AN APPLICATION OF MACROECONOMIC ANALYSIS TO THE DEMAND FOR HUMAN SKILLS AND KNOWLEDGE

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Major professor

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ABSTRACT

AN APPLICATION OF MACROECONOMIC ANALYSIS TO
THE DEMAND FOR HUMAN SKILLS AND KNOWLEDGE

by Jerome Martin Stam

Recent years have seen human capital become more highly regarded by economists as an important economic variable. Yet, despite increased research interest, many questions involving human capital have remained unanswered. For instance, it has been shown that an increased demand for human skills and knowledge has occurred as a result of past economic growth, but an accepted explanation of this increased demand is not available at the present time. Therefore, the objectives of this study were: (1) to develop a theoretical framework to better explain the observed change in demand for human skills and knowledge that occurs with the economic growth of an economy, (2) to examine evidence that bears upon the theoretical explanation developed, and (3) to suggest possible areas for empirical tests of the hypotheses developed in this study.

This macroeconomic study offers both a new approach and interpretation to the question of a demand for human skills and knowledge. Gross national product is treated as a function of the three inputs capital, labor, and natural resources, because of both statistical and economic reasons. Investment in human capital can affect and alter the nature and quality of the inputs thus changing output. Thus, human capital, in a sense, becomes embodied in the three basic inputs.

A unique series of graphs are employed in an effort to demonstrate, using the relevant production GNP = f(C,L,N), a need for human skills and knowledge. Seven factor disproportion situations involving the basic inputs of an economy are precisely spelled out. The disproportion situations,

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in turn, have the potential of generating four economic forces that possibly can act in creating a demand for human skills and knowledge. The seven proportion situations are really a catalog of specifics — i.e. the specifics are merely examples. In reality, an economy responds to the tendency toward imbalances that are exhibited by its aggregate inputs. This tendency toward imbalance is related to the real world by the use of both historical and empirical evidence.

The conclusions of this study are that the need for human skills and knowledge at an existing level of technology of an economy is a function of factor disproportions which generate certain basic forces. (1) The first force is created by population pressure upon the natural resource and/or capital base. This is the condition of a relative surplus of labor and shortage of capital, i.e. a small capital/labor ratio. (2) A depletion in either the quality or quantity of the natural resource base over time (even with population constant) produces the second force. (3) The third force is generated by the condition of a relative surplus of capital and shortage of labor, i.e. a large capital/labor ratio. Any one or combination of the three forces can be operating at any one given time. The forces are given in a decreasing order of importance. A fourth force, which was derived in the theory, is rejected on the basis of presently available evidence as a factor which could significantly help generate a need for human skills and knowledge. This is the case of diminishing or constant returns to scale as the basic inputs natural resources, capital, and labor are increased by the economy nearly simultaneously.

These forces are strictly economic in nature. Therefore whether they alone can always cause additional human skills and knowledge to be forthcoming is another matter. Effective demand requires both the need and the means to be present. Thus the means for purchasing human capital also must be available. In addition, social, political, and cultural factors are recognized to influence all phases of economic life.

AN APPLICATION OF MACROECONOMIC ANALYSIS TO THE DEMAND FOR HUMAN SKILLS AND KNOWLEDGE

By

Jerome Martin Stam

A THESIS

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Jerome Martin Stam

ACKNOWLE

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CHAPTER I

INTRODUCTION

Economists historically have regarded capital as the major factor governing the rate of economic development or growth. True to the tradition, modern economists certainly have not exhibited any tendency to underestimate the importance of capital. Many have gone so far as to consider rapid capital accumulation as the central phenomenon of the economic development process.

Capital was long defined as goods produced for use in future production. This includes such items as physical plant and stock of equipment, construction, and producer's inventories. In studying development problems, economists generally have used the narrow concept of capital partly because of the practical problems involved in imputing measurable relationships between the value of human productivity and its contribution to future output.

But, during the late 1950's, it became increasingly evident that output increases in developed economies were not fully explained by the statistical estimates of the expansion in conventional inputs. In short, economists were faced with the fact that the observed rate of economic growth in output was larger than the rate of increase in the principal inputs that were being measured.[1] In other words, the quality of the resources was not reflected in the data, e.g., a 1930 locomotive was of lesser quality than a 1960 locomotive, yet they are typically measured in terms of some common physical units such as horsepower. Economists soon discovered a number of signs pointing to improvements in the quality of human resources

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[1] T. W. Schultz, "Reflections on Investments in Man," Journal of Political Economy, Supplement, Vol. LXX (October 1962), pp. 1-8.

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[5] Ibid., p

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as one of the major sources of economic growth and to improvements in the quality of physical resources resulting from the "imbedding" of human capital in them.

Although T. W. Schultz was not the first to explore the concept of human capital,[2] he has been one of the most influential scholars in this area since his presidential address before the American Economic Association in 1960.[3] The "old" concept of physical capital suddenly was subjected to much criticism, "because if economic development is identified with a long-term increase in per capita output, this view is too narrow and obscures some important aspects of the process of economic and social change that accompanies economic development."[4] Capital has come more and more to be viewed as including investment in the technical knowledge of the population, improvements in education, health and skills.[5] Many economists now realize that for a long time physical capital received excessive attention to the neglect of human capital — i.e., the acquired qualities in humans that are obtained and nurtured by investments in education, training, health, and migration.

Consequently, within the past few years, the relationship between education and the process of economic development has become a topic of research among a growing number of scholars. The subject has claimed a degree of attention at several development conferences in various parts of the world.[6] At present, it appears that few economists deny the important role which human resources play in the drive of a country toward

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[2]For example, see Richard H. Goode, "Adding to the Stock of Physical and Human Capital," American Economic Review, Vol. XLIX (May 1959), pp. 147-55.

[3]T. W. Schultz, "Investment in Human Capital," American Economic Review, Vol. LI (March 1961), pp. 1-17.

[4]A. Pepelasis, L. Mears, and I. Adelman, Economic Development (New York: Harper and Brothers, 1961), p. 89.

[5]Ibid., p. 89.

[6]For example, "Investment in Human Capital in Underdeveloped Countries,"

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modernization. However, there still are many unresolved problems that call for study.

Statement of the Problem

To discuss all phases of the interrelationship between human capital and the process of economic growth would involve a rather gigantic undertaking. Because of the broadness of this subject matter, it is necessary to narrow the focus: this study is directed toward one of the unsolved problems involving human capital — namely that of learning more about how changes in the demand for human skills and knowledge are generated.

In his book, The Economic Value of Education, T. W. Schultz wrote the following paragraphs as a part of a chapter entitled, "The Unfinished Search."

> Nowhere have economists come to grips with the basic factors that determine the growth in demand for human agents with skills and knowledge associated with schooling. Is this growth in the demand for high-level capabilities in labor specific to our economy? Or is it also to be observed in particular low income countries? It is hard to believe that the demand for these quality components in labor increased rapidly during the early industrialization in western Europe. Labor was then abundant and "cheap"; it was mainly illiterate and unskilled; and it did mostly manual work that required much brute force. Improvements in skills and knowledge and health of workers generally appear not to have been a prerequisite to the impressive economic growth of that period.
>
> Despite a flood of schooling beyond the elementary grades entering the labor market, the earning differentials in favor of workers with such schooling imply that the rate of return to it has not been beaten down. It appears to have risen somewhat during the last decade. Meanwhile, workers who had completed 1 to 4 years of high school rose from

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a conference at Southern Methodist University, Dallas, 1961; "Policy Conference on Economic Growth and Investment in Education," Organization for Economic Cooperation and Development, Washington, D. C., October 16-20, 1961; and "The Role of Education in the Early Stages of Development," a conference at The University of Chicago, Chicago, April 4-6, 1963.

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> 38 to 52 percent, and those with some college (completed 1 to more than 4 years) rose from about 13 to 19 percent of the U. S. labor force between 1940 and 1958. If the rate of return had fallen sharply as a consequence of this flood, it might be argued that the demand for these capabilities had not shifted too much to the right since they were being priced lower down on the demand schedule. But this seems not to have happened except for a short period for high school. Therefore, the same hard question: What factors account for the high rate of growth in the demand for these capabilities of schooling beyond the 8th grade?[7]

Thus, Schultz has pointed to the increased demand for human skills and knowledge that has occurred as a result of past economic development or growth. An accepted explanation of this increased demand is not available at the present time.

Objectives

This study has three objectives. The first is to develop a theoretical framework that better helps explain the observed change in demand for human skills and knowledge that occurs with the economic development and growth of an economy.

A second objective is to examine empirical and historical evidence that bears upon the theoretical explanation developed. In other words, the goal is to demonstrate the relevance of the theoretical framework to real world economic growth problems.

The third objective is to suggest possible areas for empirical tests of the hypotheses developed in this study.

Organization of the Thesis

The procedure followed in this study is that of first reviewing past and present concepts and theories related to a demand for human skills and knowledge. In Chapter II an attempt is made at resolving various troublesome points that have hindered research efforts in this area.

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[7] Theodore W. Schultz, The Economic Value of Education (New York: Columbia University Press, 1963), pp. 67-68. See also T. W. Schultz, "Reflections on Investments in Man," Journal of Political Economy, Supplement, Vol. LXX (October 1962), pp. 6-7.

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Chapter III is devoted to developing a theoretical framework in order to explain more adequately the growth in demand for human skills and knowledge. Some implications of the theoretical framework are investigated in Chapter IV. Chapter V is an examination of the empirical and historical evidence that related to the theoretical structure. It is an attempt to give an empirical orientation to the theoretical analysis developed in Chapter III. The summary and conclusions are set forth in Chapter VI.

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CHAPTER II

PAST AND PRESENT CONCEPTS RELATING TO THE DEMAND FOR HUMAN SKILLS AND KNOWLEDGE

The purposes of this chapter are: (1) to briefly explore the development of the concepts of human capital and human capital formation, (2) to examine some of the problems that have hindered the formulation of an adequate explanation of the growth in a demand for human skills and knowledge, and (3) to investigate the dispute over the treatment of "education" or human capital as an input in the production function. The aim of this chapter is to provide a proper background of information upon which the remainder of the study can be based.

Human Capital and Human Capital Formation

Traditionally, the human resource has been viewed simply as an input in the production process, treated as a homogeneous unit of constant quality. Normally, it has been measured in terms of man-hours, number of people in the labor force, etc., and along with land and physical capital, has been considered one of the main factors to which returns are usually computed. However, as economists in recent years began to study more closely some of the sources of economic growth, a different treatment of the human factor emerged. Researchers in this area began to cope with such problems as differences in the quality of labor units over time, and the changing manner by which labor enters into combination with other factors in the production process. Moreover, it was found, due to the work of economists such as Abramovitz[1] and Fabricant,[2] that the addition

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[1]Moses Abramovitz, "Resource and Output Trends in the United States Since 1870," American Economic Review, Vol. XLVI (May 1956), pp. 5-23.

[2]Solomon Fabricant, Basic Facts on Productivity Change, Nat. Bur. Econ. Research, Occasional Paper 63, New York, 1959. Also see John W.

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of conventional inputs capital, land, and labor, simply does not explain the historical increase in productivity.

T. W. Schultz points out that the puzzle confronting economists was centered around the fact that the rate of economic growth in output that was being observed has been much larger than the rate of increase in the principal resources that were being measured.[3] In other words, economists such as Abramovitz, Fabricant, and Schultz were faced with data that indicated a rapid expansion in the productivity of the basic inputs of an economy. But the puzzle was why the increase in productivity? Schultz says that it is a result of increases in the quality of inputs. But why is the increase in productivity puzzling in the first place? Is it because economists typically assume inputs of constant quality and, as a result, in many instances, also fall into the trap of erroneously reasoning to a considerable degree in terms of constant returns to scale? Probably this is true to some extent. Therefore, it is important to remember that assuming a constant quality of inputs has nothing to do with assuming constant returns to scale. These are two different things. In other words, it is important to always adhere to the assumptions, and only the consequences that can be logically derived from them throughout any analytical system.

Schultz further notes that economists have come upon a number of signs pointing to improvements in the quality of human resources as one of the major sources of economic growth. One of Schultz' best early statements in this area is his presidential address before the American Economic Association in 1960, in which he indicated the manner by which

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Kendrick, Productivity Trends: Capital and Labor, Nat. Bur. Econ. Research, Occasional Paper 53, New York, 1956; and Robert M. Solow, "Technical Change and the Aggregate Production Function," Review of Economics and Statistics, Vol. XXXIX (August 1957), pp. 312-20.

[3] T. W. Schultz, "Reflections on Investments in Man," Journal of Political Economy, Supplement, Vol. LXX (October 1962), pp. 1-8.

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acquired skills and knowledge are a form of capital.[4] At approximately this same time Harbison also was beginning to vigorously conduct research in the area of human capital.[5]

Schultz indicates five major activities that improve human capabilities and thus produce human capital: (1) expenditures on health facilities and services; (2) on-the-job training; (3) formally organized education at the elementary, secondary, and higher levels; (4) study programs for adults that are not organized by firms; and (5) migration of individuals and families to adjust to changing job opportunities.[6]

Harbison defines "human capital formation" as the process of acquiring and increasing the numbers of persons who have the skills, education, and experience which are critical for the economic and political development of a country.[7] It becomes evident that human capital formation is thus associated with investment in man and his development as a creative and productive resource. Harbison further notes that it includes investment by society in education, investment by employers in training, as well as investment by individuals of time and money in their own development. In this context it would appear that such investments have both qualitative and quantitative dimensions, i.e., human capital formation includes not only expenditures for education and training, but also the development of attitudes toward productive activity.

Thus human capital can be defined as ". . . the acquired qualities in human beings that are fostered by investments in education and training,

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[4]T. W. Schultz, "Investment in Human Capital," American Economic Review, Vol. LI (March 1961), pp. 1-17.

[5]For example see F. H. Harbison, "The Strategy of Human Resource Development in Modernizing Economics," Policy Conference on Economic Growth and Investment in Education, Organization For Economic Cooperation and Development, Washington, D. C. (October 1961), part 3.

[6]T. W. Schultz, op. cit., p. 9.

[7]F. H. Harbison, loc. cit.

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Some Difficulties in Explaining the Changing Demand for Human Capital

When dealing with the explanation of the growth in a demand for human skills and knowledge, one discovers that little work has been done in this area, primarily because of the very specific nature of the subject matter and the fact that the study of human capital itself is rather new. There has been some probing for a theory or explanation of the growth in a demand for human skills, but so far the primary result has been the identification of certain mistakes and false leads. The purpose of this section is to outline some of the more obvious areas of difficulty that seem to lead those studying human capital astray. In addition, an effort is made at further delineating the scope and purpose of the study. This discussion will also serve as a background for the analysis to follow in the remainder of the thesis.

The Micro-Macro Fallacy

Probably no problem has led more people astray in economic analysis than the micro-macro fallacy.[9] This fallacy asserts that "what is true for the individual or part is necessarily also true for the group or whole." In the area of human capital, the fallacy becomes "what is true for the firm is necessarily also true for the economy as a whole." Therefore the reasoning goes that a firm demands research and development because "it pays," or a proprietor demands an employee with a college education because "it pays." This is quickly generalized to the economy as a whole and becomes "education pays and therefore the country demands education."

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[8] Lee R. Martin, "Social Capital and Living Standards," A Place to Live: The 1963 Yearbook of Agriculture (Washington: U. S. Government Printing Office, 1963), p. 210.

[9] For an excellent discussion of the micro-macro fallacy in economics see Abba P. Lerner, "Microeconomics and Macroeconomics" in E. Nagel, P. Suppes, and A. Tarski, Logic, Methodology and Philosophy of Science (Stanford: Stanford University Press, 1962), pp. 474-83.

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Such reasoning simply does not go very far in explaining economic activity. It is hoped that by approaching the demand for human skills and knowledge from the macroeconomic standpoint, as is done in this study, that this pitfall can be avoided.

Macroeconomics is set apart as a separate discipline with its own rules because aggregate economic behavior does not correspond to the summation of individual activities. What is true for the individual is true in the aggregate only if other things remain equal. The macroeconomic approach allows one to look "down" at the parts of the economic system, and not "up" at the economic system through the eyes of an individual. This approach does not deny the fact that the individual or entrepreneur invests in human skills because of the profit motive, but goes beyond this and shows the broader view of an economic system. Moreover, in the aggregate situation, the more general community decisions are highlighted, and the effects of an individual's actions on other people cannot be ignored. This discussion is further clarified in Chapter VI.

It should be emphasized at this point that this thesis is not intended to present a complete theoretical model on how economic growth begins and proceeds. The author is content to leave this task to others. Rather, the purpose here is to fit human capital into an overall macroeconomic framework which utilizes comparative static analysis. The demand for human skills is much more than a micro-economic problem, but micro-economic theory can apparently accommodate human capital more easily than can macroeconomic theory. Thus problems involving human capital are most often analyzed using microeconomic theory. The answers resulting from the use of micro-theory too often involve only the simple microeconomic fact that a firm or entrepreneur hired an educated employee "because education pays, etc." However, both the economist and society desire to know much more than this simple answer.

It is also important to emphasize that "Economic growth depends both upon technological knowledge about things and living creatures, and, in

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addition, upon social knowledge about man and his relations with his fellow men."[10] It took mankind several thousand years to finally organize his society socially in such a way that his intellect could produce a technology that would bring forth what is called modern economic development or a modern industrial society. But it is not the purpose of this study to explain these social changes or to explain how economic growth begins.

Human Capital and the Natural Resource Base

Natural resources are very important in the framework developed in this study — yet they are often largely ignored by economists. Barlowe believes that economists tend to underrate the importance of natural resources because, (1) many have been overly impressed with statistical reports that show that land is declining in importance as a source of income and value relative to other factors; (2) many tend to ignore the basic limitational significance of natural resources and treat them as unimportant because they are plentiful and free in a market sense; and (3) some tend to credit practically all increases in productivity to labor and capital when in fact many of these increases could be credited to land.[11] He continues by stating that it is not unusual for natural resources to decline in importance as a source of income because our supply of land has remained fixed while our supplies of capital and labor have increased both in quantity and quality. Barlowe states that, with regard to (2), we should be happy that many natural resources are "free goods." But no resource is unimportant as long as it is capable of becoming a critical factor in production. Thus he reminds that, with regard to (3), it should be remembered that much of the added productivity could well be treated as a return to land.[12]

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[10] W. A. Lewis, The Theory of Economic Growth (London: George Allen and Unwin, 1956), p. 164.

[11] Raleigh Barlowe, "Natural Resources and Economic Growth," Journal of Farm Economics, Vol. XLII (December 1960), pp. 1503-04.

[12] See also J. H. Dales, "Comment on Connections Between Natural Resources and Economic Growth" in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1964), pp. 235-38. His argument is similar to Barlowe's.

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Schultz has implied that because natural resources become a smaller portion of national income as economic growth occurs that they are less important to the economy.[13] But he does not recognize that the ratio of income originating in a sector is not a decisive measure of the importance of a sector in economic development, because, as yet, no single acceptable measure has been devised that solves the sector importance problem. Nevertheless, the fact remains that just because the relative efficiency of a sector improves — and its products become less expensive vis-a-vis other sectors — it does not necessarily follow that its relative importance to the economy has decreased.

The neglect of natural resources has caused economists to overlook an important fact. This is that improvements in human skills and knowledge augmenting capital and labor productivity have caused a reduction in the relative role of natural resources. Economists have traditionally concentrated on studying relationships involving nonhuman capital. They have been busy studying increases in the quality and quantity of physical capital while, as we have just seen, assuming that natural resources are of a declining importance to the economy. At the same time they have forgotten (or ignored) that the lack (or depletion) of natural resources might be one of the prime factors causing a need for improving the level of capital and labor productivity. Yet, improvements in physical capital and labor productivity require an investment in human capital. Thus human capital is demanded. This is not to deny that the motivation involved is always that of seeking ways to use less of expensive inputs.

Of importance in this study, equal to the natural resource problem, is the question of whether education is a production or consumption good?

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[13] T. W. Schultz, "Connections Between Natural Resources and Economic Growth," in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1964), pp. 229-230.

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"Education" — Production or Consumption Good?

In the past, various problems have arisen in both defining the production and consumption components of "education" and in allocating the costs and benefits of schooling into production and consumption segments.

Schultz states that, "The producer component of schooling is an investment in skills and knowledge which enhance future earnings, and thus it is like an investment in [other] producer goods."[14] The consumption component consists of values associated with education that are not as a rule vocational, occupational, or professional — i.e., its value can be moral, or a refinement in taste, or some other source of satisfaction.[15] He also states that the benefits from schooling can be classified into three conceptual boxes: (1) present consumption, (2) future consumption (an investment), and (3) future producer capability (also an investment). No one really knows the size of any of these. However, T. W. Schultz argues as follows: in the United States, at present, training in fields such as law, agriculture, business, engineering, medicine, dentistry, nutrition, and technology entails relatively little consumption, while general instruction in non-vocational subjects runs more toward consumption investment. Schultz estimates that only one-half to three-fifths of the costs of the general non-vocational schooling is invested in production capabilities.[16] He adds that elementary schooling is highly valued for its consumption component but also produces some producer capabilities. He notes, however, that the bulk of the producer component is generally added by secondary schooling.

The analysis presented in this study concentrates on human capital

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[14] T. W. Schultz, The Economic Value of Education, op. cit., p. 8.

[15] Ibid. For another discussion of the consumption and production aspects of education, see Ingvar Svennilson, "The Concept of Economic Growth," in Proceedings of the Eleventh International Conference of Agricultural Economists (London: Oxford University Press, 1963), pp. 24-25.

[16] Ibid., p. 58.

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as a productive agent. But as we have just seen, "education" is demanded for both consumption and production purposes.[17] Harry Shaffer has argued that: (1) it is impossible to separate consumption and investment expenditures on human capital, (2) even if it were possible, there would still be no way to allocate a specific return to a specific investment, and (3) even if both of these problems were solved, it would be ill-advised to utilize the information from a welfare standpoint.[18] Schultz states that the economic logic for allocating the costs of schooling is clear and compelling, but no one has as yet developed a satisfactory empirical procedure for identifying and measuring what in fact happens.[19] He deems any allocation in the face of this difficulty as "arbitrary." Therefore, this study will not attempt to measure the production and consumption investment in human capital, but it is primarily concerned with human capital as a productive agent.

Technology, Technological Change, and Human Capital

Over the years technology and technological change have been studied intensively by economists. During this time, they have accumulated a considerable amount of literature in this area. Samuelson demonstrates the high regard that economists hold for technology when he states that "In addition to the fundamental factors of population, natural resources, and capital formation, there is the vitally important fourth factor of technology."[20]

Technology can be defined as the stock of techniques and procedures

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[17] T. W. Schultz, "Education and Economic Growth," in Nelson B. Henry (ed.), Social Forces Influencing American Education (Chicago: University of Chicago Press, 1961), p. 52.

[18] Harry Shaffer, "Investment in Human Capital: Comment," American Economic Review, Vol. LI (December 1961), pp. 1026-34.

[19] T. W. Schultz, The Economic Value of Education, op. cit., p. 55.

[20] Paul A. Samuelson, Economics: An Introductory Analysis (4th ed.; New York: McGraw-Hill, 1958), p. 765.

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for conducting economic activity or the totality of means employed to provide objects necessary for human sustenance and comfort. Technological change can be briefly defined as "a change in a production function embodying all known techniques."[21] Stout and Ruttan state that, "Technological change can be broadly defined as a change in the parameters of a production function resulting directly from the use of new knowledge [emphasis mine]. This includes both neutral shifts and changes in the slope of the production function."[22]

In the past, economists have all too often forgotten or simply neglected the fact that technology does not stand inertly alone, but that knowledge produces what we call technology. It is important at this point to note that additional human skills and knowledge may be required: (1) to create new technology, (2) to operate the present technology, or (3) both 1 and 2.

The connection between human knowledge, technical progress, capital equipment, and economic growth has received increased attention in recent years. Ferguson writes that, "Solow was among the first to suggest that technical progress is actually embodied in new capital equipment and, therefore, that capital accumulation is essential to economic growth."[23] Leibenstein states that,

> Phrases like "the state of the arts" and the "stock of knowledge" are very vague and emphemeral in nature. Knowledge as such does not exist apart from human carriers, that is, apart from individuals capable of interpreting and communicating ideas and observations.[24]

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[21] Pepelasis, Mears, and Adelman, op. cit., p. 133.

[22] Thomas T. Stout and Vernon W. Ruttan, "Regional Patterns of Technological Change in American Agriculture," Journal of Farm Economics, Vol. XL (May 1958), p. 197.

[23] C. E. Ferguson, "Substitution, Technical Progress, and Returns to Scale," American Economic Review, Vol. LV (May 1965), p. 297. The main article that Ferguson refers to is R. M. Solow, "Technical Change and the Aggregate Production Function," Rev. of Econ. and Statistics, Vol. XXXIX (August 1957), pp. 312-20.

[24] Harvey Leibenstein, Economic Backwardness and Economic Growth (New York: John Wiley and Sons, 1957), pp. 135-36.

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Nutter believes that "Technology is knowledge — in particular, knowledge of how to produce things."[25] Martin writes that, "Technology comes largely from research and development."[26] Thus investment in human knowledge and skills, technical progress, capital equipment and economic growth are all causally related. It is important to emphasize this fact and to avoid using the term technical change as shorthand for many factors or as a cover-up item in the remainder of the thesis.[27] Technical change should be defined as the change in the parameters of a production function resulting from the use of new knowledge. Thus new human skills lead to new technology. Moreover, this implies that when new technology is demanded that new human skills for various purposes also are demanded. This is part of the major focus of this study.

When one discusses "technological change," certain changes in human knowledge and skills (education) are thus implied. As T. W. Schultz has stated,

> Many economists have been playing a game called economic growth which has made them ever more adept at disembodying the two primary inputs. Both labor and nonhuman capital have become essentially empty shells and thus it should not come as a surprise that this game has not explained growth. But it has succeeded in removing the increase in the productive essence of the real factors of production that have accounted for much of our growth during recent decades. What is happening in the economy is that an array of new factors of production is being introduced and the quality of old factors is being improved, and the growth game has been to conceal the additional productive services from these sources under so-called "technological change." The implication here

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[25] G. Warren Nutter, "The Measurement of Income and Income Change," in Theodore Morgan, George Betz and N. K. Choudhry (eds.), Readings in Economic Development (Belmont, California: Wadsworth Publishing Company, Inc., 1963), p. 30.

[26] Lee R. Martin, op. cit., p. 211.

[27] See T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), pp. 132 and 137.

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> is that the large "residual" is simply a bias of the analytical approach most economists have been using. To correct this bias it will be necessary to develop an all-inclusive concept of factors of production including the economic productivity of education [emphasis mine].[28]

"Technological change" is thus both an illusive and a very important concept. If it could be quantified or predicted, in its effects on capital and labor resources, it could be included as another factor of production. This factor would over time enhance the total product, i.e., make the traditional factors more productive. But the question remains of how to grasp such a concept? One must get behind it to determine the causes for changes in factor productivity.

The Conceptual Role of Human Skills and Knowledge — Importance Versus Explanation

In the past scholars have generally regarded investment in human skills and knowledge ("education") as an institutional or at best an exogenous variable in economic models. The importance of human knowledge has come to be more and more recognized, but its role in the overall development framework has been harder to formulate.

One article dealing with the importance of knowledge has been quite widely quoted in recent years.[29] Horvat develops a model in which he attempts to determine the optimum rate of investment for underdeveloped countries. In this model knowledge and skills are the critical investment variable in determining the rate of economic growth. In fact, knowledge in his model is "The most important scarce factor." As Bonner and Lees have stated with respect to Horvat's work:

> Indeed it is now being suggested that, far from being the primum mobile of economic growth the accumulation of physical capital is a product of growth: given investment

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[28] T. W. Schultz, The Economic Value of Education (New York: Columbia University Press, 1963), p. ix.

[29] Branko Horvat, "The Optimum Rate of Investment," Economic Journal, Vol. LXVIII (December 1958), pp. 747-67.

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> in the human factor of growth, the economy is able to produce any amount of physical capital that can be productively applied.[30]

Schultz has written that, "The Horvat formulation of the optimum rate of investment which treats knowledge and skill as a critical investment variable in determining an optimum rate of economic growth is both relevant and important."[31]

However, it is intended that the analysis developed in this study and the supporting evidence will explain more than the fact that knowledge and skills are critical variables in economic growth. As we have seen, Horvat has already formulated an optimum rate of investment which treats human knowledge and skill as a critical variable in determining an optimum rate of economic growth. Both the framework developed in this study and Horvat's model are macroeconomic in nature. But Horvat does not explain how a demand for human skills and knowledge is generated and grows. It is an objective of this study to better explain how a demand for human skills and knowledge is generated and grows.

Professional Knowledge — Damaging to the Understanding?

Economic investigation and understanding of the demand for, production, diffusion and the use of new knowledge has long been lacking. Recently, Jacob Schmookler stated that:

> During the last dozen years or so economists have shown that the production, diffusion, and use of new knowledge are more important for the growth of output per head than is the accumulation of physical capital. It seems safe to say that this discovery occasioned more surprise among economists than among educated men generally. The differential surprise is an instructive example of how damaging

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[30] J. Bonner and D. S. Lees, "Consumption and Investment," Journal of Political Economy, Vol. LXXI (February 1963), p. 70.

[31] T. W. Schultz, "Investment in Human Capital in Poor Countries," in Paul D. Zook (ed.), Foreign Trade and Human Capital (Dallas: Southern Methodist University Press, 1962), p. 12.

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> to the understanding professional knowledge can sometimes be.[32]

In his paper, Schmookler explores the reasons why economists failed to understand what other educated men did. He remarks that, in the past, Adam Smith, Karl Marx, John Stuart Mill, Alfred Marshall, Frank W. Taussig, and Irving Fisher all recognized the contribution of knowledge and skills of the labor force of a nation to its aggregate output.[33] However, in general, contemporary economists were surprised by the evidence of the importance of new knowledge due to the inadequate strategy of advancement of knowledge in the economics field.[34] In addition to teaching the generally accepted body of economic knowledge, most of the profession has been attempting (1) the further refinement and empirical testing of received principles, and (2) the solution of pressing social problems.[35] Schmookler calls these two "entirely proper objectives" but other knowledge was neglected in order to pursue them. Thus "Lacking time to learn the history of economic thought, we were doomed to repeat it."[36]

A part of Schmookler's thesis is summed up in the following paragraphs.

