THE ECONOMIC FEASIBILITY OF EMPLOYING USED MACHINERY IN LESS DEVELOPED COUNTRIES

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W. Paul Strassmann

Major professor

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Dilmus Delano James

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ABSTRACT

THE ECONOMIC FEASIBILITY OF EMPLOYING USED MACHINERY
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Since the late 1950's economists and various economic organizations have displayed interest in the feasibility of employing used machinery (UM) in less developed countries (LDC's). The advantage of UM that has been stressed is that of lower capital costs; the disadvantages stressed are those of increased maintenance costs, higher wages and decreased managerial efficiency.

Following this tradition, the costs of yarn production in the Latin American textile industry were compared. Costs associated with new equipment of 1950, 1960 and 1965 technological vintages were obtained from an Economic Commission for Latin America study. UM production costs were then derived by assuming a range of lower acquisition costs for equipment and a range of higher variable maintenance costs. The former was a proxy for the net impact of all forces affecting capital costs; the latter a proxy for the net impact of all forces affecting operating costs. The results indicated that only in rare instances could UM be purchased inexpensively enough to warrant its use.

This conclusion, however, was not compatible with the actual volume of UM imported by LDC's. By extrapolating the available data on United States exports of UM to LDC's, it was estimated that at least 10 per cent of LDCs' investment in industrial equipment takes the form of imported UM. In order to explain such a volume of demand it was necessary to identify a variety of unusual conditions that makes UM especially appealing. Each of these special situations is present in a minority of cases, yet, taken collectively, they are important.

The transfer of UM to LDC's takes place without recognizing several social benefits that obtain from its use. An increase in the employment of UM by LDC's would:

1. Improve static efficiency. A modification of the original comparison of costs, by using hypothetical shadow prices for labor and capital, suggested that these benefits would be especially pronounced if choosing production techniques were based on social opportunity costs of resources rather than market prices.

2. Increase employment due to (a) a higher labor-capital ratio associated with earlier technological vintages, (b) an ability to buy more equipment for a given budget and (c) an added incentive to spend more on maintenance.

3. Save foreign exchange for a variety of reasons.

4. Increase learning by labor, particularly with respect to maintenance and repair activities.

5. Increase the number of entrepreneurs. While it is true that producing with UM will absorb more entrepreneurial

effort than producing with new equipment, a case study of Papelera de Chihuahua, S.A., indicated that there is no a priori reason to suppose this effort is misallocated.

It was found that a substantial increase in purchases of UM by LDC's could be accomplished with no significant increase in its long-run price since (a) the LDC-UM market is a small fraction of total UM sales in developing countries, (b) new machinery is a close substitute for UM, (c) any rise in price would induce earlier scrapping by original users and (d) the LDC-UM market would be subject to powerful economies of scale.

Far from taking these social benefits into account, the institutions of the LDC-UM market tend to discourage its use. Poor communications and the marginal nature of UM sales to LDC's lead to market inefficiency. Prevailing market prices for resources, customs regulations or practices, as well as labor and tax legislation in LDC's favor a high capital-labor ratio. The attitudes of technical advisors, management, government development corporations, foreign aid agencies of developed countries, international lending agencies and, most important, government officials of LDC's tend to be biased against the employment of UM.

The final conclusion of the study holds that the economic welfare of LDC's can be enhanced by the judicious employment of more UM. Toward this end it was recommended that (1) governments subsidize the development of a workable classification and grading system for UM and extend data coverage to include trade in UM, (2) propagandization of the benefits of UM be aimed at reducing political biases against UM and (3) government and/or industry regulation be developed to eliminate the most flagrant inefficiencies of the LDC-UM market.

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PART I

CHAPTER I

INTRODUCTION

Used Machinery and Less Developed Countries: A Hypothesis

Hoping to dissuade me from this project, an engineer once asserted that "Used machinery is sold for a reason, usually for a good reason." My rejoinder was constructed along a premise that when used machinery (UM hereafter) is sold, someone or some organization is the buyer, and there is every reason to suppose that the purchasers are guided by what are, to them, "good reasons." In short, a market for UM exists. The technology, economics and institutions surrounding this market and the relationship of the UM market to the economic welfare of less developed countries (LDC's hereafter) is the subject of this dissertation.

The hypothesis of the study is that LDC's make less than optimal use of UM. Optimality is assessed in terms of the achievement of three alternative goals of LDC's: (a) maximization of current output, (b) maximization of the rate of growth in output and (c) the minimization of unemployment.

UM does not represent a panacea for the LDC's. The complementary and infectious forces of modernization cannot be generated by massive infusions of UM. Employing UM is likely to be held to a marginal role for a variety of reasons. Some newly introduced products will be associated with equipment of such recent technological vintage that no used counterpart exists on the market. Rigorous product specifications may be beyond the capabilities of UM. Economies of scale of new equipment often predominate over the advantages of UM. Increases in operating costs of producing with UM will sometimes swamp any saving in fixed capital costs. Transportation costs on imported UM may erase any advantage over locally produced machinery. The list could be extended, but these examples suffice to indicate that the proper role of UM may be a marginal one. The emphasis should be placed on selectivity and gap-filling which will contribute to modernization.

The transfer of UM from industrial nations to LDC's has drawn the attention of both academic scholars and development agencies for some time. The bulk of the published material and most agency programs were concentrated in the late 1950's and lasted through the mid 1960's. In 1958 the first comprehensive study of the subject was made by the Netherlands Economic Institute.[1] My interest in UM was first stimulated by a brief advocacy in Andrew Schonfield's The Attack on World Poverty.[2] Studies were produced by the

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[1]Netherlands Economic Institute, Second-Hand Machines and Economic Development (Rotterdam: May, 1958), Publication No. 15/58.

[2]Andrew Schonfield, The Attack on World Poverty Vintage Books (New York: Random House, Inc., 1962), pp. 177-80.

Rand Corporation in April, 1961[3] and Albert Waterson of the International Bank for Reconstruction and Development in 1962;[4] a sophisticated analysis appeared in the Review of Economics and Statistics in August, 1962.[5] In November, 1965, the Ralph M. Parsons Company study undertaken for the Agency for International Development (AID) became available,[6] and in December of the same year a group of experts deliberated on the advantages and disadvantages of UM.[7] As for activities by various agencies, in the early 1960's an Industrial Coordination Bureau was established in Stockholm for the express purpose of facilitating the flow of UM from industrial nations to LDC's. AID also established a program which

[3]Frederick T. Moore, Economic Growth and Foreign Aid: A Proposal Concerning the Export of Industrial Plant, P-2288 (Santa Monica, California: The Rand Corporation, April 20, 1961).

[4]An earlier version of Mr. Waterson's view appeared in the Technical Digest Service, Vol. I, No. 6, July, 1961, published by the U.S. Department of Commerce for the International Cooperation Administration. I have not seen this article, but an unpublished revision, "The Use of Second-Hand Machinery in Developing Economies," Oct. 4, 1962, was made available by the International Bank for Reconstruction and Development. An abbreviated version can be found in "Good Enough for Developing Countries," Finance and Development, September, 1964, pp. 89-96.

[5]A. K. Sen, "On the Usefulness of Used Machines," Review of Economics and Statistics, August, 1962, pp. 346-48.

[6]Used Equipment Study, Job No. RMP 3677-1, Contract No. AID/csd-1060.

[7]United Nations, Centre for Industrial Development, Report of Expert Group on Second-Hand Equipment for Developing Countries, December 7-22, 1965 (New York: United Nations, 1966).

permits the inclusion of UM in its activities.

Since 1965, however, general interest in UM as related to economic development of LDC's seems to have declined. The Industrial Coordination Bureau has virtually ceased its UM operations.[8] AID has recently tightened its restrictions[9] and the UN study by its group of experts was received unenthusiastically enough to discourage the UM activities of the UN Industrial Development Organization.[10]

Despite the relative lack of excitement about UM, LDC's do use it. Personal observation confirms that it is used throughout Central and Northern Mexico. The Machine Dealers National Association, a trade organization

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[8] In a letter of May 11, 1967, Mr. Hans Langenskiöld, Director, Industrial Coordination Bureau, wrote: "I regret to have to inform you that our organization has practically stopped its activities related to the sale of used machinery to the developing countries. The major reason therefore is the outcome of a report prepared by an experts group of the United Nations in December, 1965, regarding the usage of secondhand machinery in the industrial development of Asia, Africa, and Latin America that met with little or no response from the actual receivers of the assistance themselves."

[9] Julius Kaplan, "A.I.D. and the Used-Equipment Syndrome," Worldwide Projects and Installations (May/June, 1968), pp. 48-50, 52 and 54-55. Mr. Kaplan interprets the Small Business Memo of December 12, 1967, authorizing AID to stipulate and control the inspector and inspection of UM as indicating that ". . . A.I.D. is more reluctant than ever to associate its funds with used equipment." (P. 48.)

[10] Letter, May 16, 1967, from Mr. I. D. Radović, then Industrial Development Officer, Technological Division, United Nations Industrial Development Organization. Mr. Radović wrote: "I am sorry to inform you that the interest expressed by United Nations member-nations has not warranted the continuation of our project on used equipment in developing areas and that, therefore, it is not included in our current work programme."

of used metal working machine dealers, estimates the UM exports from the United States approximate 5 per cent of the total United States UM sales.[11] Roughly 2 1/2 per cent of United States sales, or one-half of United States exports of UM, are destined for LDC's.[12] As indicated above in the statement of the hypothesis, the contention is that the employment of a greater amount of UM by LDC's would be to their advantage. As will be demonstrated, a constellation of institutional forces in the UM market biases the choice of technique in favor of new machinery. All of these market frictions are by no means unfavorable to UM, but the anti-UM distortions predominate.

Choice of Technique Within the Scheme of Resource Allocation

Investment vs. Consumption

At the aggregate level, traditional economics has placed greatest stress on the division of resources between producing consumption goods and services which increase current enjoyment and the production of capital goods capable of expanding future output. Naturally, the shortcomings of this Euclidean distinction has long been appreciated.[13] Consumption expenditures on better diets, for instance, can contribute to current and future output. Despite

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[11] MDNA News Release, April 3, 1967, quoting Mr. Richard L. Studley, Executive Director.

[12] Empirical data on the UM market is presented at length in Chapter IV below.

[13] See, for instance, J. M. Clark, "Soundings in Non-Euclidean Economics," AER, Suppl. March, 1921, pp. 132-43.

this and similar conceptual difficulties, the traditional emphasis on savings and investment continues to draw sustenance from the close correlation between rates of capital accumulation and growth in total output.[14]

Emphasis by Sector

If the economy is disaggregated into large sectors, another level of generalization can be distinguished. The emphasis may be centered, for instance, on resource allocation between infrastructure and directly productive capital,[15] or between agricultural and industrial production,[16] or among

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[14]For an impressive scatter pattern presentation of this relationship see Charles P. Kindleberger, Economic Development, 2nd ed. (New York: McGraw-Hill Book Co., 1965), p.98.

[15]A good concise analytical framework with which this allocation problem can be viewed is contained in Kindleberger, op. cit., pp. 195-98. Appearing on page 196 is an illustration of expansion paths of output when social overhead is considered a substitute for directly productive activities and when the two types of capital are complements. Verbally he describes a special case suggested by Hirschman whereby extreme ratios of either DPA or SOC to one another will be self-correcting.

[16]The controversy over the relative emphasis that should be placed on industry vis-à-vis agriculture has come to be closely associated with the name of Dr. Raul Prebisch (pro-industrialization) and his followers. Probably the best source of Prebisch's views remains his "Commercial Policy in the Underdeveloped Countries," AER, May, 1959, pp. 251-73. For an (on balance) pro-agricultural view see Chapter 7, Stephen Enke, Economics for Development (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963).

A good presentation of the issues of the controversy is in Part 5, Gerald M. Meier (ed.), Leading Issues in Development Economics (New York: Oxford University Press, 1964), pp. 250-65.

small, medium and heavy industry. Resource allocation at the sector level involves various strategies of development, namely, balanced growth, unbalanced growth with lead sectors, and planned disequilibria.[17]

Allocation by Project

A third fairly distinct stratum of allocation problems can be distinguished at the "project" level, meaning an investment encompassing more than an individual plant facility but too small to constitute a sector. These units may be industries or some set of productive activities closely bound together by complementarities in production or demand. The process of ranking this array of investment projects and selecting those to be undertaken according to a criterion or some mix of criteria, is the level at which most planning effort in LDC's is aimed. Literature dealing with this level of allocation is usually lumped under the general heading of "investment criteria," and the emphasis at this level is on what specific products are to be produced.

