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ABSTRACT

To develop a theoretical framework for explaining the observed change in demand for human skill and knowledge that occurs with economic growth, a macroeconomic analysis was made of economic variables which are influenced by political, social, and cultural factors. In the three-dimensional framework, total output (Y) of all final goods and services produced in the economy during one specified time period is treated as a function of three inputs, capital (K), labor (L), and natural resources (R). Because the framework contains only four variables, an entire economy can be theoretically analyzed. Thus, to demonstrate how the need for human skill and knowledge is generated, an analysis of economic development reveals that as more complex forms of non-human capital are required, more human capital is also require . The demand for human skill and knowledge is largely a function of factor disproportions among the basic inputs, K, L, and R which generate certain basic forces. (SB)

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RESOURCE LIMITATIONS, THE DEMAND FOR EDUCATION AND ECONOMIC GROWTH—A MACROECONOMIC VIEW

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RESOURCE LIMITATIONS, THE DEMAND FOR EDUCATION
AND ECONOMIC GROWTH--A MACROECONOMIC VIEW*

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T. W. Schultz [17] has shown the increased demand for human skill and knowledge that has occurred as a result of past economic growth. Schultz [16, pp. 6-7; 17, pp. 67-68] has stated that "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." An accepted explanation of this increased demand does not exist at the present time. Therefore, the objectives of this paper are: (1) to develop a theoretical framework that helps explain the observed change in demand for human skill and knowledge that occurs with the economic growth of an economy, and (2) to examine evidence that supports the theoretical explanation developed.[1/]

Numerous research efforts, both theoretical and empirical, have examined such areas of human capital as the value and productivity of schooling. Demand for skill and knowledge has received little attention. Therefore, this report synthesizes an overview of the process whereby demand for human skill and knowledge is generated. The

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[1/] This report focuses on education demanded for production rather than for consumption purposes.

analysis is in a growth context that is macroeconomic in nature. The focus is on economic variables, but the important influence of social, political, and cultural factors on all phases of economic life is recognized.

THE THEORETICAL FRAMEWORK

When all the factors of production are completely specified, by definition, the technology is also specified. Thus, following arguments presented by Schultz [15; 18, pp. 130-144] and G. L. Johnson [9], the production function is a technical relationship; and, when education 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. Rather the product is 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 knowledge, is not a "mysterious" upward shift in the production function. Rather new technology does not enter the production function as a factor of production but instead a new conventional input or combination of inputs enters into a conventional kind of production function.

The factors of production traditionally have been classified as largely independent inputs labeled capital, labor, land, and management. However, economists as early as Marshall [12, p. 139] have shown that there are two primary factors of production, natural resources and human labor, which are combined to produce an intermediate factor of production, capital (including organization). The original capital produced, of course, can be combined with natural resources and labor to produce, in turn, still more and better capital. Natural resources are defined to include all "gifts of nature" such as arable land, forests, mineral and oil deposits, and water resources. Capital is composed of non-human, man-made aids to production and the acquired qualities of human beings. Labor refers to the physical abilities of man, including some minimal mental capacity, employed in producing goods and services. Thus in this report total output (Y) of all final goods and services produced in the economy during one specified time period, is treated as a function of three inputs, capital (K), labor (L), and natural resources (R).

(1) $Y = f(K,L,R)$

In equation (1), investment in education (E) can affect and alter the nature and quality of the inputs thus affecting output.[2/] Additional education may affect respectively inputs, L, L and K, L and R, or all of the three basic inputs at the same time. The capital (K) and natural resource (R) inputs standing alone cannot be affected by education, but are altered by education that enters through the human element or carrier labor (L). That is, education influences the nature of the conventional inputs K, L, and R, but does not enter the production function per se as a conventional factor of production. Investments in education, therefore, have a more imprecise effect on Y than simple changes in the quantity of labor, capital, or natural resources. Thus, for equation (1) the following structural set is

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[2/] This variable could also have been called human capital (H) or technology (T). These concepts are both interrelated and overlapping. The term "education" is used in a broad sense throughout this report including knowing how to produce technology, and making people more trainable and, therefore, subsequently more productive throughout life. It also can include the broad training of the masses as well as the training of a selected educational "elite."

implicit:

(1)

$$Y = f\ (K,L,R)$$
$$\left.\begin{aligned} K &= k\ (L,R,E,\ldots) \\ L &= l\ (\text{Population}, E,\ldots) \\ R &= r\ (\text{Nature}, E,\ldots) \end{aligned}\right\} \quad \text{Simultaneous Set}$$

The relevant production function equation has been specified, but a framework with which to utilize it is not present. It is now necessary to fit human capital into an aggregate framework which utilizes comparative static techniques. Production function analysis will be employed to demonstrate how the demand for human skill and knowledge is generated in an economic setting.

