic growth is not a sufficient condition for the improvement of welfare and that there is a difference between income and satisfaction of needs. Drewnowski (1966) for instance, notes that development should be measured in terms of the final aims of development that is in terms of an improvement of level of living, or welfare. The levels of living indicators are defined by the United Nations (1971) as education, health, nutrition, housing and social welfare of which clothing, transportation and communications are seen as both determining factors and end results in development.

Othik (1983) who researched into the historical study of human welfare, joins the argument by noting that the central concern has now become the distribution of the material benefits of growth and that social development has become an urgency.

It is within these perspectives that radio receivers as a social indicator finds its relevance to the present study. Of course, one is not straightforwardly saying that a society that has more access to radios is more able to integrate the technology, but mainly, that an increasing number of radios for use in a society shows that this community has satisfied its basic needs such as health, education etc., and has the capacities to buy physical necessities, which in turn enables the society to work and produce. A good explanation of how indicators should be interpreted is given by McGranahan (1972); he remarks that the temperature obtained by the use of a thermometer defines body temperature but is also an indicator of sickness or death rates, it may not indicate relative numbers of deaths but may indicate public health levels. Similarly, the present variable, radio receivers, may indicate the economic situation of a country by showing the availability of consumer products,* their distribution and the level of consumption. In fact, a study made by Beckerman and Bacon (1966) used this variable among other social indicators to predict the real private consumption per head. Seers (1972, p32), shows that the most important use of indicators such as this, is to provide the targets for planning.

Having noted the significance of this indicator, which consists of determining the welfare of society, one may conclude that this indicator has shown that social welfare is an important aspect, in the sense that a society with a better social welfare is more capable to assume productive activities than one with a low level of welfare and hence more capable to integrate the technology.

5. UNQUANTIFIABLE FACTORS AFFECTING THE TRANSFERENCE OF TECHNOLOGY.

The process of technological transfer is a complex phenomenon which combines not only economic and social factors, but also institutional, cultural and political transformations interacting in complicated relationships. Therefore, the study of technological transfer should be concerned with these disentangling forces as they impinge upon each other and upon the capacity of the system to generate either its success or failure. In historical

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* The difficulty of finding consumer goods in developing countries is dealt with in section 4.2 of this chapter.

studies of economic development, Myrdal (1957) shows that the search for the causes of economic stagnation often forces the investigator outside the purely economic framework.

Having found in the present analysis of technological transfer that quantifiable factors such as education, trade and consumption are determinant factors of the integration of transferred technology in a country, explaining a significant sixty one percent of its variance, it is now intended to discuss the factors that may affect technological transfer and that could not be included in the statistical analysis because of their qualitative and therefore unquantifiable nature.* These indicators may well be complementary factors expressing the unexplained proportion of variance, already referred to as u in the econometric analysis.

The problems to be analysed are basically related to the factors that affect the implementation of projects, as implementation is the basic process of technology integration itself. These project implementations operate not only in the industry, region and country but in perspectives without boundaries, which may be classified under spatial environment as well as political and managerial ones; the socio-economic aspects (very much related to these environments) have already been investigated in this chapter.

Although these factors are extremely interrelated, in the sense that they affect the transference of technology in a combined way, either directly or indirectly, an attempt is made to discuss each aspect at a time. The spacial aspects are discussed first as they constitute the global and international environment

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* Irma A. and Morris C.T. (1966) attempted to quantify as well as use these factors (often referred to as qualitative) in an analysis of economic growth of developing countries. However, despite their well known break up in this domain, economists are still suspicious of the reliability of these measurements. Often these phenomena are dealt with theoretically.

in which economic and political activities take place. It is then shown how political decisions and actions of the developing economies themselves may affect the implementation of projects. Lastly, the problems occurring in the field work which are mainly related to the functioning of management are discussed. In this section it is intended to trace the difficulties encountered when implementing projects as well as their causes. Some proposals are also made, when necessary, for efficient project implementation.

5.1 World Factors.

This environment is basically dominated by namely two contradictory forces, on the one hand, the developing countries, in importing technology, are trying to speed up their industrialization process, in response to growing awareness and demands for a better level of life, on the other hand, the transnational firms which provide them with the technology and control the technological market, are basically concerned with their own interests and are able to dominate and manipulate the precarious economic and political balance of most developing countries. Legorreta (1975) shows how the commercial interchange and capital investment is dominated by transnational firms, whose power is progressively increasing. The operations of the multinationals result in an intense dependence of most developing countries mainly on Japanese and American capital. Japan only invested 2,000 million dollars abroad between 1951 and 1968; about 71 million dollars were oriented towards manufacturing by transferring to South East Asia the weak industrial sector of Japan, which is dominated by textile industries. This is due to the relatively slow technological development of the textile industry in Japan and the exploitation of cheap manpower. On the other side of the Pacific, the United States investments in Latin America, represent 17 thousand million dollars; the debt of the whole area with the United States is continuously increasing which results in a growing dependence. Most African countries are also experiencing the same investment dependence from most developed countries. One may quote Legoretta (1975, p6) to show the effects of these investments:

> "We should wonder if these projects are not creating a better structuring of the subregional communications benefiting ultimately the two commercial superpowers."

Moreover, it is increasingly recognised that economic and social preoccupations do not prevail over strategic and military ones in most developing economies, for instance, the military expenses for some countries represent as much as twenty percent of the GNP, see table presented by Legoretta (1975, p15).

Although the discussion on this complex phenomena has not been thorough enough, basically because of lack of space as well as information, especially those regarding African countries; also if this aspect is to be covered, it necessitates in depth research. One may however conclude that the multinational investments, which are often used as profitable ends for the investors, may not be an encouraging and contributing factor to the development of technology integration in developing countries. Also the increasing programmes of defence in most developing countries tend to orientate the objectives of a country more towards problems of political security than towards the production of goods for the nation. It is essential for developing countries to establish national objectives allowing effective control for the capital and technology bought from or invested by multinationals, as new approaches are urgently needed for the lessening of dependence.

5.2 The Political Factor.

Having dealt with the global factors that basically represent a dilemma of interests between the developed and developing countries, one now deals with the political problems encountered within the boundaries of developing nations.

Most developing countries held special hopes for the betterment of living conditions in the 1960's decade and planning was regarded as the pillar of development. However, many events were unfavourable to the implementation of these plans, arising mainly from the political structure of the countries. The basis of these problems can be found within the proper traits of developing nations in general, which are characterized by a diversity of language, culture, religion, etc. At the earliest stage of social and economic development. It is often recognised, see Organski (1965), that the greater the initial cultural and ethnic heterogeneity of a community, the less likely modern integrative mechanisms such as education and mass communication will lead to an effective unified policy. Usually, the initial effects of urbanization and industrialization may intensify the awareness of cultural, racial and religious differences which produce social tensions that create, at least in the short run, additional obstacles to socio-economic and political development. Also, as Hagen (1962) points out, at the early stages of transformation of a traditional society, the increasing awareness of the possibility of change creates dissatisfaction and discontent that may lead to political problems if the economic achievements are not sufficient enough to allow satisfaction of the rising aspirations of the population. Historically, as countries have become more urbanized and industrialized, the closer agglomerations of the population, the greater geographic mobility as well as the greater extent of literacy and the wider spread of communication means have tended to promote the gradual development of common languages and an increase in cultural homogeneity. Therefore, there is evidence from the advanced countries that political instability may be expected as a phase in the transition to modern society and that cultural as well as religious homogeneity favour economic development.

This implies that, in the long run, social and economic development tends to be accompanied by a process of gradual transference of social and political values, from traditional to a modern structure, more compatible with industrialization, and hence with successful plans implementation.

A factor which is frequently present in most developing economies is that often officials capture for themselves a portion of the value they allocate to projects. This phenomenon of corruption has been so exaggerated that it has become a usual routine. Wade (1982, p287) quotes a report made by the ministry of Home Affairs of India:

> "The tendency to subvert integrity in the public services instead of being isolated and aberrative is growing into an organised, well planned racket... It was reported to

> us that corruption has increased to such an extent that people have started losing faith in the integrity of public administration."

Wade recalls that historically, a similar attitude was familiar in the public bureaucracies of seventeenth and eighteenth century Europe.

The problem of corruption is a phenomenon which affects administation, business, education, as well as a number of other areas and should be dealt with as a major problem by policy makers. Scott (1972) shows how so little is written about this aspect which is so obvious and known to exist in most developing economies.

Shen (1977) points out that private initiative can be inhibited by uncertainty and instability, and that most causes of implementation failure lie outside the competence of the planners and that the suitability of development planning for countries in the early stages of economic and political development was no longer taken for granted. He continues arguing that improvement in planning procedure does not hold much promise for significant improvements in implementation plans unless the general environment becomes more stable and therefore more predictable.

It was shown how some political characteristics may be a significant source of implementation failure and how most present developed countries experienced a similar political pattern.

5.3 The Managerial Factor.

Apart from the most global factors affecting the projects implementation and hence technology integration there are other factors of similar importance that may affect greatly the functioning of production. These are attributable to management procedures in developing countries.

It is well recognised that while improvements in planning have generally occurred in these countries, they have not done so for implementation. The projects that can upset most the technological efficiency and development programmes are those encountered by large scale industrial projects of important size. The medium and small size projects which are equally important to national development have the same problem of implementation, but to a lesser extent.

Implementation problems do not differ greatly between private and public projects, the former may experience greater difficulties in obtaining approvals and allocations while the latter may suffer more from organizational confusion and delays in decisions. Also the implementation problems are characteristic of most countries as their origins are the same and are formed in the very definition of "developing countries" as Kilbridge (1970, p43) remarks.

Development plans generally start with a set of objectives referred to as technological improvement, full employment, growth and hence economic independence. The pre-implementation phase consists of deciding to invest for the production of a specific product, on the general process, scale, market, financing method, location and government approval. The implementation procedure may be divided into three phases, see Kilbridge (p43), namely the planning of the project, which consist of site selection, detailed engineering design and cost estimating, the method of control and finally the construction and production process.

The contracting methods are numerous and vary from turn-key, including start-up, to delivery of equipment only, the method of contract may depend on previous experience in the type of project involved, the availability of technical and managerial personnel, the need for specialized equipment, the time allocated to the project, the technical complexities as well as the desire for training local managers and technicians.

Some difficulties may be encountered at the start of the project, the machines bought may not be useful as the accessories cannot be found and pieces of equipment may be difficult to put together unless expert technicians are available and unless the buyer has some control over the seller until the machines have been put into production. Contracting procedures require special consideration as they may lead to inefficient and costly start-up if they are poorly undertaken.

There are a number of factors that make project implementation inefficient. Shen (1977) attributes the failure to lack of will and competence as well as inconsistencies, errors and faulty forecasts in the plans. Kilbridge tends to see the scarcity of skills, lack of foreign exchange and dependence on foreign equipment at the source of implementation problems. He also presents some other factors such as the frugal use of capital, especially foreign exchange, overcapitalization, failure to estimate the market correctly and the economic consequences of locating the project in unsuitable place, other factors such as shortage of managers assuming full involvement and responsibility, deficient control procedures as well as low levels of technical efficiency are also reported, see Page (1980). One important point seems to dominate in Kilbridge's research and that is related to the inadequate estimating procedures. As cost estimating is a complex process, it is important to consider the relationship between the cost of the project and the costs caused by the delays in its implementation. Some aspects of the list provided on the sources of underestimation are presented here, see p43:

a) Additional costs of remote sites, including power source, other utilities, freight costs and roads;

b) Higher cost of first time effort as a result of learning effect;

c) Difficulty of anticipating at the time of estimate all the installations required for the project;

d) Labour estimates not adjusted to productivity;

e) Strikes and other work stoppages;

f) Possibility of devaluation;

g) Adverse climatic conditions;

h) Difficult maintenance of equipment; need for spares inventory;

i) Cost of delays caused by need to import equipment including customs clearance.

One may quote Repetto (1967)* to illustrate the above points.

"In many developing countries, one encounters large sums tied up in projects with extended gestation periods, widespread

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* quoted by Kilbridge (1977, p48).

> and considerable lags in project completion, and substantial under-utilization of both new and existing facilities. These represent a large loss to the nation in potential income and potential savings for reinvestment."

Shen refers to a transmission difficulty whereby when a target is missed, the implementation failure is transmitted to the other targets. Other problems shared by most researchers on this area agree that many physical conditions under which management operate, are caused by the most simple convenience that are taken for granted in most advanced countries. For instance, there are often difficulties in making a telephone call, inconsistent transport services, lack of secretarial assistance and reproduction facilities for documents, the inability to obtain essential spare parts for machines as well as the frustration experienced when the raw materials are difficult to obtain.

Young (1966) whose work is more concerned with management education, attributes the managerial problems in developing countries to four aspects, namely physical conditions, already discussed above, local attitudes, cultural aspects as well as the incompatibility between educational theory and practice.*

The local attitudes, very much related to the cultural heritage constitute an important factor in the sense that they often determine the physical conditions, they may be expressed as "laisser-aller" and things do not get done when they should be done, or are only done partly, information is not given a prior importance and may be inaccurately provided, also absenteeism is

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* This point has already been discussed in the section on education.

quite a frequent factor which restrict continuity in work. This lack of discipline and motivations affect the whole attitude of mind of the people and frequently defeat those competent managers.

Some factors that may be relevant to note here are related to managerial training; Young notes that many of the top managers controlling enterprises have arrived at the top without passing through the competitive management field, which provides them with the required experience, they often attend these posts by virtue of their family or cultural and financial status.

Some propositions for efficient management techniques for developing countries are made by Young.
These are:

a) Adaptation as against adoption of management techniques.

b) The development of managerial capacities through increased technical knowledge and the improvement of appropriate attitudes.

Kilbridge proposes ways to avoid implementation problems such as meticulous project planning and attention to the cost of time, the use of powerful methods such as 'critical path scheduling' which is the application of network analysis to planning and control schedule.

Adelman and Morris (1965, p565) who are more concerned on the habits and attitudes of people write:

"Fundamental to the processes of both socio-economic and political change is a transformation of basic attitudes affecting the habits, beliefs and emotions of the individual members of a society. It is this transformation of individual outlook which tends to generate not only the receptivity to technical change, enterprise and initiative..., but also the acceptance of the breakdown of ascriptive traditional norms."

CHAPTER SIX

CONCLUSIONS AND PROPOSITIONS FOR FURTHER RESEARCH

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Development economists are increasingly becoming aware that approaches to the problems of developing countries differ from those of the developed world because of social, economic and political reasons. However, efforts to develop and extend analyses that include these environmental factors are hampered by the absence of empirical knowledge about the manner in which they operate. Suitable methods to study the multiple interactions of economic and other forces would require cooperative research by interdisciplinary teams of economists, statisticians and econometricians. Unfortunately, few non-economists have shown an interest in such empirical investigations. Accordingly, it may be desirable for development economists, in addition to explanatory, to initiate these exploratory approaches and stimulate empirical research in these areas.

Consequently, the transfer of technology being part of these areas, should not be viewed merely as the flow of machinery or of physical tools and information, but should rather involve the whole environmental and societal attitudes in relation to the assimilation of the transfer. As an initial investigation, the present study of technology transfer was treated within these broader issues. The main aim was to contribute to the understanding of technological transfer, by gaining a quantitative insight relating it to empirical data.

1. MAIN CONCLUSIONS.

The current study's attempt was to find out the main socio-economic characteristics that affect the rate of technology transfer and integration. The results of the multiple regression model are encouraging and suggest that countries with the following characteristics are more able to absorb and integrate foreign technologies, than those which are deficient in those characteristics.

These are:-

i) Relatively high educational level.

ii) A comparatively low import rate of manufactured goods.

iii) Availability of certain types of consumer goods.

The indicators representing the above characteristics are respectively:

- Adult literacy rate.
- Imports of manufactured goods.
- Radio receivers per thousand population.

These were identified by the regression analysis as accurate indicators of the rate of technology integration and explain a significant sixty one percent of its total variance.

The education indicator explains a proportion of forty seven percent; it is not surprising to find that such an indicator has so high a significance in relation to the rate of technological absorption, as it complements and provides theoretical foundations; it also demonstrates the validity and appropriateness of the current approach.

The second indicator shows that reducing the reliance on foreign trade in importing less manufactured goods is an important factor in technology assimilation; more specifically, there is then a tendency to develop and encourage local industries, which will generally result in a healthier economy.

Although the third indicator explains a lower proportion of the variance, it is still statistically significant and shows the usefulness of social indicators. It basically suggests that a greater availability of a certain type of consumer goods affects the attitudes and motivations of the population; this necessarily affects productivity and hence technology integration. It also shows that societies that attain this stage can afford more than basic necessities.

The above indicators afford an empirical investigation of current data and provide further evidence that the factors that affect the assimilation of technological transfer could usefully be further investigated in further research and planning studies.

2. PROPOSALS FOR FURTHER RESEARCH.

Further empirical studies should be carried out to validate the present study and conclusions, in particular:

i) The reliability and accuracy of the present model should be assessed by using different sets of corresponding data for different countries and for different periods of time.

ii) Other indicators, more representative of developing countries' economies such as the productivity of a man's hour work should be investigated together with managerial capacitites. Again political facets that can be quantified such as stability of regimes etc., could usefully be explored.

iii) As an attempt to measure any phenomenon, and as many measurements could exist and represent this phenomenon, one may attempt to give a quantifiable measure to the technological assimilation, as was attempted in the current study. This may either improve the present approach used to quantify the aspect, or suggest improved alternative measures.

iv) Measures of technological transfer applicable at enterprises sector level etc., should be developed. These would generally require more specific information about policies, wages, employment, output, etc.

v) Other measures related to the type of technology imported i.e. whether it is capital or labour intensive in conjunction with their quantity and output, should be investigated. This would require a comparative study between two or more types of technology; the results would elucidate further facets of technological transfer.

vi) The appropriateness of other statistical and econometric methods and models such as input-output analysis could usefully be investigated.

APPENDICES

APPENDIX 1

Tables on industrial activities for some countries.