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[17] A useful concise resume of the literature can be found in Chapter 15, Benjamin Higgins, Economic Development: Problems, Principles, and Policies, revised edition (New York: Norton & Co., Inc., 1968). For the balanced growth view, see Hans W. Singer, "The Concept of Balanced Growth in Economic Development," in Eastin Nelson, ed., Economic Growth: Rationale, Problems, Cases (Austin, Texas: University of Texas Press, 1960), pp. 71-86. The seminal writer on unbalanced growth is P. N. Rosenstein-Rodan. See especially his "Notes on the Theory of the 'Big Push'" in Howard S. Ellis and Henry C. Wallich, eds., Economic Development for Latin America (New York: St. Martin's Press, Inc., 1961), pp. 57-81. The planned disequilibrium approach is set forth in Albert Hirschman, The Strategy of Economic Growth (New Haven: Yale University Press, 1958).

Choice of Technique and
Definitional Difficulties

After determining the total resources available for capital formation and establishing the sector and project priorities, the question remains as to how to produce the output. This is the choice of technique problem. We are, however, confronted with three definitional difficulties; fortunately, none is fatal.

1. The Treatment of Scale

The first comes to light in Chenery's assertion that, "The choice of techniques can be considered as a choice among projects producing the same output from different input combinations."[18] (Emphasis supplied.) He fails to indicate whether choice of technique comes into play when production is held constant for the industry, individual plant or both. Since the scale of output is one of the most important determinants in choosing the appropriate technology for a plant facility, this study will assume that the choosing of technique proceeds with industry output determined, but with the determination of plant size as an integral part of the problem.[19]

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[18] Hollis B. Chenery, "Comparative Advantage and Growth Policy," in Surveys of Economic Theory, II (New York: St. Martin's Press, 1967), 132.

[19] Only in the special case of a single plant producing all of a product would the two coincide.

2. Interdependencies

A second definitional difficulty, an unavoidable one, is that levels of allocational decisions are not entirely independent. For example, a change in technique of production could alter the pattern of investment sufficiently to "select out" some investment projects and cause others to become feasible, a change in any of the sector priorities would likely cause repercussions on the amount of savings, and so on. Fortunately these interdependencies are likely to have marginal consequences as long as the same set of normative goals is retained. This study, an exercise in one specific aspect of choice of technique, will focus on the elements influencing the private entrepreneur's selection of a technology under conditions whereby the broad patterns of capital formation, the types of goods, and the amounts of individual goods produced are given. In order to avoid a serious fallacy of composition, however, the macro-effects of shifts in the general pattern of technique will be analyzed with regard to its effect on current output, growth and employment absorption.

3. Dimensions of Changes in Techniques

A third difficulty lies in the danger of confusing several types of technological change and the results of these changes. Changes in technique can arise from the substitution of homogeneous inputs without a fundamental change in technology.[20] Such changes may, on the other hand, arise from the substitution of nonhomogeneous inputs whose availability resulted from technological change. The cumulative results of technological change give rise to technological prototypes associated with various time periods and eventually very broad differences in the character of the productive technique. Each of these aspects is discussed below:

a. Substituting homogeneous inputs. Production methodology may change by substituting homogeneous inputs of one factor for homogeneous inputs of another factor, while output remains constant. This, of course, is the well known textbook example of sliding along a given isoquant and offers very little analytical difficulty. A second possibility would have the amounts of each homogeneous input changed, thus resulting in a change in output. The economist visualizes this as a shift to another isoquant occupying a different position. Both substitution and scale effects can be present. If all inputs are increased proportionately, the scale effects can be isolated. If isoquants showing equal increments of output are equidistant from each other, constant returns to scale prevail. If at higher outputs the isoquants become increasingly close, increasing returns to scale prevail; if they become increasingly distant, the isoquants depict decreasing returns to scale.

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[20]Edward Mansfield, The Economics of Technological Change (New York: W. W. Norton & Company, Inc., 1968), defines technological change as "the advance in knowledge relative to the industrial arts." P. 3.

b. Substituting nonhomogeneous inputs. A complication arises, of course, when we drop the stipulated homogeneity for inputs and allow qualitative changes. Not only does one encounter the problem of girations in the isoquants, which can be handled with expansion paths if the relevant input prices are known, but the labels on the axes in a two-factor model would be continually changing through time.

These alterations can be due to a host of changes which are gradually introduced. Each one in isolation is likely to be so inconspicuous that a casual observer is apt to be unaware of a change. At the other extreme, the identity of a different productive system may be at once obvious to even a casual observer. When new technology is transmitted in the form of new capital equipment,[21] it is generally referred to as an "embodied" technological change; when new knowledge is introduced to improve existing facilities, "disembodied" technology is the term enjoying current vogue. A useful rule of thumb distinction might be that after installing new equipment, potential benefits of embodied technology cannot be altered; any subsequent improvement in technique after installation is due to disembodied technological change.[22]

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[21] Of course, the concepts of "embodied" or "disembodied" could be applied to human agents as well, but the jargon has not caught hold.

[22] See, for instance, Robert M. Solow, Capital Theory and the Rate of Return (Chicago: Rand McNally & Company, 1965), pp. 41-43.

c. Technological vintages. Through time one can picture a continuous flow of new knowledge that is being applied in an embodied or disembodied form. One may, then speak in terms of "vintages" of technology in this respect. In some cases the chronology of the technological change in an industry may correspond to certain "vintage prototypes" which will be distinct enough to a moderately enlightened layman.[23]

d. Broad classifications of factory technology. Finally, there are classifications of productive techniques that are much broader and distinctions are clear except in borderline situations. Nonfactory production is defined later in this chapter, but we may distinguish three levels of factory techniques: (a) unit and small batch production, (b) large batch and mass production and (c) process manufacturing.[24]

e. A summary of the dimensions of changes in techniques. A change in technique can be due to a change in factor proportions which is indicated by (1) a movement along the same isoquant or (2) a movement to a different

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[23] An example of vintage prototypes can be found in the levels of technology producing cotton textiles in Latin America corresponding to the "vintage" years of 1950, 1960 and 1965. United Nations, Economic Commission for Latin America, E/CN 12/746, Choice of Techniques in the Latin American Textile Industry, p. 3. Much of the analysis below relies on the data in this study.

[24] I am following Robert Averitt, The Dual Economy (New York: W. W. Norton & Company, Inc., 1968). Unit and small batch production is the earliest type of manufacturing technique and prevails where markets are limited. It is predominantly craft oriented and production is geared to orders received. Planning is characteristically very short term

isoquant with a concomitant change in the mix of factors used. It can also take the form of a change in technology. A worthwhile technological innovation will shift some portion (or all) of an isoquant closer to the origin. The qualitative changes in the inputs can be gradual, cataclysmic, or somewhere in between; changes can be thought of as "delivered" with the equipment as in the embodied type, or affected after installation as in the case of disembodied change. With the progression of time new technological vintages are continually produced. When the cumulative change permits a useful taxonomical division one may speak of "vintage prototypes." In an even broader classification, one can speak of "levels" of productive techniques, e.g., nonfactory, small batch, large batch and mass-production and process manufacturing.

Design Economics

Finally, it may be profitable to distinguish a fifth level of resource allocation which is even more specific than choice of technique, namely, "design economics."[25] Design

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(pp. 24-25).

With large batch and mass production, the product is standardized, management is formal and elaborate and planning is relatively long-term.

As for process production, it "represents the newest and most technically advanced stage." (P. 29.) "Any manufacturing procedure which can be converted to continuous material flow is a candidate for process production." (P. 27.) This level of technology is associated with full automation, servomechanics and cybernetics.

[25]I first encountered this term in S. K. Bhattacharyya, Capital Longevity and Economic Growth (Calcutta: Bookland

economics, as used here, deals with the minutia of technique. One might almost say that it deals with choice of technique at the intra-plant margin. After the decision is made, for example, to produce textiles by using an automatic loom with a pirn changing system, decisions must be made regarding the exact design of the equipment, its precise location in the plant, the precise space and heat requirements, etc.

The Problem of Choosing Techniques in LDC's

In view of the foregoing delineation of the various levels of generalizing about resource allocation that can be profitably identified, it is clear that the decision to employ UM or new machinery is essentially a matter of choice of technique. This raises a question as to why the problem needs any special treatment at all. Why should the analytical apparatus surrounding choice of technique which evidently suffices for mature industrial countries, be supplemented? The very fact that the subject of choice of technique receives a rather cavalier treatment in the typical economics textbook attests to its general acceptance. The same can be said of the non-proliferation of provocative literature on choice of technique in mature industrial countries. Since such a body of

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Private, Ltd., 1965), p. 1, 93 and Appendix II. Bhattacharyya does not explicitly define design economics, although from context it appears that his meaning is compatible with mine.

Many of the articles in the United Nations' Bulletin on Industrialization and Productivity series deal with design economics topics and it is one of the chief concerns of the British based Intermediate Technology Development Group, Ltd., 9 King Street, Covent Garden, London, WC 2, England.

literature directed at LDC's does exist, one harbors suspicions that the choice of technique decision in these countries must be of a greater order of difficulty. Specifically, there are four differences which deserve emphasis. Each of these is discussed below:

1. <u>The Locus of Technological Change</u>

Most new technology is generated in mature industrial economies. Prevailing factor prices can affect the flow of innovations during early stages of developmental research. At the moment a feasible principle appears, there may be, say, five or six possible paths to follow, or at a later stage there may be twenty specific designs that appear technically feasible. In ordinary circumstances some of these possibilities will be eliminated and some pursued. Salter describes this process as follows:

> The difficulty is that costs impinge upon this process at two points. First, a choice must be made as to which of the countless methods that are technically feasible in principle are sufficiently commercially promising to be worth developing in detail. No engineer goes to the trouble and expense of developing techniques which he is certain will prove uneconomic. The difficulty is that even at this early stage costs, and through them factor prices, intrude to some extent. A method, rejected for detailed development on the grounds that it is commercially impracticable, may have been regarded as promising if factor prices were different. For example, oil-fired locomotives were probably technically feasible fifty years ago but would not have been considered worth developing in view of the relative prices of oil and coal then prevailing. Secondly, in even the simplest designing process there are numerous alternatives which must be decided on the basis of cost: whether a machine should be powered by electricity or diesel power, whether control should be automatic or manual, whether bearings should be of bronze or steel, or whether the flow of materials should be mechanized or not. These, and

> countless other every-day decisions of engineers, are essentially cost decisions within the framework of technical restraints; they are quasi-economic decisions which precede choice by businessmen.
>
> In addition, the range of techniques available to the individual businessman is very often limited by the range of equipment produced by machine-manufacturers. The interests of such manufacturers lie in producing equipment which meets the needs of their market, that is, equipment which embodies minimum cost techniques. Again, costs and factor prices influence the range of equipment to be designed and marketed, so that the form of equipment actually available implies a substantial degree of preselection on the basis of cost.[26]

This places the entrepreneur of a mature industrial economy at a decided advantage. There is a far greater chance that the latest vintages of technology will be more efficient because the very economic environment in which he operates has conditioned the path of technological development.[27] Such an entrepreneur can usually be safe in confining his choice to equipment which is close to the technological frontier. Robert Sadove, an economist and engineer from

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[26] W. E. G. Salter, Productivity and Technical Change (London: Cambridge University Press, 1966), pp. 14-15.

[27] This point is important enough to deserve elaboration. That most new technology is generated in the mature industrial countries no one would deny. That there are market influences on the stream of new technology is not in doubt, either, but the degree of influence of the market is contested. Most economists seem to believe that the market exercises a very strong influence on the flow of technology. Perhaps the following statement would be a fair appraisal of the position of the bulk of economists:

"The fundamental conclusion of this paper is that technological progress is intimately dependent on economic phenomena. The evidence suggests that society may indeed affect the allocation of inventive resources through the market mechanism somewhat as it affects the allocation of economic resources generally." Jacob Schmookler, "Economic Sources of Inventive Activity," Journal of Economic History, the International Bank for Reconstruction and Development describes choice of technique as follows:

> Once the requirement has been precisely defined, the problem boils down to finding the least costly way of meeting it. The most obvious alternative paths leading to similar results are carefully considered; each path is costed in detail and then the costs are compared to show which is the cheapest, given some discount rate.[28]

(March, 1962), p. 1.