> Earlier economists studied the world and knew it was round. Only their maps were flat. Too many later economists studied the maps and mistook them for the world.
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> . . . the necessarily heavy emphasis in recent decades on the increasingly complex analytical framework conditioned our minds to the view that technological change was exogenous, not only from the standpoint of our theoretical models, but also from that of the economic system. And of course, out of sight, out of mind. When once again our attention turned to economic growth, too many of us found it natural to suggest as its chief cause

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[32] Jacob Schmookler, "Technological Change and Economic Theory," American Economic Review, Vol. LV (May 1965), p. 333.

[33] Ibid. [34] Ibid., p. 334. [35] Ibid. [36] Ibid.

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> capital formation — the main variable internal to our models which could make output per head rise.[37]

It is interesting to note that many of Schmookler's remarks are relevant with respect to the previously discussed problems involving the analytical treatment of natural resources by economists. In short, both natural resources and human capital have been neglected in economic analysis and physical capital formation was regarded as the key to economic growth. Thus today we have an inadequate theory regarding the place of natural resources, knowledge and skills in economic growth.

The Disagreement over the Manner in Which "Education" Enters the Production Function

We have seen that in the past several years the distinction between human capital and non-human capital has come to its own in economic analysis.[38] However, the debate is still raging as to whether a measure of human capital such as "education," should be treated as an input or a factor of production in a conventional production function. Griliches recently wrote that, " 'Education' does belong in the production function. . ."[39] However, G. L. Johnson writes as follows:

> Three "nonconventional" inputs have been giving students of economic development serious trouble for some time. They include technological advance, management, and improvements in the human agent. The productivity of economies depends upon inventions, organizational innovations, managerial skill, managerial capacity, and various other skills possessed by productive inhabitants. From easy observations of this relationship, it has been but a short non sequitur to (1) attempted quantification of technological advance, managerial capacity and improvements in the human agent, and (2) attempted use of such

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[37] Ibid., pp. 335-36.

[38] For example, see Milton Friedman, Price Theory (Chicago: Aldine Publishing Company, 1962), pp. 199-202.

[39] Zvi Griliches, "Research Expenditures, Education, and the Aggregate Agricultural Production Function," American Economic Review, Vol. LIV (December 1964), p. 972.

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> variables in conventional production functions as inputs. It does not follow that because output is related to technological advance, improvements in the human agent, and increases in managerial skills, these changes should be quantified and treated as factors of production. Though, for instance, a decision to use more fertilizer does change output indirectly, it is the fertilizer, not the decision, which is a factor of production.[40]

It is Johnson's thesis that,

> . . . such "unconventional" inputs, if they can be regarded as inputs at all, should not be treated as factors of production in any sense and that attempts to do so are not likely to be helpful in understanding the roles that technological advance, improvements in managerial capacity, and improvements in the human agent play in production and in economic development. Quite to the contrary, it will be argued that such attempts reduce the effectiveness with which production function analyses can be carried out and reduce our ability to understand (1) the creation of technological advance, (2) the performance of the managerial processes, and (3) the processes of investing in and of improving the human agent.[41]

Schultz states that the practice of treating new and better resources as an ad hoc variable under the label of "technological advances" is a way of covering up ignorance and is inconsistent with the economic logic of the properties of a production function.[42] He then continues with a statement that appears to make the same point as Johnson,

> To assert that a production function (say in farming) has improved, or has been shifted to the right, because of an advance in technology can only mean that at least one new resource (input) has been introduced in production, because a production function can only be derived from the properties of the resources that are employed in that production. If a production function has changed, it

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[40] Glenn L. Johnson, "A Note on Nonconventional Inputs and Conventional Production Functions," in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1964), p. 120.

[41] Ibid.

[42] T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), pp. 130-44.

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> always means that at least one additional resource with different technical properties has been introduced in production. The analytical task, therefore, consists of developing concepts and of building models that will permit us to identify and measure the resource that provides the new technical properties and not to treat all or part of the unexplained residual by simply calling it, "an advance in technology."[43]

Schultz presents a similar argument in his book, Transforming Traditional Agriculture.[44] He states that,

> What matters then conceptually is that the technology used for production is an integral part of the productive agents employed. Since the productive agents include the human agent, the knowledge (or know-how, or "instruction") of how to employ each of the productive agents including himself is also an integral part of the factors of production. Accordingly, when all of the factors of production are completely specified, the technology is also specified.[45]

Thus, the production function is a technical relationship and that when technological advance involves a new factor of production or previously unknown way of combining old factors of production, the so-called upward shift in the production function from the horizontal axis is not an upward shift from the same set of rigorously defined input axes.[46] Rather it is the product associated with a new input axis in the function, or is the result of using a previously excluded combination of inputs. The result of using some mysterious new input called new technology, is not a mysterious upward shift in the production function. Rather as Johnson states,

> New technology does not even enter the production function as a factor of production, conventional or otherwise;

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[43] T. W. Schultz, "Connections Between Natural Resources and Economic Growth," in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1962), pp. 234-35.

[44] T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), pp. 130-44.

[45] Ibid., p. 134. [46] G. L. Johnson, op. cit., p. 121.

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> instead a new but conventional type of input or a new but conventional combination of inputs enters into a very, very conventional kind of production function.[47]

Development of the Relevant Production Function

The factors of production have been traditionally classified as capital, labor, land and management (entrepreneurship of coordination).[48] However, Marshall wrote that,

> In a sense there are only two agents of production, nature and man. Capital and organization are the result of the work of man aided by nature, and directed by his power of forecasting the future and his willingness to make provision for it.[49]

Similarly, Samuelson states that there are two primary factors of production, natural resources and human labor, which are combined in order to produce an intermediate factor of production, capital.[50] The original capital produced of course, can be combined with natural resources and labor to produce, in turn, still more and better capital. As is shown in Figure 1, in the final analysis the four factors of production (A) have been reduced to three (B). Natural resources include all "free gifts of nature" such as arable land, forests, mineral and oil deposits, and water resources. Capital is non-human, man-made aids to production. Labor (human element) refers to all man's physical and mental abilities employed in producing goods and services, except management (or entrepreneurship).[51]

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[47] G. L. Johnson, op. cit., p. 122.

[48] Earl O. Heady, Economics of Agricultural Production and Resource Use (Englewood Cliffs, New Jersey: Prentice-Hall, 1952), p. 24.

[49] Alfred Marshall, Principles of Economics (London: Macmillan, 1920, 8th ed.), p. 139.

[50] Paul A. Samuelson, Economics: An Introductory Analysis (5th ed. rev.; New York: McGraw-Hill, 1961), pp. 644-45.

[51] The definitions of the economy's three basic inputs will be expanded in Chapter III.

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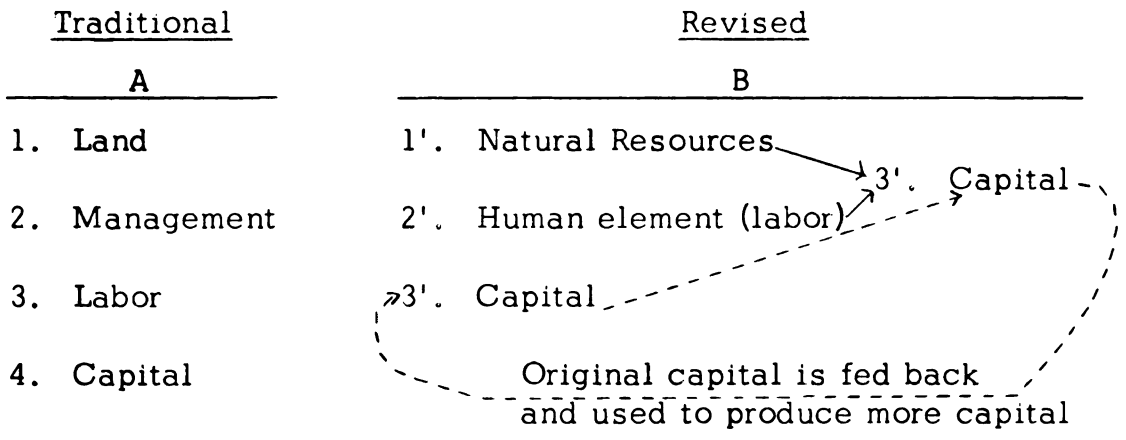

Figure 1.

Throughout this study gross national product (GNP), defined as the total market value of all final goods and services produced in the economy in one specified time period is treated as a function of three inputs, capital (C), labor (L), and natural resources(N).

$$(1)\quad GNP = F(C, L, N)$$

Changing "technology" or human skills and knowledge enters the analysis at this point. As T. W. Schultz has written,

> Classical theory began by imposing a tripartite classification on factors and by holding the state of technology constant. But as economic growth occurred in reality, the state of technology not only changed but became one of the important variables increasing income over time. Meanwhile, a good deal of apparatus for analyzing production had been developed, based on the assumption that the state of technology remains constant. Thus to reckon with obvious changes in the quality and forms of the factors of production and not forgo using this long established intellectual equipment in which so much has been invested, as every graduate student knows, the notion of technological change has become fashionable to cover what are in fact ever-larger increases in income that are not explained by conventional concepts and measures of land, labor, and capital.[52]

In equation (1), investment in human capital ("education," etc.) can

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[52] T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), pp. 136-37.

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affect and alter the nature and quality of the inputs (i.e., productivity) thus increasing output. "Education" (E) is omitted as a conventional input in order to avoid a production function of the following type:[53]

$$(2)\ GNP = f(C, L, N, E)$$

Investments in "education" affect not only the "education" input variable, but one or more of the other input variables as well. Because of this economic inter-relationship, statistical problems of multicollinearity will be encountered in statistically estimating such functions.

Therefore, the production function approach used by many — in which a measure of "education" (E) is entered as a distinct separate input — is in difficulty because it is an attempt at deriving an estimate of the following equation:

$$(2)\ GNP = f(C, L, N, E)$$

The above equation involves a fair sized intercorrelation of the first, second, and third order. This differs from the following equation:

$$(1)\ GNP = f(C, L, N)$$

where the following structural set is implicit.

$$\left.\begin{aligned} C &= f(L, N, E) \\ L &= f(\text{Pop.}, E, \ldots) \\ N &= f(\text{God}, E, \ldots) \\ &\quad \text{for a theist} \end{aligned}\right\} \text{ Simultaneous set}$$

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[53] This variable could just as well have been called human capital (H) or technology (T). It was shown earlier that these concepts are both interrelated and overlapping. Moreover, these concepts are value-laden — meaning different things to different people. Because of the confusion surrounding this area, the word education is frequently written enclosed with quotation marks in this thesis. This serves as a warning to the reader of not only the definitional problems, but of the emphasis on the productive aspects of human capital within the context of this study.

Moreover, the term "education" is used in a broad sense throughout the thesis. It includes, among other things, knowing how to produce technology, and making people more trainable and, therefore, subsequently more productive throughout life. It includes the broad training of people within a given economy as well as the training of a selected educational "elite." It is also roughly synonymous with the terms human capital, and human skills and knowledge, etc.

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In equation (1) "education" enters the production function by influencing the quality or nature of any one or all of the inputs. That is, "education" influences the nature of the conventional inputs C, L, and N, but does not enter the production function per se as a conventional factor of production. Investments in human capital have a much more imprecise or less mechanistic effect on GNP than do simple changes in the quantity of labor, capital, or natural resources. The relationships between the use of inputs L, C, and N and output GNP are rather mechanistic because they involve the conventional production function which assumes the stability of nature concept. This assumption is that exactly the same amounts and combinations of factors of production used under exactly the same physical conditions are expected to produce the same physical product.[54]

Summary

Let us briefly summarize the main points elaborated in Chapter II. The study of human capital and human capital formation in recent years developed mainly because the addition of conventional inputs — capital, land, and labor — simply does not explain the historical increase in U.S. productivity.

A number of difficulties have been encountered in the past by those investigating the changing demand for human capital. These problems include, among others, the micro-macro fallacy, the underestimation of the importance of natural resources, whether education is a production or consumption good, the relationship between technology and human capital, and "professional knowledge."

Throughout this study gross national product (GNP) is treated as a function of the three inputs, capital (C), labor (L), and natural resources (N).

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[54] G. L. Johnson, op. cit., p. 121.

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CHAPTER III

A THEORETICAL MODEL OF THE DEMAND FOR HUMAN SKILLS AND KNOWLEDGE

The Need for Human Skills and Knowledge

The Graphical Framework

The principles of production provide the foundation for analysis of resource pricing and employment. The relevant production function equation for this study has been determined, but as yet a framework with which to utilize it is not present. Thus it is the purpose of this section to develop the graphic tools with which production function analysis can be effectively conducted. Then, in turn, the production function analysis can be employed in order to demonstrate how the demand for human skills and knowledge is generated.

The elementary concept of the production function usually portrays output as a function of one input, with all other inputs held constant (ceteris paribus). Usually the ceteris paribus assumption is given little attention at this level of analytical sophistication. Thus the production function is of the following nature: $O = f(L)$. Output is a function of the labor input with all other inputs held constant. This simple production function is graphed in Figure 2.

The simple production function diagrammed in two-dimensions in Figure 2 can be expanded to three-dimensions by including another variable input. A production function of the following nature is obtained: $O = f(C, L)$. Here output is a function of the inputs capital and labor with all other inputs held constant. This production function is graphed in Figure 3. The variables C, L, and O are measured along the respective X, Y, and Z axes.

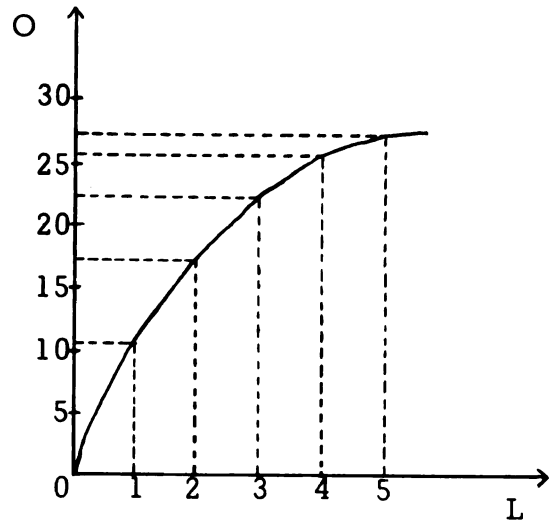
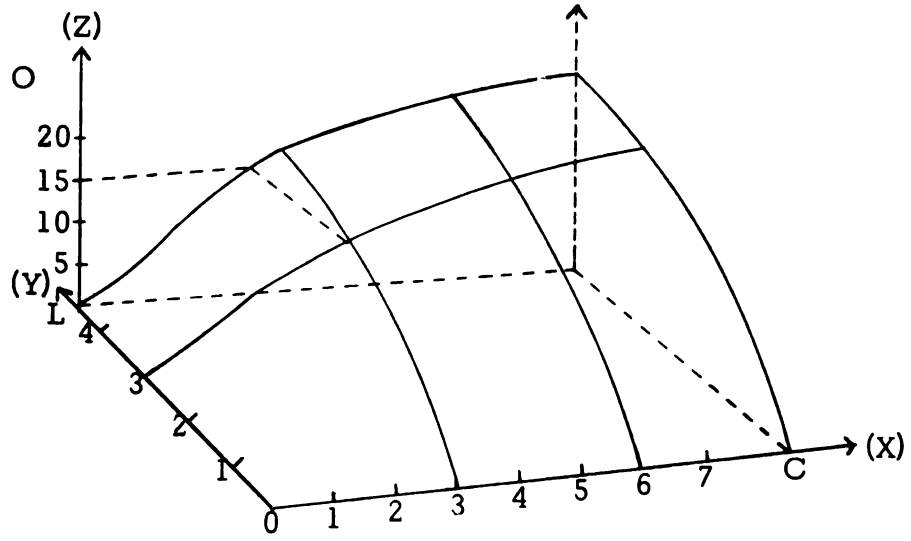


Figure 2.



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Further development of production function analysis typically begins to hint at the importance of the ratios or proportions between factors. The law of diminishing returns concept comes into focus. The idea of one of the studied factors remaining fixed while one studied factor (input) varies then can be explicitly spelled out. Thus, the production function O = f(C,L) now can be drawn in two-dimensions as is shown in Figure 4. Here output is a function of labor when capital is held equal to one unit (and ceteris paribus).

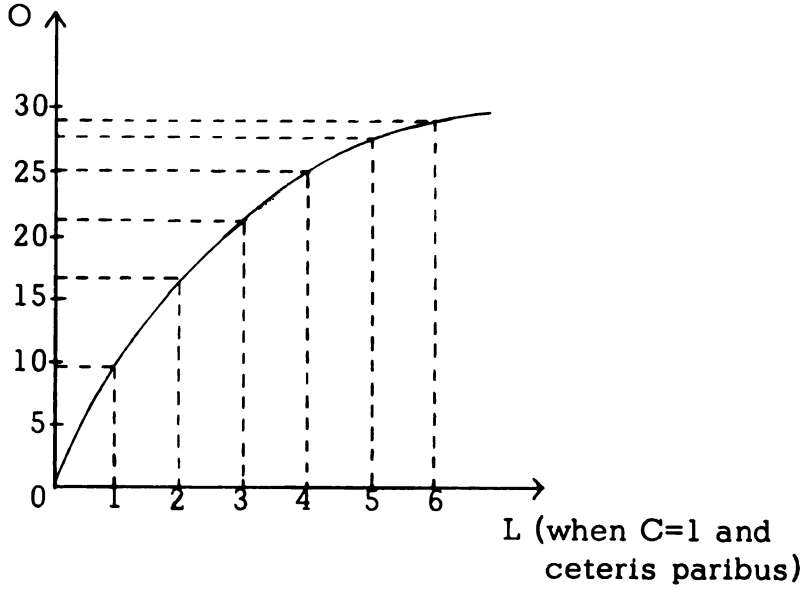

Figure 4.

In order to show the symmetry property inherent in a production function of this type, the inputs labor and land can be used. Initially land is fixed at one and labor is allowed to vary. A production function of the type shown in Figure 5 is obtained. Next labor is fixed at one unit and the input land is allowed to vary. By the use of this device one can demonstrate the symmetry between what are typically referred to as Stages I and III of a production function (Stage I for labor is Stage III for land and vice versa). However, more important to this study, this brief analysis has hinted at the importance of the ratios or proportions between factors. It introduces the important factor proportion concept but does not elaborate.

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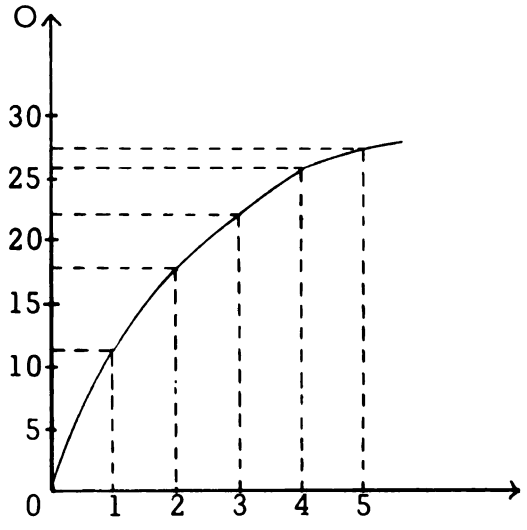

Figure 5.

Friedman presents a more advanced analysis of this question.[1] He states that what is important is not that some factors are fixed and others are variable, but rather the concern is over the effect of varying the proportions in which different factors are employed. Therefore he discards the concept of the law of diminishing returns, which assumes one or more factors fixed, and employs the concept of the law of variable proportions. Here output is treated as a function of capital and labor, when labor is fixed at a given level a, and ceteris paribus O = f(C, L =a). The ratio of capital to labor is shown on the horizontal axis. The manipulation of Figure 6 will be demonstrated shortly.

Because the equation GNP = f(C, L, N) contains only four variables, an entire economy (or a sector of an economy) can be analyzed theoretically using a three-dimensional figure. Figure 7 shows GNP as a function of C, L, and N for an economy. The ratio of capital to labor is shown on the OX axis and the ratio of natural resources to labor on the OY axis. Gross national product is measured on the vertical OZ axis.

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[1]Milton Friedman, Price Theory (Chicago: Aldine Publishing Company, 1962), pp. 123-32 and 136-38.

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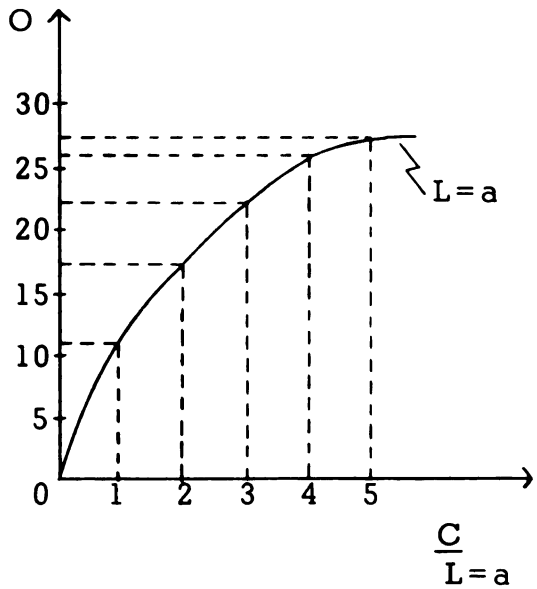

Figure 6

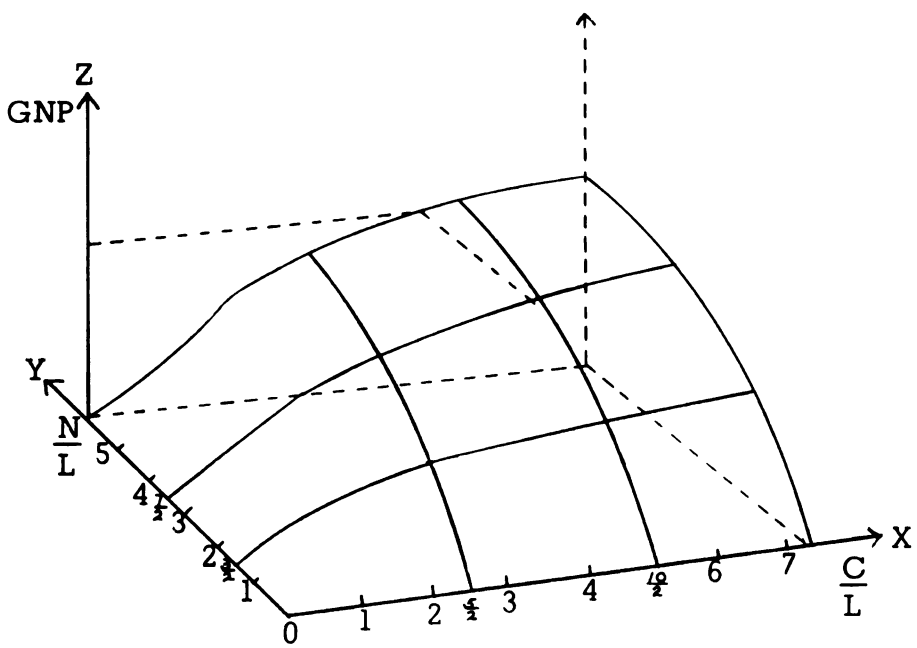

Figure 7

In this scheme both the absolute amount and the ratio of factors used determines the level of output, but the factor ratio alone determines the position or point along the OX or OY axis. This is in contrast with the way in which the production function is often drawn; i.e., with the factors

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measured in absolute amounts on the horizontal axis. Figure 8 illustrates the usual way in which a production function is pictured. Assume that we work only with two inputs C and L and that in Figure 7 we are looking in the direction of the OY plane on an eye level with and perpendicular to the OX plane. Also assume a linear homogeneous production function of the first degree and that maximum output occurs when the factors are combined in a one to one ratio. The middle horizontal axis measures the amount of C and the lower horizontal axis measures the amount of L used in production. With L fixed at 5 units a maximum output (GNP) of 50 units is obtained when 5 units of C are employed. Similarly, if L is fixed at 6 units, a maximum output of 60 units is obtained when 6 units of C are employed. If 4 units of C are combined with 5 units of L, a GNP of 47 units (point 5) is obtained. If the input L is increased to 6 units, output (GNP) increases to 53 units (Point T) and one is placed on a different production function. However, because L has increased from 5 to 6 units while at the same time total GNP has increased only from 47 to 53 units, GNP per capita has been reduced.

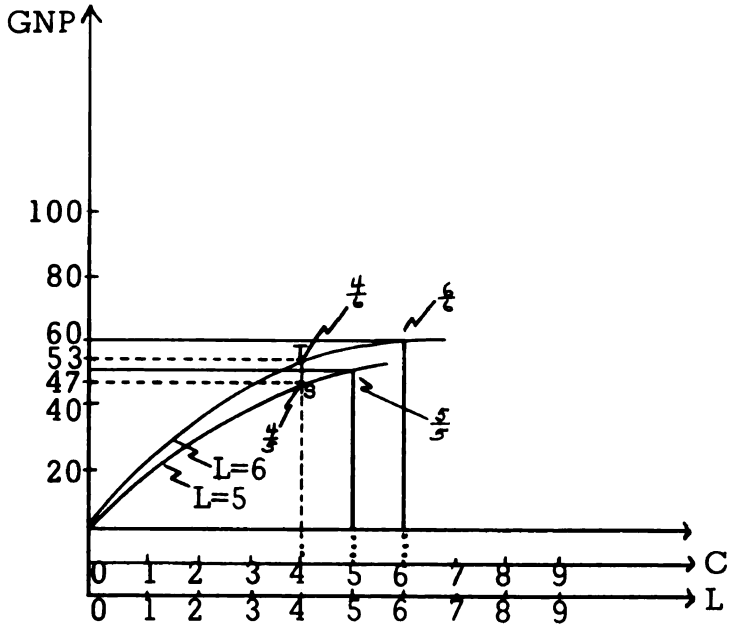

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Figure 9 utilizes the same assumptions and data as Figure 8 except that now the ratio of factors employed, rather than the absolute amounts employed, locates the horizontal position of the production function relative to the horizontal axis. The production functions now all have the same horizontal scale. Just as in Figure 8, by combining 4 units of C with 5 units of L an output (GNP) of 47 is obtained (Point S).

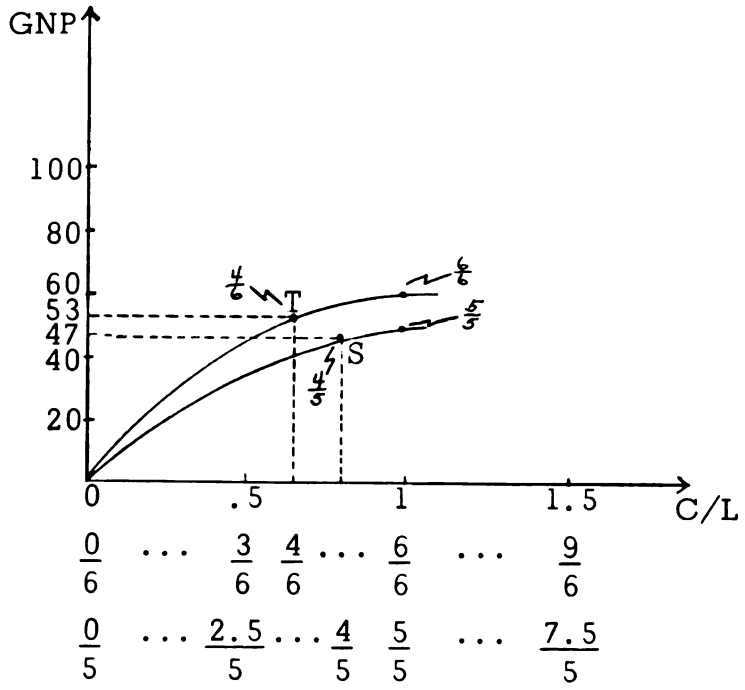

Figure 9.

When the input of L is increased from 5 to 6 units, output increases from 47 to 53 units (from point S to T) and the economy moves to a different production surface. Figure 9 thus demonstrates the type of production function used in Figures 6 and 7 and hereafter throughout this study.

The Theoretical Framework

We are now in a position to demonstrate how a demand for human agents with associated skills and knowledge is generated by an economy over time. Assume that a closed economy is represented by a three-dimensional graph of the same type as previously shown in Figure 6.

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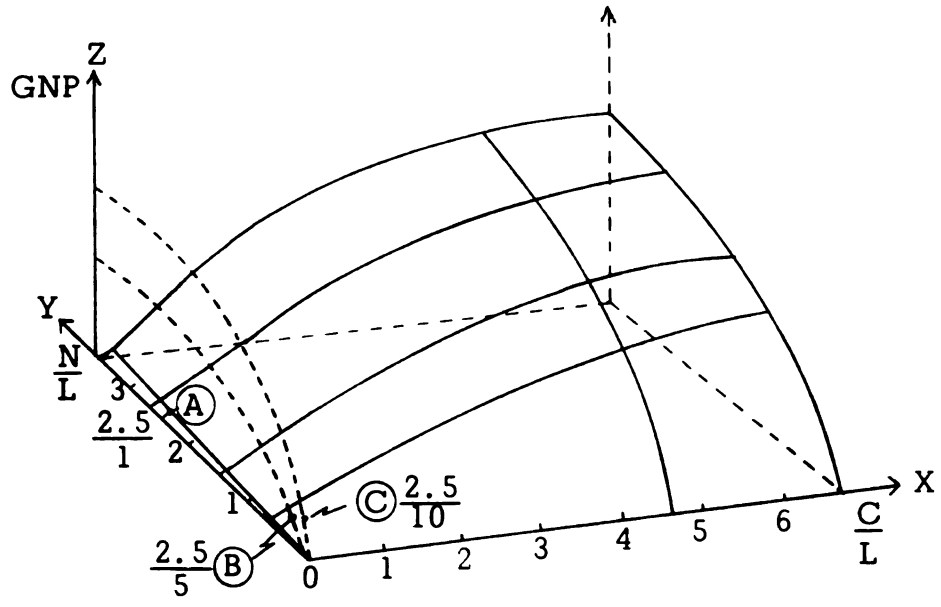

Figure 10.