TABLE 1

ALGERIA - SUMMARY

	1977	1990
- Strength of manufacturing industry	xx	xxx
- Importance as exporter of manufactures	-	x

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		Manufacture of Food, Beverages, Tobacco					- Industrialisation based on hydrocarbons. - Import substitution stressed. - Dependency on imports still in 1980s. - Foreign investment not allowed. - Favourable location for European markets. - Whole manufacturing sector nationalised. Core Elements of Industrial Policy: - Industrialisation on diversified basis. - After 1990 only oil and gas products, no longer unprocessed exports. - Economic independence intended. Technological Potential: - Low potential. - Weak administration (public sector). - Low productivity. - Difficulties in mastering imported technologies. - Lack of qualified skilled workers. - Vocational training system to be established. Characteristics of Exports: - Government practising rather a policy of de-integration. - Imports of investment goods against exports of oil and gas. - No efforts to intensify exports.
	311 312	Food manufacturing					
	313	Beverage industries					
	314	Tobacco manufactures					
32		Textile, Wearing Apparel, Leather Industries					
	321	Manufacture of textiles			+		
	322	Manufacture of wearing apparel			+		
	323	Manuf. of leather/Products of leather					
	324	Manufacture of footwear					
33		Manuf. of Wood/Wood Products, Furniture					
	331	Manuf. of wood/Wood and cork products					
	332	Manufacture of furniture					
34		Manufacture of Paper/Paper products; Printing and Publishing					
	341	Manufacture of Paper/Paper products					
	342	Printing, publishing allied industries					
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products					
	351	Manufacture of industrial chemicals					
	352	Manufacture of other chemical products					
	353	Petroleum refineries	+		+	-	
	354	Manufacture of petroleum and coal products	++		+	-	
	355	Manufacture of rubber products					
	356	Manufacture of plastic products					
36		Manufacture of Non-Metallic Mineral Products					
	361	Manufacture of pottery, china and earthenware					
	362	Manufacture of glass and glass products					
	369	Manuf. of other non-metallic mineral products	++		+		
37		Basic Metal Industries					
	371	Iron and steel basic industries	++		+	-	
	372	Non-ferrous metal basic industries			+	-	
38		Manufacture of Fabricated Metal Products, Machinery, Equipment					
	381	Manufacture of fabricated metal products					
	382	Manufacture of machinery			+		
	383	Manufacture of electrical machinery			+		
	384	Manufacture of transport equipment					
	385	Manufacture of measuring/Controlling equipment; Optical goods					
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)					

Legend: ++ very important.
+ important.
- unimportant.

Source: OCDE (1982)

TABLE 2

ARGENTINA - SUMMARY

	1977	1990
- Strength of manufacturing industry	xx	xxx
- Importance as exporter of manufactures	x	xx

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		Manufacture of Food, Beverages, Tobacco					- Change in economic policy since 1976, industry promotion questioned by entrepreneurs. - Raw material resource potential. - Lack of capital greatest bottleneck. - Development of the country not very dynamic. Core Elements of Industrial Policy: - Foreign investments since 1976 welcome and promoted by law (1977). - Equal treatment of domestic and foreign capital - most liberal regulations of whole Latin America. - Strengthening of infrastructure has priority. Technological Potential: - Relatively strong basis, insufficiently utilised. - In connection with industry promotion law (1977); regulations for transfer of technologies. Characteristics of Exports: - Exports concentrated on agricultural products - change possible only in the long run. - Share of manufactures in exports 22 per cent only, two-thirds being traditional products. - Relatively weak export orientation of industrialisation.
	311 312	Food manufacturing		+		++	
	313	Beverage industries		+		++	
	314	Tobacco manufactures					
32		Textile, Wearing Apparel, Leather Industries					
	321	Manufacture of textiles					
	322	Manufacture of wearing apparel					
	323	Manuf. of leather/Products of leather					
	324	Manufacture of footwear					
33		Manuf. of Wood/Wood Products, Furniture					
	331	Manuf. of wood/Wood and cork products					
	332	Manufacture of furniture					
34		Manufacture of Paper/Paper products; Printing and Publishing					
	341	Manufacture of Paper/Paper products	+		+	-	
	342	Printing, publishing allied industries					
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products					
	351	Manufacture of industrial chemicals					
	352	Manufacture of other chemical products					
	353	Petroleum refineries					
	354	Manufacture of petroleum and coal products	+		+	-	
	355	Manufacture of rubber products					
	356	Manufacture of plastic products					
36		Manufacture of Non-Metallic Mineral Products					
	361	Manufacture of pottery, china and earthenware					
	362	Manufacture of glass and glass products					
	369	Manuf. of other non-metallic mineral products					
37		Basic Metal Industries					
	371	Iron and steel basic industries	+		+	-	
	372	Non-ferrous metal basic industries					
38		Manufacture of Fabricated Metal Products, Machinery, Equipment					
	381	Manufacture of fabricated metal products					
	382	Manufacture of machinery	+			+	
	383	Manufacture of electrical machinery	+				
	384	Manufacture of transport equipment	++			-	
	385	Manufacture of measuring/Controlling equipment; optical goods					
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)					

Legend: ++ very important.
+ important.
- unimportant.

Source: OCDE (1982)

TABLE 3

BRAZIL - SUMMARY

	1977	1990
- Strength of manufacturing industry	xxxx	xxxxxx
- Importance as exporter of manufactures	xxx	xxxx

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		Manufacture of Food, Beverages, Tobacco					- Lack of capital. - Large raw material resources. - Dynamic industrial development. Core Elements of Industrial Policy: - Concentration on import substitution from 1960 to early 1970s. - Diversification of manufacturing industries. - Decentralisation of industrialisation. - Promotion of specific regions. - Foreign investments welcome - many joint ventures. - Industrialisation increasingly capital- and technology-intensive. - Efforts for self-sufficiency in important sectors. Technological Potential: - Manufacturing industries still depending on foreign technologies: know-how imports will continue or even increase; however, more high-sophisticated technologies. - Efforts for export of own technologies, especially to other Latin American countries. Characteristics of Exports: - Exports having key position in industrialisation. - Among manufactures mainly final products. - Share in world exports of manufactures continuously increasing. - Highest growth rates in exports machinery and other engineering products (above 40 % p.a.).
	311 312	Food manufacturing	++	+	+	+	
	313	Beverage industries	+		+		
	314	Tobacco manufactures	+	+	+	+	
32		Textile, Wearing Apparel, Leather Industries					
	321	Manufacture of textiles	++		+		
	322	Manufacture of wearing apparel	+		++	-	
	323	Manuf. of leather/Products of leather	+		+		
	324	Manufacture of footwear	+		+		
33		Manuf. of Wood/Wood Products, Furniture					
	331	Manuf. of wood/Wood and cork products	+	+	+	+	
	332	Manufacture of furniture	+		+		
34		Manufacture of Paper/Paper products; Printing and Publishing					
	341	Manufacture of Paper/Paper products	+		+		
	342	Printing, publishing allied industries	+		+		
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products	++				
	351	Manufacture of industrial chemicals	+	-	+	+	
	352	Manufacture of other chemical products	+	-	+	+	
	353	Petroleum refineries	++	+	++	+	
	354	Manufacture of petroleum and coal products	++	+	++	+	
	355	Manufacture of rubber products	+		+		
	356	Manufacture of plastic products	+		+		
36		Manufacture of Non-Metallic Mineral Products					
	361	Manufacture of pottery, china and earthenware	+		+		
	362	Manufacture of glass and glass products	+		+		
	369	Manuf. of other non-metallic mineral products	+		+		
37		Basic Metal Industries					
	371	Iron and steel basic industries	++		++	+	
	372	Non-ferrous metal basic industries	+		++	+	
38		Manufacture of Fabricated Metal Products, Machinery, Equipment					
	381	Manufacture of fabricated metal products			+	+	
	382	Manufacture of machinery	++		++	+	
	383	Manufacture of electrical machinery	++	+	++	+	
	384	Manufacture of transport equipment	++	+	+	++	
	385	Manufacture of measuring/Controlling equipment; Optical goods					
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)					

Legend: ++ very important.
+ important.
- unimportant.

Source: OCDE (1982)

TABLE 4

INDONESIA - SUMMARY

	1977	1990
- Strength of manufacturing industry	x	xx
- Importance as exporter of manufactures	-	x

Divison	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		Manufacture of Food, Beverages, Tobacco			◆	(13 %)	- Share in world oil resources about 1.6%. - Great and broad raw material potential. - Unfavourable location for export. Core Elements of Industrial Policy: - Foreign investments welcome - investors hesitating. - Broad variety of starting points for industrialisation, no dynamic progress. Technological Potential: - Lack of skilled workers, entrepreneurs and managerial skills as bottleneck. - Technology completely imported. - Imported technology relatively capital-intensive. - Weak public administration (especially concerning direct investments). Characteristics of Exports: - Very low export orientation of industrialisation. - Share of oil in exports 80 %, in future no basic reorientation. - Share of Japan in Foreign Investments 25 % (1978).
	311 312	Food manufacturing	◆			◆	
	313	Beverage industries	◆				
	314	Tobacco manufactures	◆				
32		Textile, Wearing Apparel, Leather Industries				(6 %)	
	321	Manufacture of textiles	◆	◆	◆	-	
	322	Manufacture of wearing apparel	◆				
	323	Manuf. of leather/Products of leather				◆	
	324	Manufacture of footwear	◆				
33		Manuf. of Wood/Wood Products, Furniture				(10 %)	
	331	Manuf. of wood/Wood and cork products			◆	◆	
	332	Manufacture of furniture					
34		Manufacture of Paper/Paper products; Printing and Publishing				(1 %)	
	341	Manufacture of Paper/Paper products				-	
	342	Printing, publishing allied industries					
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products			◆	(16 %)	
	351	Manufacture of industrial chemicals					
	352	Manufacture of other chemical products				◆	
	353	Petroleum refineries					
	354	Manufacture of petroleum and coal products					
	355	Manufacture of rubber products				◆	
	356	Manufacture of plastic products					
36		Manufacture of Non-Metallic Mineral Products				(4 %)	
	361	Manufacture of pottery, china and earthenware					
	362	Manufacture of glass and glass products					
	369	Manuf. of other non-metallic mineral products				-	
37		Basic Metal Industries				(10 %)	
	371	Iron and steel basic industries					
	372	Non-ferrous metal basic industries				-	
38		Manufacture of Fabricated Metal Products, Machinery, Equipment				(12 %)	
	381	Manufacture of fabricated metal products			◆	-	
	382	Manufacture of machinery					
	383	Manufacture of electrical machinery					
	384	Manufacture of transport equipment					
	385	Manufacture of measuring/Controlling equipment; Optical goods				- -	
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)				(14 %) ◆	

Legend: ◆◆ very important.
◆ important.
- unimportant.

Source: OCDE (1982)

TABLE 5

MEXICO - SUMMARY

	1977	1990
- Strength of manufacturing industry	xxx	xxxx
- Importance as exporter of manufactures	x	xx

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s	
			Import Subst.	Export Intens.	Import Subst.	Export Intens.
31		Manufacture of Food, Beverages, Tobacco		(37 %)		(20 %)
	311 312	Food manufacturing				
	313	Beverage industries	++			-
	314	Tobacco manufactures				
32		Textile, Wearing Apparel, Leather Industries		(15 %)		(10 %)
	321	Manufacture of textiles	++	+		-
	322	Manufacture of wearing apparel	++	+		-
	323	Manuf. of leather/Products of leather				
	324	Manufacture of footwear	++			
33		Manuf. of Wood/Wood Products, Furniture				
	331	Manuf. of wood/Wood and cork products				
	332	Manufacture of furniture				
34		Manufacture of Paper/Paper products; Printing and Publishing				
	341	Manufacture of Paper/Paper products				
	342	Printing, publishing allied industries				
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products		(16 %)		(26 %)
	351	Manufacture of industrial chemicals			+<40 %>	
	352	Manufacture of other chemical products				
	353	Petroleum refineries		+		+
	354	Manufacture of petroleum and coal products		++		++
	355	Manufacture of rubber products				
	356	Manufacture of plastic products		-		
36		Manufacture of Non-Metallic Mineral Products				
	361	Manufacture of pottery, china and earthenware				
	362	Manufacture of glass and glass products				
	369	Manuf. of other non-metallic mineral products	+			
37		Basic Metal Industries				
	371	Iron and steel basic industries				
	372	Non-ferrous metal basic industries				
38		Manufacture of Fabricated Metal Products, Machinery, Equipment		(20 %)		(32 %)
	381	Manufacture of fabricated metal products			+<55 %>	
	382	Manufacture of machinery		+	+<17 %>	++
	383	Manufacture of electrical machinery		+	+<21 %>	++
	384	Manufacture of transport equipment		++		
	385	Manufacture of measuring/Controlling equipment; Optical goods		+		
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)				

General Remarks

- Industrialisation according to import substitution strategy until 1972.
- Wage level about 40 % of USA.
- Broad raw material basis.
- Favourable location.

Core Elements of Industrial Policy:

- Industrialisation orientated towards oil exploitation and processing.
- Joint venture investments strictly regulated - limitations: 49 % - foreign share in general, 40 % in petrochemical industry and automotive engineering, 34 % in mining.
- 80 % of foreign investments from USA.
- Unemployment problems - nevertheless capital-intensive industrialisation.

Technological Potential:

- High potential.
- Important R&D capacities and results.
- Potential of skilled workers adequate.

Characteristics of Exports:

- Low export orientation of industrialisation - continuing in the 1980s.
- Export shares (1977): manufactures (34 %), oil (22 %), coffee (11 %).
- Important industrial products:
  - . vehicles.
  - . petrochemicals, including fertilizers.

Legend: ++ very important.
+ important.
- unimportant.

(... %) = share in exports of manufactures.

<... %> = contribution of imports to total supply.

Source: OCDE (1982)

TABLE 6

NIGERIA - SUMMARY

	1977	1990
- Strength of manufacturing industry	x	xx
- Importance as exporter of manufactures	-	x

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		Manufacture of Food, Beverages, Tobacco	++		+	(10 %)	- Share of manufacturing sector in GDP 10 % only, 15 % expected for 1990. - Food and textiles contributing about 50 % to industrial production. - Weak infrastructure. - Good raw material basis. - National development plans were unrealistic. Core Elements of Industrial Policy: - Foreign investments welcome, however, limitation because of Africanisation/Nationalisation policy. - 40 % share of foreign capital in manufacturing industry. - No policy of export promotion. Technological Potential: - Lack of entrepreneurs, managerial and other skills important bottleneck for industrialisation. - Completely dependent on imported technology. Characteristics of Exports: - Oil contributing 93 % of exports. - Low export orientation of industrialisation. - Import substitution - financed by oil exports.
	311 312	Food manufacturing					
	313	Beverage industries					
	314	Tobacco manufactures					
32		Textile, Wearing Apparel, Leather Industries				(5 %)	
	321	Manufacture of textiles	++		-		
	322	Manufacture of wearing apparel	++		-		
	323	Manuf. of leather/Products of leather	++		-		
	324	Manufacture of footwear					
33		Manuf. of Wood/Wood Products, Furniture				(5 %)	
	331	Manuf. of wood/Wood and cork products					
	332	Manufacture of furniture					
34		Manufacture of Paper/Paper products; Printing and Publishing				(5 %)	
	341	Manufacture of Paper/Paper products					
	342	Printing, publishing allied industries					
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products			++	+ (15 %)	
	351	Manufacture of industrial chemicals					
	352	Manufacture of other chemical products					
	353	Petroleum refineries				+	
	354	Manufacture of petroleum and coal products				+	
	355	Manufacture of rubber products					
	356	Manufacture of plastic products					
36		Manufacture of Non-Metallic Mineral Products					
	361	Manufacture of pottery, china and earthenware					
	362	Manufacture of glass and glass products					
	369	Manuf. of other non-metallic mineral products			++		
37		Basic Metal Industries				(10 %)	
	371	Iron and steel basic industries			++	+	
	372	Non-ferrous metal basic industries					
38		Manufacture of Fabricated Metal Products, Machinery, Equipment					
	381	Manufacture of fabricated metal products			++	+	
	382	Manufacture of machinery					
	383	Manufacture of electrical machinery			++		
	384	Manufacture of transport equipment			++		
	385	Manufacture of measuring/Controlling equipment; Optical goods					
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)					

Legend: ++ very important.
+ important.
- unimportant.

Source: OCDE (1982)

TABLE 7

SAUDI ARABIA - SUMMARY

	1977	1990
- Strength of manufacturing industry	-	[x]
- Importance as exporter of manufactures	-	[xx]

[= only several branches]

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		Manufacture of Food, Beverages, Tobacco			◆		- Oil as single basis of industrialisation (as raw material and as energy source). - Liberal market economy, nationalised oil sector. - Manufactures contributed (1975) only 5 % to GDP. - Great investments in infrastructure. Core Elements of Industrial Policy: - Reduction of dependency on oil as main target. - Foreign investments (joint ventures) most welcome. - Promotion of national industrial initiatives. - Core sectors of industrialization: refineries, petrochemical industry, steel, aluminium. Technological Potentials - Nearly complete dependency on imported (Western) technology. - Vocational training system gradually established. Characteristics of Exports: - Protectionism of European countries and Japan to be expected for steel and aluminium exports. - Fertilizer exports after 1985 to Africa and Asia.
	311 312	Food manufacturing					
	313	Beverage industries					
	314	Tobacco manufactures					
32		Textile, Wearing Apparel, Leather Industries					
	321	Manufacture of textiles					
	322	Manufacture of wearing apparel					
	323	Manuf. of leather/Products of leather					
	324	Manufacture of footwear					
33		Manuf. of Wood/Wood Products, Furniture					
	331	Manuf. of wood/Wood and cork products					
	332	Manufacture of furniture					
34		Manufacture of Paper/Paper products; Printing and Publishing					
	341	Manufacture of Paper/Paper products					
	342	Printing, publishing allied industries					
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products					
	351	Manufacture of industrial chemicals					
	352	Manufacture of other chemical products					
	353	Petroleum refineries		◆		◆◆	
	354	Manufacture of petroleum and coal products		◆		◆◆	
	355	Manufacture of rubber products					
	356	Manufacture of plastic products			◆		
36		Manufacture of Non-Metallic Mineral Products					
	361	Manufacture of pottery, china and earthenware					
	362	Manufacture of glass and glass products			◆		
	363	Manuf. of other non-metallic mineral products.			◆		
37		Basic Metal Industries					
	371	Iron and steel basic industries			◆		
	372	Non-ferrous metal basic industries				◆	
38		Manufacture of Fabricated Metal Products, Machinery, Equipment					
	381	Manufacture of fabricated metal products					
	382	Manufacture of machinery					
	383	Manufacture of electrical machinery					
	384	Manufacture of transport equipment					
	385	Manufacture of measuring/Controlling equipment; optical goods					
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)					

Legend: ◆◆ very important.
◆ important.
- unimportant.