In his book he takes an even more positive stand in relation to market influence. Invention and Economic Growth (Cambridge, Massachusetts: Harvard University Press, 1966).

R. R. Nelson in "The Economics of Invention: A Survey of the Literature," JB, April, 1959, pp. 101-127, and William Fellner in his Trends and Cycles in Economic Activity (New York: Henry Holt and Co., 1956), also contribute strong plugs for the "induced" technology hypothesis. J. R. Hicks made the original distinction between "induced" and "autonomous" inventions. The Theory of Wages (2nd ed.; London: Macmillan & Co., Ltd., 1963), p. 125. Those called forth by the pricing mechanism are "induced"; all others are considered "autonomous."

This writer believes that autonomous technological advances are more important in producing new knowledge than is generally thought among economists. Suggestive treatment of the "autonomous" theory can be found in W. F. Ogburn, Social Change (New York: B. W. Huebsch, Inc., 1922), pp. 90-102. An exception among economists is C. E. Ayres. See his Theory of Economic Progress (Chapel Hill: The University of North Carolina Press, 1944). The most complete presentation of the "autonomous" theory (called "instrumental" in the work) known to me is my unpublished Master's thesis, "The Instrumental and Induced Theories of Technological Development: A Critical Study," University of Texas, 1958.

However, even in the case of important autonomous inventions, the market place exercises a strong influence on whether it is developed further or comes to be commonly used and therefore subject to geographic diffusion. The birth of knowledge can be autonomous, but its initial use and ultimate transmission depends on market forces.

[28]Robert Sadove, "Economists, Engineers, and Development," Finance and Development (June, 1967), p. 128.

The point being made here is that the "most obvious alternative paths" to the entrepreneur of the United States or Western Europe will likely be confined to a narrow range of recent technology. The LDC entrepreneur, however, is confronted with an entirely different set of factor prices. There is no a priori reason to suspect the latest vintage of technology will yield the lowest unit cost. The complicating factor, therefore, is the expansion of the relevant range of techniques which must be investigated.

2. Conflicting Normative Goals

There is a greater possibility of serious conflicts among normatively determined economic goals that attend choices of techniques in LDC's. The maximization of current output with one set of techniques may conflict with maximizing the rate of growth or the maximization of current employment that would be furthered by alternative techniques. Much of the reasoning behind a possible conflict of goals also applies to developed countries, but such conflicts are of relatively marginal importance in the presence of relatively efficient methods, high levels of employment and many decades of growth. Conflicts are less urgent and less probable. For example, a theoretical conflict exists in LDC's if a more capital-intensive technique maximizes the rate of growth in output, but reduces current output. In a mature industrial country both efficiency and growth will more likely be compatible with a more capital-intensive method. Chapter II explores the relation of choice of technique to these normative goals more thoroughly.

3. Misleading Market Signals

In a market economy, supply reacts to prices. As will be further elaborated in Chapter VII, there is more likelihood in LDC's that profit maximization will fail to result in maximum efficiency. The most frequently cited price distortions are those of capital, labor and foreign exchange.

4. Restraints

The entrepreneur in LDC's is likely to operate under a different set of restraints than his counterpart in mature industrial countries. Chief among these is the likelihood of a smaller size of market demand. Scale of production is one of the most important determinants of unit cost associated with various techniques. Higher per capita incomes, better transportation facilities, mass advertising, and a more elastic demand are some reasons that the market limitations are likely to pose less of a problem in developed areas. This in turn affects the differential values placed on flexibility vs. specialization inherent in types of equipment, different size units of divisibility in changing scale of operations. Similar points could be made about the availability of skilled labor, specialized inputs, foreign exchange, etc. For these, and perhaps other reasons, then, the entrepreneur and policy maker in LDC's face a far more complicated choice. Actually, if present and future restraints could be identified and accurately appraised, it would simplify the problem by automatically narrowing the feasible range of techniques. The very number, variety and uncertainty of the restraints, however, result in a net increase in the number of variables that must be taken into consideration. In addition there is the likelihood that through time the techniques chosen will alter the restraining conditions themselves.

Scope, Assumptions, Methodology and Organization

Scope

1. Data gathering and analysis have been geared to the employment of UM in LDC's, which for the purpose of this study comprises Africa, except South Africa; Asia, excepting Israel and Japan; and Latin America.[29] Much of the analysis, however, could be extended to less developed areas within developed countries.

2. With a few exceptions the scope is confined to manufacturing or processing activities.

3. With the exception of incidental treatment, nonfactory industry is excluded from this study.[30] These activities are not included within the scope for the following reasons: (a) They appear to be declining in relative

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[29]Russia can be considered European or added to the Asiatic exceptions as one chooses.

[30]Nonfactory forms of manufacturing include handicraft work and cottage industry. Handicraft work corresponds

importance in LDC's,[31] (b) used tools sloughed off by developed countries are likely to be inappropriate for nonfactory forms of enterprise and (c) there is substantial evidence that this sector <u>should</u> shrink in view of its poor

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to Staley and Morse, "artisan work" defined by them as: ". . . manufacturing carried on by craftsmen working singly or with a few helpers or apprentices and without extensive division of labor." Eugene Staley and Richard Morse, <u>Modern Small Industry for Developing Countries</u> (New York: McGraw-Hill Book Co., 1965), p. 6.

Cottage industry corresponds to their "household industry" which ". . . includes all types of manufacture carried on in or near the home, mainly by family labor." <u>Ibid</u>., p. 72.

Prasad defines cottage industry as that industrial establishment which generally does not use any motive power and is operated largely by hand, which is mostly a family business, which is largely located in the rural and the semi-urban areas, and in which total investment is small. Kedarnath Prasad, <u>Technological Choice Under Developmental Planning</u> (Bombay: Popular Prakashan, 1963), p. 1.

[31]The exclusion of nonfactory production is not intended to deny its absolute economic importance in LDC's. Despite definitional and data gathering problems inherent in measuring its importance, a cursory review of the summarization of the literature on the subject, found in Staley and Morse, <u>op. cit</u>., Chapter II, is convincing on this score. There is, however, evidence in the form of historical revelation, that:

"In preindustrial societies, nonfactory producers provide nearly all of the manufactured goods. In highly industrialized societies, their manufacturing role is minor, and the factory does the great bulk of manufacturing." Staley and Morse, <u>ibid</u>., p. 93.

Also recent experience of India and Japan can be cited. Prasad is writing of Indian cottage and small industries when he says, ". . . their relative importance in both spheres [contribution to employment and income] is declining and this tendency towards decline is bound to become more marked. . . ." <u>Op. cit</u>., p. 13. In Appendix B to Chapter I, adduces data pointing to a similar trend in Japan.

performance in terms of efficiency and contributions to growth.[32]

4. Differential costs in social overhead and infrastructure capital that may be attributable to variations in the techniques of manufacturing are excluded from the study.

5. Differential rates of growth in population that may be associated with variations in the techniques of production are excluded from the study.

6. The scope is confined to economic systems in which entrepreneurs are motivated primarily by the prospect of profit, the basic information affecting the decision of the participants of the economy are prices in the factor and product markets which are established by buying and selling activities and any government intervention will attempt to influence resource allocation through the market mechanism rather than as a displacement of it.

7. The investigation includes only the "interesting cases" in which UM and new machinery are fairly close substitutes technologically and economically. Cases of obvious superiority of the most modern technique, e.g., due to product quality requirements uniquely provided by a recent vintage of technology, have been relegated to the "uninteresting" category. Given the relevant engineering restraints the

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[32] See, for instance, Gustav Ranis' findings on the textile, leather and leather goods, light engineering and plastics from a survey of Karachi, Pakistan. "Investment Criteria, Productivity, and Economic Development," QJE, May, 1962, pp. 298-302.

substitution of UM and new machinery must be technically feasible and economic substitution must be enough in doubt to inspire a careful comparison.

8. The price of UM is considered a datum independent of present or prospective demand of an individual purchaser, single LDC, and LDC's collectively.

9. With the exceptions of (a) learning and (b) the size of the UM market external economies and diseconomies to the firm are excluded.

Technical Characteristics: A Preliminary Survey

What are the likely technical characteristics of UM compared to new? The answer has two dimensions. First, there are characteristics associated with technological vintage and, second, those which relate to old equipment vis-à-vis new equipment with little or no difference in technology. It must be emphasized that these characteristics represent general tendencies. None are likely to be without exceptions. Some of the more important points of this dissertation are based on the exceptions to the tendencies of technical characteristics which are catalogued below.

Technical Characteristics Associated with Vintage

In general the more recent the technological vintage

1. The higher the capital/labor ratio (K/L hereafter) in terms of the initial cost of capital compared to annual labor costs.

2. The longer the physical life of the equipment. This is due to the tendency of having more durability engineered into the equipment and accounts, in part, for the tendency in number 1 above.

3. The larger the optimal scale of output.

4. The less flexible the equipment in terms of alternative uses and divisibility.

Technical Characteristics of UM Compared with New Equipment of Identical or Similar Technological Vintage

In general UM will tend to exhibit the following traits vis-à-vis a new counterpart:

1. A lower K/L ratio when K is initial capital cost *and* when K is capital cost per time period.

2. A higher noncapital cost per unit of output when costs are measured in terms of market prices.

3. A shorter physical and economic life.

Technical Characteristics of UM Compared with the Latest Technological Vintage

The foregoing list of tendencies can be combined in arriving at those for UM compared to equipment of the latest vintage. In general UM will tend to have the following traits:

1. A lower K/L ratio.

2. A shorter physical and economic life.

3. A smaller optimal scale of output.

4. More flexibility in alternative uses, divisibility and replacement.

Methodology

1. Review of the relevant literature on the theory of choice of technique brought to light the crucial variables that need to be measured and the relationships among these variables.

2. Data on the economics of UM was gathered from official government publications; trade associations; individual firms; international, government and private lending agencies; extensive correspondence with individuals whose views were not necessarily the official views of the organization for which they worked; and conversation and personal observation in Central and Northern Mexico.

3. The theoretical and empirical findings were combined and analyzed by using hypothetical prototypes which seemed from the data gathered to conform to reality as closely as possible.

4. The closed and static neoclassical world was then relaxed by introducing learning, international trade, some aspects of risk and uncertainty, market frictions characteristic of LDC's and market frictions of the UM market itself.

5. Policy conclusions.

Organization of the Dissertation

The brief section on methodology gives the reader a hint at the structure of the study. Chapter II provides a brief critical review of the literature on choice of technique.

In what ways and under what conditions can UM be employed in LDC's? Part Two attempts to answer this question by focusing on those characteristics that are <u>peculiar</u> to UM. Chapter III introduces learning and relates it to the employment of UM. Chapter IV introduces the attribute of flexibility and intensively treats three facets of the economics of flexibility. Part Two is concluded by Chapter V which looks at a variety of special situations in which UM may be more advantageous than new machinery.

From the purely technical aspects of the economics of UM, the focus in Part Three shifts to the institutions in LDC's or those peculiar to the UM market itself that might influence the decision of employing UM. The statistics of the UM market, the various market channels for UM sales to LDC's, and the various frictions or biases inherent in the UM market are described.

Part Four consists of the final chapter which is reserved for the exposition of conclusions and the policy implications derived from them.

CHAPTER II

BASIC CONSIDERATIONS OF CHOOSING TECHNIQUES

Since the decision whether or not to employ UM is merely one aspect of the problem of choosing techniques, a skeletal review of the relevant macro and micro theory provides a useful point of departure for the chapters that follow.

Macro-Criteria for Choosing Techniques

The primary macro-criteria for the optimum choice of techniques parallel those for investment. The maximization of (1) current output (2) employment creation and (3) the rate of growth of output are treated respectively in the next three sub-sections, while a fourth sub-section provides a summary of the salient features of the macro-criteria and their relation to the investigation of UM.

Maximizing Current Output

When fully employed inputs are used with maximum production efficiency, output will be maximized. If one abstracts from external economies and diseconomies, these results will be achieved in a neoclassical world through the decision of individual consumers and owners of resources who are motivated by enlightened selfishness, subject to the restraint of competition and unencumbered by a lack of mobility or market knowledge.