Furthermore, at the onset assume N represents the natural resources base employed by the economy, C is composed of primarily nonhuman capital, and L represents labor with some basic set of skills and knowledge, but with actually little or no real investment as yet in human capital. Technology is assumed constant and the quantities on the axes represent only the amounts of factors (N, C and L) actually employed by the economy.[2]

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[2]The theoretical framework used in this study indicates only the amount of the three basic inputs actually employed by the economy during that particular period in time. This has special implications for the natural resource input, because natural resources have been defined to include all "free gifts of nature." For example, if labor becomes more abundant, it becomes relatively less expensive and as a result is employed in larger quantities relative to the other inputs. The same is also true for capital. Either of these two inputs actually can become so relatively abundant that they hinder the productive effort of the economy. Yet society does not like to allow any segment of them to remain unemployed either due to institutional factors (as in the case of labor) or simply to avoid industrial undercapacity (which indicates idle capital). Not so for natural resources. Excess natural resources are allowed to remain unemployed until they are needed, e.g. forest or oil reserves. Therefore in the theoretical framework one is never faced with the question of too many natural resources in relation to other inputs. Such excess natural resources are simply allowed to remain unemployed. This treatment appears to be consistent with real world observations.

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To begin we assume a "nomadic or pastoral" type of economy with only inputs N and L (no significant C) producing a point A. This is assumed to be a primitive economy, using few simple tools. The people are completely conventional and traditional in their economic processes, they use the same tools (C) in the same proportion to population (L) and in the same manner all the time and their production, except for the replacement of the conventional tools, is entirely devoted to subsistence.[3] Over time population grows and the economy moves to point B. Point B is on a higher "potential" production function (assuming that the economy could develop or discover more N), but due to the relative proportions of factors employed, total GNP at B is only slightly greater than at point A. Per capita GNP at point B has declined relative to what it formerly was at point A. Point C represents a further build-up in population against the natural resource base.[4]

This concept can be perhaps more easily seen by the use of Figure 11 (in two dimensions). In this example GNP (output) is 47 at point A (on lowest production function) when 4 units of N and 5 units of L are employed. As population increases and L grows to 6 units, factor proportions change (between L and N) and output (GNP) increases to 53 units. Total GNP has increased but GNP per capita has declined. Similarly output increases to 57 units as an increase in the labor force (to 7 units) moves the economy to point C. Again per capita GNP has declined. If the labor force (L) continues to grow relative to the natural resource input (N), the relationship between the two factors may become so disproportionate that even <u>total</u> GNP may decline. Eventually an output (GNP) of zero theoretically would

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[3] B. S. Keirstead, <u>Capital, Interest and Profits</u> (New York: John Wiley and Sons, Inc., 1959), p. 9.

[4] This entire argument could also be presented in terms of a diminishing natural resource base vis-a-vis a constant population, instead of the increasing population and constant natural resource base used in this treatment.

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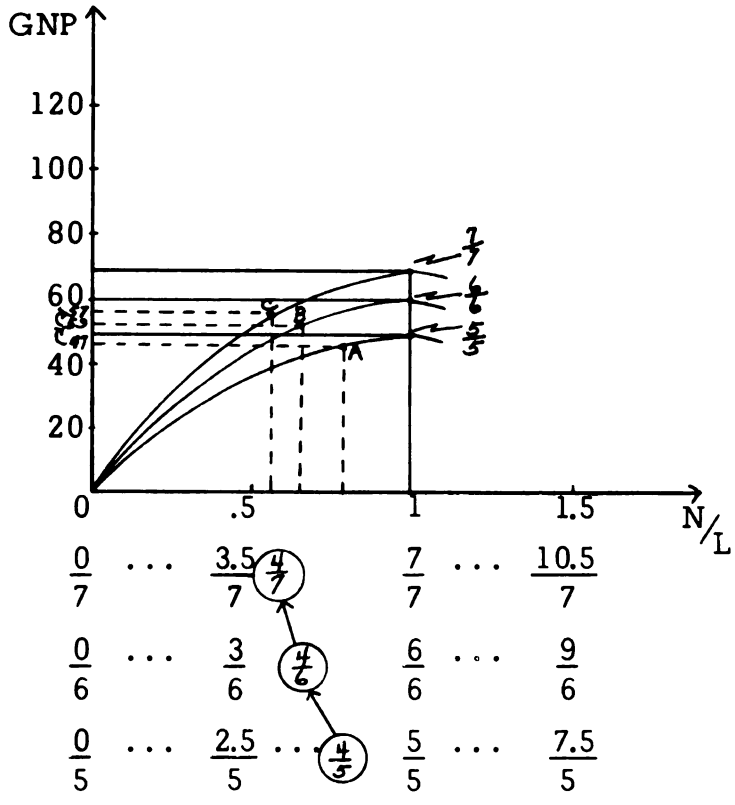

Figure 11.

To overcome the population pressure on the natural resource base the economy can: (1) attempt to reduce the rate of population growth (or even experience population reduction through war, emigration, etc.), (2) move out the OY axis by adding more units of the same kinds of natural resources,[6]

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[5]However, in the real world starvation would likely prevent one from ever observing this result.

[6]Natural resources previously have been defined to include all free gifts of nature such as arable land, forests, mineral and oil deposits, and water resources. However, it is recognized that the development of natural resources often requires a considerable expenditure on the other inputs (nonhuman capital, human capital, and labor). Thus it can be argued that arable land is not free but in many cases involved a generation of hardship (labor and capital expense). Even the seeking of gold can be an expensive process.

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(3) move out the OX axis by adding more units of the same quality of capital, or (4) do any combination of these things simultaneously (see Figure 12). It is important to note at this point that even when an economy expands its production by extension and intensification of existing techniques that a considerable amount of human capital of the same quality is required. That is, the economy demands additional human capital generally having the same level and composition of skills that the economy previously has had.[7] This additional human capital is needed to operate or develop the increased quantity of capital and/or natural resources, even though the additional units of capital and natural resources are of the same type (quality) as the original (base).

With the aid of a three-dimensional diagram, the need for developing human capital can be better demonstrated. In Figure 12, the economy is assumed to have a fixed quantity of labor and constant technology.

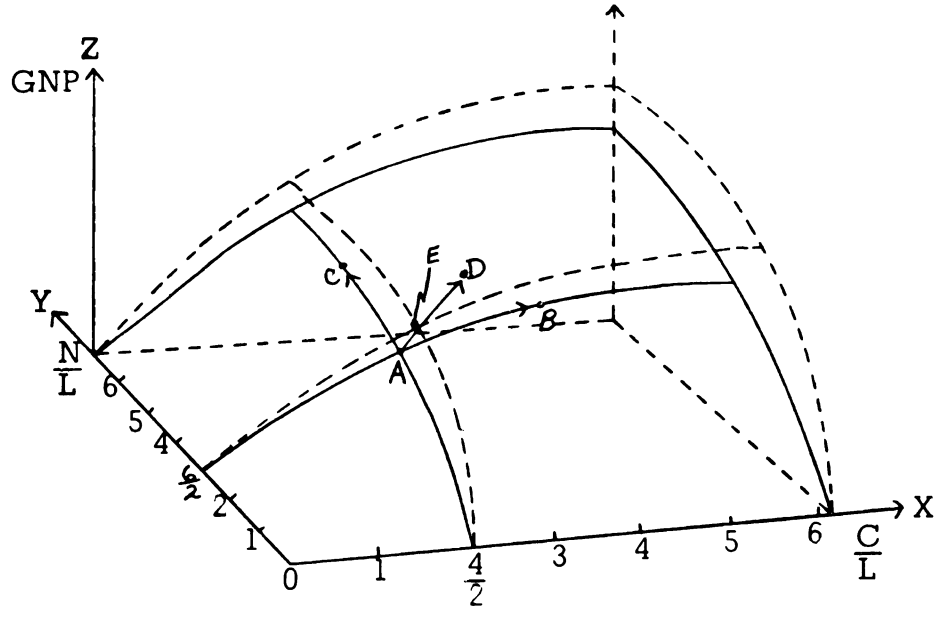

Figure 12.

[7] The question of the skill composition of the increased demand for labor will be discussed in Chapter IV.

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Assume that the economy is using 4 units of C, 2 of L, and 6 of N (i.e., producing at point A). Additional units of the same quality capital will simply move production from point A toward point B. Similarly, additional units of the same N will move the economy along the same production function toward point C. Adding constant quality units of N and C simultaneously will move the economy along the same production surface in the direction of point D. But one quickly notes that the investment necessary to add more units of the same kinds of types of natural resources and capital is an expensive process. Also moving out along the same production function or surface does not really add to GNP very rapidly. In addition there is often present the threat of population growth. If population growth does occur the result is a larger labor force and L becomes relatively cheaper vis-a-vis N and C which causes more L to become employed relative to C. As this happens (now assuming that L does increase in Figure 12), GNP per capita increases very slowly or even falls. A process like that demonstrated in Figure 11 thus takes place and in theory could continue until output (GNP) reaches zero because $\lim_{L \to \infty} N/L = 0$ and $\lim_{L \to \infty} C/L = 0$. However, in the real world total GNP rarely declines (except as a result of wars, etc.) but rather GNP grows so slowly or is so nearly constant that GNP per capita grows slowly (or even declines).

How can an economy overcome the difficulties which result from population growth pressing against the known natural resource base or similarly the depletion of the natural resource base in the face of a more or less constant population? The answer is that by investing in human capital (improved human knowledge and skills) better forms of nonhuman capital can be invested, the natural resource base can be conserved, the known natural resources can be better (more fully) utilized, more natural resources discovered, and the human agent (labor) can be improved (health, migration, etc.). In other words, in order to develop the natural resource base and capital required, the capacity for man to manage, and his ability to acquire and originate technical advance must be augmented. This requires improvement in the human agent, i.e., the development of

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human agents with additional and improved skills and knowledge. The improved human skills and knowledge result in new improved inputs that cause the production surface to "lift vertically" (from point A to E in Figure 12). The new improved inputs increase output per unit of input, but the problem is that as measured conventionally in physical terms this is largely meaningless unless one can specify how "units" for the new input compare with "units" of the old. The technological advance really involves a new factor or factors of production (L', C' and/or N') or a previously unknown way of combining old factors of production. The "upward shift" is not a movement from the same set of rigorously defined input axes. Instead one is dealing with a new, more productive, conventional input (or inputs) that produces a new, higher production function or surface. The "new" input or inputs (C' etc.) cannot be represented on the same input axes as the "old" input or inputs (C etc.) when the axes <u>are rigorously defined</u> to represent only a factor (or factors) of production <u>of unchanging composition</u> with each unit of exactly the same size. However, in the graphical framework developed in this study, inputs representing different technologies or skill levels can be shown in the same graph <u>when it is explicitly spelled out that one or more of the factors have changed in composition</u>. Only the problem of obtaining comparable units with which to position the inputs as ratios along the input axes remains. This problem may be difficult in some cases but it is not overly formidable. Common physical or monetary denominators can usually be found. For example, a bushel of hybrid corn can be compared with a bushel of open-pollinated corn by using the same graph when it is recognized that these two inputs differ and that the skill level or technology "behind" each of them differs.

Once again it has been shown how difficult it is to determine the effect of investment in human capital ("education") on output. Additional "education" may affect respectively inputs L, L and C, L and N, or all

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of the three basic inputs at the same time.[8] For instance, quite precise "education" e.g. training conservationists may affect only inputs L and N; but what if the students invent some new capital equipment as a result of their conservationist training? Thus, it has been deemed best to omit "education" from the production per se as has been done in the previous discussion (since the later stages of Chapter II).

But human capital is imbedded in the existing N, C, and L, except in the most primitive production function and the amount increases with the economic growth and development of an economy.[9] Thus in Figure 12 the distinction between the inputs N, C and L tends to lessen or become fuzzy as more and more human capital becomes embodied in them through time (i.e., the economic development process). The fact that human capital becomes embedded in the inputs N, C, and L has important implications when one considers investment choices for economic development. In particular, investment in education per se is not a choice. Rather society has to improve N, C, and L through investments in education. The choice in investment, therefore, is deciding where the biggest marginal payoff will come and then deciding whether that payoff can best be accomplished by using human capital or something else. This problem will be pursued later in this chapter as a part of the section concerning investment criteria.

The Theory Restated

Thus far the changes in relative proportions of the three basic inputs of an economy have been demonstrated, largely by the utilization of three-dimensional diagrams, in order tc show how the need for human skills and

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[8]The capital (C) and natural resource (N) inputs standing alone cannot be affected by "education." They are altered by "education" that enters through the human element or carrier labor (L). This fact is demonstrated by the simultaneous set of equations in Chapter II.

[9]See T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), p. 134.

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knowledge are generated. However, the important price interrelationships between the factors in the equation GNP = f(C,L,N) as growth proceeds may have become obscured as a result of the over-shadowing considerations of factor proportions present in the analysis up to this point. For these reasons, this section will attempt to reiterate and amplify the theoretical framework by employing different graphical techniques and comparative static analysis.

The basic graph utilized in this section is shown in Figure 13. Here the three basic inputs of the economy — capital (C), labor (L), and natural resources (N) — are shown on the respective X, Y and Z axes.

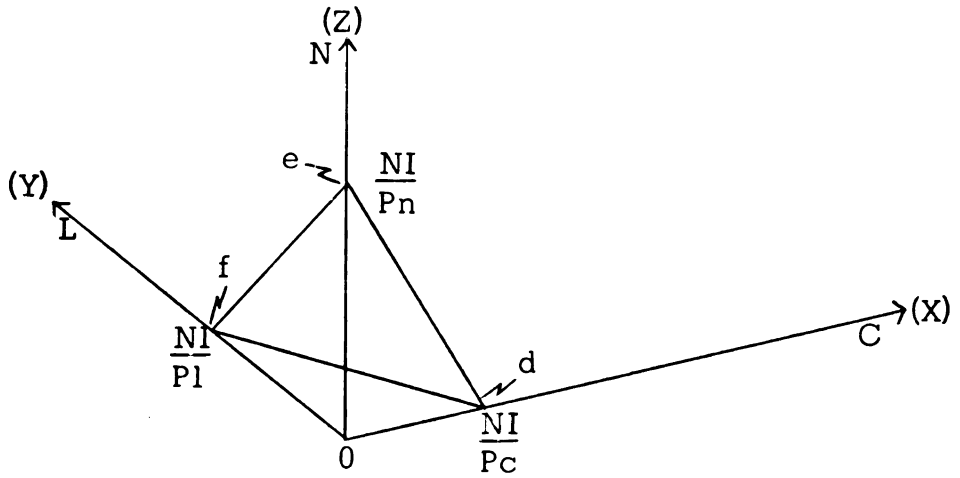

Figure 13.

The prices of the inputs N, C, and L are represented by the symbols Pn, Pc, and Pl respectively. The national income that the economy has available, during the time period under consideration, for the purchase of the three basic inputs for productive uses is indicated by the symbol NI. Thus, in the graph, the three fractions $^{NI}/_{Pn}$, $^{NI}/_{Pc}$, and $^{NI}/_{Pl}$, indicate the number of units of the respective inputs N, C and L that the economy can afford to purchase, if it purchased all of the N, C, or L respectively (one at a time). For example, if the economy spent all its national income on labor it could employ enough "units" of labor to be at point f in Figure 13.

Similarly, if all its national income were spent on capital it could reach point d, etc. Therefore, the fractions NI/P_n, NI/P_c, and NI/P_l, define points on the respective N, C, and L axes that are the three corners of an isocost surface. We are now in a position to apply this analytical tool as an aid in clarifying the theory.

Initially, every economy began, at one time or another, near the origin (point 0) of Figure 14. Subsequently, the population increased thus adding to the labor force (L). In these early stages of economic activity, the natural resource base was essentially free and production decisions were made largely on the basis of the labor input. Nonhuman capital is first developed in order to economize on labor use and investment in human capital does not return high dividends except as it permits substitution of human capital for labor. This is the case of the "nomadic" or "pastoral" type of economy which has only inputs N and L, with relatively small amounts of crude capital (C). Such an economy uses few, simple tools in a conventional and traditional manner. In addition, the same tools are used in approximately the same proportion to the population and in the same manner all the time. Except for replacement, the production of tools is entirely devoted to subsistence. The isocost surface for such a primitive economy at its particular level of national income[10] is outlined by the points d e f in Figure 14. At this stage natural resources are relatively inexpensive with respect to both capital and labor, and labor is, in turn, relatively inexpensive with respect to capital.

Over time, as economic activity proceeds, the population grows. Given the prevailing level of technology, additional natural resources are expensive to develop and they may become even relatively scarcer.[11] In

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[10] In Figure 14, the relative prices of subsequent economies will be compared at this same level of national income.

[11] This does not mean that no additional natural resources are being discovered and employed by the economy. In most cases, the net addition in natural resources discovered and employed will be very significant but the population increase simply outruns this addition. Hence, the addition

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addition, the rate of population increase may be so rapid that more labor steadily becomes combined with nonhuman capital in the production process at the prevailing level of technology, and hence, the economy is continually faced with the problem of increasing relative scarcity of nonhuman capital.[12] The net result is that the economy moves to the isocost surface g e h in Figure 14. Here one can see that natural resources have become relatively much more expensive with respect to both capital and labor, and capital has become somewhat more expensive relative to labor. In other words, both natural resources and nonhuman capital now command higher prices with respect to labor. Once natural resources command a higher price, an economy attempts to economize on their use. Also, new, more productive forms of nonhuman capital are sought.

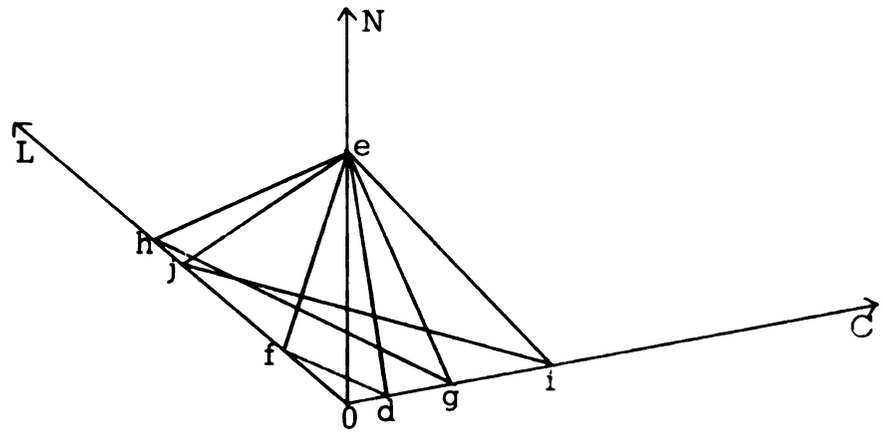

Figure 14.

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to nonhuman capital lies somewhere between the rapid increase in the labor force and the more moderate increase in natural resources employed.

Population increases have been used here for ease of explanation. The relative price change could be triggered as well by the depletion of the natural resource base or diminishing returns to natural resources given the technology and a relatively constant population.

[12]As more labor is employed, its marginal value product (MVP) decreases. Thus the incentive to invest in and demand capital increases because labor is continually approaching Stage III of the production function as more is added.

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In an attempt to economize on the use of natural resources, the economy develops and employs largely more nonhuman capital. This nonhuman capital although more complex than that employed in the "nomadic" economy, is still quite crude and requires relatively little human capital to develop or operate. Ultimately, however, the economy discovers or is forced to discover that investment in human capital can shift the production function upward by increasing the productivity of the three basic inputs of the economy, natural resources, labor, and nonhuman capital, i.e., human capital is highly productive. The investment in human capital is aided by the fact that rising population while associated with increased natural resource prices (natural resources per person are reduced) is not associated with higher costs for the development of human skills.

Therefore, in summary, what has happened is that the price of natural resources has increased with respect to nonhuman capital and labor. Moreover, additional units of the same labor and nonhuman capital cannot produce the needed increase in output for the economy rapidly enough. Therefore human capital is demanded and substituted for labor. In addition, as the economy develops, more complex forms of nonhuman capital continually are required and this, in turn, requires human capital. Thus the capital component of an economy becomes more and more composed of human capital. This is supported by the experiences of most developed countries today.

Once human capital is introduced into the economy in larger quantities the relative prices of the three basic inputs changes once again. The more skilled labor tends to become relatively more expensive and as a result somewhat less labor may be employed. Capital tends to become available in larger quantities and becomes relatively less expensive. Thus the movement is to something like the isocost surface j e i in Figure 14.

Figure 14 now can be redrawn as three two-dimensional graphs in order to better show the changes in relative price. This is done in Figure 15. Figure 15 (a) and (b) are relatively straightforward. They show labor and

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[13] Albert
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capital becoming relatively less expensive with respect to natural resources as the economy develops. Figure 15 (a) shows that investment in human capital may at some point make labor become somewhat more expensive and hence less labor would be employed at <u>that given level of national income</u> (the movement from point h to point j).

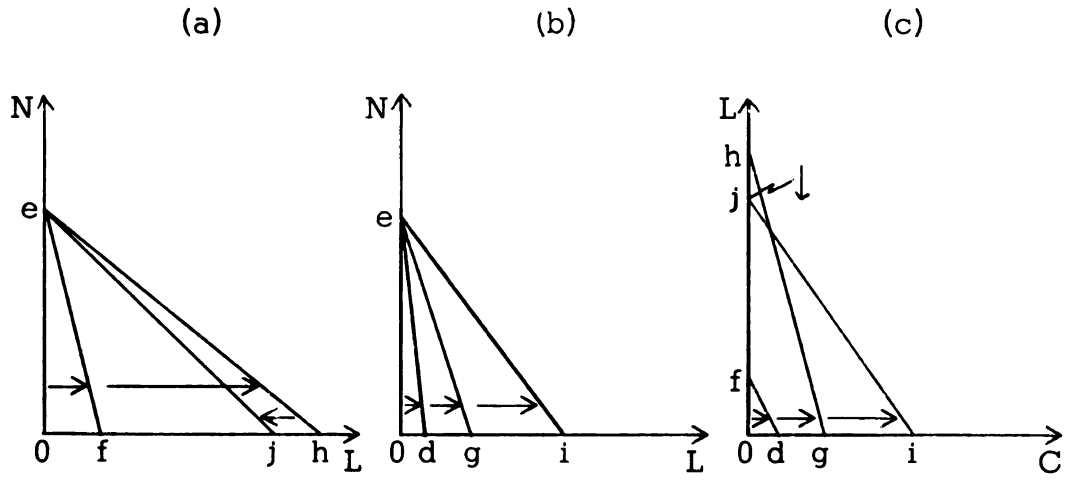

Figure 15.

Figure 15 (c) showing the price relationships between labor and capital, is somewhat more complex. The movement from the origin to isocost line fd and subsequently on to isocost line hg is characterized by an increasing abundance of labor which constantly forced the relative price of labor down. The movement from isocost line hg to isocost line ji is characterized by an increasing investment in human capital and increasing industrialization, which causes capital to become less expensive relative to labor. Less developed countries typically begin development efforts facing a labor-capital isocost line similar to hg in Figure 15 (c). With development the labor-capital cost situation changes to be more like isocost line ji.[13]

Both Figures 14 and 15 analyze relative factor costs at a <u>given level</u>

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[13]Albert O. Hirschman, <u>The Strategy of Economic Development</u> (New Haven: Yale University Press, 1961), pp. 128 and 151.

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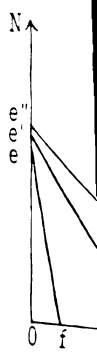

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of national income. Thus the movement from h to j on the labor axis is obtained which indicates an absolute decline in the amount of labor employed. However, in reality, one expects national income to increase during the economic development process. A growth in national income would allow the isocost lines in Figures 14 and 15 to "drift" out from the origin over time. Thus a situation more like that presented in Figure 16 would be produced. Here the movement from h to j on the labor axis is positive since the income increase overpowers the change in relative prices.

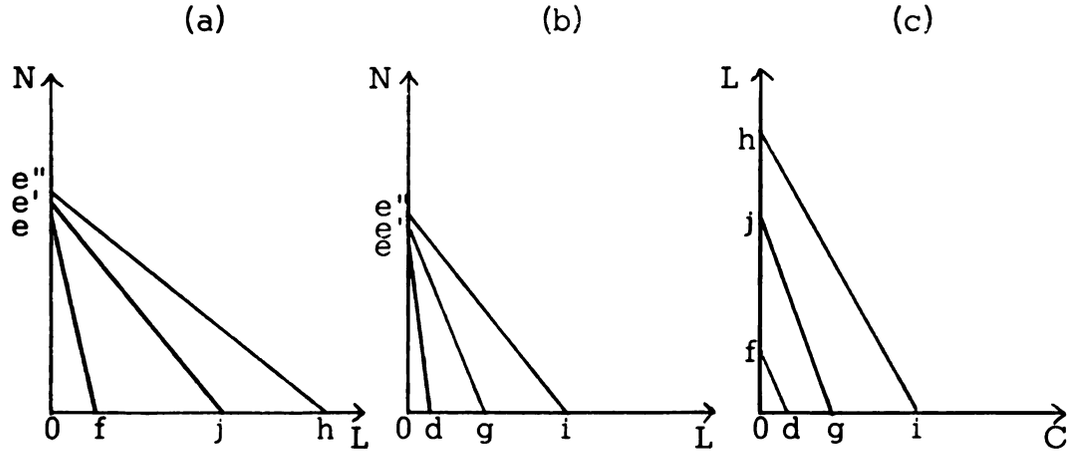

Figure 16.

A number of comments by various economists are relevant to the theory at this point. The initial desire of an economy to acquire capital (both human and nonhuman) results from the realization that the needed superior (more productive) inputs do not consist of land or other natural resources.[14] The economy has in a sense exhausted the production possibilities given the state of the arts. Better resource allocation and increases in the stock of the existing factors (using the same technology), "are high-priced sources of additional income, and for this reason they provide little opportunity

[14] T. W. Schultz, "Investment in Human Capital in Poor Countries," in Paul D. Zook (ed.), Foreign Trade and Human Capital (Dallas: Southern Methodist University Press, 1962), p. 11.

for growth."[15] Therefore, superior (more productive) nonhuman capital inputs are needed by the economy, but so are skills and knowledge for operating the better forms of nonhuman capital and "as productive inputs in their own right."[16]

Another consideration is the problem of "more and better" capital. Several times the distinction has been made between adding more of the same kinds of nonhuman capital and adding new, improved forms of nonhuman capital. In other words, this is the question of improving the quantity of tools versus improving the quality of tools. Keirstead states that "a conceptual distinction between the two processes exists, but overemphasis of this distinction leads to error of separation."[17] He continues by observing that in a progressive society the two processes are always found together. Thus human capital is needed for both increasing the quantity and the quality of nonhuman capital. Similarly a growing economy will require additional amounts of human capital of both the same and improved quality.

Natural resource scarcity, population pressure, and decreasing returns to additional units of N, C and L have been all thus far discussed as possible inducements or "shocks" that lead to an increased need for human capital. Keirstead emphasizes the necessity of a shock to induce a society to increase its stock of capital. However, he does not identify the source of the shock but is content to analyze just its effects after stating that the inquiry into the nature of the shock is of "utmost importance." Hirschman names four situations, with respect to the population variable, where the passage from aspiration to reality is more easily visualized than in others. He believes that the probability of a strong reaction is greater if the population increase comes: (1) as a sudden shock, (2) is

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[15] T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), p. 131.

[16] T. W. Schultz in Paul D. Zook (ed.), loc. cit.

[17] B. S. Keirstead, op. cit., pp. 9-12.

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combined with increased urbanization, (3) the upper as well as the lower classes are affected, and (4) the increase causes the minimum production thresholds to be passed in a number of important industries.[18] One can also see that, in certain cases, international trade can soften the shock or delay the day of reckoning before a country is forced to invest more in human capital or face a decline. It is also relevant at this point to note that Hirschman divides the events resulting from population growth into three periods:

> . . . during the first, per capita incomes do not increase, but countries, in reacting to population pressures acquire the abilities to launch undertakings that will lead to genuine economic growth; during a second period, per capita incomes begin to rise, with economic growth continuing to draw strength from population growth; and only at a later stage does economic growth wean itself from population growth and becomes self contained.[19]

Relationship of the Hirschman Statement and the Malthusian Model to this Thesis

Population Growth Versus Factor Depletion

Thus far the theoretical framework has been developed largely in terms of a growing population and constant natural resource base. But population growth is only one of several forces that may lead to a demand for human skills and knowledge. Other factors, such as diminishing returns to nonhuman capital and depletion of natural resources, also may play important roles. The population pressure example was used for expository purposes, but will be pursued in some depth before turning to other considerations.

Albert O. Hirschman[20] notes that the commonly accepted belief is that population growth frustrates attempts at economic development. But

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[18] Hirschman, op. cit., pp. 179-80.

[19] Ibid., p. 181.

[20] Ibid., pp. 176-82.

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he proposes some reasons which turn population pressures into forces that may stimulate development. Hirschman begins his analysis with Duesenberry's "fundamental psychological postulate," which says that people will resist a lowering in their standard of living.[21] The two key propositions of this theory are:

1. Population pressures on living standards will lead to counterpressure, i.e., to activity designed to maintain or restore the traditional standard of living of the community.
2. The activity undertaken by the community in resisting a decline in its standard of living causes an increase in its ability to control its environment and to organize itself for development.[22]

The view that society will react to the threat to its total income caused by population pressures hinges on an expectation of society that a successful reaction is possible. A successful response depends upon some available "slack" in the economy which can be taken up. This is contrary to the basic hypothesis of the neo-Malthusian models — that all productive forces are fully utilized and the supply of land and capital is fixed. And, due to these neo-Malthusian assumptions, demographers have neglected all reactions except the most direct ones — birth control and postponement of marriage.[23] However, these reactions are only two of many that may occur.

Hirschman seems to place himself on both sides of the population issue. He states that population pressure ranks as the least attractive of the inducement mechanisms he has studied, because: (1) it works through

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[21] Hirschman identifies psychological forces. The purpose here is to present Hirschman's analysis and not to resolve the question of accepting or rejecting his identification of psychological forces. Others have also presented development theories involving psychological forces, e.g. Everett E. Hagen, On the Theory of Social Change (Homewood, Illinois: The Dorsey Press, Inc., 1962).