Source: OCDE (1982)

TABLE 8

SOUTH KOREA - SUMMARY

	1977	1990
- Strength of manufacturing industry	xxx	xxxx
- Importance as exporter of manufactures	xxx	xxxx

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s	
			Import Subst.	Export Intens.	Import Subst.	Export Intens.
31		Manufacture of Food, Beverages, Tobacco				
	311 312	Food manufacturing	+	++	+	+
	313	Beverage industries	+		+	
	314	Tobacco manufactures				
32		Textile, Wearing Apparel, Leather Industries				
	321	Manufacture of textiles	+	+++	+	++
	322	Manufacture of wearing apparel	+	++	+	++
	323	Manuf. of leather/Products of leather	+	++	+	++
	324	Manufacture of footwear	+	+	+	++
33		Manuf. of Wood/Wood Products, Furniture				
	331	Manuf. of wood/Wood and cork products	+	+	+	+
	332	Manufacture of furniture	+		+	
34		Manufacture of Paper/Paper products; Printing and Publishing				
	341	Manufacture of Paper/Paper products	+		+	
	342	Printing, publishing allied industries	+		+	
35		Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products	++	++	++	++
	351	Manufacture of industrial chemicals	+	++	+	++
	352	Manufacture of other chemical products	+		+	
	353	Petroleum refineries	++		++	
	354	Manufacture of petroleum and coal products	++		++	+
	355	Manufacture of rubber products	+		+	
	356	Manufacture of plastic products	+	+	++	+
36		Manufacture of Non-Metallic Mineral Products				
	361	Manufacture of pottery, china and earthenware	+	++	+	++
	362	Manufacture of glass and glass products	+		+	
	369	Manuf. of other non-metallic mineral products	+	++	+	++
37		Basic Metal Industries				
	371	Iron and steel basic industries	++	++	++	++
	372	Non-ferrous metal basic industries	+	-	+	-
38		Manufacture of Fabricated Metal Products, Machinery, Equipment				
	381	Manufacture of fabricated metal products	+	+	+	+
	382	Manufacture of machinery	+	++	++	++
	383	Manufacture of electrical machinery	+	++	+	++
	384	Manufacture of transport equipment	+	++	+	+
	385	Manufacture of measuring/Controlling equipment; Optical goods	-	-	+	+
39		Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)	+	+	+	+

General Remarks

- Industrial production since 1962, 20 per cent p.a. increase.
- South-Korea and Taiwan most dynamic NIC countries.
- Large entrepreneurial and managerial potential.
- Appropriate potential of skilled workers.

Core Elements of Industrial Policy:

- Diversification of manufacturing industry.
- Intensive co-operation with foreign countries - Direct investments welcome.
- Establishment of large industrial zones.
- Production continuously becoming more technology-intensive.
- Promotion of Joint Ventures.
- No. 1 in textile production in the world.

Technological Potential:

- Development of new technologies on basis of imported technologies.
- Still dominance of imported technology, especially in the field of high technologies.
- Ambitious programs to establish R&D capacities.

Characteristics of Exports:

- Enormous export orientation of whole manufacturing industry.
- Large export share for all branches.
- Exports planned to increase by 300 per cent between 1978 and 1985.
- Share of heavy industries continuously increasing.

Legend: ++ very important.
+ important.
- unimportant.

Source: OCDE (1982)

TABLE 9

TAIWAN: SUMMARY OF INDUSTRY AND EXPORT PROSPECTS

	1977	1990
- Strength of manufacturing industry -	xxx	xxxx
- Importance as exporter of manufactures	xxx	xxxx

Division	Major Group	Industries	Ex-post Analysis 1970-1977		Ex-ante Analysis 1980s		General Remarks
			Import Subst.	Export Intens.	Import Subst.	Export Intens.	
31		<u>Manufacture of Food, Beverage, Tobacco</u>				+ (60 %)	- Entrepreneurial, managerial capacities main factor of development/industrialisation, potential of skilled workers sufficient. - No raw materials. Geographical location not very favourable. - Taiwan and South-Korea most dynamic among NICs. <u>Core Elements of Industrial Policy:</u> - Diversification of industrial structure, especially in heavy industries. - Intensification of interindustry-linkage. - Liberal economic and industrial policy - foreign investments most welcome - foreign capital contributing 17 % to industrial production (1977). <u>Technology Potential:</u> - High technological potential - imported from Western industrialised countries. - Traditional labour-intensive branches gradually substituted by capital- and technology-intensive industries. - Development of own technologies on basis of imported ones. <u>Characteristics of Exports:</u> - Strong export orientation (more than 50 % in average) of the manufacturing sector. - Reorientation to new markets (EEC) in future necessary.
	311 312	Food manufacturing	+	++		++	
	313	Beverage industries	+	+		+	
32		<u>Textile, Wearing Apparel, Leather Industries</u>				++ (70 %)	
	321	Manufacture of textiles	++	++		++	
	322	Manufacture of wearing apparel	+	++		++	
	323	Manuf. of leather/Products of leather	+		+	+	
	324	Manufacture of footwear	-	-	-	-	
33		<u>Manuf. of Wood/Wood Products, Furniture</u>				+ (80 %)	
	331	Manuf. of wood/wood and cork products	+			+	
	332	Manufacturing of furniture	- +	+		+	
34		<u>Manufacture of Paper/Paper products; Printing and Publishing</u>				(10 %)	
	341	Manufacture of Paper/Paper products	+		+		
	342	Printing, publishing allied industries	-		+		
35		<u>Manufacture of Chemicals and of Chemical, Petroleum, Coal, Rubber and Plastic Products</u>				++ (35 %)	
	351	Manufacture of industrial chemicals	++	+	+	+	
	352	Manufacture of other chemical products	++	+	+	+	
	353	Petroleum refineries	++	++	+	++	
	354	Manufacture of petroleum and coal products	++			+	
	355	Manufacture of rubber products	-	+	+	++	
	356	Manufacture of plastic products	+	+		++	
36		<u>Manufacture of Non-Metallic Mineral Products</u>				- (40 %)	
	361	Manufacture of pottery, china and earthenware	+	+		+	
	362	Manufacture of glass and glass products	+	+		+	
	369	Manuf. of other non-metallic mineral products	+	+	+	+	
37		<u>Basic Metal Industries</u>	+			(25 %)	
	371	Iron and steel basic industries	+		+	-	
	372	Non-ferrous metal basic industries	+		+	-	
38		<u>Manufacture of Fabricated Metal Products, Machinery, Equipment</u>				++ (75 %)	
	381	Manufacture of fabricated metal products	+	++		++	
	382	Manufacture of machinery	+	++		++	
	383	Manufacture of electrical machinery	++	++		++	
	384	Manufacture of transport equipment	+	++		++	
	385	Manufacture of measuring/Controlling equipment; Optical goods	+	++		+	
39		<u>Other Manufacturing Industries (Jewellery, musical instruments, sporting goods)</u>	-	+		+ (80 %)	

<u>Legend:</u> ++ very important.
+ important.
- unimportant.

(...%) = export share of production.

Source: OCDE (1982)

APPENDIX 2 :COMPUTER PROGRAMME

```
10   REM THIS PROGRAM EVALUATES THE DIFFERENT GROWTH MEASURES AND INDICES OF TEC
HNOLOGY INTEGRATION
20   REM AND CORRELATES THESE VARIABLES TOGETHER
30   REM
40   REM
50   REM THE VARIABLES ARE DIMENSIONED
60   REM
70   DIM A(6),I(8,5),Ex(2,8),Gip(8),Gip1(8),Im(2),An(8),Ana2$[100],Var$[100],Gdp
(40),Imp_tech(40),Trendgip(50),Trendgdp(50),Igip(50),Igdp(50),Rgip(50),Rgip2(50)
80   DIM Rgdp(50),Ana1$[100],Ncount(50)
90   DISP " N. OF COUNTRIES ";
100  INPUT N0
110  REM
120  REM THE DATA IS READ AND THE INDICES OF TECHNOLOGY INTEGRATION CALCULATED
130  REM
140  CALL Read(Coun$,A(*),I(*),E,Ex(*),Im(*),Gip(*),Gip1(*),N0,An(*),Trendgip(*)
,Trendgdp(*),Igip(*),Igdp(*),Rgip(*),Rgip2(*),Rgdp(*),Ncount(*))
150  REM
160  REM THE CORRELATION OF THE TWO INDICES IS ESTIMATED
170  REM
180  Ana1$="RATIO : GIP / IMP. TECH. % GIP"
190  Ana2$="RATIO ; GDP / IMP. TECH. % GDP"
200  CALL Find(Rgdp(*),N0,Xmin,Xmax,10)
210  CALL Correlation(Rgip(*),Rgdp(*),N0,Slope,Inter,R)
220  CALL Find(Rgip(*),N0,Ymin,Ymax,2)
230  CALL Plot(Rgdp(*),Rgip(*),Xmin,Ymin,Xmax,Ymax,Slope,Inter,R,N0,Ana2$,Ana1$,
Ncount(*))
240  REM
250  REM THE CORRELATION OF THE COMPONENTS OF INDICE 1 IS ESTIMTED
260  REM
270  Ana1$="TREND IN GIP"
280  Ana2$="IMPORT OF TECHNOLOGY % GIP"
290  CALL Correlation(Trendgip(*),Igip(*),N0,Slope,Inter,R)
300  CALL Find(Igip(*),N0,Xmin,Xmax,10)
310  CALL Find(Trendgip(*),N0,Ymin,Ymax,10)
320  CALL Plot(Igip(*),Trendgip(*),Xmin,Ymin,Xmax,Ymax,Slope,Inter,R,N0,Ana2$,An
a1$,Ncount(*))
330  REM
340  REM THE CORRELATION OF THE COMPONENTS OF INDICE 2 IS ESTIMATED
350  REM
360  Ana1$="TREND IN GDP"
370  Ana2$="IMPORT OF TECHNOLOGY % GDP"
380  CALL Find(Igdp(*),N0,Xmin,Xmax,10)
390  CALL Correlation(Trendgdp(*),Igdp(*),N0,Slope,Inter,R)
400  CALL Find(Trendgdp(*),N0,Ymin,Ymax,2)
410  CALL Plot(Igdp(*),Trendgdp(*),Xmin,Ymin,Xmax,Ymax,Slope,Inter,R,N0,Ana2$,An
a1$,Ncount(*))
420  STOP
430  END
440  SUB Correlation(F(*),E(*),N0,Slope,Inter,R)
450  REM
460  REM COMPUTATION OF CORRELATION COEFFICIENT & REGRESSION FUNCTION
470  REM
480  FOR I=1 TO N0
490  Ysum=Ysum+F(I)
500  Xsum=Xsum+E(I)
510  Xysum=Xysum+F(I)*E(I)
520  Y2sum=Y2sum+F(I)^2
530  X2sum=X2sum+E(I)^2
540  NEXT I
550  R=(N0*Xysum-Xsum*Ysum)/SQR((N0*X2sum-Xsum^2)*(N0*Y2sum-Ysum^2))
560  Slope=(N0*Xysum-Xsum*Ysum)/(N0*X2sum-Xsum^2)
570  Inter=Ysum/N0-Slope*(Xsum/N0)
580  SUBEXIT
590  SUBEND
600  SUB Plot(E(*),F(*),Xmin,Ymin,Xmax,Ymax,Slope,Inter,R,N0,Var$,Ana$,Ncount(*)
)
610  REM
620  REM PLOTTING OF DATA & REGRESSION FUNCTION
630  REM
640  PLOTTER IS 13,"GRAPHICS"
```

```
650  DEG
660  GRAPHICS
670  Xstep=(Xmax-Xmin)/10
680  Ystep=(Ymax-Ymin)/10
690  X1=100*MAX(1,1*RATIO)
700  Y1=100*MAX(1,1/RATIO)
710  LOCATE .2*X1,.9*X1,.2*Y1,.8*Y1
720  SCALE Xmin,Xmax,Ymin,Ymax
730  AXES Xstep,Ystep,Xmin,Ymin
740  CSIZE 2
750  LDIR -90
760  LORG 2
770  FOR N2=Xmin TO Xmax STEP Xstep
780  MOVE N2,Ymin
790  LABEL USING "MDD.DDD,X";N2
800  NEXT N2
810  LDIR 0
820  LORG 8
830  FOR P2=Ymin TO Ymax STEP Ystep
840  MOVE Xmin,P2
850  LABEL USING "MDDDD.DD,X";P2
860  NEXT P2
870  LORG 5
880  FOR I2=1 TO N0
890  MOVE E(I2),F(I2)
900  IF Ncount(I2)>9 THEN 940
910  LABEL USING 920;Ncount(I2)
920  IMAGE  D
930  GOTO 960
940  LABEL USING 950;Ncount(I2)
950  IMAGE 2D
960  NEXT I2
970  FOR X=Xmin TO Xmax STEP (Xmax-Xmin)/100
980  Y=Inter+Slope*X
990  PLOT X,Y
1000 NEXT X
1010 CSIZE 3,.5
1020 LORG 5
1030 MOVE Xmin+(Xmax-Xmin)/2,Ymax+2.5*Ystep
1040 LABEL USING "K";"GNP PLOT "
1050 MOVE Xmin+(Xmax-Xmin)/2,Ymax+.833*Ystep
1060 CSIZE 2.5
1070 LABEL USING 1080;R
1080 IMAGE "CORRELATION COEFFICIENT",3D.DD
1090 MOVE Xmin+(Xmax-Xmin)/2,Ymin-2.5*Ystep
1100 LABEL USING "K";TRIM$(Var$)
1110 LDIR 90
1120 MOVE Xmin-2.15*Xstep,Ymin+(Ymax-Ymin)/2
1130 LABEL USING "K";TRIM$(Ana$)
1140 DUMP GRAPHICS
1150 SUBEXIT
1160 SUBEND
1170 SUB Find(X(*),N0,Xmin,Xmax,K)
1180 REM
1190 REM FIND MINIMUM & MAXIMUM OF A RANGE OF VALUES
1200 REM
1210 Xmin=X(1)
1220 Xmax=X(1)
1230 FOR I3=1 TO N0
1240 IF X(I3)>Xmin THEN 1260
1250 Xmin=X(I3)
1260 IF X(I3)<Xmax THEN 1280
1270 Xmax=X(I3)
1280 NEXT I3
1290 Xmax=Xmax+(Xmax-Xmin)/K
1300 Xmin=Xmin-(Xmax-Xmin)/K
1310 SUBEXIT
1320 SUBEND
1330 END
1340 SUB Read(Coun$,A(*),I(*),E,Ex(*),Im(*),Gip(*),Gipl(*),N0,An(*),Trendgip(*),
Trendgdp(*),Igip(*),Igdp(*),Rgip(*),Rgip2(*),Rgdp(*),Ncount(*))
```

```
1350 REM
1360 REM READING OF THE DATA AND, EVALUATION OF GROWTH MEASURES AND INDICES OF T
ECHNOLOGY INTEGRATION
1370 FOR I1=1 TO N0
1380 REM
1390 REM READ COUNTRY NAME
1400 REM
1410 READ Coun$,Ncount(I1)
1420 PRINT Coun$
1430 REM
1440 REM IND SECTORS % GDP,GDP CURRENT PRICE % GDP
1450 REM
1460 FOR I=1 TO 6
1470 READ A(I)
1480 NEXT I
1490 REM
1500 REM GIP % GDP CURRENT PRICE
1510 REM
1520 Gipp=(A(1)+A(2)+A(3)+A(4)+A(5))/A(6)
1530 PRINT "GIP % GDP =";Gipp*100
1540 REM
1550 REM READ IND SECTORS (CONSTANT PRICE)
1560 REM
1570 S=8
1580 IF Coun$="RWANDA" THEN S=6
1590 FOR I=1 TO 5
1600 FOR J=1 TO S
1610 READ I(J,I)
1620 NEXT J
1630 NEXT I
1640 REM
1650 REM SUM OF IND SECTORS ( GIP CONSTANT PRICE)
1660 REM
1670 MAT Gip=ZER
1680 FOR I=1 TO S
1690 FOR J=1 TO 5
1700 Gip(I)=I(I,J)+Gip(I)
1710 NEXT J
1720 NEXT I
1730 REM
1740 REM TAKE LOG OF GIP(CONSTANT PRICE)
1750 REM
1760 FOR I=1 TO S
1770 Gipl(I)=LOG(Gip(I))
1780 An(I)=I
1790 NEXT I
1800 REM
1810 REM CALL SUB TO CALCULATE TREND USING REGRESSION
1820 REM
1830 CALL Correlation(Gipl(*),An(*),S,Slope,Inter,R)
1840 REM
1850 REM TREND=EXP OF SLOPE - 1
1860 REM
1870 Trendgip(I1)=(EXP(Slope)-1)*100
1880 PRINT "TREND OF GIP =";Trendgip(I1)
1890 REM
1900 REM READ GDP GROWTH
1910 REM
1920 READ Trendgdp(I1)
1930 PRINT "TREND OF GDP =";Trendgdp(I1)
1940 REM
1950 REM READ EXPORT % GDP (CURRENT PRICE)
1960 REM
1970 READ E
1980 N10=8
1990 IF Coun$="ZAIRE" THEN N10=6
2000 REM
2010 REM READ MERCHANDISE IMP. & EXPORT OF GOODS
2020 REM
2030 FOR I=1 TO 2
2040 FOR J=1 TO N10
```

```
2050 READ Ex(I,J)
2060 NEXT J
2070 NEXT I
2080 Mer=0
2090 Exp=0
2100 REM
2110 REM ADD MERCHANDISE IMPORT OVER 8 YEARS ,SAME FOR EXPORT OF GOODS
2120 REM
2130 FOR I=1 TO N10
2140 Mer=Mer+Ex(1,I)
2150 Exp=Exp+Ex(2,I)
2160 NEXT I
2170 REM
2180 REM MERCHANDISE IMPORT % EXPORT OF GOODS
2190 REM
2200 Meri=Mer/Exp
2210 PRINT "MACH. IMP. % TOTAL EXP. =";Meri*100
2220 REM
2230 REM READ MACHINERY & EQUIPEMENT IMPORT % MERCHANDISE IMPORT
2240 REM
2250 READ Im(1),Im(2)
2260 REM
2270 REM MEAN OF MACHINERY & EQUIPEMENT IMPORT
2280 REM
2290 Imp=(Im(1)+Im(2))/2
2300 REM
2310 REM COMPUTATION OF EXPORT % GIP
2320 REM
2330 Igip1=E/Gipp
2340 REM
2350 REM COMPUTATION OF EXP % GDP
2360 REM
2370 Igdp1=E/(100/A(6))
2380 REM
2390 REM COMPUTATION OF IMPORT OF MACHINERY % GIP
2400 REM
2410 Igip(I1)=Igip1*Meri*Imp/100
2420 PRINT "IMP MACHI % GIP =";Igip(I1)
2430 REM
2440 REM COMPUTATION OF IMPORT OF MACHINERY % GDP
2450 REM
2460 Igdp(I1)=Igdp1*Meri*Imp/100
2470 PRINT "IMP MACHI % GDP =";Igdp(I1)
2480 REM
2490 REM COMPUTATION OF RATIO :GIP GROWTH / IMP % GIP
2500 REM
2510 Rgip(I1)=Trendgip(I1)/Igip(I1)
2520 PRINT "RATIO : GROWTH GIP / IMPORTED TECH. % GIP =";Rgip(I1)
2530 REM
2540 REM COMPUTATION OF RATIO ;GDP GROWTH / IMP % GDP
2550 REM
2560 Rgdp(I1)=Trendgdp(I1)/Igdp(I1)
2570 PRINT "RATIO : GROWTH GDP / IMPORTED TECH. % GDP =";Rgdp(I1)
2580 REM
2590 REM COMPUTATION OF RATIO;GIP GROWTH /IMP % GDP
2600 REM
2610 Rgip2(I1)=Trendgip(I1)/Igdp(I1)
2620 PRINT "RATIO : GROWTH GIP / IMPORTED TECH. % GDP =";Rgip2(I1)
2630 PRINT USING 2640
2640 IMAGE /
2650 NEXT I1
2660 SUBEND
```