Under these conditions the entrepreneur attempts to choose the technique that will maximize his discounted flow of profits net of risk after having considered such restraints as limited market size, foreign exchange availability, infrastructure facilities, etc. For any given technique a firm's efficiency will be optimal when it is impossible to add or subtract a unit of input or any combination of inputs without increasing costs by more than revenue. If we assume that the firms in any industry are maximizing efficiency, industry efficiency results when it is impossible to change the level of use of resources at the internal or external margin without causing price to differ from average unit cost.[1] When all industries are producing at maximum efficiency, no reshuffle of resources among them will raise net value added in production by more than net additions to cost, thus, efficiency is optimal for the economy as a whole. If resources are fully employed in this manner, current output is being maximized.

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[1]There is one theoretical peculiarity that will be mentioned for the sake of completeness. Efficiency maximization is compatible with a spread between prices and costs if the ratio of price to cost is the same for all firms in the economy. Needless to say, this has little practical applicability.

One can picture, then, the entrepreneur scanning the range of feasible techniques that will maximize the discounted flow of profits, net of risk, over the life of his durable capital equipment.[2] Yet, what are the more obvious differences affecting choice of technique in LDC's, as opposed to mature industrial economies? To the extent that relative factor prices are reflected by relative factor endowments, the natural presumption is that in LDC's the ratio of unit capital costs to labor costs will tend to be higher than counterpart ratios in developed countries. This preliminary conclusion is consistent with the well known Heckscher-Ohlin theory of international trade in that relative factor endowments underlie relative factor costs.[3] Most Heckscher-Ohlin models, however, assume no international differences in technique of production for a given product.[4] Actually, there are two forces supporting a lower capital-labor ratio in LDC's: (a) the corollary to the Heckscher-Ohlin theory

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[2]His attention is focused on durable capital equipment for practical rather than theoretical considerations since (a) the entrepreneur is likely to be stuck with it for a considerable period of time as the adjective "durable" implies and (b) the changes in technology that are embodied in durable capital tend to be more discontinuous and obvious than in the human agents or raw material inputs.

[3]For an excellent summary of the Heckscher-Ohlin approach see Meredith O. Clement, Richard L. Pfister and Kenneth T. Rothwell, Theoretical Issues in International Economics, Chapter 2, "Trade and Relative Factor Supplies," (Boston: Houghton Mifflin Company, 1967).

[4]"Techniques of producing identical goods are the same in both countries, meaning that a given bundle of tangible factors yields the same quantity of a given output in both countries." Op. cit., p. 87.

which does not depend on difference in technique and (b) further divergence due to the deliberate choice of techniques which are more compatible with resource endowment.[5]

An extreme variant of the dictum of spreading capital can be derived from the investment criterion of maximizing the rate of "capital-turnover."[6] Capital, which is implicitly considered the only critically scarce resource, will be spread thinnest when the capital-output ratio is smallest. The arguments against this simplistic view are well known. Deficiencies of labor skills, managerial and administrative talents, entrepreneurship, foreign exchange, infrastructure, marketing and financial facilities can constitute bottlenecks as well as lack of capital. In addition there are likely to be complementary effects that can only be garnered with a high capital-labor ratio in one or more of the components of a complex of projects.

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[5]These two forces are consistent respectively with (a) substituting homogeneous inputs and (b) substituting nonhomogeneous inputs as discussed in Chapter I above.

[6]This is sometimes referred to as the Buchanan-Polak criterion. Norman S. Buchanan, International Investment and Domestic Welfare (New York: H. Holt and Company, 1945), Jacques J. Polak, "Balance of Payments Problems of Countries Reconstructing with the Help of Foreign Loans," QJE, February, 1943, pp. 208-40. Both writers were fearful that foreign exchange would be in desperately short supply in LDC's and Europe after the Second World War. There are several intriguing possibilities for saving foreign exchange by employing UM. These possibilities are mentioned throughout Part Two of this dissertation. Especially significant, however, is the possibility of facilitating import-substitution by producing with UM. This idea, which is developed later in Chapter IV, can be thought of as a neo-Buchanan-Polak argument.

A more sophisticated approach was suggested by A. E. Kahn.[7] He agreed that the capital-turnover criterion might be a useful "rule of thumb" in allocating resources, but maximum current output could only be achieved by equating social marginal productivity of all fully employed resources.

But, what are the differences between the textbook marginal productivity and the social marginal productivity approaches? There would be little theoretical difference if the prices of factors accurately portrayed their social opportunity cost. Aside from possible external economies and diseconomies, efficient choices of technique would be brought about by the market. The ratio of factor productivities to their respective prices would tend to be equal among all alternative uses. If resources are fully employed in this manner, the textbook marginal productivity and Kahn's social marginal productivity criteria are identical. However, there is a general consensus that factor prices in LDC's do not represent "real" or social opportunity costs. Jan Tinbergen was among the earliest writers who explicitly mentioned structural imbalances in LDC's factor market.[8] Tinbergen held that market wages would be higher than the social marginal product of labor, while market prices for capital and foreign exchange would likely be lower than their social

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[7]Alfred E. Kahn, "Investment Criteria in Development Programs," QJE (February, 1951), pp. 38-61.

[8]Jan Tinbergen, The Design of Development (Baltimore: The Johns Hopkins Press, 1958), pp. 37-48.

marginal products. He further recommended the use of "accounting prices" in planning which would reflect "intrinsic values."[9]

H. B. Chenery has developed a framework for judging investment projects after taking into account (a) tariffs, taxes and subsidies (b) external economies and (c) unused resources.[10] In a subsequent publication he and K. S. Kretschmer used a similar approach in formulating a method for contriving "shadow prices" which would serve as a guide for choosing projects or techniques.[11] A prerequisite to maximizing current output by means of the market are policies which alter market costs of resources to reflect their social costs.

At this point, it becomes necessary to introduce one practical consideration into the heretofore theoretical discussion. Casual empiricism would suggest a relative abundance of labor and a relatively acute shortage of capital equipment in LDC's. Hirschman, however, has suggested that if human resources are disaggregated, the important qualities of maintenance skills and entrepreneurial decision-making are in shorter supply than capital.[12] Whether or not

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[9] _Ibid_., p. 39.

[10] Hollis B. Chenery, "The Application of Investment Criteria," _QJE_ (February, 1953), pp. 76-96.

[11] H. B. Chenery and Kenneth S. Kretschmer, "Resource Allocation for Economic Development," _Econometrica_ (October, 1956), pp. 365-99.

[12] Albert O. Hirschman, _The Strategy of Economic Development_ (New Haven: Yale University Press, 1958), Chapter 9, especially pp. 139-42.

this is true in a given situation is, of course, an empirical issue, but the implication for choosing techniques is obvious. All other things being equal, the scarcer the essential qualities of labor for which capital can be substituted, the higher will be the optimum capital-labor and capital-output ratios. Indeed once these scarcities are introduced there is no a priori reason to suppose LDC's should have lower capital-labor or capital-output ratios than the more developed regions.

Both market biases and scarcities of maintenance abilities are extremely important to the question of UM feasibility in LDC's. A more extensive and analytical coverage of market biases in LDC's and their relevance to UM is included in Chapter VII, while the economics of maintenance is explored in Chapter III. An interesting complication is introduced in the next chapter by allowing the quantity or quality of maintenance abilities to vary through time as a function of learning. It will be demonstrated that learning, in turn, can be a function of the techniques that are employed. This means that production techniques and the level of maintenance abilities display an important interdependence when a dynamic analysis is applied.

The Employment Creation Criterion

Some policy formulators prefer to stress the amount of employment created as the paramount consideration in allocating resources in LDC's. Such sentiment often rests on social and political tenets.[13] As for economic ideas, if one takes the most extreme position, employment should be maximized by applying the capital-turnover criterion. It is too much to hope, however, that the goal of maximizing current output and maximizing employment are perfectly compatible in LDC's. The existence of noncapital bottlenecks, real costs of transferring factors from one sector to another, factor indivisibilities, externalities and complementarism will almost always result in some area of conflict between the two criteria.

More sophisticated versions of employment absorption criteria can be found in the Lewis family of models based on W. Arthur Lewis's seminal article, "Economic Development with Unlimited Supplies of Labor."[14] Here, the key to development is seen as the growth of the modern sectors of LDC's at a rate sufficient to make labor scarce in the traditional sectors. When this point is attained, the economy is in a neoclassical world. A perfectly horizontal supply curve for labor has now been replaced by a positively sloping curve as the relevant analytical concept. Any increase in demand

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[13] See, for instance, Eugene Staley and Richard Morse, Modern Small Industry for Developing Countries (New York: McGraw-Hill Book Co., 1965), p. 276; India's The First Five Year Plan, pp. 24-25, as quoted by Kedarnath Prasad, Technical Choice Under Development Planning (Bombay: Popular Pradashan, 1963), p. 175; Prasad, op. cit., quoting India's Khera Committee's Report of Ambar Charkha Enquiry Committee, 1959, p. v, and P. C. Mahalonobis, "The Approach of Operational Research to Planning in India," Sankya (December, 1955), p. 16, as quoted in A. S. Bhalla, "Investment Allocation and Technological Choice--A Case of Cotton Spinning Techniques," EJ (September, 1964), p. 611.

[14] The Manchester School (May, 1954), pp. 139-91.

for labor will cause a rise in wages which in turn encourages substitution of capital for labor. This is "just what the doctor ordered" for the subsistence sector, since labor productivity will rise due to the increased use of capital and a cash crop is possible. Once this occurs a virtuous cycle of development is established.

There are several important embellishments and derivative theories which apply to Lewis's original model. Eckaus pointed out the difficulty of reaching a neoclassical world if (a) factor proportions are flexible in the subsistence sector (b) factor proportions are inflexible in the modern sector (c) the modern sector is highly capital-intensive and (d) population is a direct function of investment in the modern sector.[15]

Fei and Ranis took the Lewis model further by both adding some elements and giving others more detailed and rigorous attention.[16] They (a) treated population growth with greater analytic rigor, (b) extended the Lewis model to cover a transitional stage when surplus labor's marginal productivity is above zero, but below the subsistence wage, (c) introduced a flow of savings from agriculture

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[15]Richard S. Eckaus, "The Factor-Proportions Problem in Underdeveloped Areas," AER (September, 1955), pp. 539-65. Eckaus does not mention Lewis's article, thus it may have been a totally autonomous "embellishment" of Lewis.

[16]The core of their thinking can be found in John C. H. Fei and Gustav Ranis, "A Theory of Economic Development," AER (September, 1961), pp. 533-65. A more lengthy analysis is found in authors' Development of the Labor Surplus Economy. (Homewood, Illinois: Richard D. Irwin, Inc., 1964).

which helps finance expansion in the modern sector and (d) showed that up to a point the introduction of labor-using innovations will tend to absorb employment and increase output.[17]

In addition to these theoretical extensions, Professor Lloyd Reynolds attempted to test the Lewis hypothesis empirically by a case study of Puerto Rico.[18] He found that even in the face of heavy industrialization and a shrinking labor force between 1950 and 1960, although unemployment was reduced, total employment also fell. The progress toward eroding the surplus pool was quite modest. The balance of the evidence indicates that industrialization does little to reduce surplus labor.[19] For this reason, many economists believe that employment creation must take place in non-manufacturing sectors, e.g., construction, services or even in agriculture.[20] The employment of UM in manufacturing when it is consistent with efficiency can make a contribution to

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[17]The latter point was originally developed in their "Innovation, Capital Accumulation and Economic Development," AER (June, 1963), pp. 283-313 and is included in their Development of the Labor Surplus Economy, ibid., pp. 94-95.

[18]Lloyd G. Reynolds, "Wages and Employment in a Labor-Surplus Economy," AER (March, 1965), pp. 19-39. The same conclusions are found in Reynolds and Peter Gregory, Wages, Productivity and Industrialization in Puerto Rico (Homewood, Illinois: Richard D. Irwin, Inc., 1965).

[19]In addition to the Reynolds study see Werner Baer and Michel E. A. Hervé, "Employment and Industrialization in Developing Countries," QJE (February, 1966), pp. 88-107.

[20]For some estimates of employment absorption possibilities in LDC's, see Richard L. Meier, Science and

the ultimate solution of the problem by increasing employment in several ways. First, with a given investment budget, more equipment can be purchased due to lower capital costs; second, the earlier vintage of technology implies a more labor-intensive method of production and third, as will be discussed in the next chapter, there is greater motivation to substitute maintenance for capital when UM is employed.

If trade offs between maximizing current employment and current output are necessary, value judgments are inescapable. Fortunately, the employment of UM when it is economically efficient will tend to narrow the difference between the goals.