[22] Hirschman, op. cit., p. 177.

[23] Ibid., pp. 178 and 180.

an initial decline in per capita income rather than through an uneven expansion in output, and (2) it is less reliable than the other mechanisms because "we are provided only with an aspiration to return to the status quo ante, but generally not with specific means or intermediate reaction links for doing so."[24] At one point it is even stated that "population pressures are a clumsy and cruel stimulant to development."[25]

On the contrary, Hirschman argues as follows:

> All in all, population pressure still qualifies as an inducement mechanism in the sense that it presents the developmental forces within a society with an opportunity to assert themselves. It supplies "the motive and cue for passion" (though admittedly it fails to provide many cues for action). Thus it seems wrong to say that population pressures act an an obstacle to development. There are circumstances under which these pressures are unsuccessful in performing their stimulating role just as relative price increases are at times ineffective in calling forth increases in the supply of the "signaled" commodities.
>
> The view that has been presented is consistent with the fact that population pressures have demonstrably been an integral part of the development process in all countries that are economically advanced today [emphasis mine].[26]

In conclusion, Hirschman takes an intermediate view of the problem. He states, "Our view leads us to take a far calmer view of the situation."[27] This is because a country can learn by trying to offset the effect of a population increase.

> If a community makes a genuine effort to defend its standard of living in the face of population pressures, it need not be afraid of imaginary traps, for cumulative growth is then already in the making: just as income can rise in advance of consumption so can economic progress get underway before being registered in per capita income increases.[28]

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[24] Ibid., p. 179. [25] Ibid., pp. 181-82. [26] Ibid., p. 181.
[27] Ibid., p. 182. [28] Ibid.

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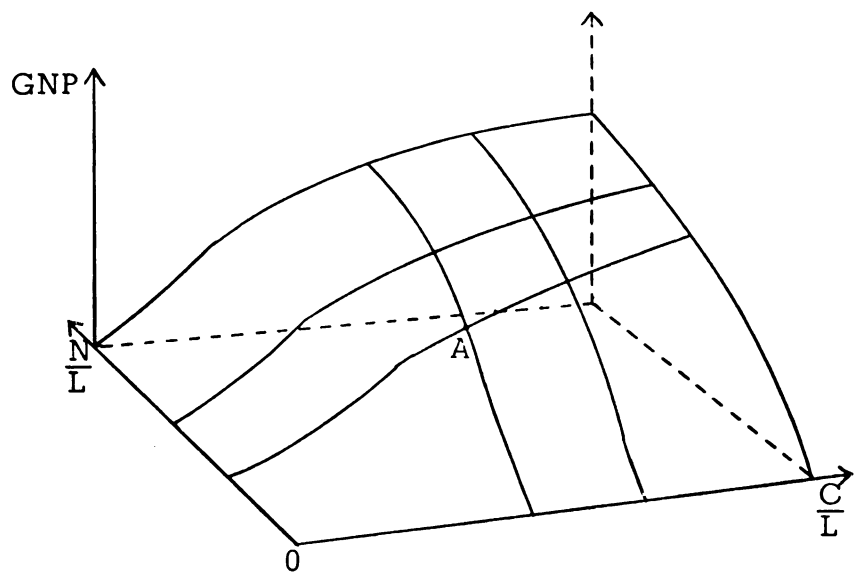
One should not draw the conclusion from these remarks, however, that rapid population increases are a good thing and should be advocated. Even for Hirschman, reducing the rate of population growth is almost without exception the desired policy.

Hirschman's analysis is presented in terms of a growing population pressing on a constant natural resource base. The analysis developed earlier in this chapter was also presented in terms of a growing population, these mainly due to the ease in presentation (expository purposes). But this is not the only factor which can cause an increase in the need for human skills and knowledge.

In terms of the three-dimensional diagram used earlier and shown in Figure 17, population growth is not the only factor increasing the need for human skills and knowledge. For example, assume in Figure 17 that the economy is at point A, population (L) is constant, and that the level of technology (human skills and knowledge) is constant. Then over time natural resources will be depleted thus creating pressure on the standard of living and generating the need for new and better technology.



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Even assuming no depletion of the natural resource base and a healthy economy that can save and invest in additional natural resources and capital, eventually new and additional human capital (skills and knowledge) will be needed. This is because even with a constant population (L), constant technology, and sufficient savings to replace and build new capital (using the same technology) the economy will eventually, given enough time, reach the point of diminishing returns to capital due to a surplus of capital at the prevailing level of technology.[29] New and better technology (human skills and knowledge) will be greatly desired at or before this time. In addition, human preferences change and aspirations may increase over time thus adding to the desire for an altered technology — hence more and new human skills and knowledge.

The inducements provided by natural resource depletion or diminishing returns to capital (assuming technology and population constant) would tend to be stronger than the inducement of a growing population on a fixed natural resource base, because a simple reduction in the rate of population growth (unless it is negative) does not provide any relief from difficulty in these instances. In other words, relief through the population variable in cases where an economy has a relatively constant population with natural resource depletion or diminishing returns to capital would have to come about through a population reduction. This would be most unusual in the real world. Relief could come through international trade, at least in part, but in the longer run new human skills and knowledge will have to be developed and utilized.

Thus, in the final analysis, the "demand" or "need" for human skills and knowledge at the prevailing level of technology of an economy depends upon or is a function of any one or all of the following: (1) diminishing

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[29] Labor becomes the limiting factor in this case. The problem is that additional units of nonhuman capital produced using the same level of technology are not very productive and hence are largely redundant.

returns to nonhuman capital (C increases, L and N relatively constant),[30] (2) depletion in either quality or quantity of the natural resource base over time (even with population constant), (3) population pressure (L increases, N and C relatively constant) upon the natural resource and/or capital base,[31] and (4) diminishing returns to scale to N, C and L.[32] Any combination of the four fources can be operating at any one given time.[33] These forces are strictly economic in nature. In addition, certain social, cultural, and political factors must be present in order to allow this demand to be met.[34]

It is now possible to see that Hirschman's population pressure argument is only part of this system. Thus instead of being concerned with

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[30]This is the case of a capital "surplus" or a large capital/labor ratio. Conversely, it also can be regarded as the case of a labor shortage.

[31]This is the case of a labor surplus or small capital/labor ratio. Conversely, it also can be regarded as the case of a capital shortage.

[32]Item 4 goes beyond the factor disproportion or imbalance problems of the first three items. It assumes a diminishing marginal product per unit of input as the quantities of the three inputs N, C, and L are increased nearly simultaneously. Thus item 4 would be irrelevant if one insisted on strict adherence to the assumption of a linear homogeneous production function of the first degree and completely ignored evidence in the real world. But one knows that in reality a linear homogeneous production function to the first degree is very unrealistic, because not all "relevant" variables can be increased to scale. Problems in expanding management to scale or other organizational difficulties almost always cause another result to be observed. Therefore, item 4 is included to both complete the theory and make it more realistic. See Friedman, op. cit., pp. 136-38.

[33]The increased demand for human knowledge and skills by these forces is largely non-neutral in nature. That is, an improvement in the quality of human factors is demanded and not just a change in quantity that results from a simple extension of the economy's existing techniques.

[34]For example, increased human aspirations undoubtedly are of considerable importance — especially countries that are economically developed or beginning to develop. In these cases, the population begins to better comprehend what investment in human skills and knowledge can do for them as well as for their economy.

considerations of population growth (pressures) versus factor depletion in generating the need for human skills and knowledge, one should emphasize that population pressures, factor depletion, diminishing returns, and human aspirations all operate to generate the need for new skills and knowledge.

A Malthusian Model?

The Malthusian model has been alluded to previously in this study.[35] It should be emphasized that the theory presented in this thesis is not simply a restatement of Malthusian ideas. Malthus claimed that population tends to increase by geometrical progression if unchecked while the means of subsistence tends to increase in arithmetical progression. Therefore, man was destined to misery and poverty unless population growth was checked. Population growth might be slowed by what Malthus called preventive checks such as late marriage, but if these were not exercised, positive checks such as famines, diseases, or wars would reduce the population to a point of subsistence. In other words, there was no real hope for man in the realm of economic progress above a subsistence level in the Malthusian framework (except with late marriages).

Malthus never fully realized the potential miracles of the Industrial Revolution and of technological innovations in shifting the production possibility curves outlined.[36] In addition, he did not foresee the fertility decline that has occurred in most Western nations. Malthus modified some of his views in later editions of his essay and should be given much more credit than he usually is for discussing a wider subject range

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[35]It is interesting that T. W. Schultz states that, "the Malthusian conception of the growth in population is by no means obsolete when one examines the recent upsurge in population in relation to the supply of food in many poor countries." T. W. Schultz, "Investing in Poor People: An Economist's View," American Economic Review, Vol. LV (May 1965), p. 510.

[36]Paul A. Samuelson, Economics: An Introductory Analysis (4th ed.; New York: McGraw-Hill, 1958), p. 27.

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than just the implications of population tending to increase at a geometric rate and means of subsistence tending to increase at a progressive rate.[37] For instance, he clarified many other points such as population growth encourages development only if it brings an increase in effective demand.[38] Yet, his basic concept of the tendency of mankind to breed to the limit provided by the means of subsistence still stands as one widely-accepted answer to the question of how far population will increase. And, in addition, this quite limited analysis still holds grains of truth for many countries today.

The analysis presented in this study provides a way out for the economy, however, If population pressures build up on the natural resource and capital base, investment in human capital can increase the productivity of the inputs N, C, and L. GNP per capita is increased and the economy is not forced to a subsistence level. Of course the population may not be able to organize itself socially so as to provide investment in human capital. The alternative to intelligent progress is all too often a "Dark Age" in many countries due to any number of factors such as war, superstition, etc.

Hirschman's statement is more general than the Malthusian model.[39] He allows the economy to have some "slack" so that additional savings can be extracted. Also some fuller application of existing technological and organizational knowledge is allowed. This is a relaxation of the Malthusian assumptions of fully utilized productive forces with a fixed supply of land and capital. This permits the economy to have some leeway for reactions other than the directly Malthusian ones of birth control, late

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[37] Raleigh Barlowe, Land Resource Economics (Englewood Cliffs, New Jersey: Prentice-Hall, 1958), p. 68. See, for example, Benjamin Higgins, Economic Development: Principles, Problems, and Policies (New York: W. W. Norton Co., 1959), pp. 99-106.

[38] Barlowe, loc. cit.

[39] Hirschman, op. cit., pp. 178 and 180.

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The framework developed in this chapter is, in turn, more general than Hirschman's statement. Hirschman presents his argument in terms of a growing economy and a constant natural resource base. The analysis presented in this chapter treats not only population growth vis-a-vis a constant natural resource and capital base, but also includes natural resource depletion and diminishing returns to factors at a given level of technology as important variables. Thus in the final analysis the Malthusian model is a special case of the Hirschman framework and the Hirschman framework is in turn only part of the model developed in this thesis.

In conclusion, both the framework developed in this study and the Hirschman analysis allow the economy to have some "slack" above the subsistence level. The Malthus framework does not. "Slack" is essential to the argument concerning the ability of an economy to invest in human capital. Foreign aid is an alternative. Borrowing may be another alternative. The desire or need for human capital is essential in any case.

The Means for Providing Additional Human Capital

The analysis developed thus far has demonstrated only why a growing economy "needs" additional human agents with more productive associated skills and knowledge. But demand theory requires both need and means in order to derive an effective demand. In other words, effective demand couples the desire to buy with the ability to pay. Thus the effective demand for human skills and knowledge depends not only on the need of a particular country, but also on the ability to pay for the needed skills and knowledge of this same country.

Economic literature includes a considerable number of ways by which a country can obtain the means necessary in order to pay for additional human

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capital.[40] These include, among others, moral suasion, taxation, confiscation,[41] foreign investment, foreign loans, private incentives (patents, etc.), foreign aid, foreign grants, export stimulation, import restrictions, inflation (including "pump-priming,")[42] and a more efficient allocation of existing resources (including labor or "disguisedly unemployed")[43] and even laissez faire.[44] Some of these methods require a reduction in the rate of current consumption, while others do not. This difference is quite easily distinguished in each case. Suffice it to say that many schemes and proposals for providing the means for economic development have been used.

There is also another question that is important with respect to the means analysis. The ability of an industry, or the society in macro terms, to pay for the extra skills must mean also that the society is able to absorb the new ideas and make them productive. This implies a transformation that in many cases is not strictly economic in nature. Often this transformation has been a difficult one for countries to make and hence it is of considerable importance in many instances.

The means analysis, in effect, "closes the ring" of the theoretical framework. It has been known for some time that only if an economy can

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[40]For an excellent overall view of the various ways of financing economic development, see, for example, Benjamin Higgins, Economic Development: Principles, Problems, and Policies (New York: W. W. Norton, 1959), pp. 457-74, 480-524, and 567-629; and Gerald M. Meier, Leading Issues in Development Economics (New York: Oxford University Press, 1964), pp. 115-93 and 338-408.

[41]Martin Bronfenfrenner, "The Appeal of Confiscation in Economic Development," Economic Development and Cultural Change, Vol. III (April 1955), pp. 201-18.

[42]See Benjamin Higgins, op. cit., p. 469.

[43]Ibid., p. 457.

[44]See P. T. Bauer and B. S. Yamey, The Economics of Underdeveloped Countries (Cambridge: Cambridge University Press, 1957).

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generate or obtain an investable surplus at some point can it invest in human capital in a sufficient amount to help produce a take-off. The means analysis also relates the theoretical framework more closely to the main body of economic literature, especially that concerned with development problems. It provides a rationale for differing patterns of development and provides some recognition for the influence of social and political impediments.

Investment Criteria and Human Capital

It is quite apparent that even when an economy has acquired resources in excess of the quantity required to maintain itself at some acceptable level, that a stubborn problem remains. The question that must now be answered is how to best allocate resources (e.g. labor and skills of various kinds, physical capital of a variety of sorts and types, money, foreign exchange, etc.) among the different sectors of the economy in order to make a maximum contribution to economic growth. It is the question of how to allocate resources in such a manner that they result in the largest increase in the capacity of the economy to produce goods and services.[45]

The investment criteria question has received a great deal of attention in the literature.[46] The intent here is not to survey the literature, but only to mention some of the criteria that have been used or proposed. These criteria include, among others, minimum capital intensity (minimum capital-output ratio and the ratio of capital to labor), marginal productivity (social marginal productivity SMP,[47] the marginal reinvestment quotient,[48]

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[45] Even after the allocation problem is solved there remains the general problem involving the choice of technique to be used in each of the sectors.

[46] For an excellent overview and bibliography of investment criteria, see Gerald M. Meier, op. cit., pp. 229-50 and 283-85.

[47] A. E. Kahn, "Investment Criteria in Development Programmes," Quarterly Journal of Economics, Vol. LXV (February 1951), pp. 38-61.

[48] W. Galenson and H. Leibenstein, "Investment Criteria, Productivity and Economic Development," Quarterly Journal of Economics, Vol. LXIX (August 1955), pp. 343-70.

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the marginal growth contribution,[49] the national product test[50]), deliberate unbalancing of an economy (depending on backward and forward linkages[51]) maximum labor absorption, and the target approach. It is important to note that if the criteria do not have conflicting objectives several may be used or employed by an economy at the same time.

For the most part, these criteria concentrate on nonhuman capital and thus have almost nothing to say about the allocation of funds for investment in human capital. Probably the cause for this weakness lies in the fact that economists have not yet agreed on the importance of nonhuman capital in economic growth. Denison states that the increase in capital stock has been one of the more important sources of United States economic growth.[52] Meanwhile Pepelasis, Mears, and Adelman argue that the role of capital shortage in limiting growth has been overstressed.[53] In other words, capital seems to be a necessary but not sufficient condition for economic progress. Thus it is difficult to base investment criteria on a variable whose importance is still subject to debate.

In discussing the theoretical framework earlier in this chapter, a brief reference was made to the fact that the distinction between the inputs N, C and L tends to lessen as more and more human capital becomes embodied in them through time. This imbedding of human capital in N, C and L causes the distinction between the basic inputs to become "fuzzy." It is an important concept in itself, but implies something else in addition. It suggests the necessity of more of a joint investment decision between

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[49]See O. Eckstein, "Investment Criteria for Economic Development and the Theory of Intertemporal Welfare Economics," Quarterly Journal of Economics, Vol. LXXI (February 1957), pp. 56-85.

[50]Jan Tinbergen, The Design of Development (Baltimore: The Johns Hopkins Press, 1958).

[51]Hirschman, op. cit., pp. 76-120.

[52]Edward F. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us (New York: Committee for Economic Development, Supplementary Paper No. 13, January 1962), p. 103.

[53]Pepelasis, Mears, and Adelman, op. cit., p. 96.

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human capital and other inputs — a balanced approach. In other words, most of the investment criteria are in terms of a single scarce resource in the production function GNP = f(N, C, L) with no recognition of the human capital distinction or even a production function of the following type: GNP = f(N,C,L,E). Therefore, it is important and necessary to recognize both the human capital component of C, L and N and the multiple expansion of inputs.

Any discussion of investment criteria almost invariably will demonstrate the great deal of impreciseness and difficulty surrounding the entire area. Even in the simplest stages of the analysis, when only the direct effects of investment are being considered, the measurement problems are severe and the results uncertain. Uncertainty is increased when "education" or technical knowledge is considered because of the heterogeneous nature of "education" in many instances. Uncertainty is also increased when a specific project may yield a number of different results or outputs.

The discussion of investment criteria and human capital has provided additional rationale for the observed differing patterns of development and has provided increased recognition for the influence of social[54] and political impediments.

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[54]See Pepelasis, Mears, and Adelman, op. cit., chap. 6; and Henry J. Bruton, Principles of Economic Development (Englewood Cliffs, N.J.: Prentice-Hall, 1965), pp. 11, 17 and 42-43. Social and cultural factors are recognized to incluence all phases of economic life even though they are only briefly mentioned in this study. Bruton would go as far as including social and cultural factors (S) as a variable in the equation GNP = f(C,L,N) making it GNP = f(C,L,N,S). He defines S to include such structural and cultural variables as "the organization of the market and entrepreneurial activity, the extent and effectiveness of the price system in allocating resources, labor's work habits, and other institutional arrangements of society that bear on the effectiveness with which the economy operates." He claims that such factors act in two different ways: (1) by influencing the rate of capital and technical knowledge accumulation and (2) on the effectiveness with which existing inputs are used. However important social and cultural factors may be they largely have resisted attempts at a systematic and quantitative investigation.

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CHAPTER IV

IMPLICATIONS OF THE THEORETICAL FRAMEWORK

A Tool for Comparison

Given reliable aggregate factor input and output (GNP) data of any number of countries, one could compare them by the use of the theoretical tools developed in this study. One way of conducting such a comparison between countries would be by the use of tabular analysis. Aggregate data giving comparable values of GNP, N, C, and L would be used in the equation GNP = f(N, C, L). Differences in GNP between countries exactly the same amounts of physical inputs would be attributable to differences in the amounts and quality of human capital, management, and technology (knowledge).

Another method of comparison would be by the use of graphical techniques. By using aggregate data estimating the variables in the equation GNP = f(N, C, L), one could place any number of countries in the three-dimensional space of the nature shown by Figure 18 (e.g. points A and B). Enough countries might be placed in this space that a pattern could become evident. Countries with the lower levels of human skills and knowledge would account for the lowest points of production (GNP) even when their endowments of physical inputs would be comparable to the countries having a higher level of human knowledge. Given different endowments of physical inputs, however, one would have much difficulty in determining whether the various countries are on the same or different production surfaces. For example, in Figure 18 one does not know if countries A and B are on the same production surface or not.

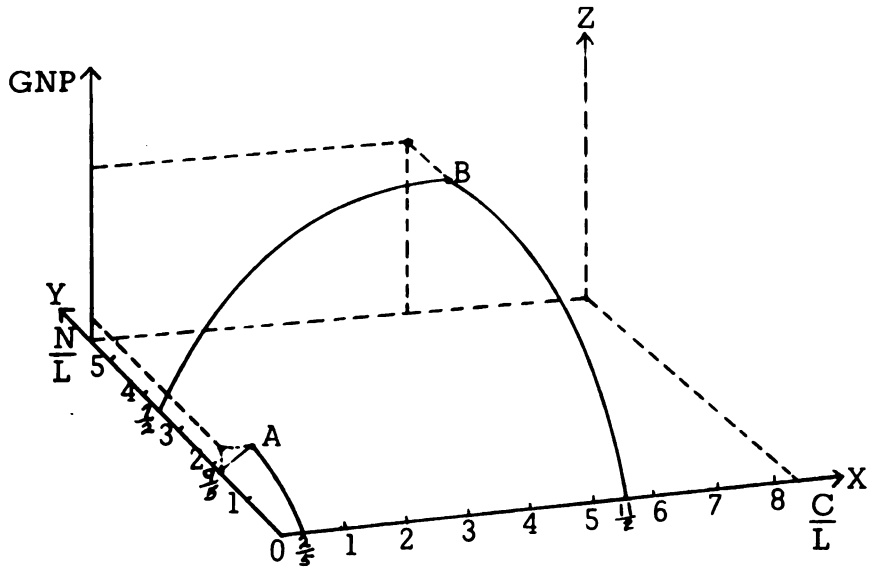

Figure 18.

If two countries have the same or similar endowments of physical inputs, they could be more easily compared using graphical techniques. Consider Figure 19. Countries C and D have identical inputs but different outputs. Country C has a GNP of 550 while country D has a GNP of 600.

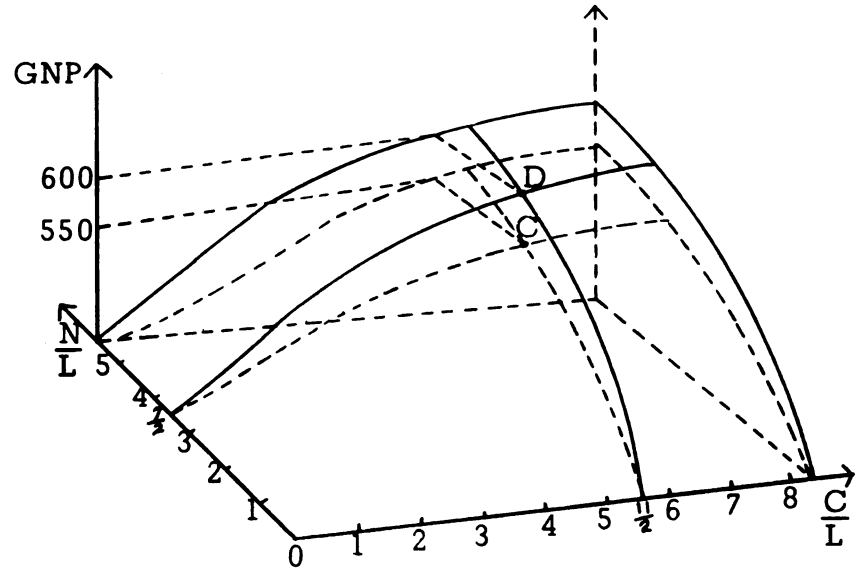

Figure 19.

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Figure 19.

utilizes inputs N', C' and L'.[1] Country D's inputs N', C' and L' have more "education" or human capital embodied which in turn makes them more productive (per unit) than country C's inputs N, C, and L.

The evidence indicating a tremendous gap in human skills and knowledge between countries such as the United States and India is so strong that one could easily conclude that they are on different production surfaces. Therefore, the United States and India could theoretically be compared as shown in Figure 20, even though their physical inputs are not identical. In Figure 20, country A (India) has more labor, less capital, and slightly less natural resource base than country B (the United States).

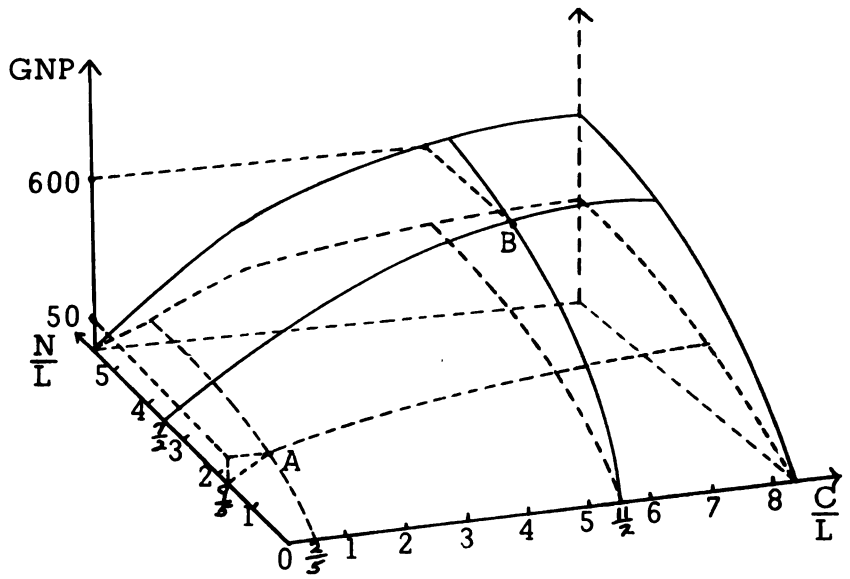

Figure 20.

But the differences are greater than one of absolute and relative factor endowments. India (A) is at a lower level of technological progress and is beset by population pressures. Also country A's population growth may be so rapid compared with the growth in capital stock and natural resource

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[1] As we have already seen (p. 42) additional "education" does not need to influence all the inputs N, C, and L and once. Additional education may affect respectively the inputs L, L and C, L and N, or all of the three basic inputs at the same time. Changes in L alone could have, for instance, caused the differences between countries C and D observed in Figure 19.

base that the country is kept on what may be termed the "verge of calamity."[2]

Almost any discussion of comparisons between countries will bring out the many problems involving accurate measurement of variables. This problem is especially acute when one is dealing with the natural resource variable as will be seen.

The Importance of Natural Resources

The analysis developed in this study allows one to avoid some pitfalls that have troubled others in the past. For example, T. W. Schultz has written that:

> 1. When we compare countries as of a particular date, we observe that the portion of natural resources to all resources employed to produce the income is greater in poor countries than it is in rich countries. (I would venture that the upper limit in the proportion of natural resources to all resources in poor countries is in the neighborhood of 20 to 25 per cent and the lower limit in rich countries is about 5 per cent.)
>
> 2. When a country achieves economic growth that increases its per capita income over time, natural resources become a decreasing proportion of all resources that are employed to produce the income. (It would appear that during recent decades that rate at which this particular proportion has declined has been large.)[3]

These points can be easily visualized with the aid of the three-dimensional diagrams used in this paper. However, Schultz went on to imply that because natural resources became a smaller percent of national income as economic growth occurred, that natural resources were less important to

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[2]Gilbert F. White, Social and Economic Aspects of Natural Resources (Washington, D. C.: National Academy of Sciences — National Research Council, 1962), p. 33.

[3]T. W. Schultz, "Connections Between Natural Resources and Economic Growth," in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1964), pp. 229-30.

the economy.[4] J. H. Dales challenged this by showing that the ratio of income originating in a sector is not a valid measure of the importance of this sector in economic development.[5] He asked,

> Are we to be compelled to say that if the efficiency of the natural resource sector of an economy improves relatively to that of other sectors, so that its products become cheaper, the importance of natural resources has shrunk?[6]

The difficulty that Schultz encountered could have been avoided by thinking in terms of GNP = f(N,C,L) and the three-dimensional graph. As more labor and capital is added to an economy during economic growth, the natural resource base is very likely to become a relatively smaller proportion of all resources of the economy — even if the natural resource base expands to some degree. Admittedly there is a problem of measurement involved here, not only in determining the value of the natural resources, but also even in defining the natural resource base. For example, what is the value of a new discovery of uranium? Or what is the present value of the sun? What is its potential value with solar batteries etc.?

It is also important to note the quantity and quality of natural resources available to a particular society are both the cause and consequence of its economic development.[7] Investment in human skills and knowledge can help the economy to both discover more natural resources and to use those

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[4]Schultz has argued similarly elsewhere, "But natural resources are not among the more promising sources because they have become so small a contributor to national income (only about 5 per cent of the national income of the United States comes from this source) . . . ." T. W. Schultz, "United States Endeavors to Assist Low-Income Countries Improve Economic Capabilities of Their People," Journal of Farm Economics, Vol. XLIII (December 1961), p. 1069.

[5]J. H. Dales, "Comment on 'Connections Between Natural Resources and Economic Growth'," in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1964), pp. 235-36.

[6]Ibid., p. 236.

[7]Pepelasis, Mears and Adelman, op. cit., p. 18.

it has more effectively (conservation, etc.). In other words, technical change brings rapid change in the value and composition of the endowment of natural resources of a given area.[8] Thus the statement that a country is rich in resources has meaning only in relation to contemporary knowledge and techniques. A country that is considered poor in resources today may be considered very rich in resources at some later time, not only because unknown resources are discovered, but that new uses are discovered for the known resources.[9] W. A. Lewis also questions "whether there is a connection between richness of resources and the quality of the human response."[10] Is there some law by which greater effort is induced in the richer than in the barren countries, or is the reverse the case? Probably both forces operate in actuality — but the latter is stronger. High natural resource endowment is simply not enough in itself to insure development — but high educational development can overcome low natural resource endowment.[11] This is shown especially by the case of Japan. Thus in the final analysis it is very evident "that further development largely comes from the better use of existing resources."[12]

The Measurement Problem

By utilizing the basic equations previously discussed in this study, it can be demonstrated that the measurement problem involves more than the just mentioned natural resource variable. We have seen that the production function approach — in which a measure of "education" (E) is entered

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[8] Lee R. Martin, "The Role of Investment in Human and Community Capital," Journal of Farm Economics, Vol. XLII (December 1960), p. 1210.

[9] W. A. Lewis, The Theory of Economic Growth (London: Allen and Unwin, Ltd., 1955), p. 52.

[10] Ibid., p. 53.

[11] Lee R. Martin, "Research Needed on the Contribution of Human, Social and Community Capital to Economic Growth," Journal of Farm Economics, Vol. XL (February 1963), p. 86.