- APPENDIX 3

Table of ratio
GIP/IT

	Algeria	Bolivia	Burma	Cameroon	Chad	Chile	Colombia	Costa Rica	Dom.Rep.	Ecuador	Egypt	El-Salvador
1. Trend of GIP over the period 1970-1977	6.07	6.74	2.74	4.87	8.22	-1.328	6.23	9.36	10.87	12.20	8.22	7.3
2. Imported technology as a percentage of GIP(1970-1977)	21.85	17.96	11.7	29.45	44	17.91	13.6	30.11	15.99	25.25	22.45	23.5
3. Ratio = $\frac{GIP}{IT}$	.278	.375	.235	.165	.187	-.074	.456	.311	.68	.483	.366	.310
4. GIP as a % GDP	55.51	38	15.8	24.3	12.53	34.50	31.91	31	35.9	38.4	30.10	26.9

	Ethiopia	Ghana	Honduras	Indonesia	Iran	Ivory Coast	Jamaica	Kenya	Madagascar	Malaysia	Mauritius
1. Trend of GIP over the period 1970-1977	2.18	-.41	5.36	12.79	4.58	8.34	-1.19	7.47	.68	9.8	14.46
2. Imported technology as a percentage of GIP (1970-1977)	17.25	11.98	32.97	16.04	15.05	30.90	16.02	38.20	20.22	31.55	19.33
3. Ratio = $\frac{GIP}{IT}$	.127	-.035	.163	.797	.304	.270	-.074	.196	.034	.311	.748
4. GIP as % GDP	19.02	23.2	28.18	35.6	56.27	29	44.7	23.64	25.7	33.8	30.95

	Morocco	Nicaragua	Nigeria	Pakistan	Paraguay	Peru	Philippines	Rwanda	Senegal	Sierra Leone	Somalia
1. Trend of GIP over the period (1970-1977)	8.1	7.02	10.48	3.94	8.90	5.42	8.99	-.401	3.29	-1.62	5.8
2. Imported technology as a percentage of GIP(1970-1977)	24.09	25.86	18.65	16.97	16.88	16.96	15.31	13.51	25.81	19.76	21.02
3. Technology Integration Ratio = $\frac{GIP}{IT}$	.338	.272	.562	.233	.528	.320	.587	-.03	.128	-.082	.276
4. GIP as % GDP	31.5	33	40.93	27.01	25.6	30.34	37.3	15.3	29.8	32.01	29.01

	Sri Lanka	Sudan	Syria	Tanzania	Thailand	Tunisia	Uganda	Upper Volta	Uruguay	Zaire	Zambia
1. Trend of GIP over the Period (1970-1977)	3.18	4.03	10.36	3.9	9.28	8.47	-4.73	1.34	2.87	-.29	-4.73
2. Imported technology as a percentage of GIP (1970-1977)	9.49	12.90	22.09	40.69	20.2	26.76	36.21	29.36	31.53	28.19	36.21
3. Technology Integration Ratio = $\frac{GIP}{IT}$	.335	.313	.469	.096	.459	.317	-.131	.046	.09-	-.011	-.131
4. GIP as a Percentage of GDP	27.28	22.6	34.10	21.45	31.4	30.55	11.08	24.32	35.16	33.90	11.08

APPENDIX 4

The list of data that follows corresponds respectively to the list of variables provided in Appendix 5. That is the first value (15401.38) represents the value for the variable population for the country Algeria, the second value (720.16) represents the value of GNP/Capita, etc. The last value represents the variable:

$$\frac{\text{GIP. GROWTH}}{\text{IT \% GIP}}$$

that is the measure of technological integration. The countries, for which a list is provided in Appendix 7, are reported at the end of their corresponding set of data.

DATA FOR THE 41 COUNTRIES

15401.380	720.160	11091.500	6186.220	46.200	38.670
21.800	3.425	10.150	13.100	37.050	2.700
37.200	74.150	2125.000	602.000	6.450	6.500
51.400	48.500	14.500	54.500	6725.000	77.000
15.000	30.500	42.500	16.300	198.000	14.450
.278					ALG

4710.130	415.190	1955.590	754.920	20.700	17.490
38.000	3.200	17.200	13.500	16.000	3.100
39.800	69.100	2128.500	294.000	4.150	4.500
29.200	45.500	17.000	50.000	2210.000	33.500
27.000	51.500	58.000	22.050	78.000	2.800
.375					BOL

29227.500	103.590	3027.600	488.020	11.300	9.240
15.800	1.500	42.800	10.000	2.850	1.600
54.800	74.600	2189.000	59.000	3.850	43.500
24.000	39.500	16.000	50.500	7190.000	17.500
21.500	67.000	57.500	17.200	18.500	1.100
.235					BUR

7310.000	235.300	1720.030	431.140	18.600	13.750
24.300	3.400	32.800	12.350	7.250	4.500
44.500	58.350	2419.500	106.500	6.800	15.500
23.750	42.550	20.500	44.000	19970.000	26.000
13.000	12.000	74.850	6.150	48.000	6.900
.165					CAM

3912.380	101.380	396.630	50.320	13.500	38.000
12.500	2.400	52.750	7.600	3.450	3.700
38.000	62.300	1946.000	24.000	6.800	3.000
12.900	44.900	22.500	42.500	52020.000	26.500
2.500	11.000	88.550	4.950	16.500	1.250
.187					CHA

22890.130	499.760	11439.590	3714.190	20.300	19.200
31.900	3.300	30.300	18.800	7.900	11.900
36.400	75.400	2229.000	663.000	4.550	20.500
62.650	33.000	9.500	60.250	1995.000	63.500
29.000	77.000	34.450	22.000	112.000	13.750
.456					COL

1894.000	895.900	1696.840	546.980	23.800	13.590
31.000	5.700	22.300	18.900	6.750	19.050
51.250	63.550	2485.000	513.000	3.750	37.500
40.500	34.900	6.500	68.500	1590.000	75.500
35.500	88.000	33.400	28.700	73.000	26.700
.311					COS

4507.040	604.040	2722.410	1006.950	22.000	15.380
35.900	1.700	22.000	18.650	9.000	10.700
36.500	66.350	2046.000	381.500	7.100	93.000
42.850	41.000	10.500	58.500	1985.000	46.000

21.500	67.100	59.600	15.000	39.000	13.000
.680					DOM
6615.880	493.320	3263.740	1288.580	25.600	22.430
38.400	4.000	23.950	16.600	12.650	1.650
40.700	67.150	2091.500	368.000	4.300	23.000
40.700	42.000	11.500	57.800	2220.000	37.000
34.000	70.950	48.500	23.000	279.000	5.700
.483					ECU
35063.250	266.830	9355.820	2757.740	20.400	12.360
30.100	4.900	29.800	22.750	5.850	25.600
29.650	53.850	2661.000	371.000	3.050	36.000
43.100	38.000	14.000	53.000	1550.000	66.000
37.000	44.000	52.700	22.400	135.000	5.200
.366					EGY
3837.380	421.540	1617.630	436.670	19.300	16.040
26.900	5.800	30.850	16.700	4.850	26.100
56.300	67.850	1937.000	232.000	3.150	183.000
39.500	41.500	10.500	60.500	3744.000	47.000
21.000	61.000	50.700	13.850	232.000	10.500
.310					ELS
27780.000	88.020	2445.220	469.730	10.600	9.230
19.021	2.300	53.850	9.350	5.100	1.600
43.500	76.500	1846.500	26.000	6.550	23.000
10.800	49.500	25.500	38.500	87925.000	6.000
5.000	8.000	82.500	6.400	6.500	1.900
.127					ETH
9583.880	535.620	5133.360	1203.850	8.900	7.920
23.200	2.800	42.350	10.400	8.050	2.600
41.450	87.350	2111.000	170.000	4.850	40.000
30.600	48.500	18.500	46.500	11575.000	35.000
30.000	30.000	56.200	17.850	92.500	5.600
.000					GHA
2962.880	330.650	979.690	285.380	20.100	11.260
28.187	3.600	32.650	15.050	8.750	8.850
48.200	60.150	2151.000	271.000	5.350	26.000
30.350	48.000	14.000	55.000	3505.000	40.000
13.000	57.000	64.750	13.600	55.500	5.000
.163					HON
31447.750	1223.550	38477.780	21916.880	27.100	37.340
56.274	3.500	14.350	12.900	35.400	2.650
41.800	81.000	2821.000	1281.000	5.000	19.000
43.150	42.500	15.000	51.000	2900.000	43.000
37.000	44.000	43.000	30.100	171.000	14.250
.304					IRA
6208.250	473.020	2936.610	930.040	23.600	16.850
29.000	5.900	25.300	12.500	8.300	5.350
39.350	73.350	2478.500	292.000	8.400	19.500
30.150	49.500	20.500	44.000	15270.000	19.000
14.000	20.000	83.250	3.300	68.500	12.500

.270					IVO
12862.250	201.970	2597.740	639.970	22.200	16.670
23.644	4.600	35.800	12.350	7.500	11.750
39.750	53.050	2191.000	138.000	6.800	22.000
11.000	50.500	14.500	52.500	8335.000	16.000
12.000	35.000	80.500	8.000	38.000	8.150
.196					KEN
7418.000	183.270	1359.470	358.430	14.600	8.760
25.700	2.400	34.000	13.550	5.400	5.100
47.500	50.650	2473.000	73.500	4.700	13.000
15.650	45.000	20.000	44.000	11085.000	18.500
12.500	44.500	86.700	4.350	96.000	6.200
.034					MAD
11827.000	517.970	6126.030	2111.470	23.100	24.210
33.800	5.900	30.250	14.950	13.050	7.900
30.250	57.200	2570.500	601.000	4.150	36.000
28.500	30.800	6.400	65.500	4443.500	62.000
39.500	57.500	48.700	17.350	118.000	16.220
.311					MAL
866.880	508.230	440.570	143.070	23.000	25.230
30.952	3.900	24.000	17.150	9.600	2.300
40.900	77.800	2501.500	303.500	2.950	425.000
44.050	27.500	7.000	65.500	3320.000	60.500
41.000	80.000	32.150	24.800	113.500	19.050
.748					MAU
16598.880	430.400	7144.120	2196.720	23.900	16.970
31.500	5.700	18.400	16.050	14.050	14.850
28.950	33.350	2506.500	236.500	4.200	37.500
36.000	46.500	15.000	53.500	11875.000	53.000
15.000	24.500	54.950	18.200	76.000	17.600
.338					MOR
2149.880	599.620	1289.100	442.020	22.100	13.280
33.000	2.600	23.850	20.000	5.800	15.900
49.550	56.350	2451.500	479.000	4.350	16.500
48.700	47.150	14.900	52.700	1800.000	70.000
19.500	55.000	47.650	14.750	57.500	16.500
.272					NIC
72388.250	281.380	20368.380	9176.190	24.100	25.180
40.931	3.800	41.200	8.000	25.200	.800
42.000	80.900	2317.500	79.500	4.650	79.000
17.200	50.500	19.000	45.500	17670.000	16.290
7.000	65.886	59.050	15.900	51.000	1.550
.562					NIG
67376.380	157.360	10602.020	2830.380	16.200	9.330
27.015	.500	34.700	15.750	7.100	56.100
33.200	24.550	2262.000	134.000	4.050	84.000
25.650	46.000	16.500	49.500	4045.000	25.000
15.500	20.500	58.450	19.350	15.000	2.900
.233					PAK

2548.130	469.070	1195.250	309.170	21.400	17.270
25.600	1.500	33.100	16.900	5.000	11.100
28.700	37.650	2808.500	170.000	3.150	6.500
37.500	40.000	9.000	62.000	1765.000	12.000
18.500	79.500	52.000	19.100	69.500	7.000
.528					PAR
14892.500	665.140	9905.640	2625.630	16.500	10.070
30.348	7.600	20.300	19.200	12.100	1.400
37.800	54.050	2297.000	632.500	4.750	12.000
60.100	40.950	13.350	54.350	1750.000	41.000
39.500	72.000	42.400	20.050	132.500	17.300
.320					PER
40595.880	315.070	12790.630	4787.500	26.900	23.030
37.300	1.800	27.750	23.600	8.500	15.300
33.200	47.650	2136.000	321.500	3.650	135.500
32.000	39.000	10.000	58.500	3150.000	39.000
53.000	84.500	52.950	15.300	41.500	8.450
.587					PHI
3959.130	105.540	417.830	64.400	12.400	3.860
15.306	2.000	59.500	8.850	5.600	1.100
48.700	68.350	2245.500	14.500	5.400	152.000
3.450	51.000	20.500	44.000	48625.000	35.000
2.000	23.000	92.600	2.300	12.000	1.300
.000					RWA
4800.380	286.000	1372.900	418.550	17.700	8.710
29.800	3.500	26.300	14.550	8.200	14.700
37.600	48.500	2262.000	157.000	2.900	24.500
23.950	47.650	23.000	41.000	16545.000	37.000
10.500	10.000	78.350	7.800	69.000	9.100
.128					SEN
2941.250	174.740	513.960	169.230	14.200	7.870
32.011	3.200	34.050	5.550	19.400	61.400
43.400	36.000	2177.000	118.500	5.550	41.500
19.650	46.000	20.500	44.000	17110.000	12.000
10.000	15.000	69.750	16.400	19.000	7.600
.000					SIE
3384.250	85.810	290.420	84.550	28.700	5.310
29.015	4.800	27.150	8.400	13.850	2.100
37.300	28.300	2204.000	67.500	5.200	4.500
25.000	47.500	21.000	41.500	18350.000	24.000
3.500	27.500	83.850	6.450	19.500	2.550
.276					SOM
13282.500	163.160	2167.210	593.860	16.300	14.120
27.281	3.200	36.600	13.700	6.350	7.050
25.100	77.700	2230.000	133.500	4.000	203.000
23.100	28.000	6.500	68.000	6230.000	20.500
54.000	77.850	54.550	14.700	38.000	6.900
.335					SRI

15453.500	249.240	3851.620	852.870	13.800	4.530
22.602	1.200	41.350	7.850	7.000	.200
40.800	71.000	2235.500	147.500	6.900	6.500
18.000	45.000	20.000	44.000	11710.000	46.000
10.000	17.500	80.500	8.900	79.000	2.000
.313					SUD
7023.750	548.920	3855.510	1294.840	28.000	16.070
34.100	10.900	20.550	13.050	12.750	25.500
36.950	68.550	2545.500	742.000	4.750	38.000
45.100	46.500	14.000	55.500	3185.000	74.000
44.000	46.500	50.000	21.900	224.000	6.600
.469					SYR
14773.880	143.960	2126.870	463.410	19.700	12.900
21.454	3.100	45.550	9.850	5.800	10.850
42.200	50.950	2089.500	63.500	7.400	15.500
8.050	47.500	17.500	49.000	19583.500	26.000
3.000	47.000	85.000	5.500	15.000	2.600
.095					TAN
39580.250	299.870	11868.750	3744.110	24.800	21.150
31.400	3.600	28.200	17.500	8.900	13.550
38.400	41.350	2103.500	287.000	3.550	76.500
13.500	37.000	10.000	59.000	8395.000	19.500
22.000	80.500	78.450	7.000	104.500	5.700
.459					THA
5479.630	574.790	3149.630	975.670	26.200	19.410
30.556	6.900	18.850	9.900	17.900	25.500
33.400	43.000	2388.500	395.000	3.700	34.000
46.000	35.500	13.000	55.500	5370.000	59.500
21.500	39.500	46.400	22.000	109.000	15.500
.317					TUN
10884.630	215.450	2345.110	243.680	8.400	10.460
11.082	3.094	64.600	6.950	2.950	.450
48.550	90.100	2192.000	65.000	7.400	46.500
8.050	45.000	15.500	51.000	18770.000	28.500
6.500	35.000	84.950	5.300	21.000	2.700
.000					UGA
5171.750	97.480	504.120	116.160	23.400	6.290
24.322	2.500	44.350	12.300	5.700	3.200
37.400	42.250	1933.500	18.000	4.450	19.000
7.150	48.000	23.000	41.000	77279.000	10.000
1.500	5.000	85.400	9.750	16.500	1.300
.046					UPP
23439.380	121.260	2842.260	1048.360	26.400	15.440
33.900	5.524	20.900	8.100	22.050	6.600
40.800	80.050	2276.500	76.000	5.200	10.000
32.600	46.000	20.000	44.000	30040.000	13.500
11.000	14.000	77.650	11.900	52.500	3.250
.000					ZAI
4617.750	440.470	2033.980	1112.030	31.300	30.140

```
   55.600      5.800     12.050     13.950     33.750       .300
   38.100     97.050   1968.000    489.000      5.400      6.500
   32.000     50.000     18.500     45.750  11945.000     39.500
   13.500     43.150     70.900      9.900     19.000     16.000
     .130                                               ZAM
```

APPENDIX 5

List of Variables

X1	Population
X2	GNP/Cap
X3	Gross National Product
X4	Gross Industrial Product
X5	Gross Domestic Investment
X6	Gross National Saving
X7	GIP as % GDP
X8	Education Expenditure
X9	Agricultural Production
X10	Production of Manufacture
X11	Industrial Production
X12	Export of Manufactured Goods
X13	Import of Manufactured Goods
X14	Commodity Concentration
X15	Food Consumption/Cap.
X16	Energy Consumption/Cap.
X17	Urban Population Growth
X18	Population Density
X19	Urban Population as % of Total
X20	Birth Rate
X21	Death Rate
X22	Life Expectancy
X23	Population per Physician
X24	Access to Water
X25	Adjusted School Enrolment Ratio
X26	Adult Literacy Rate
X27	Labour Force in Agriculture (% total)
X28	Labour Force in Industry (% total)
X29	Radio Receivers per Thousand
X30	Passenger Cars per Thousand