Maximization of the Rate of Growth of Output

The possibility of a conflict between maximizing current and future per capita output has been most forcefully stated in a path-breaking article by Walter Galenson and Harvey Leibenstein.[21] Per capita output can be maximized at some future date, they say, by maximizing the per capita reinvestment quotient. By increasing the capital-labor ratio,

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Economic Development: New Patterns of Living (2nd ed. rev., paperback; Cambridge, Massachusetts: the M.I.T. Press, 1966), p. 202. He sees, for example, construction absorbing 20 per cent of the labor force.

Richard J. Ward suggests that under favorable conditions more people can be productively employed in agriculture. "Absorbing More Labor in LDC Agriculture," Economic Development and Cultural Change (January, 1969), pp. 178-88.

[21]Walter Galenson and Harvey Leibenstein, "Investment Criteria, Productivity, and Economic Development," QJE (August, 1955), pp. 343-70.

productivity per worker is raised and the amount of surplus over consumption is increased through a reduction in the wage bill. The proportion of income garnered by capitalists will rise, causing savings and the rate of capital formation to rise due to the capitalist's higher marginal propensity to save and greater tendency to productively reinvest these savings.

This dissertation will proceed under the assumption that there is no significant difference between the goals of maximizing current output and growth.[22] Such an approach would appear justifiable for the following reasons:

1. If the proportion of output going to capitalists is increased at the expense of departing from the optimal capital-labor mix, there are two forces operating on the absolute amount of capitalist income. There is no a priori

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[22]Since the next few pages are critical of the Galenson-Leibenstein conclusions, it is only fair to mention several differences in our assumptions, emphasis, and interpretation.

1. Galenson and Leibenstein assumed that capital-intensity would decrease the rate of growth in population (ibid., p. 352) and slow the rate of urbanization (ibid., pp. 360-61). This study excludes these considerations.

2. Galenson and Leibenstein assume a closed system. Ibid., p. 346. This dissertation later maintains that the employment of UM can favorably affect balance of payments.

3. Galenson and Leibenstein recognized the importance of learning (ibid., p. 348) and flexibility (ibid., p. 348) but they do not go beyond mentioning them. Chapter III of this study deals with learning, while Chapter IV covers various aspects of flexibility.

reason why the negative effect of the fall in total output will not predominate over the increased share of output going to capitalists.

2. A shift to a higher capital-labor ratio would result in fewer workers employed in the short-run. To the extent that labor has a positive rate of saving, some loss of labor saving would have to be netted against the gain in the capitalists' income.

3. To the extent that capitalists have a positive marginal propensity to consume, this must be netted out of gains in capitalists' income.

4. If we can safely assume that one component in the social utility function mitigates against allowing starvation or permits only gradual or random, intermittent starvation, a "dole" for the unemployed must be instigated. Presumably, most of the dole would be provided at the expense of capitalists.

5. There is a likelihood that higher wage rates will be associated with higher capital intensity.[23] If so, the reduction in the wage bill will not be proportionate to the reduction in the number of workers.

6. Even assuming that an enhanced growth rate can result from policies designed to encourage capital-intensity,

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[23] A. S. Bhalla, "Galenson-Leibenstein Criterion of Growth Reconsidered: Some Implicit Assumptions," Economia Internazionale (Maggio, 1964), p. 242.

there may be alternative policies that could achieve the goal more efficiently. A transfer of resources from wages to investment by forced savings may be accomplished through appropriate public finance policies. This point was raised by Moes in critiquing Galenson and Leibenstein:

> If . . . the total wage bill exceeds the minimum consumption level, actual consumption can still be prevented from exceeding that level through the intervention of the state by means of taxation of the consumers.[24]

Galenson and Leibenstein justifiably replied that the relative efficiency of the governmental taxing system and bureaucracy would be a determining factor in appraising this alternative.[25] Nonetheless, given favorable administrative conditions, the Moes alternative could substitute for the Galenson and Leibenstein proposal and be compatible with the goal of maximizing current output.

7. There may already exist conditions in LDC's biasing the choice of technique toward a higher capital-labor ratio. The discrepancies between market prices of resources and their social marginal products bias the entrepreneur in favor of higher capital-labor ratios. Assuming diminishing marginal productivity of resources, policies which cause a further movement to a higher capital-labor ratio will prove more costly in current output than a proportionate shift

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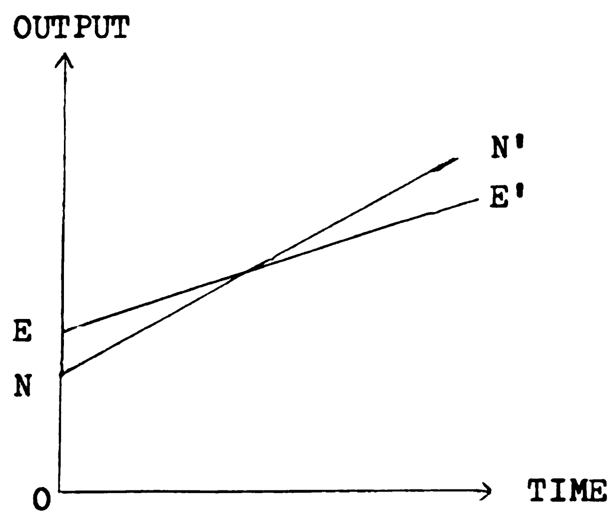
[24] John Moes, "Investment Criteria, Productivity and Economic Development," QJE (February, 1957), p. 162.

[25] Galenson and Leibenstein, "Reply to Mr. Moes and Mr. Villard," op. cit., p. 473.

in factor intensity from an initial position of optimal static efficiency.

8. For purposes of argument let us assume that policies can be implemented which raise the net reinvested profits as a proportion of output. Under these circumstances the rate of growth will be enhanced regardless of the extent of decrease in current output.[26] A graphic sketch of the old and new levels of output and growth path appears below:



E represents the efficient level of output and EE^1 the growth path of the economy with the combination of factors, income distribution and investment patterns which are compatible with maximizing current output for each time period. NN^1 represents the growth path with factor combinations, income distribution and investment patterns compatible with higher

[26] The reader will detect a bit of tautology here. Actually, we are implicitly assuming that the departure from static efficiency is not great enough to prevent a rise in net reinvested profits.

net reinvested profits. At point C the two growth paths would converge after OT time duration.

It is rather obvious that until the year T arrives the populace is likely to suffer.[27] The remaining welfare problem is one of finding a proper instrument with which to discount future opulence against the present siege of "belt tightening." The diagram above is a simple rendition of "turnpike" economics, but in reality the problem is far more complex, since in theory an infinite number of growth paths are possible. The complexity of the problem of the turnpike theorem is well put by Higgins:

> Ideally, we would design our program so as to maximize the present value of a composite index, expressing all goals: income, employment, income distribution, balance of payments, cultural values, etc. We would maximize the present value of the stream of benefits in terms of this composite index of goals. Unfortunately we do not have the data or the knowledge to do so.[28]

A recital of the conceptual and practical difficulties of selecting and computing a community discount rate would be superfluous to the purpose of this study.[29] Suffice it to say that some discount rate above that of zero is appropriate, thus causing the welfare break-even point

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[27]As every student of welfare economics knows, it cannot be proven unequivocally that such is the case, since this involves interpersonal comparisons of utility functions, but the probability of a decline in welfare is supported by the increase in unemployment and the likelihood that labor's marginal utility of income will be greater (or at least as great) than that of the capitalist class.

[28]Benjamin Higgins, Economic Development (rev. ed.; New York: W. H. Norton & Company, Inc., 1968), p. 387.

[29]These difficulties are admirably summarized in Amartya K. Sen, The Choice of Techniques, Chapter 8, "Choice Involving Time," (Oxford: Basil Blackwell, 1960), pp. 82-89.

to be realized at a point beyond time OT on the graph.

9. The final critique of the Galenson-Leibenstein type model is even more fundamental. The Galenson-Leibenstein approach is devoted to attacking the savings-investment barrier in order to accelerate growth. There is evidence, however, that restrictions on the ability to import and the inability to absorb investment productively are more formidable impediments to LDC's growth than the ability to save.[30] If so, a good deal of steam is taken out of the Galenson-Leibenstein argument.[31]

Summary of Macro-Criteria

There exist three principal macro-criteria for deciding on the optimal technique of production: maximizing current output, maximizing employment absorption, and maximizing the rate of growth.

When UM is efficient, its employment will narrow any discrepancy between the goal of maximizing current output and employment. There are reasons to suppose that little, if anything, stands to be gained in the way of growth by policies designed to raise artifically the capital-labor ratio.

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[30] Hollis B. Chenery and A. M. Strout, "Foreign Assistance and Economic Development," AER (September, 1966), pp. 679-733.

[31] As mentioned above, Chapter III deals with the growth of human abilities, a factor in investment absorption capacity, and Chapter IV includes a section on UM and import-substitution.

This study concentrates on efficiency as the overriding criterion for choosing techniques. In Chapter V, however, where special instances of employing UM are presented, it will be shown that employing UM for rural industries is particularly relevant to the employment criterion and the use of second-hand automated equipment is compatible with the growth criterion.

Cost Comparisons for a Micro-Choice Between New and Used-Machinery

Motivation for the Transfer of UM to LDC's

Why does UM go to LDC's in the first place? If the decision is determined by the market, an entrepreneur in an LDC outbids those in the developed countries. It is, then for some reason worth more to him than to his fellow entrepreneurs, or, in more sophisticated terms, his discounted stream of expected net profits is greater than those envisioned by others. What conditions may bring this about?

One of the most obvious possibilities lies in the difference between capital costs in developed countries vis-à-vis LDC's. The alternative of substituting new machinery will be more attractive in the developed countries due to the lower opportunity costs involved. Similarly wages are lower in LDC's.[32]

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[32] "The lower price of [second-hand] equipment is an important advantage especially for newly developing countries, where entrepreneurs are short of funds, and the economy as a whole lacks savings." Netherlands Economic Institute, Division of Balanced International Growth, Second-Hand Machines and Economic Development (Rotterdam:

Regarding the motivations behind UM transfers to LDC's the literature is blessed by a short but tightly reasoned analysis by A. K. Sen.[33] He begins by assuming away (or treating as negligible) (a) transportation costs, (b) machine productivity differentials, and (c) material costs. Under these conditions he points out that if maintenance costs rise with the age of the machine, lower wages for maintenance services could motivate the transfer of UM to LDC's. Even assuming away any difference in maintenance, Sen points out that:

> Similarly, a fall in the absolute productivity of the machinery with age can be easily absorbed in the underdeveloped economy thanks to its lower wages. A fall that will wipe out all profits in

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Netherlands Economic Institute, May, 1958), p. 3. "The buyer in the underdeveloped country gets a second-hand producing plant at a very low cost. . . ."--Frederick T. Moore, Economic Growth and Foreign Aid: A Proposal Concerning the Export of Industrial Plant (Santa Monica, California: Economics Department of the RAND Corporation, P-2287, April 20, 1961), p. 5. "One definite advantage of second-hand equipment on which, however, there is general agreement, is that they can be acquired at a cost often considerably lower than the cost of new equipment."--United Nations, Report of Expert Group on Second-Hand Equipment for Developing Countries, pp. 7-22, December, 1965 (New York: United Nations Center for Industrial Development, 1966), p. 7.

"Advocates of greater use of second-hand equipment in developing countries contend that not only do firms using such machinery do well in the domestic market, but, because of low wages, they may be able to compete in export markets with companies in high-wage areas which operate with more modern machinery."--Albert Waterson, "Good Enough for Developing Countries?" Finance and Development (September, 1964), p. 89, emphasis supplied. He goes on to cite an example of a firm in Calcutta which bought UM from its British parent firm and "paying wages at the low rates prevalent in India," undersells the British company in India as well as to its neighboring countries.