[12] Paul A. Samuelson, Economics: An Introductory Analysis (4th ed.; New York: McGraw-Hill, 1958), p. 760.

as a distinct separate input — is in difficulty. This is because it is an attempt at deriving an estimate of the equation GNP = f(C,L,N,E), which involves a fair sized intercorrelation of the first, second, and third order. This differs from the equation GNP = f(C,L,N) which, as we have seen, involves the expanded structural set shown below.

$$\left.\begin{aligned} C &= f(L,N,E) \\ L &= f(Pop.,\ E,\ldots) \\ N &= f(God,\ E,\ldots) \end{aligned}\right\} \text{ Simultaneous set}$$

When E for consumption is permitted, we need not develop a different equation of the form GNP = f (.....) since the other "basic" inputs are still the inputs involved and E is an input directed toward consumption.[13] However, the problem is in the "simultaneous set." Just as in the above C function, we include only L and N used to produce C for productive uses and not L and N used to produce C for output directed toward consumption. We want only that part of E directed toward "productive" use. But this is a measurement problem. As a measurement problem the difficulties are similar to those of valuing N or even L. Some of the measurement problems involving N have already been mentioned (water is free, etc.). With L there is also a problem. How do we remove the imbedded "education"? How do we aggregate over individuals? What about "unemployables," disabled people, illiterates, etc.?

In other words, the problems are not dissimilar for E, C, L and N. These problems do suggest some limits to the "operational value" of the theory. Basically they imply difficulty in the quantification of variables relevant to the theory.

Quantification of Variables

The lack of an acceptable theoretical framework and the difficulty involved in the quantification of variables results in little empirical work related to the demand for human skills and knowledge. One interesting

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[13] See Chapter II, pages 13-15.

pioneer attempt at developing some quantitative research in this area is presented in an unpublished paper written by Finis Welch. In this paper entitled "Some Aspects of the Derived Demand for Skills,"[14] he wrote that:

> If an economy which has surplus productive capacity increases its production by extension and intensification of existing techniques, there would be no reason to expect drastic changes in the skill composition of the demand for labor. We therefore assume that economic growth which is based upon increases for all skills in approximately the same proportion. That is, growth by extension is neutral with respect to the demand for skills.
>
> Conversely, we assume that economic growth which originates through the development or discovery of new techniques (improvement in the quality of productive factors) implies a non-neutral increase in the demand for skills. It is believed that production which utilizes improved quality of material factors will demand, on the average, an improvement in the quality of human factors. Our second assumption is that economic growth which draws upon a new technical base is favorable to higher skill levels and that given these conditions for growth we would expect the demand for higher skill levels to increase at a faster rate than would the demand for lower skill levels.

To prove the assumptions, Welch employs U. S. Census data and lumps various occupations into three categories as follows: (1) professions, (2) skilled laborers, and (3) semi and unskilled laborers. He then presents the earnings and employment by skill class. His argument can be presented by the use of his Table 3 (shown as Table 1 on page 70).

Upon this Table and some income data that show a similar pattern of change, Welch concludes that generally the demand for the higher skill levels has increased more rapidly than the demand for all labor in the United States during the 1939-59 period. In other words, there was an increase in the demand for higher skill levels relative to the increase in demand for lower skill levels.

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[14] Investment in Human Capital Series, Paper 63:02, October 14, 1963; The University of Chicago, Filed with the Office of Agricultural Economics, pp. 1-2 (mimeographed).

Table 1. Percent Change in Number of Persons Employed During Decade*

	1939-49	1949-59
Professions	44	84
Skilled Laborers	65	8
Semi and Unskilled Laborers	4	2

*Source: Finis Welch, "Some Aspects of the Derived Demand for Skills," Investment in Human Capital Series, Paper 63:02; October 14, 1963; The University of Chicago, Filed with the Office of Agricultural Economics, p. 9 (mimeographed).

Based on the analysis developed earlier in Chapter III, one would tend to agree that the general level of skills and knowledge possessed by a population must increase or improve as the economy develops. In other words, there is general agreement on Welch's second assumption. However, in certain instances, one would question Welch's first assumption based on the analysis presented in this paper. Economic growth based upon the existing technical foundation may not always be neutral with respect to the demand for human skills. The economy can grow by adding to any or all of the factors, N, C and L. Depending on which factor or factors are expanded, the increase in demand for human skills may be neutral or non-neutral. For example, if capital inputs are expanded rapidly, highly skilled technicians may be demanded, but if the natural resource base is enlarged by simple migration, unskilled labor may suffice. Even at the sector or industry level, growth by extension of known methods may not be neutral with respect to the demand for skills. For example, consider an economy with large coal and petroleum sectors. Assume that the coal industry is labor intensive (using unskilled labor) and that the petroleum industry is capital intensive (using highly skilled labor). Also assume the cost of expanding either industry is the same. Now it can be seen that the quality and quantity of human skills demanded will be greatly affected depending upon whether the oil industry, the coal industry, or

both are expanded — and to what degree. All this greatly weakens both of Welch's assumptions regarding the growth in demand for human skills.[15]

Later Welch adds a third assumption that ". . . the higher the average skill level of an economy, the more probable becomes the production or 'discovery' of new techniques."[16] He calls this a "heroic assumption" but states that we now have completed a growth model. This model can be criticized from the view that it could probably be best termed an "accidental" growth model. The difficulty with this model is that new technology has no cost — it is "accidentally" (or "incidentally") forthcoming from highly skilled people who are being employed to use their skills producing output.[17]

The implications of the theoretical framework developed in Chapter III and Welch's work are that economic growth which is dependent upon a new technical base generally demands higher skill levels. Hence the demand for higher skill levels can be expected to increase faster than the demand for lower skill levels. Schultz apparently agrees with this and even may have been thinking of Welch's work when he recently stated with respect to the United States economy that, "the demand for workers with high skills has been increasing at a higher rate than that for low skills."[18] Thus one would expect a primitive economy to demand comparatively more of the relatively simple skills, i.e., no formal education would be required. As development proceeds the general level of skills and knowledge of the population would be increased. The people would first require, in general, a primary level of education, then secondary, etc. This does not rule out

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[15]Thus, there are exceptions to Welch's assumptions and to the generalizations made in Chapter III of this study, which are very similar to two assumptions made by Welch.

[16]Ibid., p. 12.

[17]The only cost that is involved in this instance would be implicit, namely that the acquiring of the higher skill level of the economy involved a cost during prior time periods.

[18]T. W. Schultz, "Investing in Poor People: An Economist's View," American Economic Review, Vol. LV (May 1965), p. 518.

the possibility of a highly educated elite existing from the early stages of development, however.

Schultz's somewhat earlier thinking on this problem is very interesting. In the statement quoted at the beginning of Chapter I, from his book, The Economic Value of Education, Schultz was puzzled as to whether the growth in demand for human agents with skills and knowledge is specific to our economy or whether it is also to be observed in low income countries. He was also troubled by the fact that the early industrialization of Europe was based mainly on illiterate and unskilled labor.

We have just seen some evidence that primitive economies do not require the same level of skills and knowledge that are needed in advanced economies (and in addition, it may be more difficult for the primitive economies to pay for them). The level of technology in use during the early stages of the industrial revolution did not require a highly skilled labor force. If this new technology had required a large investment in human capital, it is doubtful if the Europeans could have afforded the development that occurred at this time.

Professor Schultz overlooks the large investment in human knowledge and skills required to keep a modern technical economy operating. This is in addition to the continual need for inventing and adapting new and more efficient techniques. New techniques are not always more complex than previous ones. Still most new technology requires new skills and knowledge.[19] In other words, new and better techniques from the increased output standpoint usually require more investment in human capital, but will normally economize on some or all of the other resource inputs, such as nonhuman capital, labor and natural resources. Technical changes set the limits on the productivity of the inputs (labor, capital, etc.), but it requires investment in human skills and knowledge to produce technical change. Thus the key to economic development is man himself.

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[19] See Burton A. Weisbrod, "Education and Investment in Human Capital," Journal of Political Economy, Vol. LXX (October 1962), p. 113.

CHAPTER V

SOME EVIDENCE SUPPORTING THE THEORETICAL FRAMEWORK

Introduction

This study utilizes a series of graphs in an effort to demonstrate, using the relevant production function GNP = f(C,L,N), a demand for human skills and knowledge. Seven factor disproportion situations involving the basic inputs of the production function GNP = f(C,L,N) are employed. These disproportion situations, in turn, have the potential of generating four economic forces that possibly can act in creating a demand for human skills and knowledge. The seven proportion situations are really the catalog of specifics — i.e., the specifics are merely examples. In reality, an economy responds to the tendency toward imbalances that are exhibited by its aggregate inputs. It reacts by attempting to correct the imbalance situations that are present during any given time period by adding various combinations of the basic inputs and human capital.

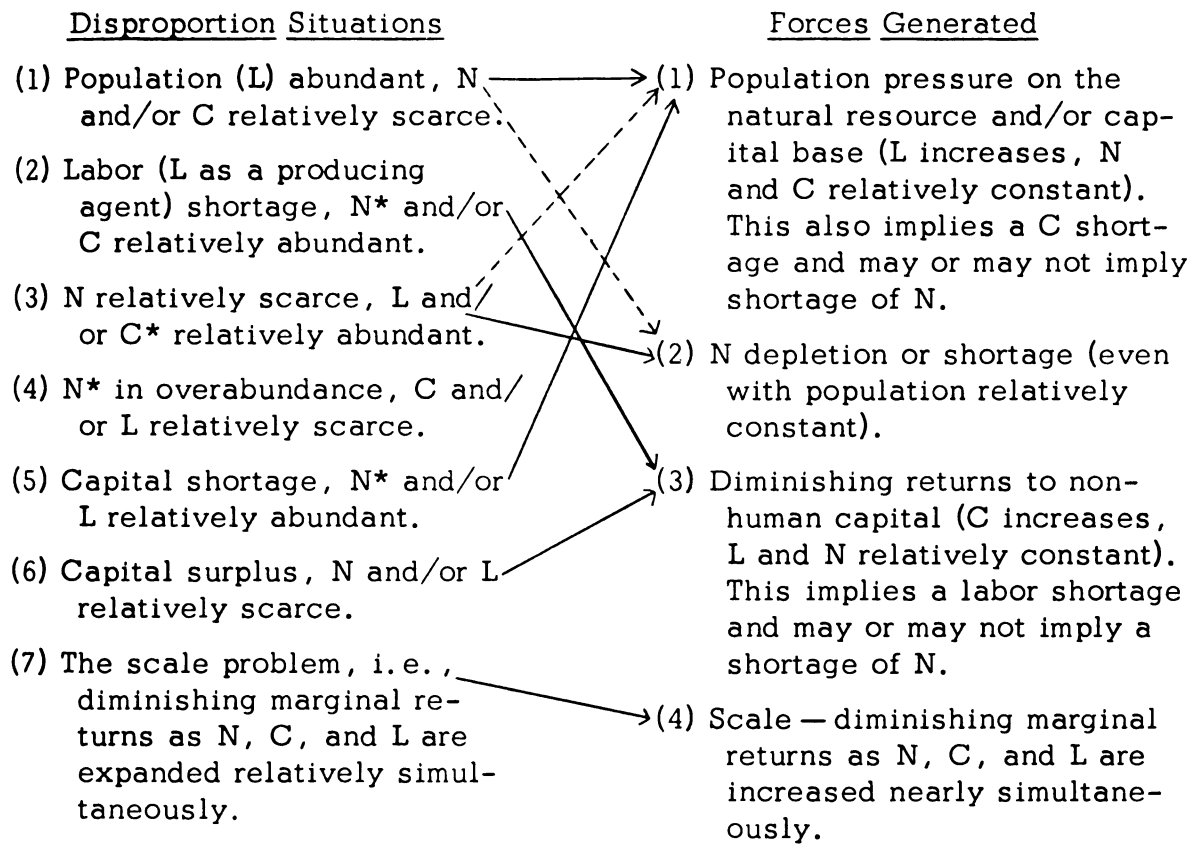
This tendency toward imbalance is related to the real world in this chapter. In order to be more systematic, the discussion will be based on a pattern suggested by the catalog of specifics. However, even though the discussion follows a pattern implied by the proportion situations and the forces they generate, it should be constantly kept in mind that the imbalance tendency and the efforts to correct it are the important things — not the catalog of specifics.

It was shown in Chapter III that the "demand" for human skills and knowledge at the prevailing or existing level of technology of an economy is a function of any one or all of four basic factors. (1) The first factor is population pressure upon the natural resource and/or capital base (L increases, N and C relatively constant). This is the condition of a labor

surplus or small capital/labor ratio. Conversely, it also can be regarded as the case of a capital shortage. (2) A depletion in either the quality or quantity of the natural resource base over time (even with population constant) is the second factor. (3) Third is the factor of diminishing returns to nonhuman capital (C increases, L and N relatively constant). This is the instance of a capital "surplus" or a large capital/labor ratio. Conversely, it also can be regarded as a case of labor shortage. (4) Lastly, is the case of diminishing returns to scale to N, C, and L. This is the instance of decreasing marginal product per unit of input as the quantities of the three inputs N, C, and L are increased nearly simultaneously. Any combination of the four forces can be operating at any one given time.

The above four factors or forces, which create the "need" for human skills and knowledge, were derived in the earlier theoretical analysis by exploring all the possible proportion situations among the three basic inputs of an economy — natural resources (N), capital (C) and labor (L). These proportion (or disproportion) situations are as follows: (1) population (L) abundant, N and C (nonhuman) relatively scarce; (2) labor (L as a producing agent) shortage, C and N relatively abundant; (3) natural resources (N) relatively scarce, C and L relatively abundant; (4) natural resources (N) in overabundance, C and L relatively scarce; (5) capital shortage, L and N relatively abundant; (6) capital surplus, N and L relatively scarce. In addition, (7) there is the scale problem. This is when an economy experiences decreasing marginal national product per unit of input as the quantities of the three basic inputs N, C, and L are increased nearly simultaneously.

Because some of the disproportion situations are merely the obverse of each other, they can be condensed and expressed as a single demand creating force. In addition, one disproportion situation is not relevant in the real world. Thus, the seven disproportion situations condense into the four basic forces in the following manner (see Figure 21).



*Asterisks indicate situations where factor overabundance is irrelevant, i.e., the factor surplus in these cases does not aid significantly in generating any of the forces.

Figure 21.

In Figure 21, all possible factor disproportion situations are spelled out systematically and completely as derived from the theoretical framework and without regard for their relevancy in the real world. Thus real world considerations have to be taken into account in deriving the four forces shown in Figure 21. For instance, it was shown earlier that excess natural resources are simply allowed to remain unemployed and as a result one is never faced with a question of too many natural resources in relation to other inputs.[1] Thus natural resources cannot be in excess so as to create a factor disproportion situation that acts as a stimulus in

[1] Chapter III, p. 37.

creating a demand for human skills and knowledge. Hence proportion situation (4) in Figure 21 is irrelevant in the real world and will not be discussed further. Also, natural resources cannot be overly abundant in proportion situations (2) and (5), but should be regarded as neutral in these cases, i.e. not present in either a surplus or shortage amount. The situations in which natural resources are not an important consideration are indicated by asterisks in Figure 21.[2]

Another related problem is that of apparent inconsistencies between the proportion situations. Because natural resources are not troublesome in large amounts in the real world, all but one apparent inconsistency is avoided in Figure 21. The one apparent inconsistency involves the capital variable in proportion situation (3). Taken together proportion situations (3) and (5) are the counterpart of proportion situation (1). Mutually the three generate force (1). However, if both situations (3) and (5) act in association with situation (1), then capital cannot be abundant in situation (3). Hence, the warning asterisk. Only situations (1) and (3) can act together and have C be relatively abundant with respect to N in situation

[2]The only case in which natural resources in abundance and C and/or L relatively scarce situations might, in a manner, create the "demand" for additional human skills and knowledge would be in the instances of young nations expanding along a frontier, e.g. earlier in the Americas or Oceania. Such young countries might aspire to find faster ways to develop their natural resources than by utilizing only the conventional presently known techniques with their present C and L. Hence, they might aspire to invest in human skills and knowledge in an attempt to improve their present inputs so as to be able to develop their natural resources more rapidly. However, they would be aspiring and not forced into the situation in the manner that an exploding population creates factor disproportions and force. Also it might be less expensive and time consuming to just expand C and L using the presently known technology than to attempt to new, additional or improved human capital. At any rate, no nation is going to "starve" or be too distressed with a situation involving very abundant natural resources (even when they are forced to allow a portion of them to remain idle or unemployed). But they are very likely to be distressed by C shortages, L shortages, or population pressures and as a result be forced to develop additional human skills and knowledge. Thus, natural resource "abundant" situations are lightly regarded as potential forces for creating the "need" for additional human skills and knowledge throughout this study.

(3) and relatively scarce with respect to L in situation (1). If only situations (1) and (5) act together, then situation (3) is not really relevant because it merely restates situation (1) in another manner. Therefore, if situations (1), (3) and (5) are acting simultaneously, then capital cannot be abundant in situation (3).

It is also important to note why the factor pairs that are either scarce or abundant under the proportion situations in Figure 21 are written as "and/or" cases. This is because one of the factor pairs may not be relatively abundant or scarce vis-a-vis the reference factor in many instances, but may be neutral, i.e. neither scarce nor abundant. For example, in proportion situation (1) N may not be scarce but neutral with C being scarce vis-a-vis L. If N were to become relatively abundant then situation (1) would become situation (5).

It is now possible to outline more clearly how the various proportion situations are related to the forces that generate the demand for human skills and knowledge. Proportion situations (1), (3), and (5) express themselves as force (1). This is the situation of population pressure and capital scarcity. Population pressure also often implies natural resource scarcity, but population does not have to increase for natural resources to become short in supply in many instances. Even with a relatively steady level of technology and with a relatively stable population, natural resources can become relatively short in supply if enough time elapses. Thus, proportion situation (3) gives rise to force (2). In many instances, proportion situation (1) acts in conjunction with situation (3) in generating force (2) — hence the dotted arrow from (1) to (2) in Figure 21. Proportion situations (2) and (6) give rise to force (3). This is the condition of abundant capital and scarce labor, with natural resources being largely neutral. The last situation is that of the scale problem which gives rise to a force of its own.

The purpose of Chapter V is not only to show how the factor disproportion situations give rise to the above mentioned four basic forces that

create a "demand" for human skills and knowledge, but also to explore how both the relevant disproportion situations and the four basic forces are expressed in the real world. In other words, the purpose of Chapter V is to demonstrate the relevance of the theoretical framework to real world economic growth problems. The above mentioned four forces that create the need for human skills and knowledge manifest themselves in the real world in a number of different ways. Thus this chapter explores topics ranging from population and natural resources, labor and capital, the question of scale, through the agricultural sector, and "education" in order to show how the theory is evidenced in the real world. In addition, various economists ideas in this area — that the model does or does not support — will be explored. The topics discussed will follow closely the disproportion situation column of Figure 21 in scope, but the order of discussion will be patterned after the forces generated column of the same figure. Hence, the order of discussion will be altered from that found in the disproportion situations column. The evidence presented in this chapter will be both historical and empirical in nature. It has been shown earlier that the quantification of variables relevant to the analysis of the demand for human skills and knowledge has been hindered by the lack of an acceptable theoretical framework on which to build.[3] Thus the evidence presented in this chapter will be empirical in the sense that it is based on observation or experience, but only a limited amount of quantified data will be presented.

Population and Natural Resources

According to the theory presented in this study: (1) population pressure on the natural resource and/or capital base (L increases, N and C relatively constant), and (2) depletion or shortage in either the quality or quantity of the natural resource base over time (even with population constant) are two important factors in creating a need for additional and improved

[3]Chapter IV, pp. 68-72.

human skills and knowledge. The purpose of this section is to study these forces in the real world. In short, the focus will be on proportion situations (1) and (3) and forces (1) and (2) in Figure 21. The emphasis in this section will be on population as a consuming agent, hence a study of proportion situation (5) will be postponed until later in the chapter where it (L as a producing agent) will be discussed in conjunction with capital.

Population Pressure

Economist's have long debated the importance of the population variable in any economic system. Population was an important part of the economics of the British classical economists. However, until the concern with economic development began following World War II, most economists in the last hundred years generally considered population to be outside of their spheres of competence. Today there is more attention being focused on population problems in the world than at any time since Malthus.[4]

There is now some general agreement among economists on the importance of population as a prime variable in any economic system of analysis, prediction or strategy. In other words, it is now recognized that more attention must be devoted to the relationship between population change and other economic variables. It is now acknowledged that population is not completely an independent (autonomous) nor a dependent variable, but a combination of both and is endogenous to the system. That is, the population variable has several facets, such as that of a producer, saver, or consumer, which operate at the same time. This view allows one to avoid overemphasizing the population variable as a consuming agent which leads to Malthusian pessimism, on the one hand, and it allows one to avoid overemphasizing the population variable as a producing agent (labor input) which can lead to Keynesian optimism, on the other hand.

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[4]Philip M. Hauser (ed.), The Population Dilemma (Englewood Cliffs, New Jersey: Prentice-Hall, 1963), p. 1.

In other words, population is significant as both a consumer and producer agent. Thus population growth is recognized to have potential as both a stimulant and retardant on the economy. Hence, the concept of an optimal population or optimal population growth is recognized as being important.

This is not to say that all economists are in general agreement on the role and importance of the population variable in economic analysis today. Rather there is yet some disagreement on the above mentioned points as well as certain other facets of the population issue. It is not intended that this discussion of population should determine whether one or the other of any opposing views on population growth or pressure is correct. Rather the purpose here is to relate the population variable to the theoretical framework developed earlier in this study. Neither is it the intention of this section to discuss the history of population theories. These are not directly related to the issue presently at hand, and can be easily gleaned from other sources.[5]

However, there is general agreement on the estimates of past world population growth. World population is estimated at approximately 250 million people at the beginning of the Christian Era. It is thought to have been approximately 545 million in 1650; 1.2 billion in 1850; 1.6 billion in 1900; and 2.4 billion in 1950. It is estimated to stand in excess of 3 billion people today and almost all predictions are that it will easily exceed the total of 6 billion people by the year 2000. Quite often this information is graphed in publications dealing with population problems yielding an impressive upward sloping curve that reminds one of the graph of an exponential function.[6]

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[5]See, for example, United Nations, The Determinants and Consequences of Population Trends, Population Studies No. 17 (New York: Department of Social Affairs, Population Division, 1953), pp. 21-44; Warren S. Thompson and David T. Lewis, Population Problems (5th ed.; New York: McGraw-Hill, 1965), pp. 14-54; and Ralph Thomlinson, Population Dynamics (New York: Random House, 1965), pp. 47-68.

[6]For historical population estimates and future predictions see Lester

Thus, what has happened in that the world has seen thousands of years of infinitesimal growth in population followed in the late 1600's by a population explosion that has continued to the present day. For instance, Kuznets notes that with a base population of 250 million people, the average rate of growth per century from the year 0 to the year 1750 was 6 percent, but that it was 85 percent during the last two centuries.[7] Some scholars look at the situation from a very long-run point of view and note that, in reality, the rate of increase of population has been not only slow, but very slow. Thompson and Lewis observe that there were only 600 million people in the world in 1650 although man had been on the early "many tens of thousands of years."[8] Others take a more short-run view and have a somewhat different outlook. For example, in 1945 Notestein wrote, "The world's population has increased fourfold since the middle of the seventeenth century. It has more than doubled since 1800 and even now continues its rapid growth."[9] Brown states, in thinking of the future, that "the startling aspect of the population projected for the end of the century then is not so much the actual numbers but the rapidity with which the increase will occur.[10]

There are many explanations put forth as to why the sustained rise in world population, that began in Europe in the seventeenth century, occurred.

R. Brown, Man, Land and Food, Foreign Agr. Econ. Rept. No. 11 (Washington, D. C.: Economic Research Service, 1963), pp. 6-15; Hauser, op. cit., p. 10; J. O. Hertzler, The Crisis in World Population (Lincoln: University of Nebraska Press, 1956), p. 19; M. K. Bennett, The World's Food (New York: Harper and Brothers, 1954), pp. 3-21; and United Nations, Demographic Yearbook. For graphs, see Georg Borgstrom, The Hungry Planet (New York: Macmillan Co., 1965), p. xii; Lester R. Brown, op. cit., p. 6; and Hauser, op. cit., p. 10.

[7]Simon Kuznets, Economic Growth and Structure (New York: W. W. Norton Co., 1965), p. 9.

[8]Thompson and Lewis, op. cit., p. 382.

[9]Frank W. Notestein, "Population — The Long View," in T. W. Schultz (ed.), Food for the World (Chicago: University of Chicago Press, 1945), p. 37.

[10]Lester R. Brown, op. cit., p. 6.

The commonly accepted view is that it was due to a marked fall in the death rate and increased longevity due to improvements in medicine, public health, better food, etc. Others believe that industrial development stimulated population growth (Malthusian) while others argue that the increase in population stimulated industrial expansion (Keynesian). Some believe that a rise in the birth rate was the major determinant of the population increase in pre-industrial Western societies even though it is admitted there was great variability in this high fertility.[11] Also, there are those who are skeptical of the conclusion that specific medical measures introduced during the eighteenth century contributed substantially to a reduction in the death rate, but that general improvements in living conditions were more important in the decline in mortality.[12] Finally, Habakkuk writes that to him this sudden surge of population appears to have been fortuitous — i.e. happening by chance or accidental.[13] Thus, no one really seems to be able to definitely agree on the cause of the population increase. What is important to gather from this discussion is that the evidence strongly suggests that the population variable is endogenous to the economic system and thus population growth has important implications on the other economic variables such as technology.

Why did world population fail to increase rapidly prior to the seventeenth century? The answer that most scholars give is that the standard

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[11]See Gerald M. Meier and Robert E. Baldwin, Economic Development: Theory, History, Policy (New York: John Wiley and Sons, Inc., 1957), pp. 150-51; John T. Krause, "Some Implications of Recent Research in Demographic History," Comparative Studies in Society and History, Vol. I (January 1959), pp. 164-88; and John T. Krause, "Some Neglected Factors in the English Industrial Revolution," Journal of Economic History, Vol. XIX (December 1959), pp. 528-40.

[12]See Meier and Baldwin, op. cit., p. 151; and Ansley J. Coale and Edgar M. Hoover, Population Growth and Economic Development in Low Income Countries (Princeton: Princeton University Press, 1958), pp. 9-11.

[13]John Habakkuk, "Population Problems and European Economic Development in the Late Eighteenth and Nineteenth Centuries," American Economic Review, Vol. LIII (May 1963), pp. 607-18.

Malthusian variables of hunger, famine, disease, epidemics, war, infanticide, abortion, and marriage customs designed to reduce the rate of population increase were all operating in such a manner as to hold world population to a very slow rate of growth. In fact, these checks were so effective that the population of Europe declined at one point between the years 200-700 A.D. and again during the fourteenth century.[14]

It is generally accepted today that the Malthusian doctrine, involving persistent population pressure on the food supply, was very relevant during these earlier times. Keeping food production abreast of the population has long been a critical problem constantly requiring large increases in food production. Bennett estimates that the population of the world increased about 8-1/2 times in the 9-1/2 centuries from the year 1000 to the year 1949, and that the food intake of the population of the world must have been multiplied by approximately the same factor.[15] This required a tremendous effort directed toward food production.

Today many scholars believe that the Malthusian doctrine still applies in much of the world. Research is conducted on food and famine problems and in relating the Malthusian framework to present day underdeveloped countries.[16] Often comparisons are made between conditions prevalent in the present day underdeveloped countries and those existing earlier during the population explosion in Europe. Various similarities and differences are pointed out and the needs for modernization in the less developed countries are discussed. Thus, it is commonly thought that Malthusian pressures existed earlier in most countries and are evident now in the less developed countries. Moreover, the consensus is that Malthusian pressures are not very important today in the advanced economies.[17]

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[14] See Bennett, op. cit., pp. 4-5, 9-10. [15] Ibid., p. 23.

[16] Ibid., pp. 23-58; and E. F. Penrose, "Malthus and the Underdeveloped Areas," Economic Journal, Vol. LXVII (June 1957), pp. 219-39.

[17] See Roy G. Francis (ed.), The Population Ahead (Minneapolis: University of Minnesota Press, 1958), p. 11.

However, in the final analysis, the discussion of population, both past, present, and future, adds up to one thing — population pressure. But what is population pressure? Entire chapters or even books have been written about it. Thompson and Lewis define population pressure as follows:

> In very general terms, population pressure may be thought of as the difficulties people encounter in trying to make a living. Throughout most of man's experience, as we have seen, these difficulties have been so great that comparatively few of the persons born have been able to live long enough to reproduce, and only a few have exceeded the "ripe old age" of 45 to 50 years. In general, these difficulties in making a living arise from two factors: (1) the nature of the particular environment, such as deserts, high altitudes, high latitudes, the abundance or scarcity of natural resources, and finally, but now becoming increasingly important, the limited quantities of natural resources; and (2) the state of development of man's technology by means of which he can utilize natural resources. The forms of social organization man has developed should be included in this second category because they in large measure determine his technological achievements and the use he makes of them.[18]

Historically, what has been the effect of population pressure? According to the theory developed in this study it is <u>one</u> of several forces that act in generating a need for human skills and knowledge. Habakkuk believes that population growth might have stimulated invention directly. He notes that the simple and initial effect of population growth is to reduce per capita incomes and provide an increased amount of less expensive labor but "there are a variety of ways it might have had favorable effects."[19] In Habakkuk's view, population growth diminished the incentive to search for improvements which saved labor, but it stimulated the search for those which saved natural resources. He even goes so far as to quote Professor Hick's speculation that "perhaps the whole industrial

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[18]Thompson and Lewis, <u>op. cit.</u>, p. 501.