APPENDIX 6

List of countries

1. Algeria
2. Bolivia
3. Burma
4. Cameroon
5. Chad
6. Chile
7. Colombia
8. Costa Rica
9. Dominican Republic
10. Ecuador
11. Egypt
12. El Salvador
13. Ethiopia
14. Ghana
15. Honduras
16. Indonesia
17. Iran
18. Ivory Coast
19. Jamaica
20. Kenya
21. Madagascar
22. Malaysia
23. Mauritius
24. Morocco
25. Nicaragua
26. Nigeria
27. Pakistan
28. Paraguay
29. Peru
30. Philippines
31. Rwanda
32. Senegal
33. Sierra Leone
34. Somalia
35. Sri Lanka
36. Sudan
37. Syria
38. Tanzania
39. Thailand
40. Tunisia
41. Uganda
42. Upper Volta
43. Uruguay
44. Zaire
45. Zambia

APPENDIX 7

Percentage of the mining sector.	Mining
1. Algeria	27.7
2. Bolivia	12.1
3. Burma	0.9
4. Cameroon	0.3
5. Chad	0.7
6. Chile	6.3
7. Colombia	1.4
8. Costa Rica	
9. Dominican Republic	2.8
10. Ecuador	11.1
11. Egypt	
12. El Salvador	0.2
13. Ethiopia	0.2
14. Ghana	2.3
15. Honduras	2.4
16. Indonesia	17.4
17. Iran	35.3
18. Ivory Coast	0.2
19. Jamaica	10.3
20. Kenya	0.4
21. Madagascar	0.5
22. Malaysia	7.3
23. Mauritius	0.1
24. Morocco	6.3
25. Nicaragua	0.4
26. Nigeria	32
27. Pakistan	0.7
28. Paraguay	0.2
29. Peru	6
30. Philippines	2.2
31. Rwanda	2
32. Senegal	2.8
33. Sierra Leone	14.9
34. Somalia	6.3
35. Sri Lanka	1.3
36. Sudan	0.3
37. Syria	8.5
38. Tanzania	0.8
39. Thailand	1.7
40. Tunisia	8.6
41. Uganda	0.7
42. Upper Volta	0.1
43. Uruguay	
44. Zaire	14.9
45. Zambia	30.2

APPENDIX 8 : CORRELATION MATRIX FOR THE 41 COUNTRIES

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10	X11
X 2	-.12546										
X 3	.64164	.51939									
X 4	.50231	.57267	.97164								
X 5	.01510	.44402	.28052	.33976							
X 6	.12661	.48486	.46540	.54541	.59601						
X 7	.15940	.55708	.51574	.55090	.52399	.42406					
X 8	-.22168	.34086	-.00258	-.00485	.38613	.15168	.31696				
X 9	.09571	-.64062	-.26246	-.29565	-.74569	-.41759	-.72761	-.47512			
X10	.07257	.42171	.16473	.08444	.27726	.14393	.34936	.06869	-.48293		
X11	.15593	.46498	.52993	.61205	.68644	.60139	.66060	.26207	-.60318	-.14755	
X12	.18310	-.04845	-.02745	-.08464	-.05078	-.10648	.06472	.06468	-.12581	.13388	-.06224
X13	-.17554	-.02211	-.16349	-.09631	-.29627	-.22657	-.22952	-.11146	.28108	-.24726	-.16667
X14	-.05121	.23065	.13053	.18738	-.04628	.29701	.12454	.07615	.07762	-.19339	.25665
X15	.03571	.46303	.34031	.35302	.15100	.09873	.26773	.29661	-.32559	.25936	.10687
X16	.00168	.88345	.62584	.65585	.49617	.52304	.64156	.43124	-.65296	.44665	.52356
X17	-.14804	-.15945	-.11068	-.06104	-.09170	.00701	-.26670	-.10316	.30665	-.51176	.04667
X18	.02631	-.01858	-.06303	-.06295	-.07089	.06651	-.01562	-.06850	.05603	.21423	-.16512
X19	-.09335	.71947	.26183	.24176	.45400	.32665	.45066	.41415	-.73512	.59946	.31647
X20	.02537	-.25724	-.06466	-.01761	-.06947	-.18044	-.09962	-.06011	.19252	-.45157	.16626
X21	.01409	-.49013	-.14709	-.10051	-.26211	-.26656	-.24013	-.19625	.35756	-.63641	.04435
X22	-.06312	.48413	.09076	.05417	.24885	.28123	.19603	.21259	-.33762	.62043	-.07356
X23	-.03148	-.51289	-.23075	-.18956	-.26058	-.19062	-.40616	-.22947	.58167	-.49298	-.17352
X24	-.19134	.63832	.13024	.12837	.41603	.24060	.22921	.41248	-.49116	.46975	.19140
X25	.06822	.51259	.29975	.24826	.17105	.24232	.40276	.30674	-.44642	.62779	.04171
X26	.09711	.40146	.18560	.13167	.16927	.22641	.30698	.08592	-.27462	.61722	-.06647
X27	-.08273	-.71861	-.35362	-.32360	-.34598	-.36660	-.42303	-.27516	.57668	-.59124	-.25629
X28	.13407	.68864	.42707	.41356	.27615	.29542	.49811	.25237	-.54321	.44908	.30663
X29	-.08951	.57714	.29312	.30257	.40882	.35945	.30589	.46216	-.49711	.35497	.26936
X30	-.27466	.75474	.13636	.15869	.41467	.34308	.42681	.42712	-.64604	.52192	.26605

	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22
X13	-.11496										
X14	-.54417	.31395									
X15	.10545	-.24212	-.14808								
X16	.01067	-.14468	.20846	.44775							
X17	-.25714	.17003	.26995	-.28679	-.16221						
X18	.05248	.02056	.14861	.01476	-.08394	-.34618					
X19	.11256	-.18881	.08911	.36907	.71888	-.34495	.04586				
X20	-.06876	.28340	.00461	-.30909	-.28349	.50032	-.49955	-.39474			
X21	-.11277	.22640	-.01259	-.32475	-.45745	.45649	-.43606	-.53237	.78127		
X22	.11774	-.21130	.02127	.30321	.43345	-.45521	.44785	.51895	-.78074	-.99027	
X23	-.23066	.11463	.03461	-.46109	-.46589	.32641	-.12125	-.60221	.40570	.67550	-.62325
X24	.09288	-.06090	.12179	.32693	.65024	-.25303	.12437	.69774	-.34076	-.50415	.51707
X25	.07428	-.32399	.14635	.36672	.58320	-.50142	.37676	.58660	-.70170	-.74459	.73531
X26	-.07498	-.02164	.10777	.20192	.36171	-.47169	.37668	.44864	-.64242	-.85604	.62615
X27	-.17825	.16493	-.10629	-.39566	-.66768	.54699	-.28273	-.64455	.59063	.73966	-.74293
X28	.25695	-.18736	.04805	.44471	.65432	-.56007	.16677	.72093	-.49669	-.59886	.59677
X29	.00639	-.01663	.14530	.25616	.59789	-.31251	.06659	.60507	-.24768	-.42069	.42109
X30	.08938	-.08438	.04252	.38229	.63295	-.22650	.17055	.67320	-.42004	-.55622	.56723

	X23	X24	X25	X26	X27	X28	X29
X24	-.48955						
X25	-.57706	.47424					
X26	-.61602	.30637	.66874				
X27	.62632	-.67479	-.74567	-.64596			
X28	-.53905	.54704	.68658	.51204	-.90795		
X29	-.44889	.54263	.49670	.31555	-.56547	.51505	
X30	-.46160	.65900	.45126	.39051	-.65869	.50260	.51955

CORRELATION MATRIX FOR THE 45 COUNTRIES

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10	X11
X 2	-.22293										
X 3	.66753	.33354									
X 4	.51652	.40461	.96844								
X 5	.00006	.18974	.20155	.27422							
X 6	.11625	.25081	.42758	.50151	.61737						
X 7	.14104	.55299	.47939	.52520	.44421	.36711					
X 8	-.19777	.29642	-.03002	-.02260	.36241	.14408	.33000				
X 9	.18143	-.71955	-.16618	-.23729	-.54775	-.28941	-.72225	-.45217			
X10	-.11074	.58168	.09101	.04496	.08568	.01569	.35723	.06216	-.57167		
X11	.16127	.37920	.50398	.59061	.64935	.57423	.66346	.31047	-.55236	-.14949	
X12	.03463	-.00494	-.07887	-.12026	-.05228	-.18210	.04439	.03775	-.12590	.16678	-.10013
X13	-.10064	-.20286	-.16351	-.10499	-.17083	-.14378	-.26856	-.09267	.36116	-.36006	-.14502
X14	.02666	.06142	.16420	.20774	-.05991	.27752	.05236	.03775	.13968	-.21469	.20999
X15	-.14055	.62052	.20493	.24301	-.00653	-.01806	.29971	.19769	-.45506	.47148	.06044
X16	-.12093	.91295	.38600	.43744	.22243	.25700	.62032	.37741	-.71266	.54708	.44180
X17	-.13087	-.35548	-.13526	-.08576	.04398	.08654	-.33741	-.06528	.39986	-.54425	.03563
X18	.01623	.02234	-.06941	-.06906	-.01697	.07423	.03609	-.00689	.02624	.14710	-.05355
X19	-.19386	.79230	.17089	.17369	.17043	.12301	.42963	.30397	-.75786	.72219	.21623
X20	.04785	-.51902	-.07418	-.03731	.15702	-.01981	-.20335	-.05501	.37399	-.60354	.15142
X21	.08972	-.58140	-.11042	-.08215	-.15607	-.14570	-.29636	-.20646	.45641	-.67259	.01446
X22	-.16411	.62965	.03362	.02055	.11399	.15963	.26569	.20980	-.47013	.69260	-.04246
X23	.04377	-.50069	-.18814	-.16529	-.22455	-.15121	-.41464	-.22981	.59130	-.50618	-.16719
X24	-.31735	.73860	.02182	.04998	.23242	.15049	.27620	.35880	-.59052	.61607	.15014
X25	-.05550	.66592	.20630	.18568	.03984	.11463	.45034	.28653	-.55867	.64337	.06607
X26	.06428	.53111	.16537	.13973	.04338	.12560	.37014	.08643	-.36963	.65360	-.03091
X27	.02884	-.80431	-.27121	-.26312	-.14822	-.19370	-.46176	-.24022	.66128	-.66736	-.22779
X28	-.03149	.76402	.32057	.33486	.12380	.16766	.51717	.23163	-.62898	.57315	.27211
X29	-.19045	.71141	.13360	.16697	.16948	.16061	.34967	.34998	-.57736	.53517	.19082
X30	-.28753	.82095	.00179	.04084	.10750	.08567	.42257	.28310	-.65930	.62532	.19021

	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22
X13	-.12330										
X14	-.53115	.31183									
X15	.16068	-.35557	-.20862								
X16	.01008	-.27895	.00140	.57001							
X17	-.25383	.29107	.28763	-.44182	-.34668						
X18	.02634	.03191	.07715	-.00043	.03247	-.28217					
X19	.14229	-.33369	.01296	.56845	.73023	-.49144	-.00200				
X20	-.08884	.41176	.08163	-.52005	-.52333	.62975	-.37349	-.60146			
X21	-.11201	.30343	.04978	-.42601	-.55167	.50970	-.41730	-.58643	.77706		
X22	.13549	-.31320	-.07748	.47232	.56987	-.54003	.40852	.62235	-.81177	-.97472	
X23	-.23446	.15636	.06157	-.45796	-.45322	.34502	-.12068	-.56976	.41121	.68158	-.62126
X24	.13882	-.19502	-.00168	.52009	.71124	-.38324	.11434	.76516	-.51277	-.57440	.63185
X25	.09472	-.41126	.00103	.52971	.71224	-.54191	.35165	.66976	-.77140	-.77261	.79666
X26	-.05738	-.15074	.03087	.35230	.56272	-.56449	.34680	.54607	-.71254	-.86155	.64494
X27	-.17576	.30180	.00214	-.55895	-.75114	.54036	-.24542	-.87142	.71927	.76925	-.80133
X28	.25701	-.29987	-.03802	.57811	.71163	-.62923	.15379	.77512	-.62221	-.65734	.68638
X29	.09370	-.19864	-.05554	.52332	.70481	-.48532	.07737	.69486	-.51466	-.49587	.57709
X30	.13342	-.26520	-.16728	.60907	.77444	-.44034	.16049	.72076	-.63461	-.57125	.66956

	X23	X24	X25	X26	X27	X28	X29
X24	-.50025						
X25	-.56751	.60516					
X26	-.61371	.41996	.72485				
X27	.60827	-.74681	-.81180	-.71553			
X28	-.54982	.65089	.75554	.59498	-.92526		
X29	-.42830	.67681	.65470	.45529	-.66556	.63030	
X30	-.39887	.73546	.65142	.51014	-.73051	.62060	.66406

APPENDIX 9

Critical values for the significance of Pearson correlation coefficients

Sample size	Critical values of correlations required for significance	
	at 5% level	*at 1% level*
5	0·755	0·875
10	0·576	0·714
15	0·483	0·605
20	0·425	0·538
25	0·380	0·488
30	0·338	0·440
35	0·320	0·417
40	0·300	0·394
45	0·280	0·370
50	0·262	0·346
60	0·248	0·328
70	0·233	0·308
80	0·220	0·290
90	0·206	0·272
100	0·194	0·255
150	0·158	0·209
200	0·137	0·182
250	0·125	0·163
500	0·088	0·115

Source: D. Child, *Essentials of Factor Analysis*, 1970, p. 95.