The analysis stresses the importance of ratios or proportions among factor inputs. Graphic techniques have been illustrated by Friedman [4] that demonstrate the importance of the factor ratio concept. These techniques are utilized to place the demand for humand capital in a more easily understood perspective. In this scheme both the absolute quantity and the ratio of factors used determines the level of output, but the factor ratio alone determines the position along the input axis.[3/] This is in contrast with the way the production function is often drawn, with the factors measured in absolute quantities on the horizontal axis.

Because the equation Y = f (K,L,R) contains only four variables, an entire economy (or sector of an economy) can be analyzed theoretically using a three-dimensional figure. Figure 1 shows Y as a

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[3/] It is especially important to note that the ratios R/L and K/L alone are not sufficient to determine output since the scale of productive activity and hence the scale of output is left in question. Thus, the absolute quantity employed of the three respective factors also is important in determining the ultimate level of output.

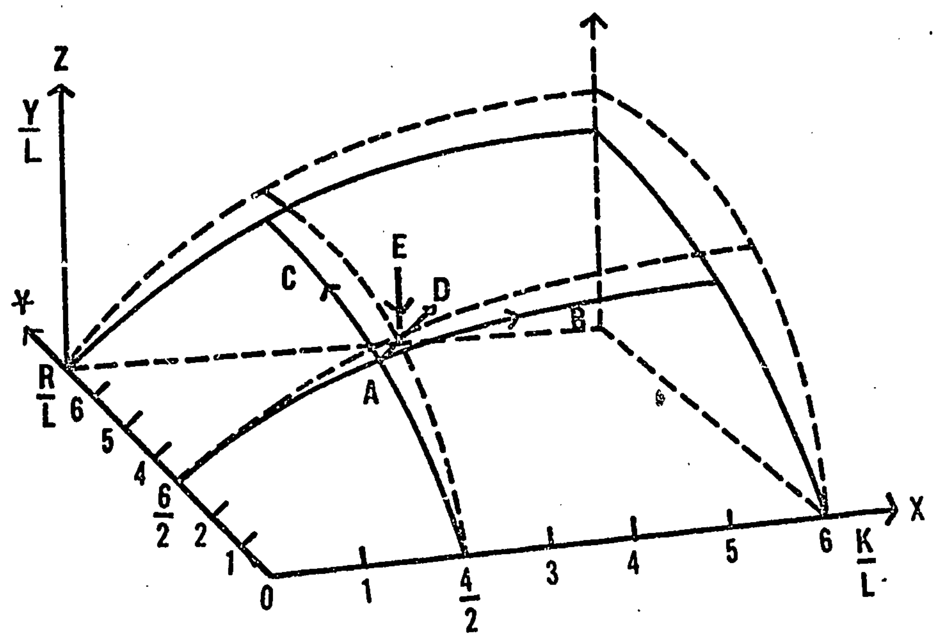

Figure 1. Three-dimensional Diagram of the Aggregate Equation Y = f (K,L,R)

function of K, L, and R 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. Output Y/L is measured on the vertical OZ axis.[4/]

We can now demonstrate in an economic framework how the need for human skill and knowledge is generated by an economy over time. Assume a closed economy represented by Figure 1. Furthermore, assume R represents the natural resource base employed by the economy, K is primarily nonhuman capital, and L represents labor with little or no real investment as yet in human capital. Technology is assumed constant and the quantities on the axes represent the amounts of factors (K,L, and R) actually employed by the economy.[5/] Relative factor prices determine factor input proportions at all times, although this is not explicitly stated throughout the analysis.