[33]Amartya Kumar Sen, "On the Usefulness of Used Machines," Review of Economics and Statistics (August, 1962), pp. 346-48.

the advanced economy, may still make a profit margin in the low-wage underdeveloped country.[34]

Sen considered the foregoing as "obvious" and being desirous of exploring some more interesting analytical aspects of UM, he assumed away any change in productivity due to age of the machines and, in essence, asks if there are reasons for transfer even in this case. He offers several possibilities: (a) differential rates of technological progress causing earlier economic obsolescence in advanced countries, (b) differential rates of increase in unit wage cost, the faster rise occurring in the advanced countries, and (c) the possibility that older vintages of technology are also associated with a higher degree of labor-intensity.[35]

What if differential rates of obsolescence are assumed away? Would a transfer still be feasible? "Quite so," says Sen. Using the straight-line depreciation method he indicated that the older the used machines are, the better investment they make. His algebraic formulation is set forth below where:

R = rate of return on the depreciated value of the machine
M = the price of a new machine
P = annual gross profits of the machine
T = the life of the machine in years (Physical life here. In the original article these calculations appeared before economic obsolescence had been assumed away.)
n = the n^{th} year of the machine's life.

$$R = \frac{P - \frac{M}{T}}{\frac{(T - n + 1)}{T} \cdot M}$$

[34] Sen, op. cit., p. 347.

[35] Ibid., p. 347.

Under these conditions, as n rises, the machine becomes a more and more attractive investment. This, however, does <u>not</u> explain a transfer to LDC's. Indeed, it merely indicates that any owners of older machinery would consider it a better investment than new. At this point, however, Sen introduces the lower wages in LDC's. Other things being equal, this raises gross profits for any given type of machine in LDC's. He called this new rate (P+d) per year and allowed r to represent the equilibrium rate of profit in the advanced country (where the price of equipment is presumed to be determined). The market value of the machine in the advanced country one year before its obsolescence would be $\frac{P}{(1+r)}$. Two years before its obsolescence it would be: $\frac{P}{(1+r)} + \frac{P}{(1+r)^2}$, and so on, until the year T. In order to make comparisons, he shows what the profit rate per unit of investment would be in LDC's one year before its obsolescence, which will be called A, and what it would be if the LDC bought it two years before its obsolescence and sold it back to the advanced country after one year. The rate on this year will be called B.

$$A = \frac{(P+d) - \frac{P}{1-r}}{\frac{P}{1+r}} = \frac{d}{P}(1+r) + r$$

$$B = \frac{(P+d) - \frac{P}{(1+r)^2}}{\frac{P}{(1+r)} + \frac{P}{(1+r)^2}} = \frac{(P+d)\quad(1+r)^2 - P}{P(2+r)}$$

Since P>o, d>o, r>o, A>B, and since $A-B = \frac{d\ (1-r)}{P\ (2+r)}$, the older the machine is, the more lucrative it is in the LDC.

The reader will note that the foregoing analysis involves possibilities. Lower initial capital costs or lower capital-labor ratios do not necessarily mean lower capital-output ratios on an annualized basis. Lower wages and a lower capital-labor ratio may be offset by lower efficiency on the part of labor.

Comparing Used Machinery with New Machinery

The first approximation to comparing production costs with UM versus new involves comparing higher operating costs with lower capital costs.[36] Although there are some important exceptions to the rule,[37] the literature contains little disagreement with the generality that higher costs due to problems of decision making, maintenance, and spare parts will usually predominate over any advantage

[36]Two comments are useful at this point. First, as I just implied a sentence or so previously, lower capital costs may not obtain on an annualized basis just because the initial purchasing price of UM is lower than its new counterpart. The reason "lower capital costs" is used above is that if it is not lower per year than the new counterpart, it would be an unusual situation that would not automatically rule out UM.

Second, the term "operating costs" is evidently applied rather loosely. The UN Report of Experts for instance cites lower operating costs as an advantage for UM. It is obvious from context, however, that my analysis is in general agreement with the report. I am going to use "operating costs" rather loosely also, but the following classification should clear up any semantic problems: operating costs here refer to costs other than fixed capital charges. Since I am assuming no differences in material input cost per unit of output, this boils down primarily to labor and spare part costs.

[37]These exceptions form an important segment of Chapter V.

derived from a lower wage rate. The reader's attention will now be directed toward a more detailed discussion of operating and capital costs.

Operating Costs

As previously stated, operating costs are most likely to change significantly when employing UM due to problems of maintenance, decision making, and spare parts. A countervailing element is the likelihood that older vintages of technology are simpler to operate and therefore better suited to existing labor skills in LDC's.

Maintenance. As we have seen above, A. K. Sen in one explanation of the transfer of UM to LDC's hypothesized lower maintenance costs due to lower wages. The preponderance of the literature, however, holds that maintenance costs will generally be higher with UM than with new. Since economics of maintenance and repair receive extensive treatment in the next chapter, only a sampling of this literature will be introduced at this point.

The Netherlands Economic Institute's study assumes higher overhaul, repair, and labor costs per year. The report refers to the increased risk of breakdowns saying:

> This is one of the main disadvantages of second-hand equipment, especially of more complicated types of equipment. If the period over which it has been already used is relatively long in comparison to its technical lifetime, the risk becomes considerable. The risk results in unexpected losses due to lower production and added repair costs.[38]

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[38] Second-Hand Machines, op. cit., p. 4.

This view is shared by the U.N. Report:

> . . . the older the machine, the greater are the risks of breakdown and consequent losses from reduced production and larger repair costs.[39]

Both of these citations focus on the probability of breakdown as an increasing function of age. An additional factor reinforces this need for maintenance. Since the UM is likely to represent an earlier technological vintage with less durability engineered into it, more maintenance will be required vis-à-vis new equipment.[40]

Not only are more maintenance and repair needed, but maintenance abilities are less prevalent in LDC's.

> It is a common observation in underdeveloped countries that it is far easier to start an industry than to keep it operating efficiently over a period of several years. The difficulty of ensuring regular maintenance and repairs of irrigation canals, highways, buildings and machinery is one of the most striking common denominators of the underdeveloped world.[41]

The Division of Industrial Development of the United Nations comments as follows:

> United Nations technical assistance experts in industry have noted on a number of occasions [in LDC's] that, because of neglect, valuable equipment operated

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[39] Report of Group of Experts, op. cit., p. 9.

[40] Blitz has pointed out that maintenance and durability are substitutes in achieving longevity: "Longevity can be purchased as a mix of durability and maintenance outlays, subject only to the restraint that it must contain some outlay on durability; it need not contain maintenance outlays." Rudolph C. Blitz, "Maintenance Costs and Economic Development," JPE (December, 1959), p. 561.

[41] Albert O. Hirschman, The Strategy of Economic Development (New Haven: Yale University Press, 1958), p. 46.

at only a fraction of capacity, was out of production for prolonged periods of time and, in some cases, had been damaged beyond repair.[42]

In summary, maintenance costs are likely to be greater for production with UM in LDC's for two reasons. First, there is a greater need for maintenance due to (a) increased physical age and (b) an older technological vintage, and second, there is a scarcity of maintenance abilities in LDC's.

Spare-Parts. Procurement of spare parts for UM can cause difficulties when they are no longer stocked by the original supplier, operator's manuals and parts catalogs are lost, identification plates are missing or because of long delays at customs.[43] These problems of "shakier" information and longer procurement time are compounded by the more frequent need for spare parts by UM. Higher costs are incurred from the greater consumption of spare parts and either the costs of carrying a larger parts inventory or increased downtime of the equipment.

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[42]United Nations, Division of Industrial Development, "Use of Industrial Equipment in Under-developed Countries: Problems of Maintenance, Repairs, Replacement and Obsolescence," Industrialization and Productivity Bulletin, No. 4 (New York: United Nations, April, 1961), p. 31. See also a similar view in "Some Problems of Industrial Management Reported by Technical Assistance Experts," Industrialization and Productivity Bulletin, No. 2 (New York: United Nations, March, 1959), p. 55.

[43]See N.E.I., Second-Hand Machines, op. cit., p. 5; and Professor Adam Wiener, The Potential of Second-Hand Equipment in the Industrialization of Developing Countries (United Nations, Department of Economic and Social Affairs, Centre for Industrial Development: February, 1966) (CID/VI/Background Paper No. 7, Restricted Distribution), p. 47.

Managerial Decision-Making. Higher costs due to problems of managerial decisions can be treated fairly rapidly, since the arguments parallel those for maintenance. One of the main theses of Hirschman's The Strategy of Economic Development holds that a certain type of decision-making is the crucially short resource in LDC's.[44] He divides decision-making into genuine (nonroutinized) and habitual (routinized) decisions. The former he regarded as autonomous entrepreneurial decisions; the latter he regarded as induced.[45] His idea is to maximize induced decision-making to free more entrepreneurial talent for the genuine variety. A good summary of his thesis is as follows: "We have identified the ability to make [induced] decisions as the scarce resource which conditions all the other scarcities and difficulties in underdeveloped countries."[46] Meier agrees that management, among other things, is just as scarce as capital.[47]

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[44] It may seem more reasonable to use "decision makers" here, but due to our inability to quantify entrepreneurial talent, an increase of entrepreneurs at the external margin could be quite insignificant compared to increases at the internal margin, i.e., existing entrepreneurs increasing the quantity and quality of their decisions.

[45] Hirschman, op. cit., p. 27.

[46] Ibid.

[47] Richard L. Meier, Science and Economic Development: New Patterns of Living (2nd ed., paper; Cambridge, Massachusetts: The M.I.T. Press, 1966), p. 200.

Does greater capital-intensity, in the higher capital-labor ratio sense, conserve managerial decision-making? Both Hirschman and Meier reply in the affirmative:

> Certain types of modern technology perform a crucial function in aiding management in the performance of new, unfamiliar, and perhaps somewhat uncongenial tasks. By predetermining to a considerable extent what is to be done where and at what point of time, the machines and the mechanical or chemical processes they perform reduce these difficulties immeasurably in comparison with a situation where work schedules depend exclusively on the convergence and coordination of many human wills and actions.[48]

Also the LDC's:

> . . . will find upon careful investigation that the most automatic designs for factories, as elaborated by European or American engineering firms, would consistently use fewer engineers, managers and skilled workers than the alternatives available to them.[49]

An economist with the African Development Fund regards increased managerial efficiency as one result of larger scale.

> . . . costs may be reduced by an increase of efficiency in management, which tends to be better organized in large enterprises owing to the specification of functions as well as the more scientific approach to the task of coordination. Management would also be expected to apply more technical methods of production, or better techniques of combining and transforming resources, so as to bring about a new production function, as was emphasized by the late J. A. Schumpeter; the saving of management is especially important in developing countries because managerial skill is scarce.[50]

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[48]Hirschman, op. cit., pp. 146-47.

[49]Meier, op. cit., p. 200.

[50]G. Nguyen Tien Hung, "Economies of Scale and Economic Integration," Finance and Development (June, 1968), p. 37.

The core of the problem, therefore, is similar to that of maintenance, i.e., a scarcity of decision-making talent in LDC's and a greater need for it when using older vintage equipment.

Machine Operation. Not all operating costs are likely to increase. Earlier vintages of technology are often simpler to operate than modern machinery. When true, the equipment is more compatible with the existing skills found in LDC's. While the report of the group of experts agrees that maintenance skills required for modern machinery are usually greater for older equipment, they believe that the overall question of skills "is not clear-cut."[51] Waterson cited a United States official who had come to believe that obsolete machinery from the United States may be feasibly used in India because it ". . . is less complicated and hence more usable by workers unaccustomed to a high degree of automation."[52]

Capital Costs

Initial capital costs. The initial and annual cost of capital equipment will be lower than that of a new counterpart of the same technological vintage. But regardless of whether we speak of new equipment of an identical technological vintage or a later one, the (a) initial cost of

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[51] Report of Expert Group, op. cit., p. 13.

[52] Albert Waterson, "The Use of Second-Hand Machinery in Developing Economies," revised (October 4, 1962), mimeographed, p. 2.

capital, (b) its annual cost and (c) the cost of capital per unit of production must ordinarily be lower for UM in order to justify pursuing further calculations.

The Netherlands Economic Institute's example hypothesized an original cost of $40,000 and $100,000 for second-hand and new equipment, respectively. When differences in the life expectancy of equipment and a discount rate of 10 per cent were applied to capital cost, annual cost was $6,000 for the second-hand versus $11,500 for the new, a cost advantage slightly under 50 per cent for the UM.[53]

Adam Wiener gives the following figures as being typical comparisons of initial capital costs.[54]

> For standard metalworking tools such as lathes, grinders, brakes, millers and drill presses the following ratio of acquisition costs may be considered typical:

Type of Equipment	Cost Index
New 1965, USA	100
New 1965, Japan	70-80
Second-hand, new 1955, USA, rebuilt	65-75
Second-hand, New 1955, USA, in good operating order	25-45

> For heavy and special metalworking machinery such as boring mills, forging hammers, presses and vertical turrett lathes the following ratio of acquisition costs may be considered typical:

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[53]See the Appendix to this Chapter, Table 1, for the NEI figures.