APPENDIX 10

Correlation figures

Fig. 1 TECHNOLOGY INTEGRATION AND IND. PROD. % GDP

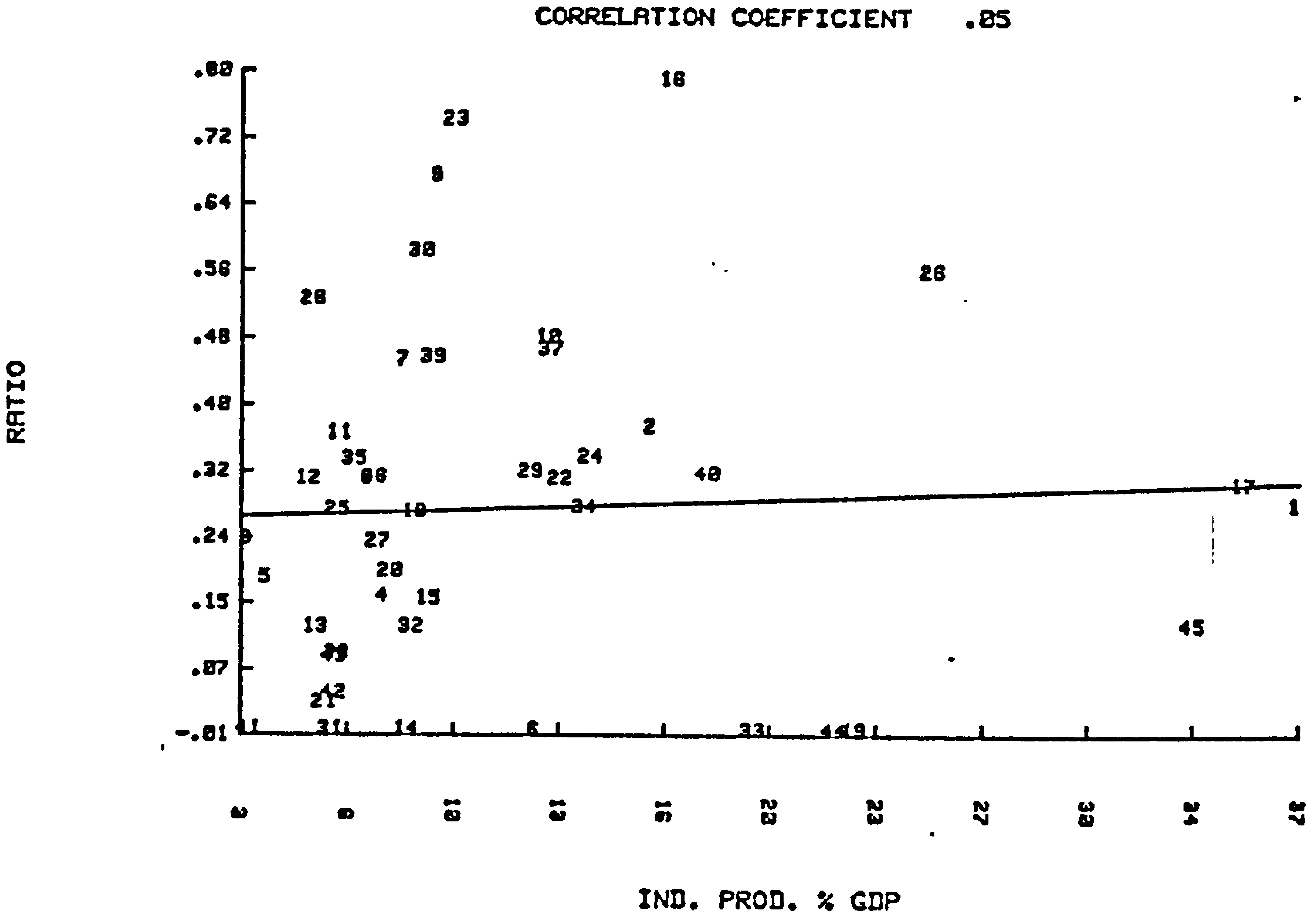


Fig. 2 TECHNOLOGY INTEGRATION AND GDI % GDP

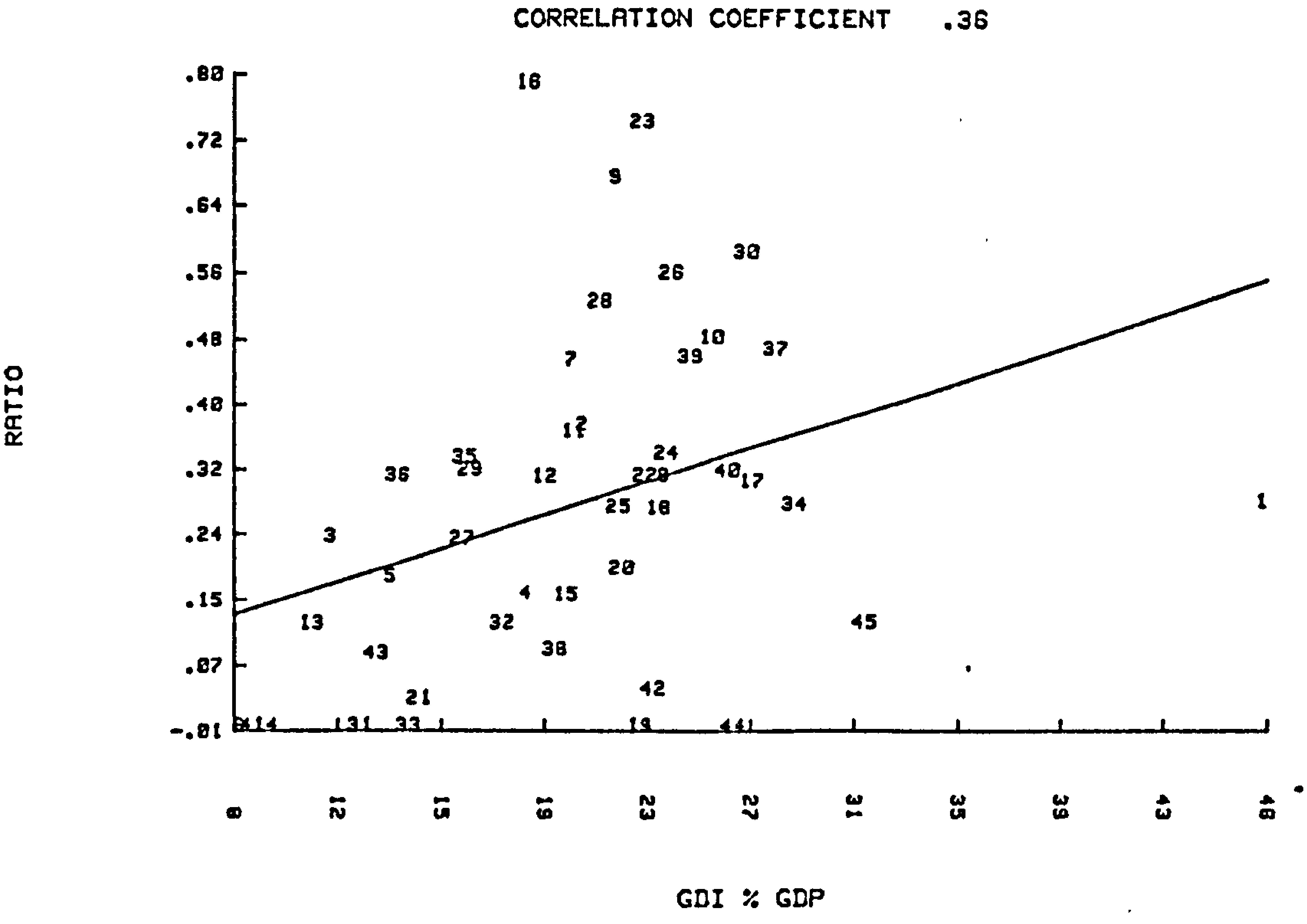


Fig.3 TECHNOLOGY INTEGRATION AND MANU. PROD. % GDP

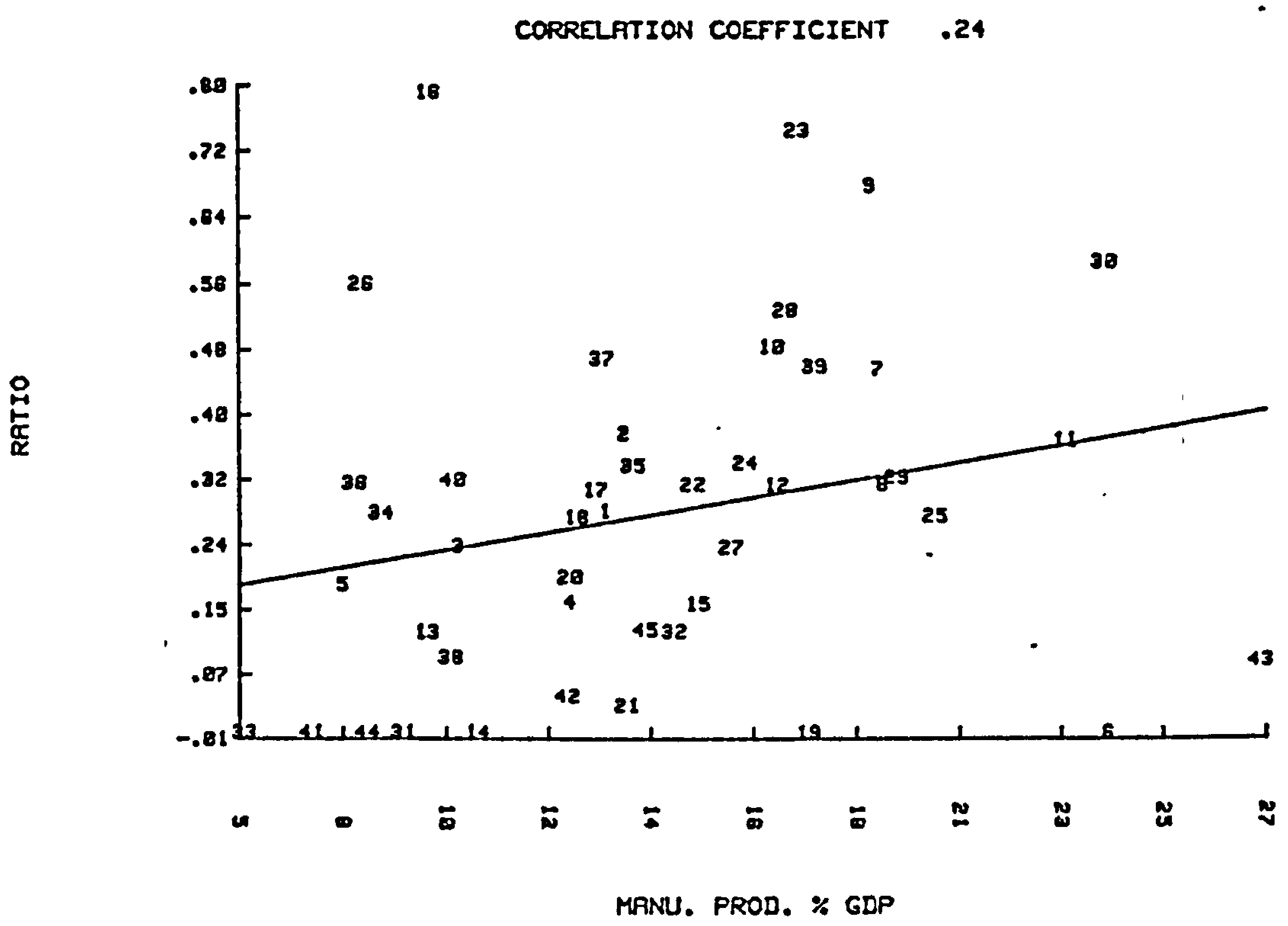


Fig. 4 TECHNOLOGY INTEGRATION AND AGRI. PROD. % GDP

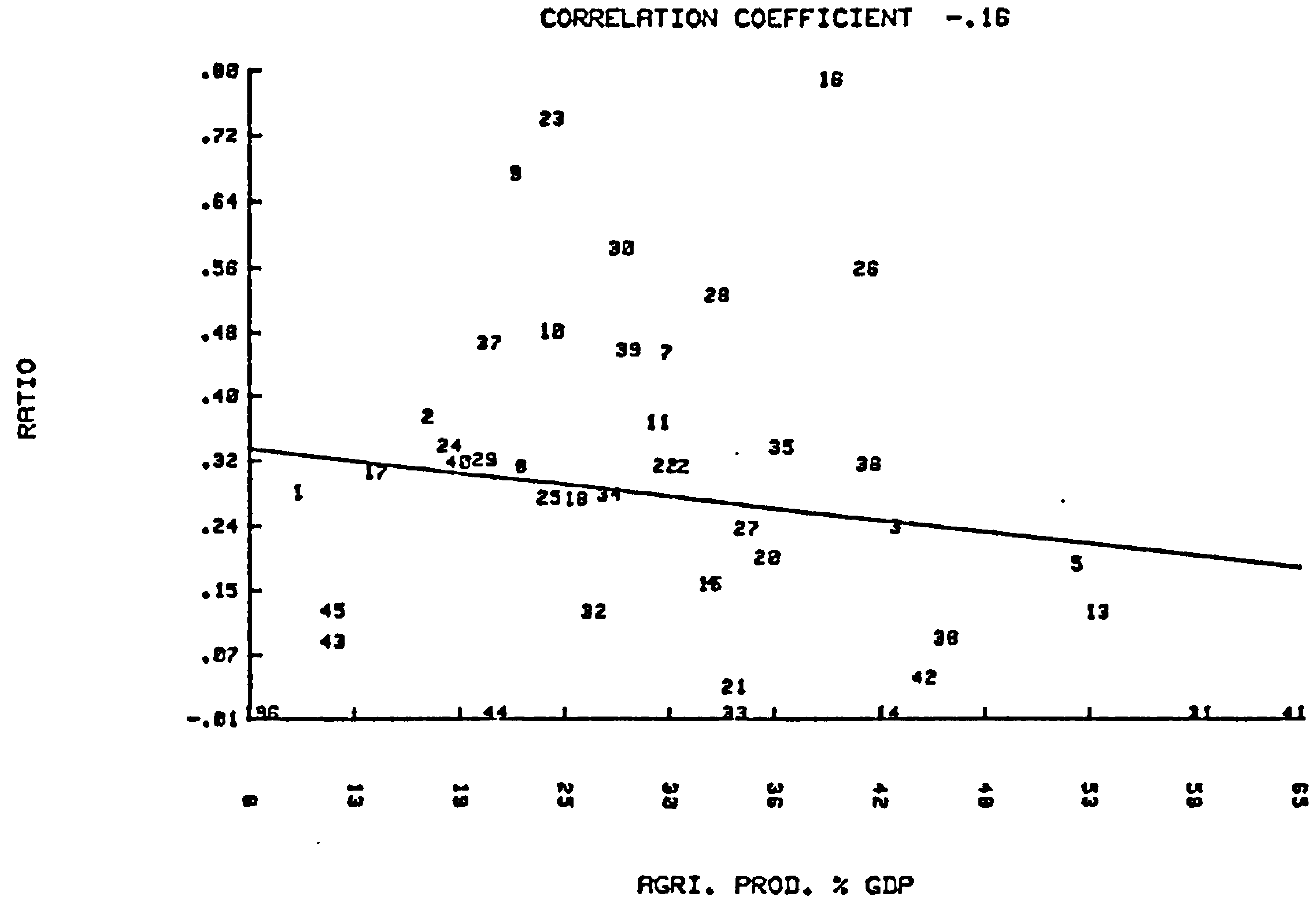


Fig. 5 TECHNOLOGY INTEGRATION AND URBAN POP. GROWTH RATE

CORRELATION COEFFICIENT -.20

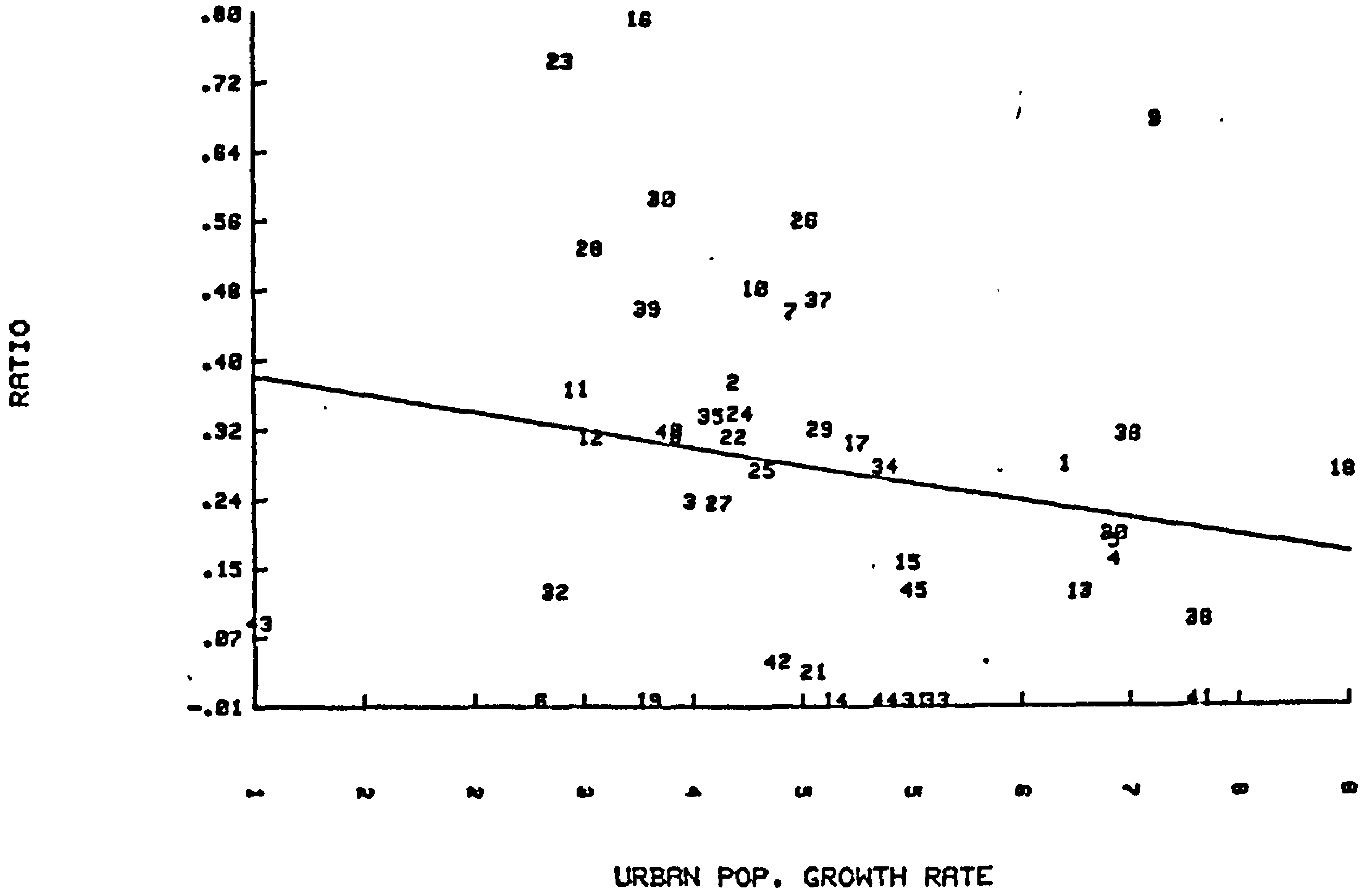


Fig. 6 TECHNOLOGY INTEGRATION AND ACCESS TO WATER % POP.