Initially also assume a primitive pastoral type of economy with only inputs R, L, and no significant K. In this stage of economic activity, the natural resource base is essentially free and production

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[4/] In Figure 1, Y increases when L increases, with R and/or K fixed, because one moves to successively higher production surfaces. However, even here it would theoretically be possible to have so much L in relation to R and/or K that total Y would decline absolutely.

[5/] This has special implications for the natural resource input, because it has been defined to include all gifts of nature. If either capital or labor become relatively more abundant, and as a result less expensive, they are employed in relatively larger quantities. Either of these two inputs theoretically 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 under-capacity (which indicates idle capital). This is 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. This treatment appears to be consistent with real world observation.

decisions are made largely on the basis of the labor input. Non-human capital is first developed to economize on labor use and investment in human capital does not return high dividends. The people are completely conventional in their economic processes; they use the same tools (K) in largely the same proportion to population, in quite the same manner through time, and their production, except for the replacement of conventional tools, is largely devoted to subsistence. Such an economy is located near the OY axis in Figure 1 and, because population (L) is relatively small with respect to the natural resource base (R), is located closer to Y than O along this axis.

Over time, as economic activity proceeds, the population (L) grows.[6/] Given the prevailing level of technology, additional natural resources are expensive to develop and they become relatively scarcer. In most cases, the net addition in natural resources discovered and employed is significant but the population increase simply outruns this addition in the absence of significant new technology. The price of natural resources increases with respect to non-human capital and labor. Moreover, additional units of the same labor and non-human capital cannot produce the needed increase in output for the economy rapidly enough. Therefore, human capital is demanded to augment factor productivity. Thus, as the economy develops, more complex forms of non-human capital continually are required and this, in

6/ Historically, 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, (R and K) 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. Moreover, this entire analysis 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 the above treatment.

turn, requires human capital. Hence, the capital component of an economy becomes more and more composed of human capital. This is supported by the experience of most developed countries today.

In terms of Figure 1, to overcome the population pressure on the natural resource base, the economy can: (1) reduce the rate of population growth (or even experience population reduction through such variables as war and emigration), (2) move out the OY axis by adding more units of the same kinds of natural resources, (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. Even when an economy expands its production by extension of existing techniques, a considerable amount of human capital of the same quality is demanded. Usually, however, both more and better human capital is demanded.[7]

Now that the argument has been briefly presented, let us view it systematically by more fully utilizing Figure 1. Assume that the economy initially has a fixed quantity of labor, stable technology, and that it is producing at point A by using 4 units of K, 2 of L, and 6 of R. Additional units of the same quality K will simply move production from point A toward point B. Similarly, additional units of the same R will move the economy along <u>the same</u> production function toward point C. Adding constant quality units of R and K simultaneously will move the economy along <u>the same</u> production surface in the direction of point D. Thus, the investment necessary to add more

[7] A conceptual distinction exists between human skill and knowledge required: (1) to create new technology, and (2) to operate the present technology, but it is difficult to apply in the real world. Usually both are involved.

units of the same kinds or types of natural resources and capital is expensive. Moving out along the same production surface does not really add to Y rapidly. In addition, there is often present the threat of population growth. If population growth occurs the result is a larger labor force and L becomes relatively cheaper vis-a-vis R and K which causes more L to become employed relative to K. As this happens, assuming that L increases, Y per capita increases very slowly or even falls. However, business cycles aside, total Y rarely declines except as a result of war. Rather Y grows so slowly or is so nearly constant that Y per capita grows slowly, remains fairly constant, or declines.

Thus, an economy faced with 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 constant population must find a solution. It will be forced to find that by investing in human skill and knowledge, better forms of non-human capital can be invented, the natural resources base can be conserved, the known natural resources can be better utilized, more natural resources discovered, and the human agent can be improved. 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 human skill and knowledge. The improved skill and knowledge results in new improved inputs that cause the production surface to "lift vertically" from points A to E in Figure 1.

In a primitive economy, the need for improved human capital is an immediate pressing issue of survival. The individuals concerned with the productive processes of the society must adapt and create new improved technology if the society is to continue. If the society cannot or will not create new or improved technology, it will stagnate or go out of existence due to the population pressure. However, it may choose to live at its "original" level and not develop new technology if it is able to control its level of population (typically a technological achievement in itself!).