[54]Wiener, op. cit., pp. 54-55. They are also restated in a different form in the final report for which Professor Wiener prepared his background paper. (Report of Expert Group, op. cit., p. 11.)

Type of Equipment	Cost Index
New 1965, USA	100
New 1965, Germany	70-90
Second-hand, new 1955, USA rebuilt	40-60
Second-hand, new 1955, USA in good operating order	30-50

A U.N. study reports that:

> Chemical process equipment, in good operating order, but not rebuilt, will sell for as little as 25 per cent to as much as 50 per cent of the original replacement cost for mechanical equipment, and up to 70 per cent for plate fabrication.[55]

An entrepreneur in Juarez, Mexico, purchased a gas compressor in Lansing, Michigan, for about 10 per cent of its original cost.[56]

The Ralph M. Parsons Company surveyed UM dealers and found "The results clearly indicated that a tremendous stock of used equipment exists, and could be purchased for an average of less than 50 per cent of similar new equipment costs."[57] The study also included a survey of quotations of rebuilt UM in the Los Angeles area. They found that:

> Generally, the price of completely remanufactured equipment with guarantees equal to new equipment ranged from 50 to 80 per cent of the cost of comparable new equipment, with most quotes from 65 to

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[55] Report of Expert Group, op. cit., p. 11.

[56] Information supplied by Mr. Carlos Borunda. This example appears again in Chapter V as an instance of an exception to some of the generalities expressed in this chapter.

[57] The Ralph M. Parsons Company, op. cit., p. 21.

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> 70 per cent. The actual cost of rebuilding equipment ranged from 15 to 33 per cent, the average being approximately 20 per cent.[58]

It is dangerous to generalize about UM.[59] But we may make some fairly safe statements about calculating the capital costs. The initial cost should be ascertained and, needless to say, should include the costs of initial repair, rebuilding, installation and transportation costs. This figure should then be expressed in annual terms, determined, of course, by the expected economic life of the equipment and discounted by the rate of return which would have been expected in alternative opportunities with similar levels of risk.[60] The cost of new equipment can be similarly calculated. Data can be converted into capital costs per unit of output by dividing the discounted annual cost of capital by annual output.

Economies of scale. One of the most intensively investigated techniques of conserving capital is that of economies of scale. The general thrust of technology has been to take advantage of the economies of scale. These economies have involved a greater initial expenditure

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[58] Ibid., p. 22.

[59] "Second-hand equipment, be it an individual machine, a group of machines, or an entire plant, must always be evaluated on its own merits. There is no existing reliable method for determining, a priori, the types of second-hand equipment suitable for use in developing countries. . . ." Report of Expert Group, op. cit., p. 7.

[60] I am assuming away scrap value and treating differences in costs of the gestation period as a separate point below.

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on capital equipment.[61] But, a higher original capital cost or a higher capital-labor ratio per year may still be capital saving in the sense of lowering the capital-output ratio.

Some of the beneficial effects of economies of scale naturally influence operating costs by increasing labor productivity, saving management, permitting savings in raw material through bulk purchases, and through the application of stochastic efficiencies in material and product handling. Direct reduction of capital costs results because of indivisibilities in advanced machines.

> Indivisibility implies that certain machines, which may not be built in small sizes, often operate at less than full capacity in a smaller-scale operation. When this happens, then the expansion of production merely uses up the excess capacity; this is particularly true in manufacturing that requires heavy initial investment cost,

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[61]There are, of course, notable exceptions. T.M.C. Systems and Power Corporation, a subsidiary of Technical Materiel Corporation, has designed a small Diesel engine. It ". . . develops approximately 20 B.H.P. on practically any fuel and has been designed to run irrigation pumps, small electric plants and small carriers such as light trucks." The engine is in a pilot stage at this writing and is ". . . specifically keyed to sales in relatively underdeveloped countries. . . ." Letter, R. H. de Pasquale, President, The Technical Materiel Corporation, September 10, 1968.

Also, as an example, the Intermediate Technology Development Group, Ltd., 9 King Street Covent Garden, London, W.C. 2, is a private nonprofit organization which is devoted to encouraging the development and marketing of small scale equipment. Those interested should see their current catalog, Tools for Progress; A Guide to Equipment and Materials for Small-Scale Development, 1967/1968.

such as steel mills, railroads and hydroelectric plants.[62]

Undoubtedly, economies of scale are very often formidable and when such technology is not restricted by, say, a small market size, lack of sufficient or dependable raw materials, etc., such economies are a major reason for preferring new to older equipment.[63]

Special plant requirements. Aside from the costs of the core equipment there may be differences in plant requirements associated with different technological vintages. Two forces operate on plant requirement costs, each in the opposite direction. The space per unit of output is likely to be lower for newer equipment either due to physical compactness or economies of scale. On the other hand, newer technological equipment often requires special temperature and/or humidity control within the plant, thereby raising the cost of the entire installation. This was, for instance, the findings of the ECLA investigation of the textile industry in Latin America.[64] The space requirements for

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[62] Tien Hung, "Economies of Scale and Economic Integration," op cit., p. 37.

[63] In Chapter V the various limitations of scales of production will be discussed. Also, the case of the Chihuahua paper plant will be related to problems of scale and will provide some fascinating insights into the possible use of old automated equipment in LDC's.

[64] United Nations, Economic Commission for Latin America, Choice of Technologies in the Latin American Textile Industry (Santiago Chile: ECLA, January 13, 1966), mimeographed.

Level A (1950 technology), B (1960 technology), and C (1965 technology) was 16,830, 17,050 and 16,530 square meters, respectively.[65] Since annual output was assessed 16,833, 19,629 and 21,495 thousands of meters of product,[66] it is obvious that space per unit of output decreases as the vintage of technology approaches the present. The opposite was found to be true for air conditioning requirements as the following citation indicates:

> The costs necessary to cover buildings and auxiliary installations were calculated in the light of the specific requirements of each technological level as regards operating conditions. For example, at level C air conditioning was postulated for the whole of the built-over area, because the high speed of the machinery and the delicacy of the controls mean that there must be not only humidity control, but also a constant room temperature. For level B, the air conditioning is restricted to the area occupied by the ring frames, the remaining areas having only humidity control, while for Level A no air conditioning is assumed, and there is humidity control only for the areas where it is regarded as indispensable.[67]

Differences in gestation period. The gestation period is used here to mean the time lag from the day plant construction incurs costs to the day it is in full operation. The typical phases will be those of planning, construction, and a period of testing and adjustment. The longer the gestation period, the higher two principal costs:

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[65] UN, ECLA, op. cit., p. 62.

[66] Ibid., p. 9.

[67] Ibid., p. 15.

(a) the loss of revenue due to postponement of sales, and (b) higher opportunity costs of the expenditures that are incurred.

The gestation period with UM will generally be shorter for several reasons:

1. Less specialized atmospheric control equipment is likely to be needed, as mentioned above.

2. A lower probability of a time-lag in acquiring the machinery from the manufacturer.[68]

3. Methods of installation and operation are known and usually observed elsewhere in the case of UM. This advantage is particularly pronounced when an entire plant is available on a turn-key or packaged plant basis with technical assistance available. Wiener describes such a case involving a synthetic rubber plant which had a difference in the gestation period of one year.[69]

4. Due to the greater divisibility of earlier vintages of technology there is a greater chance of beginning production on a partial basis as the construction proceeds.

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[68]When a significant lead time develops in new machinery, however, it inevitably drives the price of UM up, thus countering the advantage of reducing the waiting time.

"The price level fluctuates widely with the business cycle. As lead time for new equipment lengthens, large manufacturers eager to increase production enter the second hand market and push prices up." Wiener, op. cit., p. 32.

[69]Wiener, op. cit., pp. 8-9.

Hypothetical Cost Comparisons

An Economic Commission for Latin America study of the Latin American textile industry has been selected to supply the data from which hypothetical calculations can be made.[70]

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[70]Two other types of studies could have been selected. Several studies have compared hand or small factory versus mill production in Asia. See, for instance, Gustav Ranis, "Investment Criteria, Productivity and Economic Development: An Empirical Comment," QJE (May, 1962), pp. 298-302; A. A. Bhalla, "Investment Allocation and Technological Choice--A Case of Cotton Spinning Techniques," EJ (September, 1964), pp. 611-22 and his "Choosing Techniques: Handpounding vs. Machine Milling of Rice: An Indian Case," Oxford Economic Papers (March, 1965), pp. 147-57; and D. R. Campbell's "Comment" on Bhalla's articles, Oxford Economic Papers (March, 1967), pp. 133-35.

Another series of studies has been conducted by various United Nations agencies on the economies of scale. Among these are Economic Commission for Latin America, A Study of the Iron and Steel Industry in Latin America (New York: United Nations, 1954); United Nations, Interregional Symposium on the Application of Modern Technical Practices in the Iron and Steel Industry to Developing Countries (New York: United Nations, 1964); United Nations Bureau of Economic Affairs, "Problems of Size of Plant in Industry in Under-developed Countries," Industrialization and Productivity Bulletin, No. 2 (March, 1959); Economic Commission for Asia and the Far East, Formulating Industrial Development with Special Reference to Asia and the Far East (Bangkok: United Nations, 1961); United Nations, "Plant Size and Economies of Scale," Industrialization and Productivity Bulletin, No. 8 (New York: United Nations, 1964), pp. 53-61.

The hand methods, however, have little scope for employing used equipment and there are serious conceptual problems in handling the amount and cost of working capital. The studies on scale are less interesting than the ECLA textile study because they are really dealing with only one variation of what is essentially the same basic technological vintage. Aside from these reasons the textile study is used here and in a later chapter because the various components of total cost are given in much greater detail.

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The ECLA study[71] has the disadvantage of not including a fully automated technique. The closest approximation, a semi-continuous yard production which is combined with shuttleless looms, was in the experimental stage at the time that the study was conducted. The study does, however, provide an excellent variety of technological vintages. A 1930 vintage was not considered, but equipment associated with 1950, 1960 and 1965 was used. Extremely detailed information was gathered on equipment used in production of opening room, cards, equipment used in preparation for combing, combers, drawing frames, slubbing and roving frames, ring frames, cone winders, pirn winders, warpers, sizing machines and looms.[72] The number of permutations is staggering:

> . . . there is in fact no a priori guarantee that any particular combination will offer the most economic solution. For instance, production costs could be reduced to the minimum with any one of the 177,000 theoretically possible combinations of the three production alternatives and the eleven processing stages.[73]

Based on usual industry practice, however, they were able to select the stages most commonly associated with each vintage. Costs were then calculated in detail for labor and capital. The unit cost of material inputs were assumed to be the same for all vintages. The results of these calculations appear in Table 2 of the Appendix to this chapter.

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[71] Economic Commission for Latin America, Choice of Technologies in the Latin American Textile Industry (January 13, 1966), E/CN, 12/746, mimeographed.

[72] Ibid., Table 2, between pp. 12-13.

[73] Ibid., pp. 4-5. A footnote explains that to be exact it would be 177, 147 combinations.

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A Comparison of UM and New Machinery Using the ECLA Choice of Technologies Study

For comparative cost purposes we will use a hypothetical range of lower capital costs associated with UM, and a hypothetical range of net increases in operating costs associated with UM. To represent the lowered capital costs, the annual cost of used basic equipment will take the values of 50 per cent, 75 per cent and 90 per cent of new basic equipment.

The word "represent" is used advisedly; annual basic equipment cost differentials are chosen as the most logical proxy for all differences in annual capital costs which may arise. For example, basic equipment costs may be only a fraction lower for UM, but huge savings on a gestation period may lower its *effective* capital cost.

A rate of interest of 12 per cent per annum will be used as the opportunity cost of capital and basic equipment bought new will be depreciated on a fifteen year straight line basis.[74] Calculated on this basis the annual equipment costs are as follows:

Vintage of Technology	Annual Cost of Basic Equipment
1950	405,180
1960	557,570
1965	645,850

[74]Original costs for the basic equipment can be found in Appendix A, Table 2, Item 2, Line I, B.

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The ratio of annual UM costs to new machinery costs is determined by the net impact of many factors, the most important of which are age, condition, ease of repairing, gestation period and the effect on plant costs in terms of space and atmospheric conditioning.