[19]See Habakkuk, <u>op. cit.</u>, pp. 614-15.

revolution of the last two hundred years has been nothing but a vast spectacular boom, largely induced by the unparalleled rise in population."[20]

If population pressure, acting in conjunction with other factors, historically has induced a more or less steady increase in the production of human skills and knowledge, it does not follow that what we know as modern economic growth should have appeared long ago or almost overnight. Rather the development process appears to require a great deal of time. Hence, from monumental works such as Usher's The History of Mechanical Inventions one can see that man historically has produced a quite continuous stream of new technology.[21] However, there also has existed much discontinuity in the stream of advance and the impact of technology was restricted in early societies. In addition, often as man acquired new technology he destroyed his resource base due to inability to discipline himself in the use of the new technology.[22]

There is a considerable amount of historical evidence indicating the importance of social and political factors in hindering economic progress even when knowledge is increasingly or potentially present. For instance, the early Greeks despised manual labor and did not apply their knowledge for technical advance.[23] Greek philosophers and some others considered the application of science to useful purposes as unworthy and even downgrading. The Romans added little to technology.[24] The Greeks and Romans

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[20] Ibid., p. 615.

[21] Abbott Payson Usher, The History of Mechanical Inventions (New York: McGraw-Hill, 1929). Also see Charles J. Singer, E. J. Holmgard, and A. R. Hall (eds.), A History of Technology (New York: Oxford, Claredon Press, 1954-58).

[22] Raleigh Barlowe, Land Resource Economics (Englewood Cliffs, New Jersey: Prentice-Hall, 1958), p. 314.

[23] See Harold G. Bowen and Charles F. Kettering, A Short History of Technology (West Orange, New Jersey: Thomas A. Edison Foundation, Inc., 1954), p. 59; and S. C. Salmon and A. A. Hanson, The Principles and Practice of Agricultural Research (London: Leonard Hill, 1964), p. 79.

[24] Salmon and Hanson, ibid., pp. 21 and 24.

did much the same thing as man had always done; they had labor producing capital using the simplest tools. Lewis states that when techniques are stagnant the economy builds pyramids or other such durable goods.[25] Science began to be studied more for its practical results as time passed. What we know as modern science began to emerge in the 17th century in Western Europe. By the 18th century, even Russia was aware of the role education could play in national economic progress.[26] The Rothamsted experiment station began agricultural research work in Great Britain in 1843 (the first original paper published by Rothamsted was in 1847). Thus, the present tremendous payoff from developing human agents with associated skills and knowledge resulted from a long, hard struggle by mankind.

It is recognized that the men producing technological advances historically have acted to a wide variety of stimuli — ranging from the profit motive to nationalism. Some began with the lack of a specific objective in mind and yet produced economically viable results. Others sought one invention and found another. Some pathbreaking discoveries were made by science and no outlet could be found for them in industry. Thus, a need for human skills and knowledge must be present in an economy before an invention can succeed in becoming economically productive and hence useful to society in general. Therefore, a single inventor can only produce generally accepted innovations in response to the larger macroeconomic "demand." In other words, some inventions are made by accident but most are made on purpose.[27]

New inventions, products, and processes are abundant in history, i.e. technological change is not a new phenomenon unique to modern

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[25] W. A. Lewis, "Economic Development with Unlimited Supplies of Labor," in Okun and Richardson (eds.), Studies in Economic Development (New York: Holt, Rinehart, and Winston, 1962), p. 292.

[26] Arcadius Kahan, "Russian Scholars and Statesmen on Education as An Investment," in Anderson and Bowman (eds.), Education and Economic Development (Chicago: Aldine Publishing Company, 1965), pp. 3-4.

[27] Jacob Schmookler, op. cit., p. 335.

economics, but this does not mean that there is nothing new about modern technology. Modern technology is characterized by a massive application of techniques, rapid diffusion of all types of technology throughout the economy, and the impact of automated techniques on certain groups of workers. It is evident that the focus of invention shifts from the practical man to the scientist. This requires time to develop and results in characteristic modern economic growth — sustained and substantial increases in per capita incomes with an accompanying increase in the total population.[28]

Therefore, even after the Industrial Revolution began in Britain, it was some time before even a few countries could adapt the new techniques, begin economic development, and thus begin catching up with Britain in applied technology. Other countries have only begun this time-consuming process. In other words, the diffusion and adaptation of technology is a very necessary and time-consuming process for such countries largely due to the many forms the diffusion process takes. Added to this problem is the evidence that indicates that a high level of schooling must be attained before new technology can be borrowed or acquired by a country today. Easterlin indicates that countries which successfully acquired British technology first in the 19th century all had a higher level of formal schooling than Britain at that time.[29] In addition, in all countries that have attained substantial and sustained economic growth, formal education was either already at a high level or raised to a high level in fairly short order. The achievement of this amount of human capital takes time and even some degree of luck as Martin indicates in the case of the United States.[30] Some

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[28]Simon Kuznets, Six Lectures in Economic Growth (Glencoe, Illinois: The Free Press of Glencoe, 1959), p. 14.

[29]Richard A. Easterlin, "A Note on the Evidence of History," in Anderson and Bowman (eds.), Education and Economic Development (Chicago: Aldine Publishing Company, 1965), p. 423.

[30]Lee R. Martin, "Research Needed on the Contribution of Human, Social and Community Capital to Economic Growth," Journal of Farm Economics (February 1963), p. 84.

countries were seriously set back along the way as Ireland was by its potato famine. Others such as Japan present a nearly textbook case of how time and perserverance overcame a host of problems.

Today man has organized himself into very complex societies that require a great deal of time and effort in order to sustain with a continued input of additional and new human skills and knowledge. For example, in the United States alone, expenditures on research and development increased from 5.4 billion dollars in 1953 to 16.4 billion dollars in 1962-63.[31] The number of scientists and engineers engaged in research and development work nearly doubled in the last decade and now stands at more than 450,000. To develop such complexes requires a great deal of time in any society. History suggests that man has developed such knowledge in response to pressures from his environment. Even so a great deal remains to be learned from a study of history in the light of the impact of increased knowledge and the resulting improved technology on economic development.[32]

Thus, the evidence suggests that population pressure historically has been one of the forces inducing the production of human skills and knowledge. It has taken a long period of time, but today we find that improved technology (human skills and knowledge) has chased the so-called Malthusian devil from a large segment of the population of the world. Nevertheless, there are those who view the world population and food situation

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[31]See, for example, Dexter M. Keezer, "The Outlook for Expenditures on Research and Development During the Next Decade," American Economic Review, Vol. L (May 1960), pp. 355-69; Richard R. Nelson, "The Simple Economics of Basic Scientific Research," Journal of Political Economy, Vol. LXVII (June 1959), p. 297; National Science Foundation data published in Economic Report of the President, January 1964; and Manpower Report of the President, United States Department of Labor, March 1964.

[32]See Richard A. Easterlin, "Is There a Need for Historical Research on Underdevelopment," American Economic Review, Vol. LV (May 1965), pp. 104-108.

with alarm at the present time — even in the developed areas. For example, Borgstrom believes that the modern world is at the edge of famine and that, in short, "Technology has bitten off more than it can chew."[33] There are many other individuals that share this same general outlook.[34]

On the contrary, there are those individuals that take the opposite extreme view that technology is some type of scientific magic that is easily forthcoming and is going to soon solve all the problems of the world. They believe that a wider application of present and forthcoming technologies will produce the needed increases in world food supplies in the future. Hagen stated the optimist position well when he wrote as follows:

> In the countries of the world where population has grown the fastest during the past 150 years, the advance in technology has far outstripped it, and per capita income has steadily risen. There is reason to assume that this relationship between technological progress and population growth will hold true in the future for the entire world. Technological progress is now spreading to the other major countries of the world, and during the twentieth century will probably have to spread to virtually all countries. There is no reason to place any given limits on the creation of resources by technology.[35]

This recent disagreement between the optimists and pessimists over population and technology is now new. In an interesting article in Scientific Monthly, W. H. Leonard reports that in 1793 William Godwin in his book, Political Justice, wrote that he was convinced that man with the aid of science

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[33] Georg Borgstrom, The Hungry Planet (New York: Macmillan Co., 1965), see p. 431.

[34] Fairfield Osborn, 60,000 More Every 24 Hours! (New York: The Newcomen Society of North America, 1951), 24 pp.; Fairfield Osborn (ed.), Our Crowded Planet: Essays on the Pressures of Population (Garden City, New York: Doubleday and Co., Inc., 1962), 240 pp.; and Julian Huxley, The Human Crisis (Seattle: University of Washington Press, 1963), 88 pp.

[35] Everett E. Hagen, "Population and Economic Growth," American Economic Review, Vol. XLIX (June 1959), p. 326. Also see Harrison Brown, James Bonner, and John Weir, The Next Hundred Years (New York: The Viking Press, 1961), pp. 52-69; and Merrill K. Bennett, "Longer and Shorter Views of the Malthusian Prospect," Food Research Institute Studies, Vol. IV (1963), pp. 3-11.

could solve any problems which might arise.[36] According to Leonard, Godwin evidenced unbridled optimism, with a disregard of the limitations imposed by nature and Malthus challenged this position. Leonard states that a seesaw conflict between optimists and pessimists has continued to this day. Leonard's view of present day conditions is somewhat pessimistic. He believes that some measure of population control is necessary and he hopes that the recent improvements in agricultural yields will buy time in which the world can stabilize its population.

Finally, what do the facts appear to be in the population-technology debate and what implications do the facts have upon the theory developed in this study? First, from all the studies conducted by very reputable and responsible organizations and individuals one can conclude that the world has had a population problem in the past and has one today.[37] Further, the best indications are that the world will face a continued problem with population pressure in the future as the estimated population for the year 2000 now stands at 6.9 billion people.[38] Secondly, because of the continuing and anticipated future problems regarding population, an intense effort has been and is going into research and technology in order that the resources of the world can be made to supply man's needs. Consider the tremendous effort that has and is being expended in an effort to solve the food problem of the world alone.[39] Thus, the population-food problem by

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[36]W. H. Leonard, "World Population in Relation to Potential Food Supply," The Scientific Monthly, Vol. 85 (September 1957), p. 123.

[37]United Nations, The Determinants and Consequences of Population Trends, Population Studies No. 17 (New York: Department of Social Affairs, Population Division, 1953); National Academy of Sciences--National Research Council, The Growth of World Population (Washington, D.C., 1963), 38 pp.; Political and Economic Planning (PEP), World Population and Resources (London, 1955), 339 pp.; and Coale and Hoover, op. cit., 389 pp.

[38]See Hauser, op. cit., p. 21. This estimate was presented by Harold F. Dorn who is Chief of the Biometrics Research Branch of the National Heart Institute, U.S. Public Health Service.

[39]Many of the references cited previously in this section on the subject of population also have good discussions of the world food situation — past

itself should sober those overly optimistic about technology. Nevertheless, past technological success in this and other problem areas should encourage those overly pessimistic about population pressures.

Therefore, it can be concluded that population pressure upon the natural resource and capital base has and is being evidenced in the real world (i.e. there is a disproportion problem), and that the evidence strongly indicates that this has been and now is presently one of the forces operating in bringing forth additional and improved human skills and knowledge (technology). Let us now consider the counterpart of population pressure — that of natural resource depletion and shortage.

Natural Resource Depletion and Shortage

The theory presented in this study states that a depletion or shortage in either the quality or quantity of natural resources over time is one of the factors acting in creating a need for additional human skills and knowledge. This is in many ways the obverse of the population pressure situation. It is considered separately here because it is argued that, if given a long enough period of time at one general level of technology, an economy will eventually face natural resource depletion and shortage even if the economy in question has a relatively stable population. In other words, a long time period at one level of population can have the same effect as a much shorter time period with a population explosion. Hence, rapid population growth is not necessary to bring about a shortage or depletion of

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and present. Also see any of the following: Food — One Tool in International Economic Development (Ames: Iowa State University Press, 1962), 419 pp; Sir E. John Russell, World Population and World Food Supplies (London: George Allen and Unwin, Ltd., 1954), 513 pp.; Lester R. Brown, Increasing World Food Output Problems and Prospects, Foreign Agricultural Economic Report No. 25 (Washington: U.S. Department of Agriculture, 1965); P. Lamartine Yates, Food, Land and Manpower in Western Europe (London: Macmillan and Co., Ltd., 1960); United States Department of Agriculture, Changes in Agriculture in 26 Developing Nations: 1948-1963, Foreign Ag. Econ. Report No. 27 (Washington: November 1965), 134 pp.; Grant Cannon, "Hybrid Wheat," Farm Quarterly, Vol. 18 (Fall 1963), p. 46.; and Food Technology Journal, March, April, and July 1963 issues.

natural resources, though admittedly it is usually a factor in the real world.

Views, both optimistic and pessimistic in nature, can be found among professional circles concerning the future role of natural resources. The pessimistic view is based on the Ricardian - Malthusian scarcity doctrines. Natural resources, being non-reproducible, have a finite supply according to this view. The result is that as the gradual increase in the labor supply causes all the available natural resources to be brought into use, the law of variable proportions operates and the marginal productivity of labor and capital diminishes as these factors expand against the fixed amount of natural resources. The economic welfare of individuals is impaired as output per capita declines and, since economic growth is measured by the increase in output, diminishing returns slow the growth rate and ultimately as output reaches a maximum, economic growth will cease.[40] Thus, the pessimistic view leads quite obviously to questions about natural resources limitations on economic growth and development.

Many studies have attempted to validate the pessimistic views concerning resource scarcity.[41] The fact that a large part of the population of the world is undernourished and that large segments of the world are overworked or even near depletion agriculturally, is used as empirical evidence that the Ricardian - Malthusian scarcity model holds. In such areas, land rents are high, while labor productivity and standards of living are extremely low.

The optimistic view is based on realized past advances and expected future progress involving technology (human skills and knowledge). The new concept of resources is a dynamic view that technological improvements

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[40] For an analysis of these points, see J. J. Spengler (ed.), Natural Resources and Economic Growth (Washington, D. C.: Resources for the Future, Inc., 1961), p. 23.

[41] For example, see Fairfield Osborn, Our Plundered Planet (Boston: Little, Brown and Company, 1948), 217 pp.; and Georg Borgstrom, op. cit., especially pp. 346-439.

can expand or maintain the resource base in the face of an incipient shortage or depletion of resources. According to Cotner:

> The new concept of resources is that at any given time the supply of a particular material or group of resources may be limited, but over the long run the total supply of resources can be expanded. The technology and knowledge springing from science, in effect, can expand the supply of the resources either in developing the same resource or providing a substitute.[42]

This is the concept of natural resources that is employed in the theoretical framework of this study.

Thus, according to this dynamic view as man's knowledge grows, an increasing part of the total environment can be utilized to provide needs such as tools, food and machines. Only a small part of the total environment is used for these purposes today. Furthermore, if it is accepted that there is a huge amount of matter on the earth (or an infinite amount of matter in the universe), then the possibilities are unlimited, because if matter is never destroyed by being used (only its current arrangement into useful resources is destroyed), then man can use his knowledge to develop some new or improved replacement (or substitute) resources.

Cotner notes that:

> The implications of this view for economic growth and welfare are profound. There would be no lasting resource limitation on growth. As pressures on resources mount and as the marginal productivity of labor and capital diminish, forces would be set off in either the private or public sector to develop substitute resources. Economic welfare need not decline because of resource scarcity as long as the forces of science and technology can be controlled and directed to this end.[43]

Empirical validation of the optimistic view concerning resource scarcity

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[42] Melvin L. Cotner, The Role of Agricultural Water Resource Development in Regional Growth, Agri. Econ. Misc. 1965-13, Dept. Agr. Econ., Michigan State University and Natural Resource Economic Division, ERS, USDA (November 1965), p. 4.

[43] Ibid., p. 5.

is typically based on the fact that the increased population pressure on the natural resource base in the developed countries has not resulted in high scarcity returns to the owners of the natural resources. It has been shown for the U.S. that natural resources for agriculture and mineral production have been declining in economic importance over time.[44] It has also been shown for the U.S. that the marginal productivity of labor in the use of natural resources has increased, not decreased, with the result being lower labor costs per unit of output.[45] New and improved "non-conventional" inputs have entered the agricultural production process in many countries.[46] Thus, the evidence supplied by the experience of the developed countries indicates that both the quality of natural resources has been increased and that certain factors in the environment have been manipulated in such a way as to bring about effective substitutes for natural resources. In the area of agriculture alone, this is evidenced by the efforts directed into such improvements as hybrid seeds, drainage, irrigation, fertilizer and pesticides, etc., that have improved the productive capacity of the land.

In Chapter IV, it was shown that conventional natural resources have produced a declining portion of the national output of countries as they develop economically, but this does not mean that natural resources are becoming unimportant. The incipient threat of natural resource shortage or depletion over time has been one of the forces acting to induce the production of the human skills and knowledge required in order to develop the necessary conservation, improvement and substitution techniques so that

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[44] Harold J. Barnett, Measurement of Change in Natural Resource Economic Scarcity and Its Economic Effects, Reprint No. 26 (Washington, D.C.: Resources for the Future, Inc., March 1961), pp. 87-88.

[45] Neal Potter and Francis T. Christy, Jr., Employment and Output in the Natural Resource Industries, 1870-1955, Reprint No. 26 (Washington, D.C.: Resources for the Future, Inc., March 1961), p. 128.

[46] T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), pp. 17, 89, and 130-61.

natural resources have not yet placed a lasting limitation on growth in the so-called developed countries. Empirically, this reasoning is supported by the evidence of the huge effort that man has put into developing effective resource substitutes in the past several centuries. For example, consider the huge sums of money that have been spent in the last 100 years on agricultural research for finding effective natural resource substitutes in the U.S. alone. This research investment burden could have been lessened significantly by an even more abundant supply of natural resources. Considering the developed countries as a whole, if it had not been for the research and development effort that they have conducted, their populations would have pressed much more sharply on their natural resource base causing severe negative impacts on their growth efforts. Thus, in reality, the Ricardian-Malthusian scarcity doctrines have not been denied — they simply have not been allowed to operate.

It was also shown in Chapter IV, that in recent years many economists in developed areas have lessened their regard for natural resources.[47] However, it is interesting to note that a qualifying statement almost invariably accompanies analyses which express this view. Denison is typical when he qualifies his remarks by stating that natural resources will not be a problem for the U.S. in the foreseeable future, "if we do not deny ourselves access to foreign supplies," and "if we can assume that technological

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[47] For example, T. W. Schultz believes that natural resources (including land) are of declining importance in the United States and any developing economy for that matter. He states this belief in a number of his writings. See T. W. Schultz, Economic Crises in World Agriculture (Ann Arbor: The University of Michigan Press, 1965), p. 70. Similarly, Denison does not have a very high regard for the importance of natural resources or land. Edward F. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us (New York: Committee for Economic Development, 1962), pp. 88-94. Spengler states that ". . . the influence of natural resources in the United States, though still considerable, has been neither as compelling nor immediate as in former times or as in the less developed countries or regions." Joseph J. Spengler (ed.), Natural Resources and Economic Growth (Washington: Resources for the Future, Inc., 1961), p. vii.

progress . . . continues at a reasonable pace."[48] Thus, what has really happened is that an investment in human capital has improved technology to such a degree that natural resources appear to be less important because they come to comprise a continually smaller share of national income. In other words, such analyses have concentrated on the effects of this technological advance and not on its causes (with the result being an underemphasis on natural resources).

Thus, there is an important relationship existing between natural resources and technology (human skills and knowledge). Today this fact should be quite evident due to the considerable number of competent research efforts that have been conducted in this area in recent years, which have pointed out shortage and depletion problems involving natural resources over wide areas.[49] Many of these studies also very effectively demonstrated the importance of the natural resource - technology relationship. As a result, it came to be more recognized that all countries have problems involving the natural resource - technology relationship — no matter what their present state of economic development — and that this is not a new problem. For example, Joseph L. Fisher has written that,

> One of the great questions before any nation concerns the adequacy of natural resources to provide the kind of

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[48] Denison, op. cit., p. 93.

[49] See for example, J. L. Fisher and Neal Potter, World Prospects for Natural Resources (Baltimore: The Johns Hopkins Press, 1964), 73 pp.; H. H. Landsberg, L. L. Fischman and J. L. Fisher, Resources in America's Future (Baltimore: The Johns Hopkins Press, 1963), 1017 pp.; J. F. Dewhurst, et. al., America's Needs and Resources: A New Survey (New York: The Twentieth Century Fund, 1955), 1148 pp.; J. F. Dewhurst, J. O. Coppock, and P. Lamartine Yates, Europe's Needs and Resources (New York: The Twentieth Century Fund, 1961), 1198 pp.; Harrison Brown, The Challenge of Man's Future (New York: The Viking Press, 1954), 290 pp.; Political and Economic Planning, op. cit., pp. 23-85; and United Nations, op. cit., pp. 181-90; Harold J. Barnett and Chandler Morse, Scarcity and Growth (Baltimore: The Johns Hopkins Press, 1963), 288 pp.; Neal Potter and Francis T. Christy, Jr., Trends in Natural Resource Commodities (Baltimore: The Johns Hopkins Press, 1962), 568 pp.; and Marion Clawson (ed.), Natural Resources and International Development (Baltimore: The Johns Hopkins Press, 1964), 462 pp.

> living its people want, or in some countries, merely to keep the population alive. The question is not new or transient. Even in the United States, with large resources of land, water, energy, and minerals and the world's highest average level of living, one finds concern regarding the over-all adequacy of resources to support the rate of growth of the economy that is within the nation's reach. And if sheer quantities of raw materials and of resource services will suffice, then what will happen to the quality of the resource base itself and its capacity to sustain further economic growth? How may resource conservation and development reflect proven social values and at the same time promote such changes as society at its best would like to make? More specifically, can the flow of raw materials be obtained effectively without higher costs? . . . What reliance can be placed on discovery of new sources, and on technological advances in extraction, processing and use?[50]

Thus, more economists now really recognize that bottlenecks regarding natural resources are present in varying degrees at all times, and that today some of the bottlenecks are a growing concern (e.g. problems of air pollution and water desalination). Hence, not only is it much more evident that the ultimate dependence of a country on natural resources never remains far below the surface of things, but that a poor knowledge of the resources of a country, is in itself a symbol of underdevelopment.

The net result of all this is that it is becoming increasingly true that no economist dismisses the natural resource problem as trivial. This is because it has come to be seen more and more that natural resource abundance is dependent on the rate of technological advance which, in turn, depends on investment in human skills and knowledge. Thus, the evidence suggests that a depletion or shortage of natural resources over time is an important factor in generating a need for human skills and knowledge.

Labor and Capital

The theory presented in this study indicates that either: (1) a capital shortage with N and/or L relatively abundant, or (2) a capital surplus with

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[50] H. H. Lansberg, L. L. Fischman, and J. L. Fisher, op. cit., p. v.

N and/or L relatively scarce are two important factors in "creating" a need for additional and improved human skills and knowledge. The purpose of this section is to examine these forces in the real world. In short, the focus will be on proportion situations (2), (5), and (6) and forces (1) and (3) in Figure 21. First, the manner in which proportion situation (5), (capital shortage), operates through force (1) will be studied. Next, proportion situations (2) and (6) — i.e., capital abundant and labor scarce — and their generation of force (3) will be examined. For reasons outlined in connection with Figure 21, the fact that the theory states that natural resources are relatively abundant in proportion situations (2) and (5) above is largely unimportant in real world situations. Hence, natural resources in relative abundance will be largely disregarded in the cases discussed below.

Thus far, in this chapter, the emphasis has been on studying population as primarily a consuming agent. However, in this section, the emphasis shifts to the study of population as primarily a producing agent.

Labor Surplus and Capital Shortage

Very briefly, the theory presented in Chapter III indicates that every economy began, at one time or another, with the population increasing thus adding to the labor force (L). The natural resource base was essentially free and production decisions were made largely on the basis of the labor input in the early stages. Nonhuman capital is first developed in order to economize on labor use and is quite simple consisting of certain basic tools, etc.

Moreover, according to the theory, the population grows over time as economic activity proceeds. Given the prevailing level of technology, natural resources become relatively more expensive to develop and thus relatively scarcer. Hence, natural resources become relatively more expensive with respect to labor and capital. Also labor becomes relatively less expensive with respect to capital because of the increase in population. The result is that an economy is forced to find ways to economize

on the use of natural resources, and discover new ways of meeting the needs and aspirations of the expanding population (labor force). Thus the economy is forced to find and develop new, more productive means of production (capital) in order to meet the needs and aspirations of the population. Moreover, the development of more productive forms of nonhuman capital requires the application of new and additional human skills and knowledge (human capital). The development of new and additional human skills and knowledge can also greatly increase the productivity of the basic inputs N and L, but the most important way in which new and additional human skills and knowledge are manifest is through additional improved (more productive) nonhuman capital. Improved N and L alone are not enough; additional, improved nonhuman capital is required.

Historically, in addition to increasing the number of consumers, population increases have increased the supply of laborers. Moreover, population increases also have typically implied an increase in the labor supply with the result that labor has become less expensive relative to the other factors (N and L) and relatively more labor has become employed. This is not to deny that there are a number of factors, such as age-sex structure, which influence the size of the economically active population. Nevertheless, historically population growth almost invariably has meant an increase in the human effort or activity directed toward production. Today the growth in population and the labor supply is nowhere more evident than in the technologically lagging (underdeveloped) countries. The result in such areas has been very cheap labor.[51]

The fact that abundant population and cheap labor most often has been the case, especially in technologically lagging areas, has greatly influenced economic thinking. For example, the belief that in the real world man was and would continue to experience an abundant, cheap, and growing labor

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[51] See Gerald M. Meier (ed.), Leading Issues in Development Economics (New York: Oxford University Press, 1964), p. 235; and Wilbert E. Moore, Industrialization and Labor (Ithaca: Cornell University Press, 1951).

supply is shown by the theories of Ricardo and Malthus. In recent years, the belief that labor was so abundant in large areas of the world, that its marginal product could be treated as being zero was widely expressed. As Enke stated, "It is generally held that much of the rural labor force in backward countries, limited almost entirely to agricultural work, is redundant."[52] Some economists held this belief so firmly that theories, such as those presented by Lewis, and Ranis and Fei, were developed in which agricultural labor was assumed to have a marginal product in agriculture of zero.[53] Since this time, the view that the marginal product is actually zero has come to be disputed.[54] Nevertheless, it is held to be very low in many cases. Thus, the evidence suggests that a long history of abundant supplies of cheap labor in many developing and underdeveloped areas has affected theoretical economic thinking to a great extent.

The counterpart of surplus labor is a capital shortage. In many ways capital shortages are both historically and empirically more evident than labor surpluses. Historically, primitive economies have possessed little capital. It is well known that capital shortage was generally a problem in Europe throughout its earlier periods of development — especially in the nineteenth century.[55] Historically, capital has been relatively scarce and has been required in order to just keep pace with the

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[52]Stephen Enke, "Speculations on Population Growth and Population Development," Quarterly Journal of Economics, Vol. LXXI (February 1957), p. 24. Remember that in such countries the agricultural labor force is most of the labor force.

[53]W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labor," The Manchester School of Economic and Social Studies (May 1954), pp. 139-91; and Gustav Ranis and John C. H. Fei, "A Theory of Economic Development," American Economic Review, Vol. 51 (September 1961), pp. 533-65.

[54]Charles H. C. Kao, Kurt R. Anschel, and C. K. Eicher, "Disguised Unemployment in Agriculture: A Survey," in C. K. Eicher and L. W. Witt (eds.), Agriculture in Economic Development (New York: McGraw-Hill, 1964), pp. 129-41.

[55]See P. Lamartine Yates, Food, Land and Manpower in Western Europe (London: Macmillan and Co., 1960), pp. 6-7.

growth in population even in countries rich in natural resources, such as the United States.[56] Meier and Baldwin have reported, with respect to Britain, that, "As a stimulus to capital accumulation, population growth was important. Keynes estimated that over the period 1860-1913 something like half of all the capital accumulation that occurred was required merely to maintain capital per head."[57]

Just as in the case of labor surpluses, the empirical evidence concerning capital shortages has historically affected economic thinking. For example, to the classical writers the fundamental feature of economic development was capital formation. This thinking has come down to the present day in many ways largely intact. For instance, the Harrod-Domar models assign a crucial role in the process of growth to capital accumulation. A recent United Nations study states that ". . . capital accumulation may very well be regarded as the core process by which all other aspects of growth are made possible."[58] Lewis states that economic growth is associated with an increase in capital per head.[59] Therefore, Meier and Baldwin note that, ". . . as most theories of development emphasize, capital accumulation is a fundamental part of economic growth."[60] Thus, there is wide agreement on the important role of capital in economic growth, even though a considerable amount of divergence exists as to the exact manner in which capital is treated among particular economists in their theoretical models.

There are numerous empirical studies which not only substantiate the importance with which economists hold capital, but in addition show that

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[56]Simon Kuznets, Capital in the American Economy, Its Formation and Financing (Princeton: Princeton University Press, 1961), p. 62.

[57]Meier and Baldwin, op. cit., p. 175.

[58]Meier (ed.), op. cit., p. 92.

[59]W. Arthur Lewis, The Theory of Economic Growth (Homewood, Illinois: Richard D. Irwin, Inc., 1955), p. 201.

[60]Meier and Baldwin, op. cit., p. 172.

the historical trend of capital formation has been upward in all economies that have developed.[61] This upward trend was induced by innovations that were favorable to capital.[62] Hence, because innovations increased the marginal productivity of capital relatively more than the other basic inputs, large amounts of capital were demanded in developing economies.[63] Most evidence, at present, indicates that capital will be even more important in the future.

The net result of the analysis in this section is that the evidence strongly suggests that the conditions of labor surplus and capital shortages have been chronically present throughout much of man's history — at least since the long general upswing in world population began many centuries ago. In addition, man has been forced to not only improve labor and natural resource productivity, but to continually add physical capital as well. In reality the net additions to the stock of physical capital have been necessary to improve total productivity by aiding in the production process, i.e. improvements in N and L were and are not enough by themselves to alleviate the problem.

But what does this empirical and historical evidence, which indicates that a steady influx of physical capital has occurred in the developing countries have to do with the demand for human skills and knowledge? The answer is a great deal. In recent years, economists have come to realize as never before just how intertwined technology and capital really are in

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[61] See for example, Denison, op. cit., p. 100; and Kuznets, Capital in the American Economy, op. cit., pp. 55-117.

[62] Henry J. Bruton, Principles of Development Economics (Englewood Cliffs, New Jersey: Prentice-Hall, 1965), p. 83; and Lewis, "Economic Development with Unlimited Supplies of Labor," op. cit., p. 290.