In a more advanced economy, which has some level of competency on the part of the labor force, most inventions are created by the workers themselves rather than through formal research or educational processes. In such economies, the formal research and educational process is largely underdeveloped in terms of economically productive payoff, while the society concentrates on perpetuating classical formal knowledge. This could be thought of as the period just prior to the early Industrial Revolution.

As society develops the success of the innovators generates income for those who see the most need for the innovation and they seek out productive education on an informal basis either for themselves or for their children. It also suggests the success of investing in innovative activity to those who are not already participants. Thus, "neighbors" seek to acquire knowledge because it appears to help the innovator.

The transfer of technical knowledge on an informal basis is soon discovered to be a slow and difficult process. Society then presses for more formal kinds of education in order to develop and transfer productive knowledge between people. The result is a movement toward something that promises to fulfill this needed function, such as the Land-Grant College System in the United States. However, often this formal transfer of knowledge is expressed in much less dramatic form through slow changes in attitudes toward mass education for the entire population, a more practical curriculum, trade schools, etc.

In modern economies, the development and transfer of productive knowledge has taken on many complex forms. Witness the large expenditures in the United States on research and development activities. Typically, these complex productive research and education activities exist side by side in modern economies with the earlier forms of innovation. Thus, individual citizens make new inventions and patent them, as well as just seek ways "to do the same job easier." The economic rewards for such activities, of course, vary from individual to individual but are in total positive.

The discussion, so far, has focused on the market mechanism as the instrument which conveys the need for new improved education through the economy. However, the market mechanism is greatly facilitated or hindered by the particular actions, responsiveness, and even the form or organization of the government involved. Thus, the government can facilitate the market system in its functioning and let it determine the nature of the productive educational activity or interfere on the basis of non-economic criteria (e.g. in the present Mainland China atomic weapons development program).

In terms of Figure 1, the application of new improved inputs to the production process increases output per unit of input, but as measured conventionally in physical terms this is largely meaningless unless one can compare "units" of the new input with "units" of the old. The technological advance really involves a new factor or factors of production (K', L', and/or R') 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 that produces a new, higher production surface. The "new" input or inputs (K', etc.) cannot be represented on the same input axes as the "old" input or inputs (K, etc.) when the axes are rigorously defined to represent only a factor (or factors) of production of unchanging composition 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 when it is explicitly spelled out that one or more of the factors have changed in composition. 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 of technology "behind" each of them differs.

The analysis developed thus far has demonstrated only why a growing economy wants additional improved human skill and knowledge, but demand theory requires both wants and means in order to derive an effective demand. It couples the desire to buy with the ability to pay. Thus, the effective demand for human skill and knowledge depends not only on the wants of a particular country, but also on the ability to pay for the wanted skill and knowledge of this same country.[8/] Moreover, the wants and means that generate an effective demand for improved human skill and knowledge must not be thwarted by social, cultural, or political factors if economic growth is to occur. Society must be able to absorb the new ideas that economic forces are demanding and make them productive. This implies a transformation that is more than strictly economic in nature and often this has been the difficult transformation for countires to make.

Even when an economy has acquired resources in excess of the quantity required to maintain itself at an acceptable level, such stubborn problems as investment criteria and choice ot technique remain. Both of these problems have received much attention in the literature and will not be pursued to any length. There is impreciseness surrounding the entire area, with even the existence of some conflicting objectives between different criteria. Investment criteria have concentrated on non-human capital and thus -ave little to say about the allocation of funds for investment in human capital.

It has been shown that human capital is imbedded in the existing inputs K, L, and R except in the most primitive production function and that the quantity increases with the economic growth of an economy. This continual imbedding of human capital in K, L, and R causes the distinction between the basic inputs to become fuzzy. This suggests the necessity of a more balanced joint investment decision between human capital and other inputs. Yet, most investment criteria are in terms of a single scarce resource in the production function $Y = f(K,L,R)$ with no recognition of the human capital distinction.

[8/] It is not the purpose of this report to delve into the body of economic literature that indicates the considerable number of ways by which a country can obtain the means necessary in order to pay for additional human capital.

The choice of investment, therefore, must be in deciding where the biggest marginal payoff will come and then deciding whether that payoff can best be accomplished by emphasizing human capital or something else.

This brief discussion of means and investment criteria suggests how the theoretical framework relates 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.