CORRELATION COEFFICIENT .06

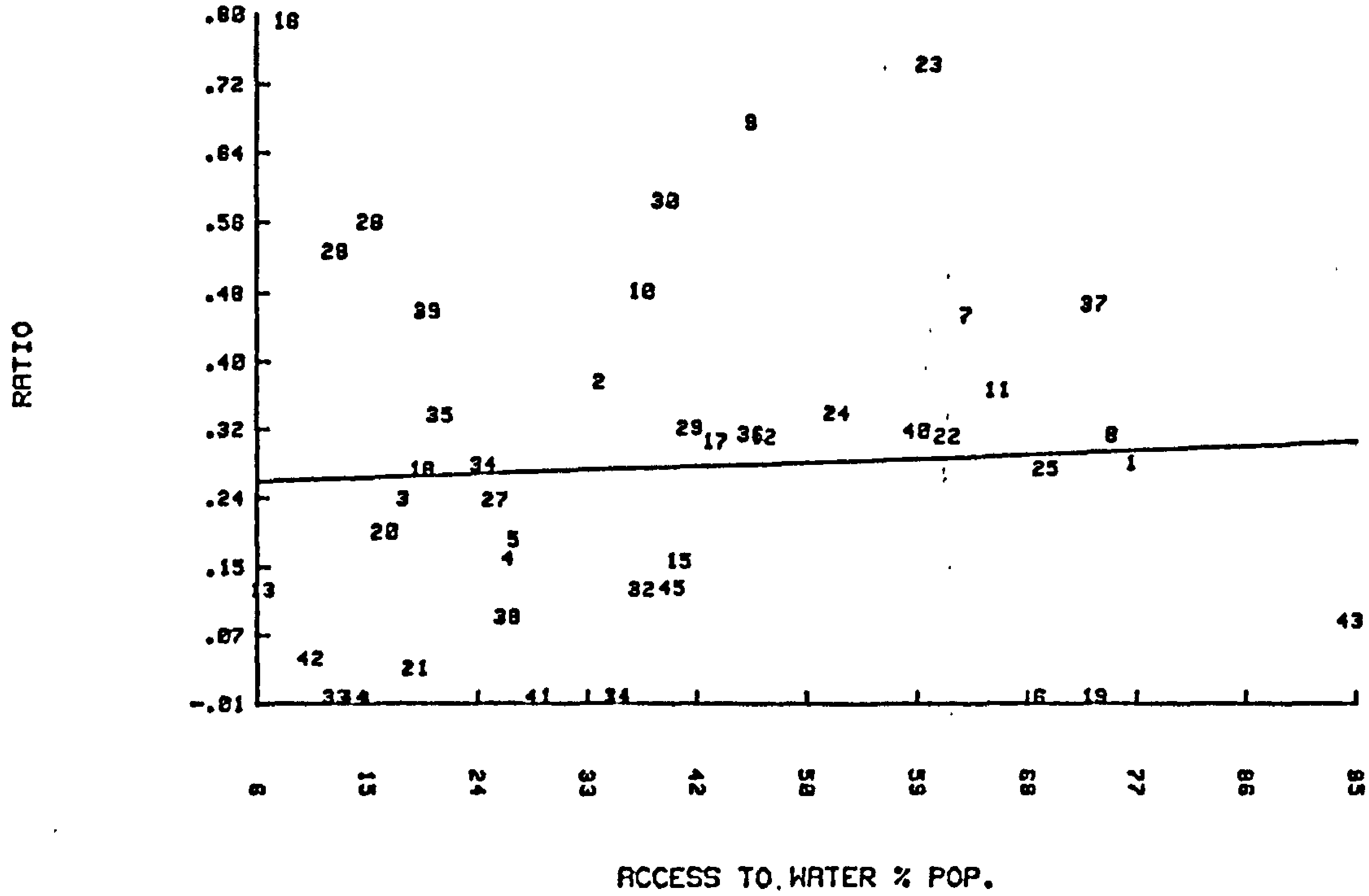


Fig. 7 TECHNOLOGY INTEGRATION AND RADIO PER 000'S

CORRELATION COEFFICIENT .04

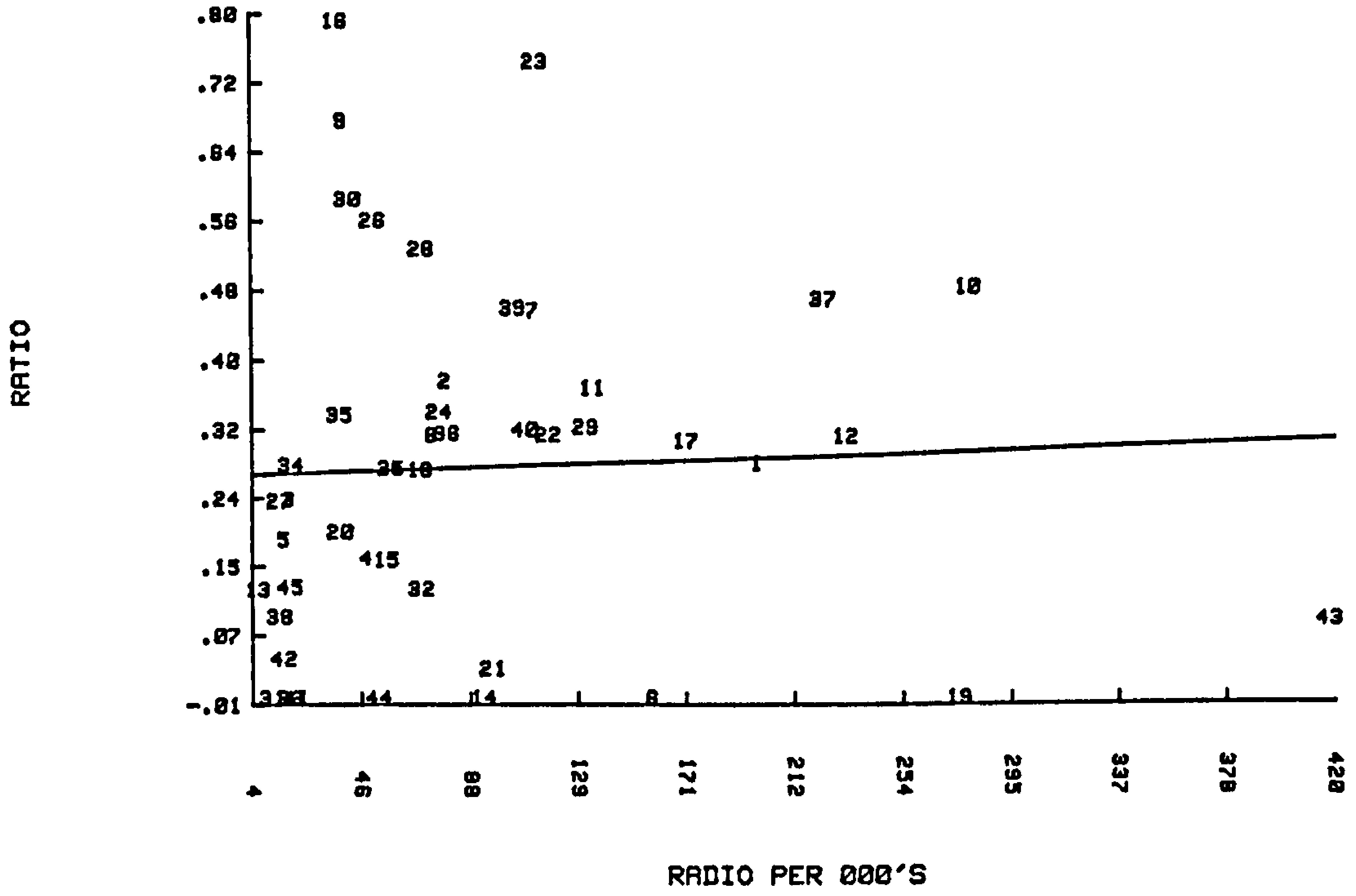


Fig. 8 TECHNOLOGY INTEGRATION AND CAR 000'S

CORRELATION COEFFICIENT -.08

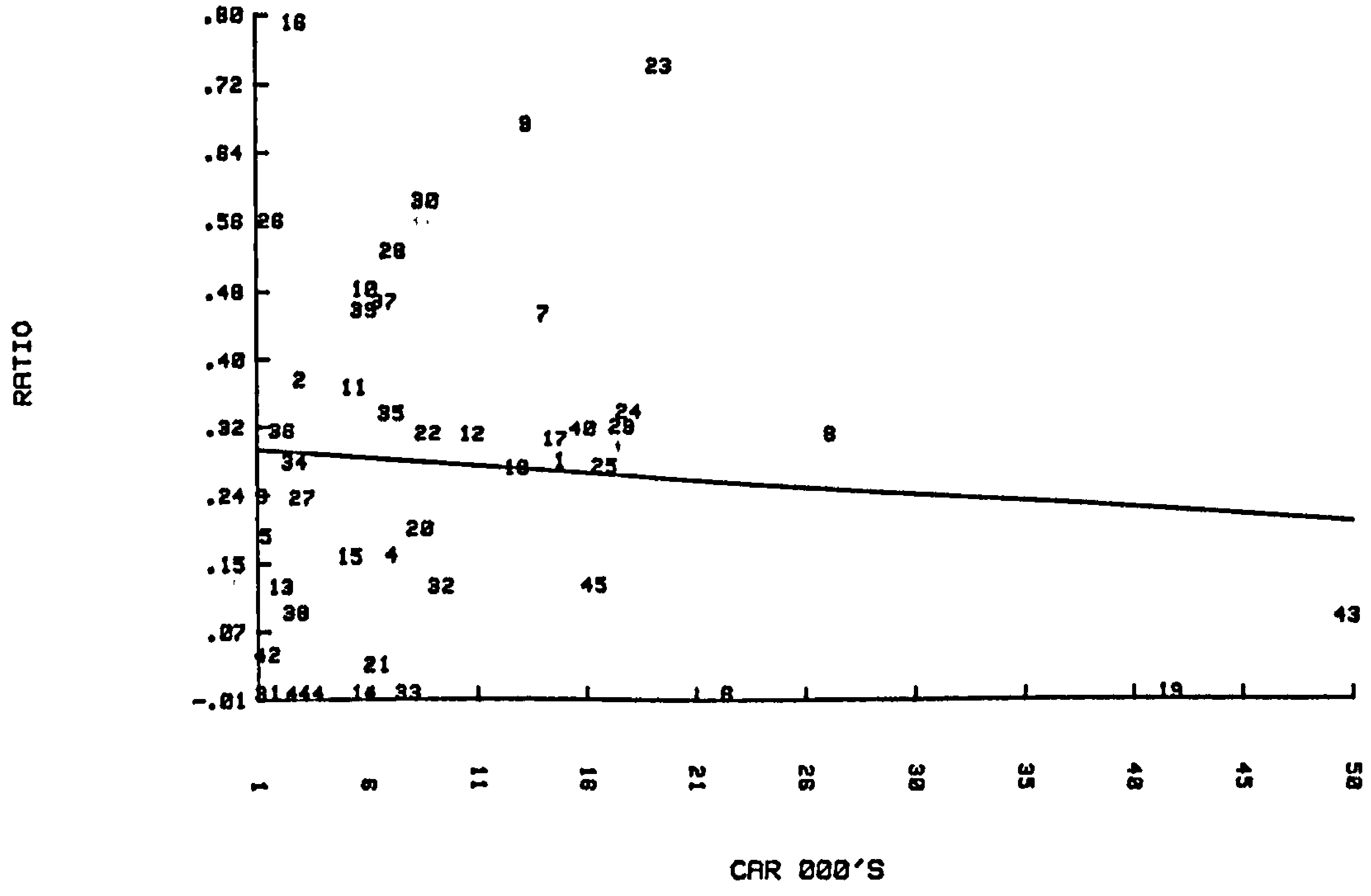


Fig. 9 TECHNOLOGY INTEGRATION AND ADULT LITERACY RATE

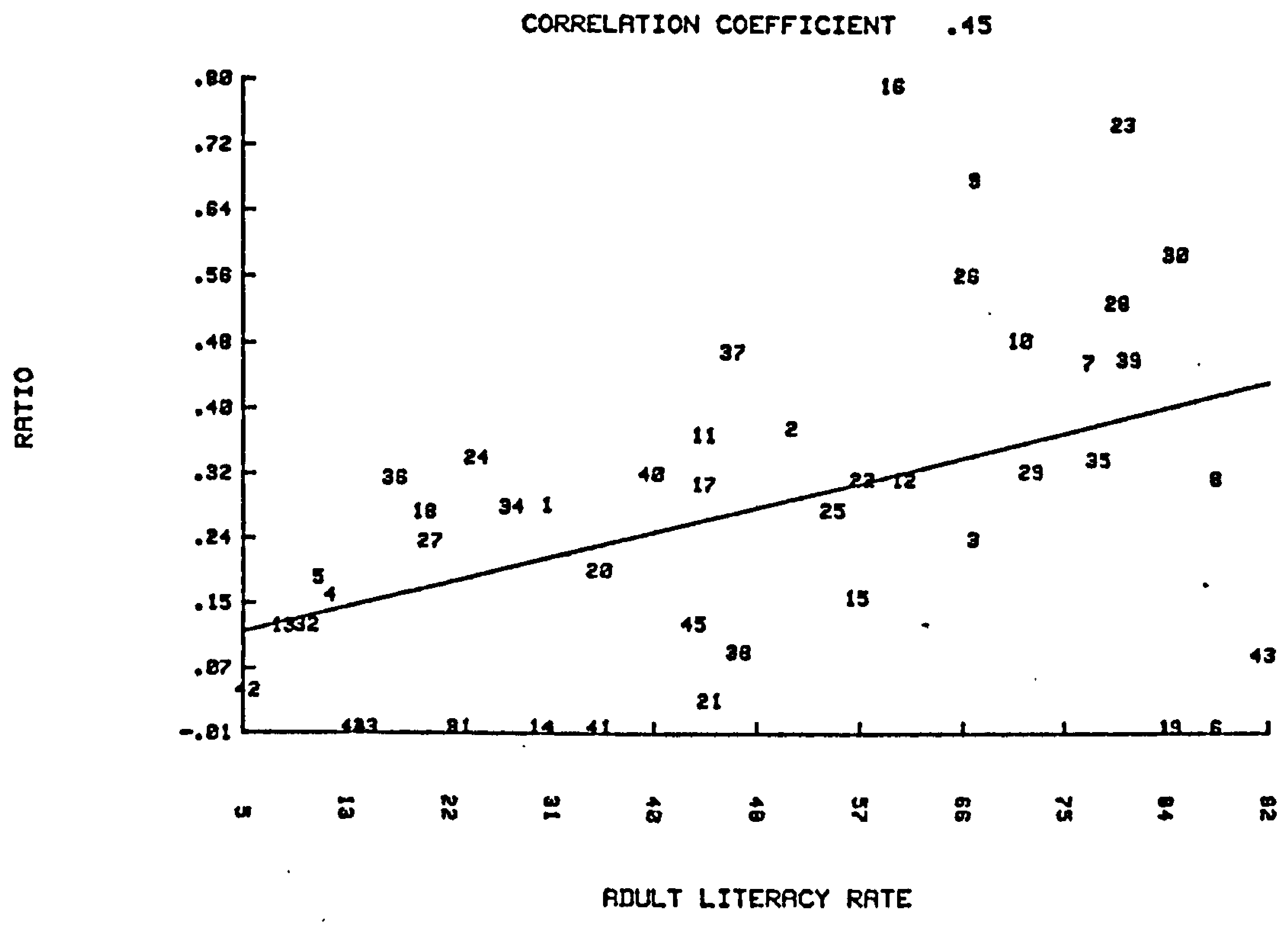
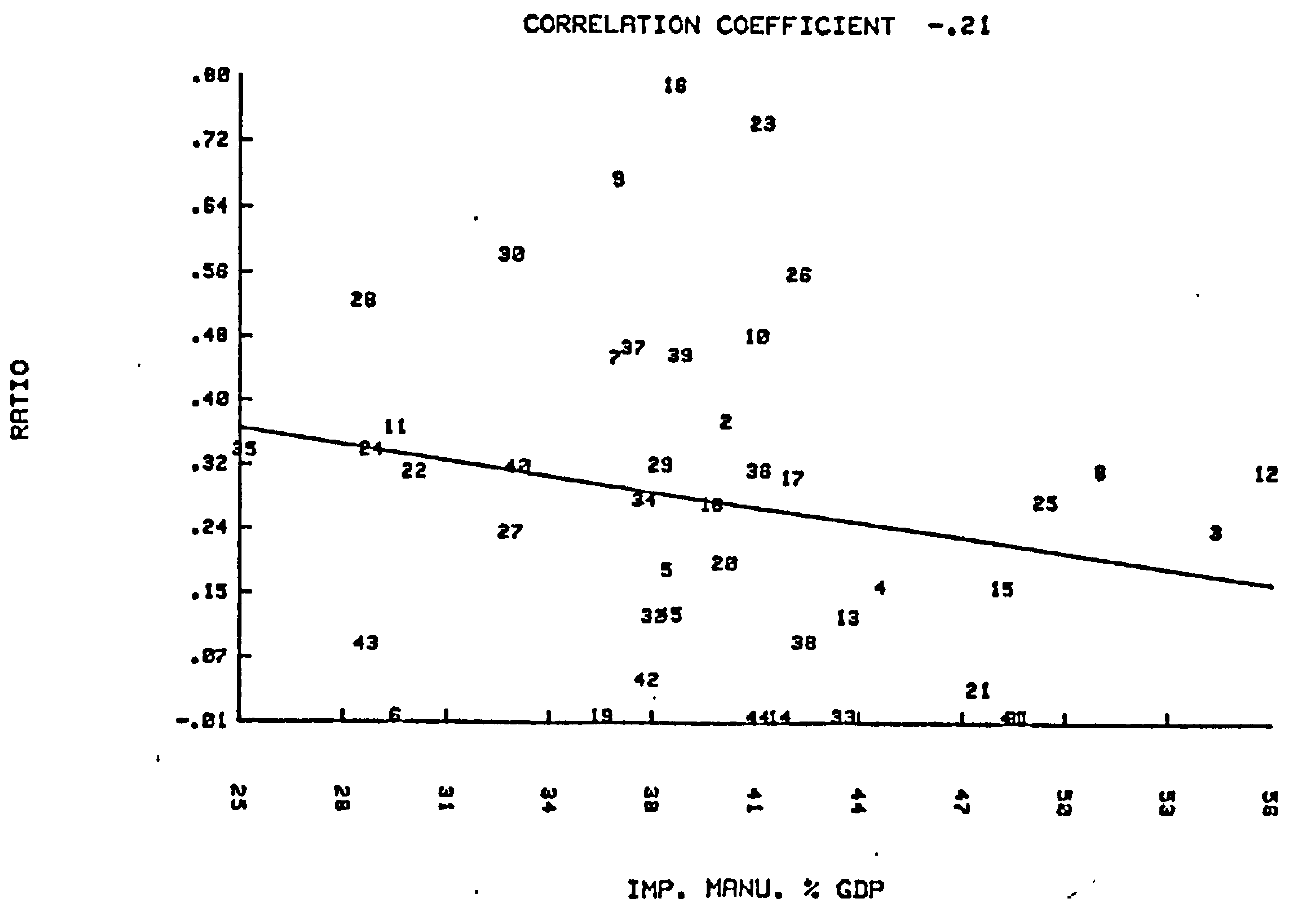


Fig. 10 TECHNOLOGY INTEGRATION AND IMP. MANU. % GDP



APPENDIX 11
MATRIX ALGEBRA

This appendix summarises essentials of matrix algebra used in chapters 3 and 4.

1. Definitions.

Matrix: A matrix is a rectangular array of numbers or elements arranged in rows and columns. More precisely, a matrix of order M by N (written as MXN) is a set of MXN elements arranged in M rows and N columns.

Order: The order of a matrix is the number of rows and columns.

Column Vector:

A matrix consisting of M rows and only one column is called a column vector.

Row Vector:

A matrix consisting of only one row and N columns is called a row vector.

Transposition:

The transpose of an MXN matrix A, denoted by A′ (read as A prime or A transpose) is an NXM matrix obtained by interchanging the rows and columns of A; that is the i^{th} row of A becomes the i^{th} column of A′.

2. Matrix Operations.

Matrix addition:

let A = $[a_{ij}]$ and B = $[b_{ij}]$. If A and B are of the same order, one defines matrix addition as:

$$A + B = C$$

Where C is of the same order as A and B and is obtained as $c_{ij} = a_{ij} + b_{ij}$ for all i and j; that is, C is obtained by adding the corresponding elements of A and B.

Matrix subtraction:

Matrix subtraction follows the same principle as matrix addition except that C = A-B; that is, one subtracts the elements of B from the corresponding elements of A to obtain C, provided A and B are of the same order.

Matrix multiplication:

Let A be MXN and B be NXP. Then the product AB is defined to be a new matrix C of order MXP such that:

$$c_{ij} = \sum_{k=1}^{N} a_{ik}b_{kj} \qquad \begin{array}{l} i = 1,2,\ldots,M \\ j = 1,2,\ldots,P \end{array}$$

That is, the element in the i^{th} row and the j^{th} column of C is obtained by multiplying the elements of the i^{th} row of A by the corresponding elements of the j^{th} column of B and summing over all terms.

Matrix division:

The division of matrix is first performed by calculating the inverse of the divising matrix and then multiplying this inverse matrix by the matrix to be divided. The inverse of A is denoted by A^{-1}. It should be noted that the inverse of A exists only when A is a square matrix and nonsingular, that is ($|A| \neq 0$).

Matrix inversion:

An inverse of a square matrix, denoted by A^{-1} (read A inverse), if it exists, is a unique square matrix such that:

$$AA^{-1} = A^{-1}A = I$$

Where I is an identity matrix whose order is the same as that of A.

example:

$$A = \begin{bmatrix} 2 & 4 \\ 6 & 8 \end{bmatrix}$$

then $$A^{-1} = \begin{bmatrix} -1 & \frac{1}{2} \\ \frac{6}{8} & -\frac{1}{4} \end{bmatrix}$$

for $$AA^{-1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I$$

3 Determinants:

To every square matrix A, there corresponds a number (scalar) known as the determinant of the matrix, which is denoted by det A or by the symbol $|A|$, where $|\ |$ means "the determinant of".

The process of finding the value of a determinant is known as the evaluation, expansion or reduction of the determinant. This is done by manipulating the entries of the matrix in a well-defined manner.

A 2x2 determinant can be evaluated by

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

Its determinant is evaluated as follows:

$$|A| = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} = Q_{11}\ Q_{22} - Q_{12}\ Q_{21}$$

Which is obtained by cross multiplying the elements on the main diagonal and subtracting from it the cross multiplicatior of the elements on the other diagonal of matrix A, as indicated by the arrows.