[63] There are many facets to a study of capital and many problems involved when a country attempts capital formation, e.g. rate of saving, basic attitudes and social structure, etc. However, these are not directly related to this study at this point and as a result are not discussed. The literature of the profession is very adequate in these areas.

the real world. For example, Meier and Baldwin state that "Capital formation . . . was linked in large part to technological progress" in Britain during the 1870-1939 period that they studied.[64] Frankel believes that one cannot separate the knowledge of a technique from actually doing it.[65] Denison states that new capital embodies new techniques.[66] Dunlop writes that "Education is both the root of technological change and the basis for successful adaptation."[67] In Chapter II it has already been shown that knowledge produces what is called "technology." However, most economists have failed to see just how strong the relationship is which exists between human knowledge and physical capital. This relationship is emphasized by Boulding in the following statement:

> It is reasonable to assume, therefore, that economic development is primarily a learning process and that the capital goods in which it is embodied are merely material structures which reflect the mental structures out of which they come — though we may postulate, indeed, that all production comes out of knowledge and that it is precisely the nonconserving property of knowledge which enables us to produce anything in the first place. In the last analysis, the reproduction both of wheat and automobiles may belong to somewhat the same category of systems, though the gene structure of automobiles is contained in the minds of men or in drafting-rooms and libraries of automobile companies, whereas the gene structure of wheat is contained in the seed itself.[68]

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[64] Meier and Baldwin, op. cit., p. 202.

[65] S. H. Frankel, "Some Aspects of Technical Change," in Okun and Richardson (eds.), Studies in Economic Development (New York: Holt, Rinehart, and Winston, Inc., 1962), p. 410.

[66] Denison, op. cit., p. 235.

[67] John T. Dunlop (ed.), Automation and Technological Change (Englewood Cliffs, New Jersey: Prentice-Hall, 1962), p. 175.

[68] Kenneth E. Boulding, "Knowledge as a Commodity," Series Studies in Social and Economic Sciences, Symposia Studies Series No. 11 (Washington, D. C.: The National Institute of Social and Behavioral Science, 1962), p. 3.

Thus, in a sense, one cannot really make a precise distinction between advances in knowledge, technological change, and improved physical capital. The result is that additions to the physical capital stock of a country also imply additional, new and improved human skills and knowledge. Hence, an increase in the demand for physical capital also carries with it an implied increase in the need for human skills and knowledge. Historically, developing countries have had to add additional physical capital over time, as we have seen, and as a result additional human skills and knowledge have been also added. Really physical capital has been the product of the additional human skills and knowledge. As Boulding has recently said:

> It is now widely recognized that knowledge is the most important single factor in economic development. Development does not come from the mere accumulation of physical capital; it comes from the change in the form of both material and human capital which results from an increase in knowledge.[69]

It is also evident that as economies have developed they have employed increasingly complex forms of physical capital. To develop this physical capital, increasingly complex human knowledge and skills have been required. Thus, it is known that the demand for more and better skills increases with development. The result is that today often the amount of knowledge embodied or used in the physical plant is a greater indication of the change from the past than is the actual physical plant, because the more developed an economy is the more the capital component comes to be composed of human capital.[70] This fact also requires some attention to be paid by planners in achieving a proper capital balance between human and nonhuman capital because there are implied limits as to the substitutibility between them.[71] However, the end result is clear. Labor surplus and

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[69] Kenneth E. Boulding, "Knowledge as an Economic Variable," The Economic Studies Quarterly, Vol. XIV (June 1964), p. 1.

[70] Schmookler, op. cit., p. 333.

[71] C. Arnold Anderson and Mary Jean Bowman (eds.), Education and Economic Development (Chicago: Aldine Publishing Co., 1965), pp. 225-27.

capital shortage situations lead to a need for additional human skills and knowledge of a higher level of complexity.

Let us now turn to the opposite case — that of a capital surplus and labor shortage.

Capital Surplus and Labor Shortage

Historically, the proportion situation involving abundant (or "over-abundant") capital and scarce labor can be found in a number of instances. Yet it has been less prevalent than the proportion situations previously examined in detail in this chapter. Capital is expensive and requires a sacrifice by the population in order to acquire in economically significant amounts. Hence, economies obviously could not afford the luxury of accumulating capital to the point where it became overly abundant in the past. They cannot afford this luxury at present nor is this possibility contemplated for the future.

Therefore, historically when the abundant capital-scarce labor situation has developed, it almost invariably has come about as the result of a sudden reduction in the size of the labor force and not as the result of an increase in the capital stock. The sudden reduction in the labor force has been typically brought about as the result of either famines, disease epidemics, or wars. For example, it is known that the Black Death caused a sudden reduction in the population in Europe in the fourteenth century. However, at this time the capital stock was very small compared to what we know today to be required for what is known as modern economic growth. In addition, the European labor force was very unskilled at this time. Thus, the reaction to this depopulation was simply to replace the labor force over time and not to improve technology (human skills and knowledge). This pattern has been repeated many times in early history in response to depopulation forces other than Black Death.

At various periods wars have so depopulated areas for a time that capital requiring new and additional human skills and knowledge has been introduced. During our own Civil War, House states that, "The societal push

behind the adaptation of the reaper in America was directly connected with the labor shortage on farms in the North arising out of the Civil War."[72] He believes that apart from the war situation that the reaper would probably have been adapted more slowly and gradually. Of course, there is also always the more direct effects caused by the actual loss of life during wartime to consider. Modern warfare has come to be total warfare, with the result being that capital as well as labor is destroyed in the warring countries during wartime, e.g. in World War II Japan and Germany. The result has been that after the war countries are more often faced with a capital rather than a labor shortage — even though a large amount of labor typically is required in order to rebuild the capital that was destroyed during the war.

Modern economic growth has often caused factor shifts between sectors that have in many cases resulted in an abundant capital-scarce labor situation in certain sectors. For example, during the nineteenth century the industrial demand for manpower in several European countries caused a reduction in the absolute numbers of laborers in the agricultural sector.[73] The result was that even more complex forms of capital were required in the agricultural sector in order to maintain and even expand agricultural output in these cases. This more complex capital, of course, required additional human skills and knowledge to produce.

Various countries, at one time or another, were thought to suffer from a labor shortage and too slow a rate of population growth. For instance, some economists have placed both France and the United States in this category.[74] However, in such cases of alleged labor shortage, it is important to note the argument is that the labor force is too small in comparison with what have been defined as natural resources in this study and not with respect to capital. Thus, instead of having a capital abundant-

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[72] Alvin House, "Developments in Food Production Technology" (East Lansing: Michigan State University, Department of Agricultural Economics, 1965), p. 8. (Mimeographed.)

[73] Yates, op. cit., p. 7.

[74] Hirschman, op. cit., p. 176.

scarce labor situation, such countries really have the abundant natural resource situation that has been previously discussed in this chapter (p. 76). In such situations, population growth is the least expensive way to solve the problem over time. At any rate, such a situation is not very distressing to the economy involved and in all probability relatively few additional human skills and knowledge will be demanded (see p. 76). In such a case the economy involved aspires to develop its natural resources more rapidly, but it is not forced necessarily to develop additional human skills and knowledge.

Often modern economies in developed countries are faced with a "surplus" of capital that was developed using a given level of technology. Over time this level of technology has been outdated. Thus, the capital that was produced with it becomes "surplus" or is obsolescent. However, this does not mean that a labor shortage exists. Thus, such cases do not involve the strict abundant capital-scarce labor situation that is employed in this section.

Typically, economies faced with the abundant capital-scarce labor situation have solved it in the least expensive manner by simply expanding the labor supply over time. The more expensive route of improving human skills and knowledge was not followed. However, modern industrial economies rely on science-oriented technology that requires trained labor. Hence, any situation that calls for an expansion in the labor supply, e.g. the abundant capital-scarce labor situation will require a considerable amount of additonal human skills and knowledge.

In conclusion, it can be said that historical and empirical evidence suggests that the proportion situation of abundant capital and scarce labor has induced a "demand" for additional human skills and knowledge in a number of instances. Nevertheless, this force is much less important than either population pressure or natural resource depletion in this respect.

The Question of Scale

Scale is not a proportion situation in the sense of those previously

discussed. Instead of involving disproportion situations between factors, scale refers to the "proportion" situation between total output and total input, when the inputs are all expanded by the same percentages. The economies of scale question asks by how much would national output increase, if the quantity of every factor of production were increased by a given percentage? It assumes no change in technology (the state of the arts) the average quality of the factors, the percentage distribution of production among final products, the intensity of demand relative to the ability of the economy to produce, or the efficiency with which the economy operates for reasons other than size.

In the theory presented in this study, it is hypothesized that diminishing returns (diseconomies of scale) in total national product as the inputs N, C, and L are expanded nearly simultaneously (by the same percentages) are a force in creating the "need" for new and additional human skills and knowledge. Even constant returns to scale could theoretically be an important force in generating the need for additional human skills and knowledge, if the aspirations of the population for an increased output exceeded the slow expansion that they were obtaining under constant returns. Thus, in theory, diminishing or even constant returns to scale could be important forces inducing the production of additional human skills and knowledge. In addition, theoretically any economy, which expands according to scale, would require additional new forms of human skills and knowledge in order to cope effectively with the growing problems involving management, coordination, and communication within the expanding economy.

Therefore a demand for additional, mostly <u>improved</u> human skills and knowledge that is induced by diminishing or even constant returns to scale goes beyond the question of an increased demand for largely the same level of human skills and knowledge, which arises out of a simple expansion of the economy (not to scale). It is recognized that simple, non-scalar expansions of an economy will increase the quantity, but not always

necessarily the quality, of the human capital demanded. However, the question of scale involves the broader problem of the needed necessary improvement in the quality of human skills and knowledge, which is due to a lower than desired factor productivity accompanying expansions in the size of the operation to scale. In other words, the focus at this point is on changes in the size of an economy according to scale, and this has different implications than simple changes in the size of an economy not according to scale. Simple, non-scalar expansions of an economy, of course, almost always require larger amounts of human skills and knowledge, but not always larger amounts of a higher level of human skills and knowledge.

Denison notes that the problem of scale is one of the most perplexing, as well as potentially important, questions in the entire study of economic growth. He has expended considerable effort researching this area and states with respect to the U.S. economy that "acceptable statistical measures of the importance of economies of scale for the economy as a whole, or even for single industries are not available."[75] Various studies of economies of scale have been made. However, they have suffered immensely from conceptual problems and have been unable to isolate the scale factor from differences in technology or the quality of inputs. At other times all that has really been measured are monopoly returns or short run disequilibria. Upchurch has pointed out the tremendous problems associated with just defining and quantifying economies of scale in the U.S. agricultural sector alone.[76] In addition, he casts much doubt on past empirical research in this area and indicates that there exists very little precise knowledge, at present, about economies of scale in U.S. agriculture. The problems that Denison and Upchurch identify in researching

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[75]Denison, op. cit., p. 173.

[76]M. L. Upchurch, "Implications of Economies of Scale to National Agricultural Adjustments," Journal of Farm Economics, Vol. XLIII (December 1961), pp. 1239-46.

the U.S. economy are almost without exception more acute in other parts of the world.

The result has been that anyone conducting research in this area has been faced with an extreme scarcity of reliable empirical evidence. As a result, Denison states that "we are forced to fall back upon a priori reasoning and 'expert opinion'."[77] Nevertheless, based on his empirical work on the U.S. economy, Denison rules out the likelihood of diminishing or even constant returns to scale.[78] He ends up by "assuming" on the basis of his research that "in the 1929-57 period economies of scale increased the contribution of all other sources to economic growth by 10 per cent."[79] In his work, Kuznets also indicates some evidence that suggests that economies experience increasing returns (economies of scale) with growth in size.[80]

Thus, based on the sketchy empirical evidence, which economists possess at present, one must conclude that economies generally experience increasing returns to scale as they expand in size. As a result, in this study diminishing as well as constant returns to scale, as the basic inputs N, C, and L are expanded relatively simultaneously, have to be ruled out as factors which significantly help generate a need for human skills

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[77] Denison, op. cit., p. 174.

[78] Ibid. However, he does admit that decreasing returns to scale are possible in certain cases. He mentions that such things as the national government and communications enterprises cannot very well be expanded to scale and may result in decreasing returns to scale.

[79] Ibid., p. 175. Denison also mentions that Stigler and "other economists" have conducted international comparisons, which have also indicated economies of scale. See Denison, p. 181.

[80] Simon Kuznets, Six Lectures on Economic Growth (Glencoe: The Free Press of Glencoe, 1959), pp. 89-100. See especially p. 98. The research indicating increasing returns to scale undoubtedly suffers from some problems involving measurement. Some of the results then might not reflect increasing returns to scale, but the fact that inputs are not the same years later due to improved technical skills and knowledge, and the techniques of the researcher have not eliminated this source of bias from the data.

and knowledge. This conclusion is reached in spite of theoretical and empirical confusion with respect to economies of scale,[81] and despite quite strong evidence which indicates that a considerable amount of additional human skills and knowledge are required in order to facilitate organizational changes as an economy expands in scale.[82] Much more research is required in this entire area.

This section concludes the study of empirical evidence relevant to the individual proportion situations and the forces which they generate. Next, an attempt will be made at relating the entire theoretical framework to the sectors of an economy.

The Agricultural Sector

Any attempt at relating the theoretical framework to various sectors of a real world economy raises the question of which sector or sectors can yield the most empirical evidence relevant to the theory. For instance, what can be termed the nonagricultural sector includes a heterogeneous

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[81] Upchurch, op. cit., p. 1240. Upchurch notes that economies of scale and economies of variable proportions even have been confused at various times. This is a very easy trap to fall into. For example, in a study of technical change in the U.S. economy during the 1909-49 period Solow writes that "the aggregate production function, corrected for technical change, gives a distinct impression of diminishing returns, but the curvature is not violent." The casual reader might think that Solow is referring to economies of scale, but he is actually referring to economies of variable proportions. This is due to the fact that he is using the aggregate production function $Q = f(K, L, T)$ where Q is output, K is capital in physical units, L is labor in physical units and T is time (this allows for technical change). Thus he is getting diminishing returns to K and L as they are increased relative to what is called N in this study. See Robert M. Solow, "Technical Change and the Aggregate Production Function," Review of Economics and Statistics, Vol. XXXIX (August 1957), pp. 312-20. In addition, T. W. Schultz is quite critical of techniques employed by Solow in his first attempt at empirically studying technical change. See T. W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), p. 141.

[82] For example, see Bruton, op. cit., pp. 22, and 37-41; and Edwin Mansfield, "Rates of Return from Industrial Research and Development," American Economic Review, Vol. LV (May 1965), pp. 310-15.

mix of major industrial divisions, such as manufacturing, trade, services, and others. Even though the productivity increase data for both the agricultural and nonagricultural sectors of the United States economy are impressive the heterogeneous nature of the nonagricultural sector makes it a difficult area to study. Data for divisions, such as manufacturing, trade, service, etc., often are not available or are not strictly comparable over time. Therefore, the data often cannot be adequately compared between sectors. Handy indicators such as the man-land ratio of the agricultural sector do not exist for the nonagricultural sector. Therefore, the more homogeneous agricultural sector is a more useful sector with which to test the theoretical framework.

The explanation of the increased need for human skills presented in this study is supported by the historical evolution of agriculture from hunting to nomadic to permanent cultivation.[83] Each step involved a greater use of human capital relative to land. It is known that earliest cultural methods of man for crops were extremely crude, yet early records show that various attempts were being made to increase yields.[84] It has been shown in a study of agriculture from the times of ancient Babylon to present that "Mechanization began when nomadic tribesmen were forced by dint of a rising population and a demand for more food, to adopt a higher and more settled form of agriculture and to introduce the first power in the form of oxen."[85]

B. H. Slicher Van Bath has developed the connection between population,

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[83]See N. S. B. Gras, A History of Agriculture in Europe and America (New York: F. S. Crofts and Co., 1940), pp. 5-20.

[84]Salmon and Hanson, op. cit., p. 7.

[85]J. L. Meij (ed.), Mechanization in Agriculture (Amsterdam: North-Holland Publishing Co., 1960), p. 39. Also see E. Cecil Curwen, Plough and Pasture (New York: Henry Schuman, 1953), 329 pp.; and Norman E. Lee, Harvests and Harvesting Through the Ages (Cambridge: Cambridge University Press, 1960), 208 pp. Curwen traces the early history of farming and Lee presents another study of agricultural inventions from Babylon to present.

area, and farming techniques for Europe during the Middle Ages.[86] He indicates that much change occurred in agricultural techniques during and immediately following the Middle Ages in response to overpopulation. Thus, this was not a period of complete agricultural stagnation as many have thought. Inventions during this period ranged from improvements in plowing and harnessing of horses to the spur, horseshoe, horse collar, and the water-mill. Slicher Van Bath shows that beginning about 1150 direct agricultural consumption in Europe (subsistence agriculture) receded and indirect agricultural consumption (market-oriented agriculture) emerged. This transition required the gradual development of a better technology (hence human skills and knowledge).

Similarly, Clark and Haswell have shown how population pressure in early Europe and other areas often stimulated the adoption of new technology in response to pressing space requirements.[87] For example, they indicate that the area which now comprises the United States and Canada had a population of approximately one million American Indians in the sixteenth century when the white man arrived. The Indians about this time were facing a "population crisis," and were beginning to find it necessary to change over to agriculture from nomadic hunting. Clark and Haswell also stress how the deterioration of the natural resource land can contribute to the transition to a more settled type of agriculture.[88]

Habakkuk shows how population pressure continued to be a problem in Europe during the seventeenth and into the nineteenth century.[89] He indicates that the institutional obstacles to introducing new agricultural techniques were quite strong earlier in Europe, but that agricultural output

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[86] B. H. Slicher Van Bath, The Agrarian History of Western Europe A. D. 500-1850 (New York: St. Martin's Press, 1963), pp. 9, 54-57, 63, 70-71, and 113.

[87] Colin Clark and Margaret Haswell, The Economies of Subsistence Agriculture (New York: St. Martin's Press, 1963), pp. 26-28.

[88] Ibid., p. 45. [89] Habakkuk, op. cit., p. 612.

probably became much more responsive to a given population pressure in the late eighteenth and early nineteenth century. However, others have shown that the desire to improve knowledge concerning agriculture was so great that 440 English books dealing with agriculture were published prior to 1800.[90] This was during the period previous to and during the early part of the Agricultural Revolution, when there were no agricultural experiment stations or agricultural colleges, and agriculture was not taught in the universities.

Therefore, historical evidence suggests that the theoretical framework developed in this study can be used to demonstrate the necessity of a change from an extensive to an intensive type of agricultural output expansion. When the extensive agricultural margin is reached, the economy demands more productive inputs, hence better technology and human skills. Thus, history shows that the importance and need for agricultural advance (hence human skills and knowledge) in the face of population pressure has long been at least implicitly evident and understood. Moreover, the more recent agricultural history of the United States is a good example of this process at work. Recent empirical research by Loomis and Barton places the shift in U.S. agricultural production from extensive to intensive techniques of expansion at about the time of World War I.[91] They state that:

> Agricultural productivity has doubled in less than a century; from 1870 to 1957, it increased 102 per cent. During the first 40 years of this period, from 1870 to 1910, overall productivity advanced 32 per cent. This compares favorably with the 34 per cent increase in the succeeding 40 year period, 1910-50. Based on this comparative advance in productivity, what is frequently referred to as the recent "revolution" in agricultural productivity seems to be more of an "evolution." However, from 1940 to 1957, a

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[90] Salmon and Hanson, op. cit., p. 11.

[91] Ralph A. Loomis and Glen T. Barton, Productivity of Agriculture: United States, 1870-1958, Tech. Bul. No. 1238 (Washington: U. S. Department of Agriculture, April 1961), pp. 6-8.

period of only 17 years, productivity advanced 31 per cent, and in the 7 years from 1950 to 1957, productivity increased 14 per cent.

Between the Civil War and 1900, agricultural productivity increased greatly. The causes of the increase in the early period differed from those in more recent times. The early period was one of expansion of farm production through extensification, in contrast to the intensification since World War I. The westward movement opened up new, fertile land, and our agricultural plant was expanded through an increase in labor and real estate inputs. Concurrently, we shifted from primitive agricultural tools to the then new and relatively more efficient types of horse drawn machinery, such as the gang plow, grain binder, mower, cultivator and seed drill. It was the technological advancement in farm machinery in this early period that made possible the rapid development of the Great Plains.

Shortly after 1900, agricultural expansion began to slow down. This lessening of expansion lasted until the mid-thirties. During this period total inputs continued to rise as did total output, although at a slower rate. Productivity changed very little for about three decades. This does not mean that no important developments occurred. About the time of World War I, mechanical power began to replace animal power and human labor. The total quantity of labor began the steady decline (interrupted by the depression) that is still going on, and the process of mechanizing farms with tractors, motor trucks and development of the many new and improved farm machines was underway.

Immediately preceding the depression of the 1930's productivity again began to increase. It was arrested temporarily by the depression years, but for the last two decades it has increased steadily. Although total inputs have increased relatively little, total output has increased sharply.

Average output per man-hour of labor has increased phenomenally in recent years relative to any period prior to the 1930's. Average output per unit of real estate continues to advance as a result of combining more and improved outputs with each unit of land. However, the average output per unit of inputs other than labor and land (or in a broader sense, capital and intermediate product inputs) has been declining since the turn of the century.

A number of other independent studies of the historical changes in productivity of U.S. agriculture provide evidence that is very much in agreement with the findings of Loomis and Barton. For instance, in their respective studies, both Shaw and Johnson place the transition date from extensive to intensive production expansion methods at about 1920.[92] Lave's impressive work on technical change in U.S. agriculture 1850-1958 indicates a tremendous jump in U.S. agricultural productivity following 1920.[93] According to Schultz, agricultural output grew in the United States after 1925 in response to three interrelated developments.[94] These were: (1) advance in knowledge, (2) supply of new material inputs, and (3) the advance in farmers' know-how. Schultz also argues that the United States agricultural research establishment has not always provided a stream of new, highly productive inputs and that, in fact, during the decades prior to the mid-1920's, it produced a trickle that is hard to detect.[95] Similarly, Harbison and Myers believe that the land-grant colleges only had begun to make a contribution to the modernization and improvement of U.S. agriculture by 1900 or 1910.[96] Brown believes that "the United States provides a clear-cut, well-documented instance of a country making the transition from the area-expanding method of increasing output to the

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[92] Byron T. Shaw, "Land Resources for Increased Agricultural Output," Journal of Farm Economics, Vol. XXXIV (December 1952), pp. 673-81; and Sherman E. Johnson, "Prospects and Requirements for Increased Output," Journal of Farm Economics, Vol. XXXIV (December 1952), pp. 682-94.

[93] Lester B. Lave, "Empirical Estimates of Technological Change in United States Agriculture, 1850-1958," Journal of Farm Economics, Vol. 44 (November 1962), pp. 941-52.

[94] T. W. Schultz, Economic Crises in World Agriculture (Ann Arbor: The University of Michigan Press, 1965), pp. 72-74.

[95] Ibid., p. 61.

[96] Frederick Harbison and Charles A. Myers, Education, Manpower and Economic Growth (New York: McGraw-Hill, 1964), p. 149. Nevertheless, Salmon and Hanson indicate that the earlier passage of the Morrill Act resulted from a growing appreciation of the need for education and research relating to agriculture. Salmon and Hanson, op. cit., p. 23.

yield-raising method."[97] He indicates that the area-expanding ended about 1915 and that the difficulties in making the transition to the yield-raising method have been clearly documented. Thus the evidence indicates that the shift of United States agriculture from an extensive to an intensive type of expansion around the time of World War I (and the period following) seems to have been more due to the agricultural sector reaching the extensive margin and demanding new technology (hence human skills and knowledge) than to the push of new ideas and skills from the then small land-grant college system.[98]

Past experience indicates that agricultural output expansion by yield-raising techniques requires a relatively much greater effort than area-expansion methods. In terms of the theoretical framework, the yield-raising technique is both more difficult and productive because of the investment in human skills and knowledge required. As a result, man typically has expanded agricultural output by increasing the land area under cultivation thus minimizing the need for costly yield-raising improvements. Therefore, even today countries with reserves of potentially arable land tend to expand their agricultural output in an extensive manner. For example, agricultural expansion in Brazil is still predominately extensive. Furtado attributes four-fifths of the increase in Brazilian agricultural output of the past decade to an increase in the area under cultivation and less than one-fifth to an improvement in yield per acre.[99] Thus, Brazil has not really been forced (or has not been able) to develop the human

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[97] Lester R. Brown, Increasing World Food Output: Problems and Prospects, Foreign Agricultural Economic Report No. 25, USDA, ERS (April 1965), p. 20.

[98] The earlier U.S. transition is also interesting from another viewpoint. Schultz indicates that the behavior of the agriculture of India today is much like that of the United States during the first quarter of this century. See T. W. Schultz, Economic Crises in World Agriculture (Ann Arbor: The University of Michigan Press, 1965), p. 72.

[99] Celso Furtado, "The Development of Brazil," Technology and Economic Development (New York: Alfred A. Knopf, 1963), p. 163.

skills and knowledge necessary for a modern intensive agricultural sector. This is in contrast to the development of a very intensive agricultural sector in Japan by the means of investment in human skills and knowledge — thus improving technology.

Present indications are that future developments surrounding world agriculture will continue to lend support to the theoretical framework. The reasons for this belief are several. World population has continued to grow at a rapid rate and present indications are that by using current techniques an expansion of agricultural output would encounter rising real costs.[100] Today opportunities for large scale emigration from overpopulated areas no longer exist and the prospects for economically expanding the cultivated land area of the world are dim. In the 1960's agricultural per capita output even has trended downward in much of the less developed areas of the world. It therefore follows that due to the higher rates of population growth and the limited possibilities for expanding the area under cultivation, the land-man ratio is declining more rapidly in the less developed countries of today than it did in the past. Thus, the central agricultural question facing less developed countries today is how quickly they can make the transition from the area-expanding method of increasing food output to the yield-raising method of increasing food output. The less developed countries today have a Hobson's choice of: (1) achieving a yield takeoff, (2) accepting a decline in the per capita food output with all its subsequent effects, or (3) becoming increasingly dependent on international trade for food supplies. The need for increasing agricultural productivity in these countries is of critical importance.

Just as our theory would predict, efforts to solve the agricultural productivity problem in such areas, has resulted in an increasing emphasis on the need for human capital development in agriculture in recent years.

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[100] Edward S. Mason, "Raw Materials and Economic Development," in Okun and Richardson (eds.), Studies in Economic Development (New York: Holt, Rinehart and Winston, 1962), p. 276.

For example, one recent study states that the classic inputs land, labor, and capital have no power by themselves to lead a country along the road to agricultural development. In the words of this study: "It takes an elusive 'x factor' which might be called a national will to succeed, to breathe life into the human, physical and social elements of an economy."[101] Included in the "x factor" are such things as capital, human and technological factors. These act to increase output per worker, yield, and total output. Thus, as this article states, "A nation increases agricultural output because of the quality as well as the quantity of its human, technical, physical and financial resources."[102]

Therefore, it is concluded from the evidence presented in this section that when the extensive agricultural margin is reached an economy tends to demand more productive inputs in order to shift towards more intensive agricultural methods. As a result, human capital (human skills and knowledge) is required in new forms and in larger amounts in order to raise the agricultural production function of the economy. However, this is not always a neat process that follows the same economically induced path in country after country. It is recognized that important social and political factors shape the economic development path of a country as well. Nevertheless, the study of the historical economic development tendencies of the agricultural sector lends support to the theoretical framework developed in this study.

Let us now examine some implications that real world "education" holds for the theoretical framework.

Real World "Education"

The purpose of this section is to briefly relate some evidence provided by real world "education" to the theoretical framework. First, the theoretical framework of this study indicates that countries demand more and more human capital as economic development proceeds. This is supported by real

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[101] "Nations That Lead the Way," The Farm Index, USDA, ERS (October 1965), p. 16.

[102] Ibid.

world evidence. For example, consider the U.S. experience. T. W. Schultz has indicated that schooling accounted for one-fifth of the increase in United States gross national product in the 1929-1957 period.[103] Between 1900 and 1956 the resources allocated to United States' education rose about three and one-half times.[104] Denison estimates that, in the 1929-1957 period, the amount of education the average worker received was increasing almost 2 percent per year, and this in turn was raising the average quantity of labor by 0.97 percent each year, while contributing 0.67 percentage points to the growth rate of real national income.[105] Thus, it was the source of 23 percent of the growth of total real national income and 42 percent of the growth of real national income per person employed.

Secondly, the theory stresses "education" for production and not for consumption purposes. It indicates that the "demand" will be primarily for human skills and knowledge directed toward practical productive ends if the economy is going to experience what is called modern economic growth. Hence, it suggests that any country which undertakes a deliberate policy should not overemphasize education for consumption purposes over that directed for production uses. Also, the theory suggests that the education of an elite in a country — either in the sense of a small number of people educated to a high level at the expense of general mass education or in the sense of overemphasizing the more fashionable consumption subjects, such as the humanities — may slow economic progress.

Therefore, it does not come as a surprise when real world evidence shows that many countries have experienced difficulty because they have

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[103] T. W. Schultz, The Economic Value of Education (New York: Columbia University Press, 1963), p. 11.

[104] T. W. Schultz, "Education and Economic Growth," in Nelson B. Henry (ed.), Social Forces Influencing American Education (Chicago: University of Chicago Press, 1961), p. 60.

[105] Denison, op. cit., pp. 67-78.

invested in the kinds of "education" and skills not needed in large quantities for economic development. Students often tend to enroll in large numbers in law, arts and the humanities, while neglecting medicine, the natural and biological sciences and engineering.[106] Part of this phenomenon is also induced by the fact that it is cheaper for the government to provide humanities training than it is natural science or medical training. Increasingly, real world evidence indicates that educational "elites" largely are not needed. India and Egypt are countries that immediately come to mind where there has been an over-investment in certain types of elite education such as law. Such cases have resulted in many unemployed or underemployed holders of the doctoral degree.

Thirdly, the theoretical framework of this study emphasizes the close linkage between human skills and knowledge, technological change, and technology. Nevertheless, the "chicken and egg" argument of whether human skill development (education) must precede economic growth or whether growth must (or can) precede education has been and still is very much alive in the real world. This is the question of timing of "education."