FACTOR DISPROPORTIONS

The theoretical framework has thus far demonstrated the importance of factor ratios or proportions as the source of the economic forces which generate a demand for human skill and knowledge. Theoretically, seven possible factor disproportions may be derived by exploring all the possible proportion situations among the three basic inputs of the economy--K, L. and R. These are shown in Column I of Figure 2. The seven disproportion situations are a catalog of specifics. An economy responds to the tendency toward proportion imbalances that are exhibited in varied combinations by its aggregate inputs. It reacts by attempting to correct the imbalances that are present during a given time period by adding various mixes of the basic inputs and human capital.

Thus, the disproportion situations have the potential of generating economic forces that can act in creating a demand for human skill

(I) Disproportion Situations

(1) Population (L) abundant, R and/or K relatively scarce.

(2) Labor (L as a producing agent) shortage, R* and/or K relatively abundant.

(3) R relatively scarce, L and/or K* relatively abundant.

(4) R* in overabundance, K and/or L relatively scarce.

(5) Capital shortage, R* and/or L relatively abundant.

(6) Capital surplus, R and/or L relatively scarce.

(7) The scale problem, i.e., decreasing returns to scale as R, K, and L are expanded relatively simultaneously.

(II) Forces Generated

(1) Population pressure on the natural resource and/or capital base (L increases, R and K relatively constant). This also implies a K shortage and may or may not imply shortage of R.

(2) R depletion or shortage (even with population relatively constant).

(3) Diminishing returns to nonhuman capital (K increases, L and R relatively constant). This implies a labor shortage and may or may not imply a shortage of R.

(4) Scale--decreasing returns to scale as K, L, and R are increased nearly simultaneously.

*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.

———> Force generated by indicated situation.

– – – –> Force generated by indicated situation only if other situations also present.

Figure 2. FORCES GENERATED BY THE VARIOUS DISPROPORTION SITUATIONS

and knowledge.[9/] Because some of the disproportion situations are merely the obverse of each other, they can be combined and expressed as a single demand creating force. In addition, one disproportion situation is not relevant in the real world. Therefore, the seven disproportion situations condense into the four basic forces shown in Column II of Figure 2.

Notice, to formalize the argument, that in Figure 2 all possible factor disproportion situations are spelled out systematically and completely as derived from the theoretical framework without regard for their relevancy. Then real world considerations are taken into account in deriving the four forces shown in Figure 2. For instance, excess natural resources can be allowed to remain unemployed so one is never faced with a question of too many natural resources in relation to other inputs. Thus, natural resources cannot be in excess and create a factor disproportion situation that stimulates and creates a demand for human skill and knowledge. Hence, proportion situation (4) in Figure 2 is irrelevant in the real world and will not be discussed further. Also, natural resources cannot be overly abundant in proportion situation (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

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[9/] In the real world, precise criteria cannot be delineated which indicate the degree of factor ratio disproportionality or disequilibrium because the production surface for an economy is unknown. In other words, since one never really knows the production surface for an economy in the real world, one does not know the degree to which it is experiencing factor disproportions. But this is no different a situation than that encountered in determining whether or not an economy is, in fact, in equilibrium in any Hicksian sense.

resources are not important are indicated by asterisks in Figure 2.[10/]

A related problem is the apparent inconsistency between some proportion situations. However, because natural resources are not troublesome in large amounts, all but one apparent conflict is avoided. The one apparent inconsistency involves the capital variable in proportion situation (3). Proportion situations (3) and (5) together 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), capital cannot be abundant in situation (3). Hence, the warning asterisk appears. Only situations (1) and (3) can act together and have K be relatively abundant with respect to R in situation (3) and relatively scarce with respect to L in situation (1), i.e. K is present in an amount between the abundant L and the scarce R in this case. If only situations (1) and (5) act together, situation (3) is not relevant because it merely restates situation (1) in another manner. Therefore, if situations (1), (3), and (5) are acting simultaneously, capital cannot be abundant in situation (3).