4 Matrix differentiation.

If $a' = [a_1 a_2 \ldots a_n]$ is a row vector of numbers,

and $x = \begin{bmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_n \end{bmatrix}$ is a column vector of the variables $x_1, x_2, \ldots x$

then the derivative with respect to a is:

$$\frac{\partial(a'x)}{\partial x} = a = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}$$

Considering the matrix x'Ax such that:

$$x'Ax = \left\{x_1 \ x_2 \ \dots \ x_n\right\} \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & & & \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$$

then,

$$\frac{\partial(xAx)}{\partial x} = 2\ A\ x$$

which is a column vector of n elements, or

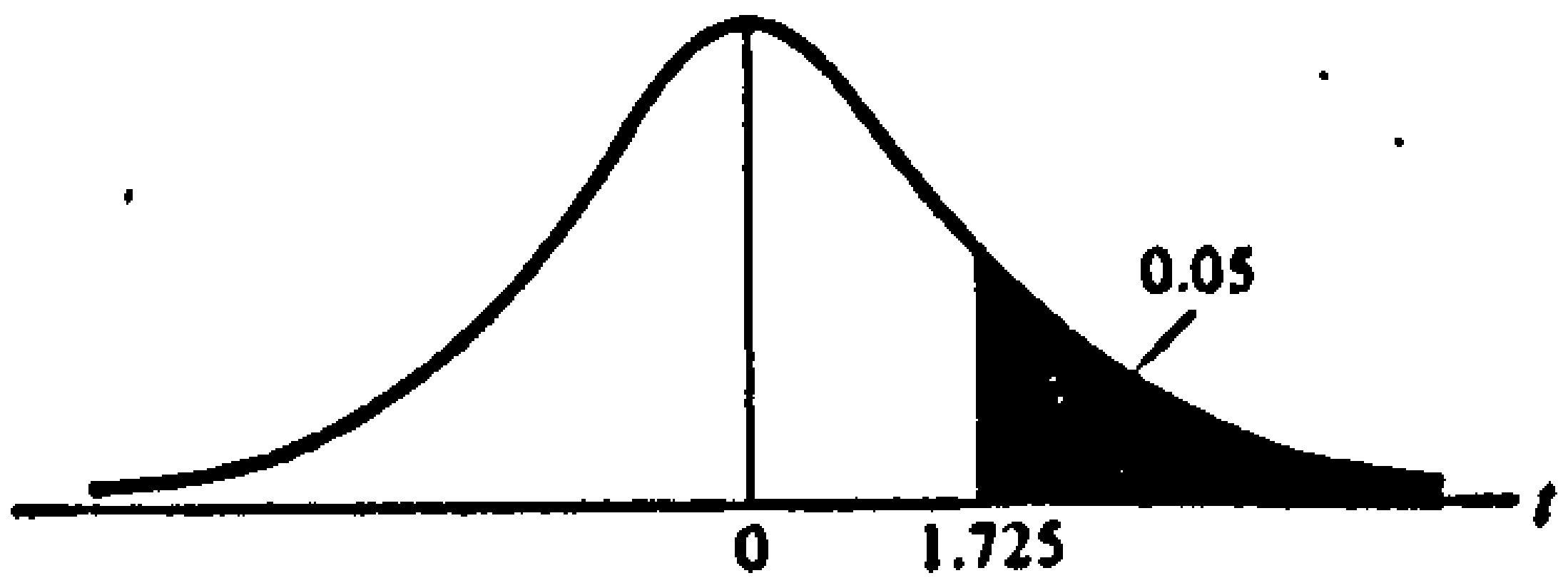
$$\frac{\partial(x'Ax)}{\partial x} = 2\ x'A$$

which is a row vector of n elements.

APPENDIX 12.

Percentage Points of t Distributions

Example
Pr ($t > 2.086$) = 0.025
Pr ($t > 1.725$) = 0.05 for df = 20
Pr ($|t| > 1.725$) = 0.10



Pr / df	0.25 0.50	0.10 0.20	0.05 0.10	0.025 0.05	0.01 0.02	0.005 0.010	0.001 0.002
1	1.000	3.078	6.314	12.706	31.821	63.657	318.31
2	0.816	1.886	2.920	4.303	6.965	9.925	22.327
3	0.765	1.638	2.353	3.182	4.541	5.841	10.214
4	0.741	1.533	2.132	2.776	3.747	4.604	7.173
5	0.727	1.476	2.015	2.571	3.365	4.032	5.893
6	0.718	1.440	1.943	2.447	3.143	3.707	5.208
7	0.711	1.415	1.895	2.365	2.998	3.499	4.785
8	0.706	1.397	1.860	2.306	2.896	3.355	4.501
9	0.703	1.383	1.833	2.262	2.821	3.250	4.297
10	0.700	1.372	1.812	2.228	2.764	3.169	4.144
11	0.697	1.363	1.796	2.201	2.718	3.106	4.025
12	0.695	1.356	1.782	2.179	2.681	3.055	3.930
13	0.694	1.350	1.771	2.160	2.650	3.012	3.852
14	0.692	1.345	1.761	2.145	2.624	2.977	3.787
15	0.691	1.341	1.753	2.131	2.602	2.947	3.733
16	0.690	1.337	1.746	2.120	2.583	2.921	3.686
17	0.689	1.333	1.740	2.110	2.567	2.898	3.646
18	0.688	1.330	1.734	2.101	2.552	2.878	3.610
19	0.688	1.328	1.729	2.093	2.539	2.861	3.579
20	0.687	1.325	1.725	2.086	2.528	2.845	3.552
21	0.686	1.323	1.721	2.080	2.518	2.831	3.527
22	0.686	1.321	1.717	2.074	2.508	2.819	3.505
23	0.685	1.319	1.714	2.069	2.500	2.807	3.485
24	0.685	1.318	1.711	2.064	2.492	2.797	3.467
25	0.684	1.316	1.708	2.060	2.485	2.787	3.450
26	0.684	1.315	1.706	2.056	2.479	2.779	3.435
27	0.684	1.314	1.703	2.052	2.473	2.771	3.421
28	0.683	1.313	1.701	2.048	2.467	2.763	3.408
29	0.683	1.311	1.699	2.045	2.462	2.756	3.396
30	0.683	1.310	1.697	2.042	2.457	2.750	3.385
40	0.681	1.303	1.684	2.021	2.423	2.704	3.307
60	0.679	1.296	1.671	2.000	2.390	2.660	3.232
120	0.677	1.289	1.658	1.980	2.358	2.167	3.160
∞	0.674	1.282	1.645	1.960	2.326	2.576	3.090

APPENDIX 13 : COMPUTER OUTPUTS

```
0* * * * * * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * * * * * * * * * * *
ODEPENDENT VARIABLE..    RATIO

 MEAN RESPONSE           .27822      STD. DEV.       .18986

 VARIABLE(S) ENTERED ON STEP NUMBER   1..   X26

 MULTIPLE R              .68681         ANALYSIS OF VARIANCE     DF       SUM OF SQUARES        MEAN SQUARE           F      SIGNIFICANCE
 R SQUARE                .47170         REGRESSION                1.              .68016             .68016      34.82220            0
 ADJUSTED R SQUARE       .45816         RESIDUAL                 39.              .76177             .01953
 STD DEVIATION           .13976         COEFF OF VARIABILITY     50.2 PCT


 ------------------- VARIABLES IN THE EQUATION --------------------        ---------- VARIABLES NOT IN THE EQUATION ----------

 VARIABLE            B          STD ERROR B         F            BETA          VARIABLE      PARTIAL     TOLERANCE        F
                                               ------------  ----------                                              ------------
                                               SIGNIFICANCE  ELASTICITY                                              SIGNIFICANCE

 X26          .52300185E-02   .88628847E-03    34.822264      .6868069         X13          -.45951       .99953     10.171096
                                                       0        .84337                                                    .003
 (CONSTANT)   .43578431E-01   .45359396E-01    .92301478                       X29           .24099       .90043     2.3429858
                                                    .343                                                                  .134


 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


 VARIABLE(S) ENTERED ON STEP NUMBER   2..   X13

 MULTIPLE R              .76371         ANALYSIS OF VARIANCE     DF       SUM OF SQUARES        MEAN SQUARE    .      F      SIGNIFICANCE
 R SQUARE                .58325         REGRESSION                2.              .84101             .42050      26.59098          .000
 ADJUSTED R SQUARE       .56132         RESIDUAL                 38.              .60092             .01581
 STD DEVIATION           .12575         COEFF OF VARIABILITY     45.2 PCT


 ------------------- VARIABLES IN THE EQUATION --------------------        ---------- VARIABLES NOT IN THE EQUATION ----------

 VARIABLE            B          STD ERROR B         F            BETA          VARIABLE      PARTIAL     TOLERANCE        F
                                               ------------  ----------                                              ------------
                                               SIGNIFICANCE  ELASTICITY                                              SIGNIFICANCE

 X26          .51749693E-02   .79765639E-03    42.090479      .6795778         X29           .26600       .90033     2.8172862
                                                    .000        .83449                                                    .102
 X13         -.91469658E-02   .28680927E-02    10.171096     -.3340651
                                                    .003      -1.31499
 (CONSTANT)   .41190450       .12249065        11.308037
                                                    .002
```

```
VARIABLE(S) ENTERED ON STEP NUMBER   3..   X29

MULTIPLE R            .78278       ANALYSIS OF VARIANCE     DF      SUM OF SQUARES        MEAN SQUARE            F    SIGNIFICANCE
R SQUARE              .61274       REGRESSION                3.            .68353             .29451         19.51426           0
ADJUSTED R SQUARE     .58134       RESIDUAL                 37.            .55840             .01509
STD DEVIATION         .12285       COEFF OF VARIABILITY     44.2 PCT


------------------- VARIABLES IN THE EQUATION --------------------      ---------- VARIABLES NOT IN THE EQUATION ----------

VARIABLE           B           STD ERROR B          F           BETA         VARIABLE      PARTIAL     TOLERANCE        F
                                               ------------  ----------                                            ------------
                                               SIGNIFICANCE  ELASTICITY                                            SIGNIFICANCE

X26         .47403921E-02   .82112642E-03   33.327941      .6225090
                                                 .000        .76441
X13        -.90983792E-02   .26020242E-02   10.543488     -.3322906
                                                 .002      -1.30801
X29         .52313557E-03   .31166817E-03   2.8173682      .1809762
                                                 .102        .14611
(CONSTANT)  .38825165       .12048947       10.383133
                                                 .003

ALL VARIABLES ARE IN THE EQUATION.
1STEPWISE REGRESSION ANALYSIS                                                  84/02/23.     13.11.20.     PAGE    5

 FILE   NONAME   (CREATION DATE =  84/02/23.)
0* * * * * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * * * * * * * * * * * *
0DEPENDENT VARIABLE..   RATIO


                                                 S U M M A R Y   T A B L E

STEP      VARIABLE                  F TO       SIGNIFICANCE  MULTIPLE R  R SQUARE  R SQUARE  SIMPLE R       OVERALL F   SIGNIFICANCE
     ENTERED   REMOVED         ENTER OR REMOVE                                      CHANGE

  1  X26                          34.82220            0         .68681    .47170    .47170    .68681       34.82220          0
  2  X13                          10.17110         .003         .76371    .56325    .11155   -.34877       26.59098       .000
  3  X29                           2.81737         .102         .78278    .61274    .02949    .36293       19.51426          0
```

APPENDIX 14

Diagrammatically, the two variable regression model homoscedasticity can be shown in fig. a, where Y represents the savings and X represents income. This figure shows that the conditional variance of Y_i (which is equal to U_i) conditional upon the X_i, remains the same regardless of the values taken by the variable X.

Fig. a Homoscedastic disturbances

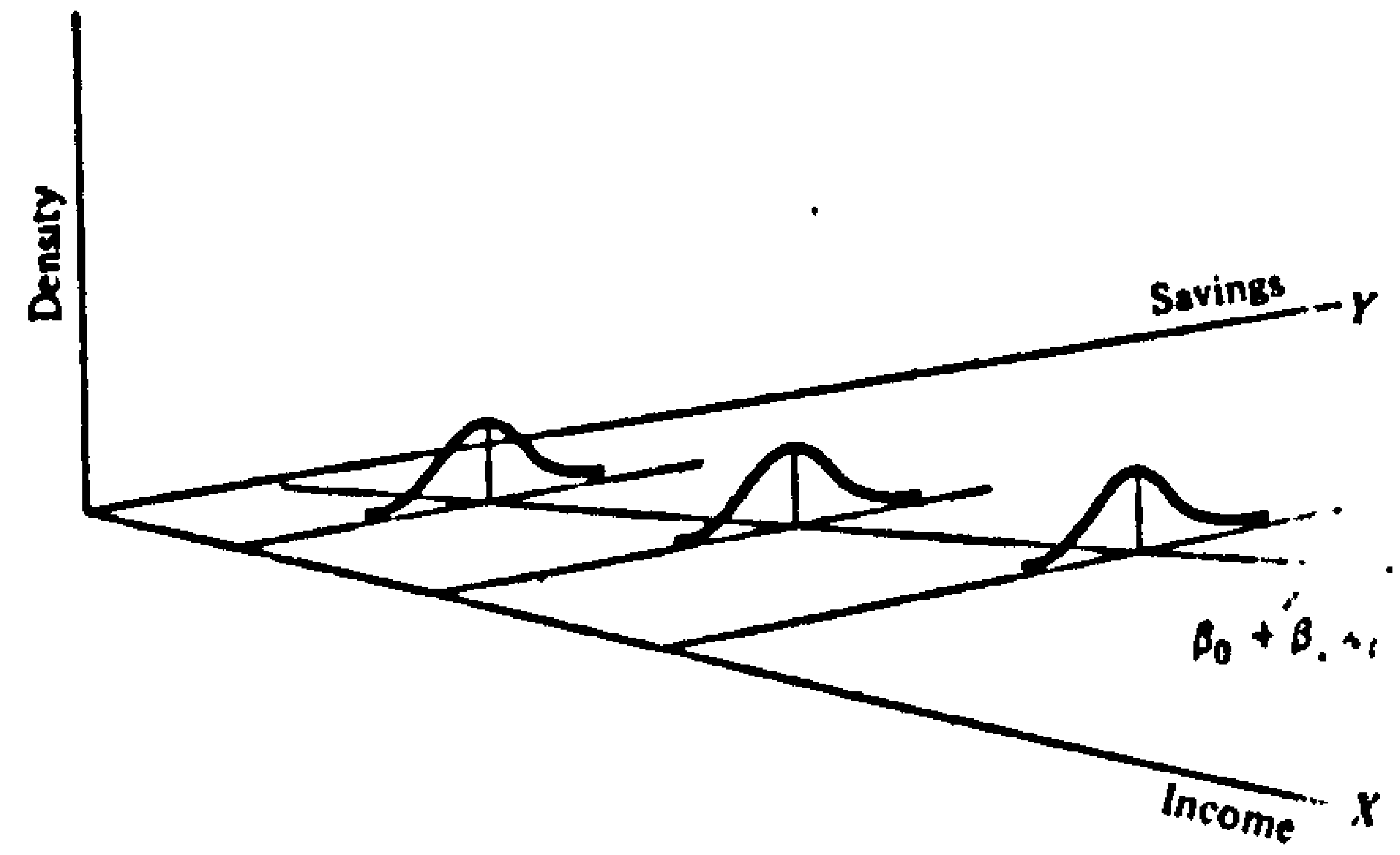
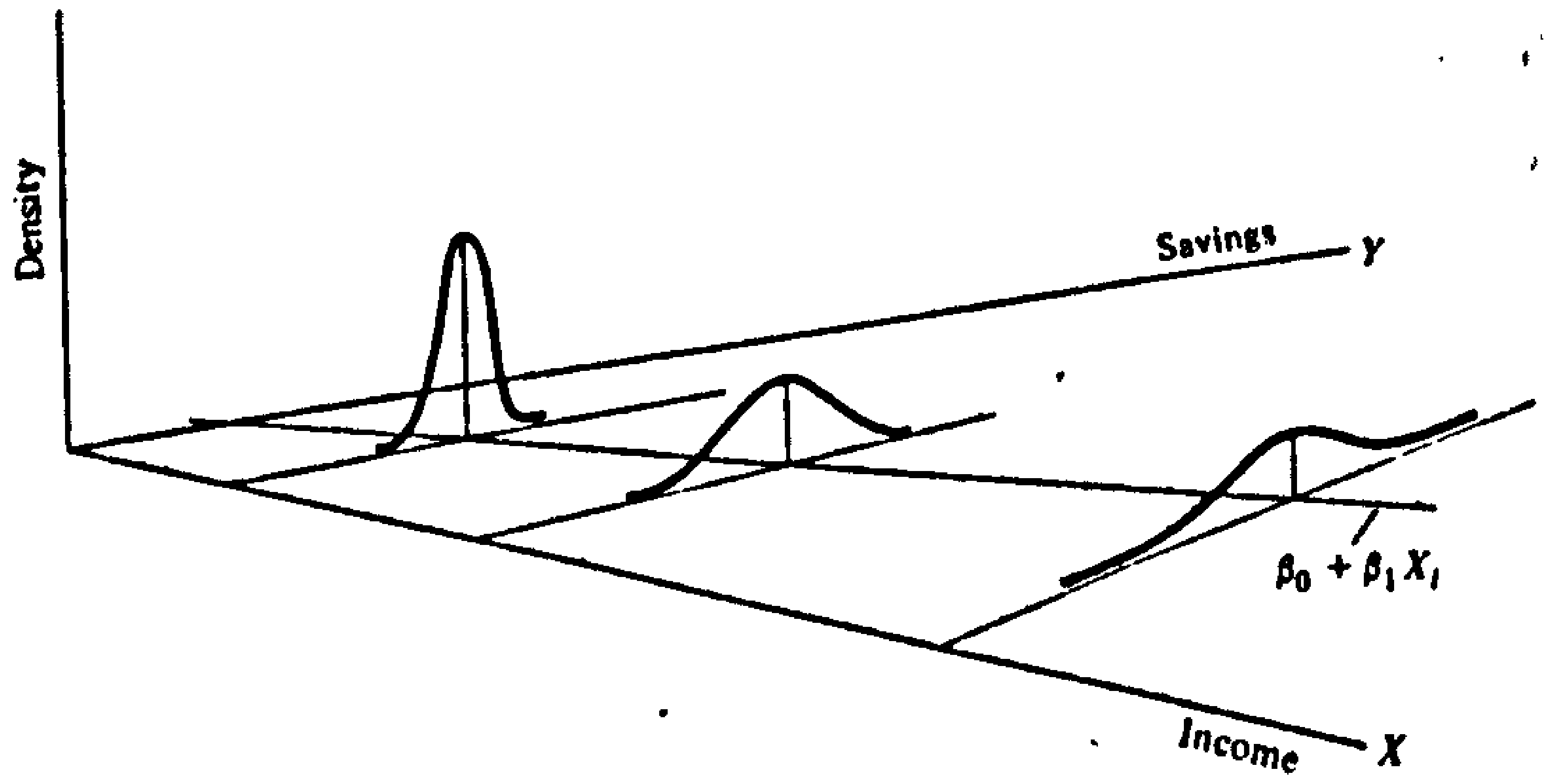


Fig b, in contrast, shows that the conditional variance of Y_i increases as X increases, therefore the variances of Y_i are not the same and there is heteroscedasticity.

Fig. b Heteroscedastic disturbances



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