One side argues that the industrialization of Western Europe was accomplished, for example, without the prerequisite of mass public education and that, hence, the demand for mass public education appears only at a fairly advanced phase of development. Krishna states that it is not clear from the historical record that general mass public education is a prerequisite for economic growth.[107] He states that growth more often has preceded mass education than vice versa, and that expenditures on

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[106]Frederick Harbison and Charles A. Myers, Education, Manpower and Economic Growth (New York: McGraw-Hill, 1964), p. 85. See also Ladislav Cerych, Problems of Aid to Education in Developing Countries (New York: Frederick A. Praeger, 1965), p. 61; and Thomas Balogh, "The Problem of Education in Africa," Centennial Review, Vol. VI, 1962), p. 526.

[107]Raj Krishna, "Discussion: The Role of Investment in Human and Community Capital," Journal of Farm Economics, Vol. XLII (December 1960), p. 1221.

education have not been inspired by prospective returns but by farsighted statesmanship.[108]

On the contrary, Japan is often cited as a case where human skill development preceded economic growth.[109] Tang believes that improved human attributes are more than a technical complement — they can be a prime mover as well. He continues by saying that "just as western railroads in this country were wisely built ahead of demand to induce United States regional development, so should human capabilities be developed before existing settings can justify the move."[110] In addition, it is believed that, unlike the earlier historical situations, less developed countries today may now find it necessary to have a quite high level of skill and knowledge in order to take advantage of the more complex equipment and techniques that may be obtained from more advanced countries.[111] Thus, "education" in advance of economic growth is stressed by people sharing this view.

More recently, real world evidence and views that lend much more support to the theoretical framework have been presented. This is the idea that skills and knowledge are tightly interwoven with what is called technology, and that as a result economic and "educational" development must generally proceed together, i.e. neither can be allowed to run ahead without the other. For example, Cerych believes that the requirements for accelerated development today undoubtedly call for at least a parallel emphasis on educational and economic expansion. He states that, "It is immaterial which comes first — education or economic expansion: what cannot be denied is the existence of a close link between the high level

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[108] Ibid., pp. 1222-26.

[109] For example, see Harbison and Myers, op. cit., p. 184; and Anthony M. Tang, "Discussion: United States Endeavors to Assist Low-Income Countries Improve Economic Capabilities of Their People," Journal of Farm Economics, Vol. XLII (December 1961), p. 1079.

[110] Ibid. [111] Harbison and Myers, op. cit., p. 121.

of economic and of educational development."[112] Hence the educational situation in most advanced countries is that it is yet a major bottleneck in their economic and social growth. Is it any wonder that these countries often ask the following: "If we have to contribute to the development of others, why should we do it in a field which represents one of our own weakest points?"[113] This thinking goes along with Frankel's views that were previously presented in this chapter — i.e. we cannot separate the knowledge of a technique from actually doing it.[114] In other words, according to Frankel a technical activity does not consist as if it were two parts, namely of (a) knowing how to do a thing, and of (b) doing it. Rather it consists of essentially one process — the conducting of the activity itself. This is perhaps the best solution to the whole "education" timing or prerequisite dilemma. It is similar with the conclusion that human capital and technology are highly interrelated, which was reached in Chapter II of this study and utilized thereafter.

Thus, in conclusion, evidence presented in this chapter concerning the amounts, kinds or types, and timing of real world "education" generally lends support to the theoretical framework developed in this study. In addition, it has been shown that these involve a number of policy implications.

Summary

The purpose of this chapter has been to relate real world evidence to the theoretical framework. First, it was shown from the relevant production function of the study GNP = f(C, L, N) that seven factor disproportion situations are possible. Secondly, it was shown how the relevant disproportion situations give rise to four fources that could possibly generate a need for human skills and knowledge at the prevailing or existing level of

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[112] Cerych, op. cit., p. 29.

[113] Ibid., p. 30.

[114] Frankel, op. cit., pp. 410-11.

technology of an economy. These four forces are as follows: (1) population pressure on the natural resource and/or capital base (capital scarcity is implied), (2) depletion or shortages of natural resources, (3) relatively abundant capital and scarce labor which causes diminishing returns to nonhuman capital, and (4) scale — diminishing marginal returns as N, C, and L are increased nearly simultaneously.

Both the empirical and historical evidence presented in this chapter indicates that the world chronically has experienced population pressures, and natural resource shortages and depletion at the then existing levels of technology. In much of the world this problem is yet severe. Population pressure typically has meant a surplus of labor and a shortage of capital. This situation has forced economies to invest in developing better human skills and knowledge in order to improve the productivity of the basic inputs, N, C, and L. This also meant the finding of ways to conserve existing and discover additional natural resources. The addition of nonhuman capital, alone, requires a considerable investment in human skills and knowledge, because nonhuman capital goods merely reflect the mental structures from which they come.

The empirical and historical evidence presented in this chapter also indicates that the capital surplus and labor shortage situation at a given level of technology has and can in numerous instances give rise to a need for additional human skills and knowledge. In addition, based on the empirical evidence, which economists possess at present, one must conclude that either diminishing or constant returns to scale as N, C, and L are expanded relatively simultaneously have to be eliminated as factors which significantly help generate a need for human skills and knowledge.

Thus, it is concluded that the forces of population pressure, and natural resource depletion or shortages are quite significant in generating the demand for human skills and knowledge. The force created by a capital surplus and labor shortage is somewhat less important or significant, and the scale situation has no significance as a human skills and knowledge

"demand" generator. In the significant cases, often a considerable amount of time is required in the real world before an economy can effectively organize itself in order to supply the needed human skills and knowledge.

Both the agricultural sector and the real world "education" experiences and trends were studied for possible empirical evidence that they might hold relative to the theory. It was shown, historically, that often the need to change from an extensive to an intensive type of agricultural output expansion has created an increased need for human skills and knowledge. Real world experience concerning the amounts, kinds or types, and timing of "education" also lends support to the theoretical framework. In other words, it was concluded that the evidence which both the agricultural sector and the real world "education" experiences supplied largely supported the theoretical framework.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Historically, economists have considered physical capital as the principal factor governing the rate of economic development. Human resources were thought of "as one of the more or less inert input factors necessary in the life of the community."[1] Now, thanks to the research of recent years, human resources have come to be highly regarded by most economists. It is now thought that if the knowledge and skills of the populace are inadequate to take advantage of the production potential provided by the basic physical factor availability of a society, then that society will fall behind other societies which invest more intelligently in human development.[2]

Yet many questions involving human capital have remained unanswered. T. W. Schultz has shown the increased demand for human skills and knowledge that has occurred as a result of past economic growth.[3] An accepted explanation of this increased need is not available at the present time. Therefore, the objectives of this study were: (1) to develop a theoretical framework that helps better explain the observed change in "demand" or need for human skills and knowledge that occurs with the economic growth of an economy, (2) to examine evidence that bears upon the theoretical explanation developed, and (3) to suggest possible areas for empirical tests of the hypotheses developed in this study.

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[1] See Harbison and Myers, op. cit., p. 12.

[2] Ibid.

[3] T. W. Schultz, The Economic Value of Education (New York: Columbia University Press, 1963), pp. 67-68.

In economics it is a generally accepted notion that, given the technological environment, the amount of any factor input per unit of output and the proportions in which various inputs are combined depends on the relative costs of factors. During the course of economic development the relative costs of factors, the patterns of their use, and the technological environment all undergo change.

Thus it is the thesis of this study that an economy demands investments in human skills and knowledge (education or human capital) largely as a result of several key forces. These forces result when society is unable, in some sense, to meet its needs using the prevailing or existing level of technology. Consequently, a "demand" for human capital at an existing level of technology is created in order to enable the economy to overcome or avoid: (1) population pressure upon natural resources and/or nonhuman capital, which causes N and/or C to become more expensive relative to L; (2) increases in the price of natural resources relative to labor that were caused by the shortage, deterioration, and depletion of natural resources, and either an increase in the population over a relatively short time span, or a relatively stable population over a much longer time period; (3) relative labor shortage and nonhuman capital surplus, which causes L to become more expensive relative to C; and (4) factor price increases caused by diminishing or constant marginal returns to scale to N, C, and L as they are increased nearly simultaneously. Any one or a combination of these forces can be operating at any one given time. In addition, certain social, cultural, and political factors must be present in order to allow the demand to be met. The human capital that is supplied enables the societies not only to utilize existing resources more efficiently but also to produce new more productive inputs.

Recent years saw the study of human capital and human capital formation develop largely because the addition of the conventional inputs capital, land, and labor simply did not explain the historical increase in United States productivity. Yet even when the importance of human capital

was recognized little work was done on explaining the growth in demand for human skills and knowledge primarily because of the specific nature of this topic and because other facets of the study of human capital drew first attention. So far the primary result of the probing for an explanation of the growth in demand for human skills has been the identification of certain mistakes and false leads.

Gross national product (GNP) is treated as a function of the three inputs capital (C), labor (L), and natural resources (N) throughout this study. Investment in human capital ("education") can affect and alter the nature and quality of the inputs (i.e., productivity) thus increasing output. Human capital in a sense becomes embodied in the three basic inputs.

Production function analysis, utilizing both two and three dimensional graphs, is employed in order to demonstrate theoretically how the demand for human agents with associated skills and knowledge is generated by an economy over time. The theoretical framework that is developed is more general than the Hirschman statement (which is based on a favorable reaction to population pressure provided that there is some slack for investment present in the economy), and the Hirschman statement is, in turn, more general than the Malthusian model.

The theoretical framework has several important implications. First, it can be employed as a tool for intercountry comparisons and for comparing the same country across two or more time periods. Second, it suggests the importance of natural resources to an economy. Third, it demonstrates that the measurement problem involves more than the natural resource variable. Fourth, it shows that the lack of an acceptable theory has hindered the quantification of important variables.

Historical and empirical evidence is used in demonstrating the relevance of the theoretical framework in the real world. The forces that generate a need for human skills and knowledge express themselves in the real world in a number of different ways. Thus, in order to bring real world evidence to bear on the theoretical framework the following topics

were explored in the real world: population pressure, natural resource shortage and depletion, labor surplus and capital shortage, capital surplus and labor shortage, returns to scale, the agricultural sector, and "education."

Conclusions

The conclusions of this study are that a "demand" or need for human skills and knowledge at a prevailing or an existing level of technology of an economy is a function of factor disproportions which generate certain basic forces. (1) The first force is created by population pressure upon the natural resource and/or capital base (L increases, N and C relatively constant). This is the condition of a relative surplus of labor and shortage of capital, i.e. a small capital/labor ratio. (2) A depletion in either the quality or quantity of the natural resource base over time (even with population constant) produces the second force. (3) The third force is generated by the condition of a relative surplus of capital and shortage of labor, i.e. a large capital/labor ratio (C increases, L and N are relatively constant). Any one or combination of the three forces can be operating at any one given time. The forces are given in a decreasing order of importance. That is, force (2) is less important than force (1) and force (3) is, in turn, less important than force (2). A fourth force, which was derived in the theory, is rejected on the basis of presently available evidence as a factor which could significantly help generate a need for human skills and knowledge. This is the case of diminishing or constant returns to scale as the basic inputs N, C, and L are increased by the economy nearly simultaneously.

These forces are strictly economic in nature. Therefore whether they alone can always cause additional human skills and knowledge to be forthcoming is another matter. The means for purchasing additional human capital must be available. In addition, social, political, and cultural factors are recognized to influence all phases of economic life.

Thus, the forces generated by the various factor disproportions may be thought of as sufficient but not necessary conditions in creating a change in "demand" or need for human skills and knowledge. They are not always necessary because they can be circumvented in certain cases by various social, political, and cultural factors. For example, the religion of a society may cause it to demand skills in order to build pyramids, or knowledge may be needed in order to satisfy a faddish demand of an advanced society for certain plastic toys.

Further Research Indicated

In 1962, Robert Solow commented that recent study had shown the importance of such activities as research, education, and public health.[4] He continued by saying that, as of 1962, even though economists were now convinced of the significance of these factors in economic growth, they were still a long way from having any quantitative estimate of the return to society of resources devoted to such factors. Similarly, North has states with respect to the U.S. economy that ". . . we are far from well endowed with the quantitative information necessary to outline the contours and patterns of American economic change from the past. We have only scratched the surface."[5] North also observes that "A more difficult problem faces us in the development of the theoretical hypotheses necessary for shaping the direction of quantitative research."[6] Thus, it appears that a good way to begin the search for quantitative answers on the demand and returns to human knowledge and skills is by explaining the origin and growth in the demand for such skills. It has been the purpose of this study to attempt at least a step in this direction.

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[4]Robert M. Solow, "Technical Progress, Capital Formation, and Economic Growth," American Economic Review, Vol. LII (May 1962), p. 86.

[5]Douglass C. North, "Quantitative Research in American Economic History," American Economic Review, Vol. LIII (March 1963), p. 129.

[6]Ibid.

Yet much more remains to be learned about factors influencing the demand for human skills and knowledge. The implications stemming from this study are that the analysis needs to be much more comprehensive in order to provide a basis for policy formulation and development.

First, much more effort needs to be put into the quantification of the key variables presented in this study. We have seen that "education" becomes "imbedded" in the basic inputs of an economy or in other words is endogenous to the system. Thus what is needed is the quantification of the variables of the basic aggregate production function of various real world economies in simultaneous equation format. This hopefully would help better indicate the changing demand for human capital. Intercountry comparisons would be facilitated, as would intracountry comparisons across time periods. The improvement of education and skill levels of various populations as they develop economically could be shown. More data that can be used in solving these problems become available as time passes. For example, recent years have seen much more data and information become available concerning the research and development efforts of the United States economy. Perhaps this information would suggest that there is a real difference in the way traditional and modern economies generate a "demand" for human skills and knowledge. If such a discontinuity exists, it would have implications for the theory presented in this study.

Secondly, there is a need to make research on the demand for human skills and knowledge much more interdisciplinary. This study has been almost strictly economic in nature. But education and human capital are much broader than economics. Social, political, and cultural factors also can be very important influences changing the "demand" for human skills and knowledge. Thus much more study is needed on how social, political, and cultural factors influence the "demand" for human skills and knowledge. Perhaps a more comprehensive theory in this area can be developed. This would help us to better understand the role of human skills and knowledge in the development process.

The Ultimate Technology

Modern economies require an increasingly complex array of human skills and knowledge in order to produce the technological advance required. We have seen that the increasing complexity of modern economies has altered the locus of technological advance from single inventors to expensive research and development complexes. The United States continually has needed more and better forms of human capital throughout its history of economic development. These facts raise the following questions concerning the attempts at meeting this growing demand. Is there a limit on the advance in knowledge and skills the United States or any economy can generate? Is there a limit on both the speed with which the society can be educated with the necessary human skills and knowledge as well as on the portion of the soceity that can be educated with the various necessary skills and knowledge? In short, is there an ultimate technology or ultimate brainpower "potential" beyond which man does not have the ability to advance?[7] These questions require additional research. Also, it easily can be seen that these questions have important implications for the theoretical framework developed in this study as well as for the United States. Therefore, it is important briefly to consider whether the United States economy is approaching "Stage III" in a production economics sense in the near future with regard to the rate of increase in the quantity of schooling. Schultz states that:

> Two lessons may be drawn for studies that have been made of schooling as a source of economic growth. During the last three decades, schooling has been a larger source of growth than material capital represented by structures, equipment, and inventories as presently measured. The other lesson pertains to earlier decades

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[7] See, Harrison Brown, James Bonner, and John Weir, The Next Hundred Years (New York: The Viking Press, 1961), pp. 142-46. The main implication of the theory, with respect to the concept of an ultimate technology, is that if such a concept does exist in reality then there is a real maximum limit placed on GNP (for the earth if no life can exist on other planets). How Malthusian can one get?

> and to the decades ahead. Between 1909 and 1929, as will be shown below, schooling played a much smaller role in growth than it has since then. During the next two decades the prospects are that schooling will continue to be a major source of growth, but beyond that it will not be possible to keep on increasing the capital stock of schooling at the rate which has characterized recent decades [emphasis mine].[8]

Similarly, Denison states with respect to the United States economy that:

> . . . what is required to maintain the contribution of more education to the growth rate is maintenance of the percentage increase in the amount of education received, adjusted for the greater importance of the upper grades. For the long pull, this seems simply unattainable.
>
> This prospect makes it all the more important to seek improvement in the quality of education, so as to offset the slackening of the increase in its quantity. But we should not be overly sanguine about this. Such objective evidence as is available suggests that the quality of a day's schooling has been improving for many years, even though my estimates cannot measure it. What is needed to prevent the contribution of education to growth from falling very sharply before the end of this century is a great acceleration in the rate of increase in quality.[9]

In commenting on Denison's work Schultz writes as follows:

> The historical comparisons presented by Denison lend support to the following inferences with regard to schooling: (1) The contribution of schooling to growth between 1909 and 1929 was a little more than one-half of that between 1929 and 1957. (2) The projected 1960-80 growth from this source is a little less than that between 1929 and 1957. (3) For the longer run, it is impossible to maintain the rate of increase in the amount of schooling achieved during recent decades. (4) Between 1909 and 1929, material capital contributed to growth almost twice that of schooling, but between 1929 and 1957, the contribution of schooling exceeded that of material capital.[10]

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[8] T. W. Schultz, The Economic Value of Education (New York: Columbia University Press, 1963), p. 44.

[9] Denison, op. cit., pp. 76-77.

[10] T. W. Schultz, The Economic Value of Education, op. cit., pp. 44-45.

Brown, Bonner, and Weir also have written with respect to the U.S. that:

> It is also important to note that our supply of working scientists and engineers cannot continue indefinitely to grow at an ever increasing rate, as it has in the past. The curve of numbers of scientists and engineers is leveling off as we approach more closely the full utilization of our potential supply. Once we have fully tapped the potential resources by the methods discussed earlier, it will be possible to expand our supply only as populations increase — unless, of course, we change some of the factors which are involved. Thus, it is possible that the proportion of students who choose technical vocations might increase. Or we might import our own talent from other regions.[11]

Thus, future rapid increases in the quantity (percentage of the population) of education in the United States will slow down. Therefore an increase in the quality of education will be necessary in order to more than offset this factor. Thus, at present it is believed that education and advances in knowledge can be produced and will play still larger roles in a higher United States growth rate during the 1960-80 period.[12] No limiting ultimate educational barrier is in sight for the United States at present.

With respect to mankind as a whole, nobody really knows for sure if there is such a thing as the ultimate technology or ultimate "total" knowledge. Present indications are that no real ultimate exists. Thus, when man is faced with diminishing returns, population growth, resource depletions, and increasing aspirations, additional and human skills and knowledge will be forthcoming, due to this increased need, providing that man can overcome his own organizational (social and political) problems. Nevertheless, much more research is needed in this entire general area.

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[11] Harrison Brown et al., op. cit., p. 143.

[12] See Lee R. Martin, "Research Needed on the Contribution of Human Social and Community Capital to Economic Growth," Journal of Farm Economics, Vol. XLV (February 1963), pp. 76-77.

Concluding Remarks

Numerous research efforts both theoretical and empirical in nature have been examined in the general subject matter of human capital. Most of these have been cited in this study and their relevance to the subject matter at hand was brought out at that time. These include, for example, research work done by the following: Abramovitz, Fabricant, Kendrick, Solow, Welch, Horvat, Schultz, Denison, Harbison, Harbison and Myers, and Kuznets. The overwhelming majority of this work is consistent with the theory, analysis, and conclusions of this study in so far as they cover material that is relevant to this study. Other studies in the area of human capital not specifically related to the demand for human skills and knowledge were not reviewed in this study, but they are neither inconsistent nor in conflict with the conclusions of this thesis.[13] Other studies offer substantial portions that help in substantiating the analysis presented in this study, but are not in themselves directed at the subject of the demand for human skills and knowledge.[14]

Most research in the area of human capital is not directly related to the subject of the demand for human skills and knowledge. That research which is directly related supports this study. That research which is only indirectly related typically tends to support certain necessary points that are implicit in this work, e.g. a larger part of the capital component is human capital as a country develops.

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[13] For example, see Fritz Machlup, The Production and Distribution of Knowledge in the United States (Princeton: Princeton University Press, 1962), 416 pp.; Gary S. Becker, Human Capital: A Theoretical and Empirical Analysis, With Special Reference to Education (New York: National Bureau of Economic Research, 1964), 187 pp.; and Journal of Political Economy, Supplement, Vol. LXX (October 1962). Machlup's analysis is somewhat policy oriented. Becker concentrates on the effects on earnings and rates of return from education. The JPE Supplement on "Investment in Human Beings" explores topics such as on the job training and health as an investment.

[14] For example, Denison, loc. cit.

This study offers both a new approach and interpretation to the questions of a demand for human skills and knowledge. It is not microeconomic, but macroeconomic in nature. Microeconomics deals primarily with the allocation of resources among alternative uses and with the distribution of the product. It entails the study of particular or individual firms, households, prices, wages, incomes, industries and commodities. It employs the tools of demand and supply, marginal analysis, and the theory of the individual firm and industry. In microeconomics, attention is focused on a part of the economic system. Reactions from the outside are abstracted from and are assumed negligible. A great number of variables are held constant, and only a few variables are explored at a time.

Macroeconomics, on the contrary, focuses attention on the economic system as a whole and it is the details at the individual and firm level within the system that are abstracted from or disregarded. It is the part of economics which deals with the great aggregates and averages of the system rather than with particular items within. It attempts to define these aggregates in a useful manner and to examine how they are related and determined. Macroeconomics treats heterogeneous collections of many different kinds of things as if they were homogeneous quantities of the same simple substance. Thus, in a compromise with our ability to comprehend, macroeconomic models have few variables; but they do help us to understand something about certain aspects of the economic system as a whole, such as the determination of the level of economic activity.

The essential difference between microeconomics and macroeconomics is the nature of the abstractions made in the two approaches to comprehending the complexities of reality. In other words, the difference between macroeconomics and microeconomics lies not so much in the analytical methods as in the questions to be answered. Thus, aggregation is done not for the sake of aggregation alone. Rather, such aggregation is interesting only if the aggregates can be functionally related. Moreover, because governments have to think in terms of large groups and aggregates

of individuals, macroeconomics is extremely important from the point of view of economic policy.

This discussion, however, is not intended to overstress a dichotomy between microeconomics and macroeconomics. This would be too much of an oversimplification. Rather one is faced with a spectrum along which different economic studies may be placed. The placement along this spectrum depends upon the kind of reaction from outside that is being abstracted from in different degrees. In other words, the placement depends on whether the abstraction is from variables outside the firm (micro) or from detail within the larger system (macro).

Nevertheless, the fact remains that the distinction between microeconomics and macroeconomics is still somewhat fuzzy. But what is important to recognize for the purposes of this thesis is that macroeconomics is set apart as a separate area of inquiry with its own "rules" because aggregate economic behavior does not correspond to the summation of individual activities. This reality is accepted by most economists because they recognize, for example, that a decrease in wages may allow a firm to hire more workers, but it does not follow that the economy as a whole will expand employment. Other examples are that individuals usually must pay back a debt at some future date but the community as a whole can go much longer without repaying its debt; or an individual can increase his savings by consuming less, but if the community as a whole makes such as effort the resulting decline in income may result in lower savings than before. Such seemingly paradoxical results stem from the fact that what is true for an individual is true for the economy as a whole only if other things remain equal.

Therefore, this study has been based on a macroeconomic approach. Such an approach allows one to look "down" at the parts of the economic system, and not "up at the economic system through the eyes of the individual or entrepreneur. This approach allows one to deal with an economic system that produces, distributes, and consumes wealth rather than just

a simple summation or collection of individuals. By viewing the economic system in the aggregate, one can observe the broad changes affecting a need for human skills and knowledge. Thus, it can be seen using the macro approach that an individual or firm may need more human capital and can afford it, but the economy in general may not be able to afford the more general outlay on human capital. Such an approach does not deny the fact that the individual or entrepreneur invests in human skills because of the profit motive. However, it goes beyond this and shows the broader view of an economic system that is "real" in the sense that the necessary larger, more general, community decisions are highlighted. In this situation, the effects of an individual's actions on other people cannot be ignored. As a result, one can see reasons why the economic system demands human skills in a broader context and, for example, why the capital component must come gradually to be more and more composed of human capital as an economy develops. Thus, it shows the decisions that must be made in some manner by all economies at one time or another.

Moreover, whether such an economy is "planned" or "free," or underdeveloped or developed is of little consequence in this framework. This is because the economy-wide response to education demanding stimuli such as factor imbalance tendencies must be met if growth is to be fostered no matter whether the payoff is the profit motive at the firm level in a "free" economy or the increased returns to the state in a "planned" economy. Thus, both the dichotomy between developed and underdeveloped countries, and the dichotomy between "planned" and "free" economies become largely empty shells in this framework. Therefore, a more meaningful theory is possible at the macroeconomic level because macroeconomic reasoning can take account of many limitations and relationships which are not applicable to individual parts, e.g. savings must always equal investment, etc.

A number of new perspectives on human capital were developed in formulating the background necessary for the framework and analysis

presented in this study. Much of this material was previously unessayed. Other material had not been previously applied to the concept of human capital. In addition, it is shown that it has not been an easy task for economists to develop the concepts of human capital and human capital formation to their present day levels of sophistication.

This study analyzes some of the problems that have hindered the formulation of an adequate macro explanation of the growth in demand for human skills and knowledge in the past. Some of the items discussed in this context are quite common except that they are here presented with reference to human capital. Examples of these are the discussions involving the fallacy of composition and the frequently misplaced emphasis of professional knowledge.[15] Other items offer both important insights and aid in preparing the way for the development of the theoretical framework. Examples of these are the emphasis on education as a production good and the re-emphasis of the importance of natural resources. However, the most important contribution of the introductory analysis is probably the discussion involving technology, technological change, human capital, education, and human skills and knowledge. It is shown that these are value-laden concepts having different meanings to different people depending on their backgrounds and training. As a result, many different, overlapping, and in some cases, contradictory definitions are given of these concepts. The confusion has been so bad that some people have forgotten that human skills and knowledge are what produces that which is called technology. Thus the study shows that many have been satisfied to say that human skills and knowledge are important conceptually and have stopped short of very much explanation concerning the role of human capital. Therefore, part of the purpose of this inquiry was to explain more concerning the role of human skills and knowledge — not just their importance.

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[15]The result has been that human capital and natural resources have been neglected to a large extent with the end condition being that we have an inadequate theory regarding them today.

This study investigated the dispute involving the treatment of "education" or human capital as an input in the production function. It provides a fresh look at this somewhat difficult area. The result is that because of both statistical and economic reasons gross national product (GNP) is treated as a function of the three inputs capital (C), labor (L), and natural resources (N) throughout this study. "Education" (E) is omitted as a conventional input in order to avoid a production function of the following type: GNP = f(C,L,N,E). First, such an equation can be rejected because of a conceptual problem of economics. Investment in human capital can affect and alter the nature and quality of the inputs thus increasing output. Additional "education" may affect respectively inputs L, L and C, L and N, or all of the three basic inputs at the same time. Thus, the "education" variable does not stand alone but affects the other input variables of the equation. Moreover the capital (C) and natural resource (N) inputs standing alone cannot be affected by "education," but are altered by "education" that enters through the human element or carrier labor (L). Secondly, such an equation can be rejected because of statistical reasons. Thus the equation GNP = f(C,L,N) was employed throughout the remainder of the thesis.

This study then employs a unique series of graphs in an effort to demonstrate, using the relevant production function GNP = f(C,L,N), a need for human skills and knowledge. Seven factor disproportion situations involving the basic inputs of an economy are precisely spelled out. These disproportion situations, in turn, have the potential of generating four economic forces that possibly can act in creating a demand for human skills and knowledge. The seven proportion situations are really the catalog of specifics — i.e. the specifics are merely examples. In reality, an economy responds to the tendency toward imbalances that are exhibited by its aggregate inputs. This tendency toward imbalance is related to the real world in Chapter V.

The graphical system developed in this study offers a somewhat unique or novel approach to answering questions concerning a demand for human

skills and knowledge. For example, some new techniques are employed in defining the axes, price changes are emphasized, etc. It also presents a much broader approach than either Hirschman's statement (which is based on a favorable reaction to population pressure provided that there is some slack for investment in the economy), or the Malthusian model. The series of graphs are purely a regime of "calculus" or process of reasoning which is interpreted or rendered in a growth context in order to offer some new perspective on a need for human skills and knowledge. This system shows the need for a particular economy to move to a higher more productive production function if incomes are to be above subsistence levels. It reveals how additions of more units of capital, natural resources, and labor or even population control cannot always maintain a particular economy at the necessary levels of production. Therefore, human capital is demanded in order to help the economy in question augment the productivity of its basic inputs. Often this becomes a policy question. Thus, this theoretical system also sheds considerable light on how various countries have met this problem in the past in an aggregate sense. That is, the model aids in interpreting the past by emphasizing the dynamic imbalance tendency of basic factors of any economy. The framework developed in this study offers some fresh and more lucid insights on how the skills are produced and how an economy responds, in general, when such an economy is faced with a population-factor productivity problem. However, this study does not answer the question of how new skills and knowledge are forthcoming in a given society in more of a micro sense. Indeed, sociologists, economists, and psychologists are still searching in an attempt to identify all the key forces that come into play and result in what is known as an entrepreneur, inventor, etc.

The analysis developed in this study offers several other important new perspectives on human capital. First, it provides a more lucid view of an aggregate effective demand for human skills and knowledge. It is easy to see in this setting the distinction between the need for additional

human capital and the means or ability to provide it. Also this approach shows how investment criteria become important within the context or framework of the means analysis. Thus, the evidence indicates that a joint decision becomes necessary between investing in human capital as opposed to other inputs — i.e. a balanced approach. Secondly, the exposition presented in this study has provided a basis for several well-marked inferences or implications. It provides the basis for use as a tool for comparison between countries or between a number of time periods within the same country. It provides a clear-cut ex post view of the importance of natural resources and relates all of the basic aggregate inputs of an economy more clearly with human capital. Lastly, it provides a theoretical basis on which the basic variables of an economy can be more effectively quantified and utilized in the future.

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