Factor pairs that are either scarce or abundant under the proportion situations in Figure 2 are written as "and/or" cases. This

[10/] The only case in which natural resources in extreme abundance might, in a manner, help create a demand for additional human skill and knowledge would be in instances of young nations expanding along a frontier, such as earlier in the Americas or Australia. Such young countries might theoretically aspire to invest in human skill and knowledge in an attempt to improve their present inputs so as to be able to develop their natural resources more rapidly. Nevertheless, they would be aspiring and not forced. No nation is going to be overly distressed with abundant natural resources. Hence, natural resource abundant situations are lightly regarded as human skill and knowledge demand generators.

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. For example, in proportion situation (1) R may not be scarce but neutral with K being scarce vis-a-vis L. If R were to become relatively abundant, situation (1) would become situation (5).

It is now possible to outline how the various proportion situations are related to the forces that generate the demand for human skill and knowledge. Proportion situations (1), (3), and (5)--population pressure and capital scarcity--express themselves as force (1). Population pressure also often implies natural resource scarcity, but population does not have to increase for natural resources to become short in supply. Even with a relatively steady level of technology and a relatively stable population, natural resources can become relatively short in supply if depleted over time. Thus, disproportion situation (3) gives rise to force (2). In many instances disproportion situation (1) acts in conjunction with situation (3) in generating force (2); hence, the dotted arrow from (1) to (2) in Figure 2, and conversely from (3) to (1). 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.[11/] A basis has now been established to examine evidence for the theoretical framework in an orderly manner.

[11/] The scale problem derives logically from the analysis although it is not strictly a question of factor proportion. It goes beyond the ratio problem and examines product response to nearly simultaneous factor quantity changes.

SOME EVIDENCE

To be more systematic, the discussion will be based on a pattern suggested by the catalog of specifics, and the topics will follow the disproportion column of Figure 2 in scope. But the order of discussion will be patterned after the forces generated column of the same figure. Even though the discussion follows the pattern implied by the proportion situations and the forces they generate, the imbalance tendency and the efforts to correct it are the important considerations --not the catalog of specifics.

Population and Natural Resources

According to the theoretical framework: (1) population pressure on the natural resource and/or capital base, 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 helping create a demand for additional and improved human skill and knowledge. Thus, the focus in this section will be on proportion situation (1) and (3) and forces (1) and (2) in Figure 2. The emphasis will be on population as a consuming agent. L as a producing agent will be discussed in conjunction with capital, when proportion situation (5) is considered in a later section.

Population Pressure - The world has seen thousand of years of slow population growth followed in the late 1600's by a population explosion that has continued to the present. There are many explanations of the sustained rise in world population, that began in Europe in the seventeenth century. Habakkuk [6] even goes so far as to call it fortuitous. However, what is important is that this increase created population pressure, which still is present in much of the world.

This population pressure has both stimulated and retarded economic growth. Often the retardant aspects are over-emphasized. Economists, such as Hirschman [8] and Habakkuk [6] have shown that even though population pressures are sometimes a clumsy and cruel stimulant to development, they are an inducement mechanism in the sense that the developmental forces of society are given an opportunity to act. Thus, population pressures on living standards lead to activities designed to restore the level of living, and these activities, in turn, cause the society to better control and organize its environment for development. Hirschman believes that there are circumstances when these pressures are unsuccessful just as relative price increases are sometimes ineffective in increasing supply. He states [8, p. 181] that this over-all view "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." Hicks [7, Ch. 24] once wrote "that perhaps the whole Industrial Revolution of the last two hundred years has been nothing but a vast secular boom, largely induced by the unparalleled rise in population." One should not draw the conclusion from these remarks, however, that rapid population increases are good and should be advocated. Even for Hirschman, reducing the rate of population growth is almost without exception the desired policy.

Therefore, population pressure upon the natural resource and capital base has and is being evidenced in the real world, and the evidence strongly indicates that this has been and is one of the forces operating to bring forth additional human skill and knowledge, which in turn leads to economic development and growth.

Natural Resource Depletion and Shortage - This is in many ways the obverse of the population pressure situation. It is considered separately because it is argued that, if given a long period at one level of technology, an economy will eventually face natural resource depletion and shortage even if the economy in question has a relatively stable population. Hence, rapid population growth is not necessary to bring about a shortage of natural resources, though it is usually a contributing factor.

Optimistic and pessimistic views can be found among professionals concerning the future role of natural resources. The pessimistic view is based on the Malthusian-Ricardian scarcity doctrines where natural resources, being non-reproducible have a finite supply. This view leads obviously to questions about the stock of natural resources and its limitations on economic growth. Many studies have attempted to validate the pessimistic views by arguing that a large part of the population of the world is already undernourished while large segments of the world's resources are overworked or even near depletion agriculturally.

The optimistic view is based on realized advances and expected future progress involving human skill and knowledge. This concept of resources is a dynamic view that technological improvements can expand or maintain the resource base in the face of an incipient shortage or depletion of resources. This argument has been well presented by Raup [4] and Georgescu-Roegen [5, pp. 96-97]. Empirical validation 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. The evidence supplied by the experience of the developed countries indicate that the quality of natural resources has been manipulated to bring about effective substitutes for natural resources. Empirically, this reasoning also is supported by the huge effort that man has put into developing effective resource substitutes in the past several centuries. This research investment burden could have been lessened significantly by an abundant supply of natural resources; but population pressure would have been more severe without this human skill development. Thus, the Malthusian-Ricardian scarcity doctrines have not been denied--they simply have not been allowed to operate.

Recently, many economists in developed areas have lessened their regard for natural resources, but it is interesting to note that a qualifying statement almost invariably accompanies analyses which express this view. Denison [3, p. 93] is typical when he qualifies his remarks by stating that natural resources will not be a problem for the United States in the foreseeable future "if we can assume that technological progress . . . continues at a reasonable pace." (Emphasis added.) Investment in human capital has improved technology so much that natural resources appear to be less important because they come to comprise a continually smaller share of national income. Such analyses have concentrated on the effects of technological advance and not on its causes. Thus, there is an important relationship between natural resources and human skill and knowledge. Moreover, the evidence is that a depletion or shortage of natural resources over time generates a need for human skill and knowledge.

Labor and Capital

The theoretical framework indicates that either: (1) a capital shortage with R and/or L relatively abundant, or (2) a capital surplus with R and/or L relatively scarce both help to generate a demand for additional and improved human skill and knowledge. Thus, the focus will be on situations (2), (5), and (6) and forces (1) and (3) in Figure 2. First, the manner in which proportion situation (5), capital shortage, operates through force (1) will be examined. Next, proportion situations (2) and (6), abundant capital and scarce labor, and their generation of force (3) will be studies. In this section, the emphasis shifts to the study of population as primarily a producing agent.

Labor Surplus and Capital Shortage - Historically, 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. Thus, relatively more labor has become employed. The empirical evidence that abundant population and cheap labor most often has been the case, especially in technologically lagging areas, has greatly influenced economic thinking. The theories of Malthus and Ricardo reflect the belief in an abundant, cheap, and growing labor supply. More recently the idea that labor was relatively abundant, or even redundant, in large areas of the world is reflected by Lewis [11], and Ranis and Fei [13].

The counterpart of surplus labor is capital shortage. In many ways capital shortages have been more evident than labor surpluses. Non-human capital has been relatively scarce and has been required just to keep pace with the growth in population in many countries.

Just as in the case of labor surpluses, the empirical evidence concerning capital shortages has affected economic thinking. To the classical writers, the fundamental feature of economic development was capital formation. That this thinking has come down to the present day largely intact is shown by models, such as the Harrod-Domar, which assign a crucial role in the process of growth to capital accumulation. Moreover, there are numerous empirical studies which substantiate the importance with which economists hold non-human capital, and show that the historical trend of capital formation has been upward in all developed economies.

These studies have recently helped economists to realize more fully just how intertwined human knowledge and non-human capital really are. This has been brilliantly stated by Boulding [1, 2] on several occasions. He has said [2, p. 1] that "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." Thus, labor surplus and capital shortages lead to a demand for new and additional human skill and knowledge.

Capital Surplus and Labor Shortages - Historically this situation has not been too prevalent, because capital is expensive and the population must sacrifice to acquire it in significant amounts. Hence, economies could not afford the luxury of accumulating non-human capital until it became overly abundant. Therefore, when the abundant capital-scarce labor situation has developed, it almost invariably has resulted from a sudden reduction in the size of the labor force and not from 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 of Europe in the fourteenth century. During our own Civil War, labor shortages in agriculture in the North led to a more rapid adoption of the reaper. Modern economic growth has sometimes caused factor shifts between sectors that have in some cases resulted in an abundant capital-scarce labor situation in certain sectors. During the nineteenth century, the demand for industrial manpower in several European countries reduced the absolute numbers of laborers in agriculture.

Various countries, such as France and the United States, at one time or another were thought to suffer from a labor shortage and too slow a rate of population growth. 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 resouces in this paper and not with respect to capital.

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. Usually the more expensive route of improving human skill and knowledge is 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 usually will require considerable, additional human skill and knowledge.

In conclusion, the evidence indicates the proportion situation of abundant capital and scarce labor has sometimes induced a demand for additional improved human skill and knowledge. Nevertheless, this force is much less important than either population pressure or natural resource depletion in this report.

The Question of Scale

Scale does not involve disproportion situations among factors, but 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: "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 average quality of the factors, the percentage distribution 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.

Thus, in the theoretical framework it is hypothesized that decreasing returns to scale in total national product as the inputs K, L, and R are expanded nearly simultaneously are a force in creating a demand for new and additional human skill and knowledge. This demand for additional, mostly improved, human skill and knowledge that is induced by decreasing returns to scale goes beyond the question of an increased demand for largely the same level of human skill and knowledge, which arises out of a simple nonscalar or disproportionate expansion of the economy. Simple, nonscalar expansions of an economy almost always require larger amounts of human skill and knowledge, but not always larger amounts at a higher level of sophistication.

Various studies of economies of scale have been made. They have suffered immensely from conceptual problems and have been unable to isolate the scale factor from differences in technology or in the quality of inputs. At other times all that has really been measured are monopoly returns or short run disequilibria. Denison [3] 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 [3, p. 173] with respect to the United States 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." Upchurch [19] casts doubt on past economies of scale research concerning the United States agricultural sector and indicated that there is little precise knowledge on this subject. These problems are generally more acute in other countries.

The result has been that anyone researching this area has been faced with an extreme scarcity of reliable empirical evidence. Denison states [3, p. 174], "we are forced to fall back upon a priori reasoning and 'expert opinion'." Nevertheless, Denison's empirical work on the United States economy rules out the likelihood of decreasing returns to scale. 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 ten percent. In his work, Kuznets [10] also suggests that economies experience increasing returns to scale with growth in size.

Thus, based on the sketchy empirical evidence which economists possess one must conclude that economies generally experience increasing returns as they expand in size. As a result, decreasing returns to scale as the basic inputs K, L, and R are expanded relatively simultaneously, is to be ruled out as a factor which significantly helps generate a demand for human skill and knowledge. This tentative conclusion is suggested while recognizing the theoretical and empirical confusion with respect to economies of scale and other evidence which indicates that a considerable amount of additional human skill is required in order to facilitate organizational changes as an economy expands in scale.

CONCLUSIONS

The conclusions are that a demand for human skill and knowledge for economically productive purposes in a macroeconomic setting is largely a function of factor disproportions which generate certain basic forces.

(1) The first force is created by population pressure upon the natural resources and/or capital base (L increases, R and K are relatively constant). This is also the condition of a relative surplus of labor and shortage of capital, i.e. a small capital/labor ratio.

(2) A depletion in either 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 (K increases, L and R are relatively constant).

The forces are listed in a decreasing order of importance. Diseconomies of scale, a fourth force derived in the theoretical framework, is rejected on the basis of available evidence as a factor which can significantly help generate a demand for human skill and knowledge. This is the case of decreasing returns as the basic inputs K, L, and R are increased by the economy nearly simultaneously.

These forces deal with economic wants or needs. Therefore, whether they alone can always cause additional human skill and knowledge to be forthcoming is another matter. The means for purchasing or accumulating additional human capital must be available. Moreover, there are some economic forces operating on the microeconomic end of the scale which have not been considered. In addition, social, political, and cultural factors are recognized to influence all phases of economic life.

Thus, if the means exist and socio-cultural factors do not interfere, the forces generated by the various factor disproportions are sufficient but not necessary conditions in creating a change in demand for human skill 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 to build pyramids, or knowledge may be needed to satisfy a faddish demand of an advanced society for certain plastic toys. However, this circumventing demand is largely for consumption and not for productive purposes. Moreover, no matter how important social and cultural factors may be they largely have resisted systematic and quantitative investigation.

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