In a similar vein, variable maintenance costs are used as a proxy representing the many factors affecting operating costs. These figures are $36,270, $50,474 and $58,630 for the 1950, 1960 and 1965 vintages of technology, respectively.[75]

Since we will assume the 1966 vantage point of the ECLA study, the calculations will proceed by assuming that the 1965 technology is not yet available in the UM market. For annual capital costs for UM of the 1950 and 1960 vintages, a range of 50 per cent, 75 per cent and 90 per cent will be applied to the annual costs of the new equipment. The variable maintenance costs of UM, however, will be assumed to rise by a range of 50 per cent, 100 per cent, 150 per cent and 200 per cent over the variable maintenance costs of the corresponding new equipment.

The net impact on unit cost of production has been set forth in a matrix shown in Table 3, Item 2, of the Appendix to this chapter. Total cost of production for the 1950 and 1960 technologies was adjusted to reflect various net impacts of a reduction in capital costs and an increase in

[75]See Appendix A, Table 2, Item 3, Line II, E.

operating costs. The adjusted UM cost of production was then divided by the annual output of the appropriate technology.[76] The unit costs of production are shown in a matrix in Appendix A, Table 3, Item. 2.

The results indicate that (a) the 1950 technique is not the most efficient under any assumed cost combination[77] (2) the 1960 technique is more efficient than the 1965 technique when the annual cost of used 1960 equipment is 50 per cent of that for new and (3) the 1960 technique is slightly more efficient than the 1965 technique when operating costs rise only moderately[78] and used 1960 equipment has an annual cost of 75 per cent of new.

At the time of the original study, the 1960 technique was only six years old, hence it is doubtful that such equipment could ordinarily be obtained at a price which would allow annual capital cost to be as low as 50 per cent of the new 1960 equipment. The most probable combination of costs in our example then, is the single case of 1960 technique with a low rise in operating cost and an annual capital cost of 75 per cent of the new.

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[76]See Appendix A, Table 2, Item 1, for annual output for the three technologies. Unit costs for the new technologies are shown in Table 3, Item 1.

[77]However, if the 1950 technique is used because of a political or social decision to increase employment, some of the UM cost combinations could cut the loss in static efficiency significantly.

[78]A 50 per cent rise may, on first glance, appear anything but moderate. It should be remembered, however, that variable maintenance cost is being used as a proxy for <u>all</u> factors that influence total operating costs.

The foregoing can be thought of as representing a first approximation to the methodology of comparing UM feasibility. On first glance the results seem compatible with what we observe in the real world. As a percentage of the total UM market in the United States, precious little is transferred to LDC's.[79] In Chapter VI, however, we will arrive at a rough guess that UM represents about 10 per cent of LDC's gross investment in equipment. Our first approximation to a cost comparison cannot account for such a large transfer of UM to LDC's. The explanation lies in a variety of "special situations" in which UM have added attraction. These special situations are reviewed in Chapter V.

This is by no means the only fashion in which the first approximation to a cost comparison will be altered. The hypothesis of this study states that LDC's are not using as much UM as they should. Even if attitudinal biases against UM were nonexistent (Chapter VI), there are social benefits associated with judicial employment of UM that should not be ignored. These additional benefits can be broadly classified as (1) differential rates of learning associated with UM and new machinery (Chapter III); (2) differential flexibility and balance of payments effects associated with UM and new

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[79]No world trade UM figures are available. The available United States data are scrutinized in Chapter VI.

machinery (Chapter IV) and (3) the likelihood that factor prices revealed by the market in LDC's bias comparative cost calculations against UM (Chapter VII).

APPENDIX A

APPENDIX A

Table 1

DATA FOR THE NETHERLANDS ECONOMIC INSTITUTE EXAMPLE OF COSTS WITH USED AND NEW EQUIPMENT

Hypothetical Production Costs with Second-Hand and New Equipment[a]

	Second-Hand	New
Price (including installation costs, etc.)	$40,000.-	$100,000.-
Depreciation (i.e., useful) period	10 years	15 years
Rate of interest for loans	10%	10%
Yearly output (maximum)	18,000.-	18,000.-
Normal output level required	16,000.-	16,000.-
Overhaul and repair costs per year	500.-	400.-
Yearly costs of light, floor space, insurance, etc.	1,000.-	800.-
Fuel and raw material costs for output of 16,000 pieces per year	16,000.-	15,000.-
Labor costs for output of 16,000 pieces per year	32,000.-	30,000.-
Raw material costs for output of 16,000 per year	16,000.-	16,000.-

Cost Information on the Two Machines Based on Output of 16,000 Units per year[b]

	Used	New
Sales value or price	$4,000.-	$15,000.-
Useful period	5 years	15 years
Rate of Interest	10%	10%
Yearly overhaul and repair costs	600.-	400.-
Yearly costs of light and space	1,100.-	800.-
Fuel and raw materials' cost per year	5,000.-	4,500.-
Labor costs per year	2,000.-	1,500.-

[a]Netherlands Economic Institute, Second-Hand Machines and Economic Development (Rotterdam: NEI, May, 1958), p. 9.

[b]Ibid., p. 14.

Table 1 (Cont'd.)

Calculation of Costs	Direct Operating Costs, Used Machine	Full Costs, New Machine
Annuity, based on purchasing costs of new machine of 15,000, depreciation period of 15 years and rate of interest of 10%:		
$\frac{1}{15} \cdot 15{,}000.- + \frac{1}{2} \times 0.10 \cdot 15{,}000 =$		\$2,250
Overhaul and repair costs	\$600.-	400.-
Light and space	1,100.-	800.-
Fuel and raw materials	5,000.-	4,500.-
Labor costs	2,000.-	1,500.-
Totals	\$8,700.-	\$9,450.-

Annual Cost per Year for Output of 16,000 Units[c]

	Second-Hand	New
Annuity	\$6,000.-	\$11,500.-
Overhaul and repair costs	500.-	400.-
Light, floor space, etc.	1,000.-	800.-
Fuel and raw materials	16,000.-	15,000.-
Labor costs	32,000.-	30,000.-
Raw materials	16,000.-	16,000.-
Total costs	\$71,500.-	\$73,700.-

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[c] *Ibid.*, p. 10.

APPENDIX A

Table 2

DATA ON COSTS USED BY THE ECLA TEXTILES STUDY ON CHOICE OF TECHNIQUES

1. Annual output of Fabrics (in Thousands of Meters) and Labor Force[d]

	1950 Technology	1960 Technology	1965 Technology
Output	16,833	19,629	21,495
Labor force (three shifts)	668	446	315

2. Total Investment Requirements for Each Hypothesis[e]

Type of expenditure	1950 Technology	1960 Technology	1965 Technology
I. Fixed investment	3 992 780	5 136 792	5 942 273
A. Buildings & ancillary fittings	922 090	962 720	1 108 190
B. Equipment	2 170 602	2 987 102	3 459 942
C. Freight & insurance	217 060	298 710	345 994
D. Construction cost	90 675	126 185	146 573
E. Pre-operational costs	102 012	131 241	151 821
F. Interest payments during construction period	490 341	630 834	729 753
II. Working capital	460 560	521 750	565 360
A. Permanent stock of working capital	460 560	521 750	565 360
III. Total investment	4,453 340	5 658 542	6 507 633

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[d]ECLA, Choice of Technologies in the Latin American Textile Industry (Santiago: ECLA, January 13, 1966), p. 9.

[e]Ibid., p. 64.

Table 2 (cont'd.)

3. Annual Production Costs by Vintage Technology and Cost Category[f]

Cost Category	1950 Technology	1960 Technology	1965 Technology
I. Fixed costs	1 130 812	1 304 969	1 470 927
A. Fixed labour	165 000	134 400	126 120
B. Administrative labour	81 840	75 840	93 120
C. Social security	98 736	84 096	87 696
D. Maintenance	18 135	25 237	29 315
E. Depreciation	227 751	302 339	349 976
F. Interest	534 400	679 025	780 916
G. Overheads	4 950	4 032	3 784
II. Variable costs	2 361 023	2 437 663	2 514 539
A. Raw material	1 644 064	1 917 632	2 100 896
B. Ancillary materials	32 881	38 352	42 018
C. Variable labour	397 272	240 432	153 864
D. Social security	158 909	96 173	61 546
E. Maintenance	36 270	50 474	58 630
F. Electric power, water & steam	56 735	58 576	60 424
G. Sales expenditure	34 892	36 024	37 161
III. Total costs	3 491 835	3 742 632	3 985 466

[f]*Ibid.*, p. 67.

APPENDIX A

Table 3

1. Unit Cost of Production of New Machinery[g] (in cents)

Technological Vintage	Cost per Meter
1950	20.744
1960	19.067
1965	18.541

2. Unit Cost of Production with Used Machinery (in cents)

Percentage Rise in Variable Maintenance Cost		Ratio of UM Cost to New Machinery Cost		
		50%	75%	90%
1950 Technology	50%	19.715	19.921	20.049
	100%	19.813	20.029	20.157
	150%	19.921	20.137	20.265
	200%	20.028	20.245	20.372
1960 Technology	50%	17.775*	18.485*	18.987
	100%	17.904*	18.614	19.156
	150%	18.032*	18.742	10.244
	200%	18.161*	18.871	19.373

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[g]Adapted from data in <u>ibid</u>., p. 9 and p. 67.

*Those combinations of cost changes that result in a lower cost of production than the 1965 technology.

PART II

CHAPTER III

MAINTENANCE, LEARNING, AND USED MACHINERY

This chapter is essentially a little treatise on the economics of maintenance in LDC's. It is more general than the chapter title implies in at least two respects. First, much of the analysis could be applied to new capital equipment, and second, much of the analysis could be slightly modified and applied to any learnable process. Maintenance is chosen as a proxy for learnable activities due to its typically magnified importance as a complement to UM. Only toward the end of the chapter will the connection between the economics of maintenance and UM be made. It is hoped that, by that point, the connection will be rather obvious.

Maintenance consists of those activities that keep the physical plant in good operating order. For purposes of economic analysis, however, it is desirable to define the term more precisely. "Maintenance" will be defined as activities performed in order to prevent malfunctions from occurring as opposed to "repair" which consists of taking measures to restore equipment to proper working order. There is a compelling practical reason for making this distinction because the need for repair is almost always evident, while such is not often the case for maintenance. Since our concern will center primarily on maintenance as a substitute for capital, it is also convenient to exclude those actions which are unavoidable if day-to-day production is to take place. Following Strassmann and Blitz, maintenance is postponable and it extends the life of capital equipment.[1]

The Nature of Maintenance

It is easier to define maintenance than to describe its nature adequately. "Maintenance capability" depends on a complex of inputs, including the following:

1. The tools of the trade, such as lubricants, cleaning cloths, testing equipment, etc.

2. Disembodied knowledge taking such forms as equipment manuals and standard operating procedures.

3. A range of human abilities which include attitudes, managerial talent, technical skills and manual skills that are important to maintenance. We will refer to these as "maintenance abilities." Since maintenance abilities make up the most complicated component of maintenance capability, further elaboration is warranted.

Maintenance Abilities

Perhaps the most important element in maintenance abilities is the most difficult to quantify. If the entrepreneurial or top management group "believes in" or has

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[1] W. Paul Strassmann, Technological Change and Economic Development (Ithaca, New York: Cornell University Press, 1968), p. 197. Strassmann cites Rudolph C. Blitz, "Capital Longevity and Economic Development," AER (June, 1958), pp. 320-22.

"faith in" ultimately reaping positive results from resolutely pursuing a maintenance program, the chances for maintenance capabilities to be translated into better maintenance is immeasurably enhanced. In a mature industrial society where the benefits of applying maintenance procedures is well known, the undertaking of a maintenance program is scarcely an act of faith or an act of pure entrepreneurial risk taking; indeed, not spending on maintenance would be the mark of a deviant. The difference in LDC's hinges mainly on (a) the lack of carefully compiled data on the application and results of maintenance in LDC's and/or the lack of dissemination of such data (b) the lack of simple, routinized maintenance programs that can be easily imitated (c) the postponability of maintenance (up to a point) and (d) the concentration of managerial effort on immediate profits.

Under these conditions, formulating and implementing a comprehensive maintenance program is an entrepreneurial function; it necessitates risk taking and innovation. Middle management (when it exists) has the responsibility of developing a detailed procedure prescribing objectives, responsibilities scheduling, coordination among departments, priorities, and budgets in connection with maintenance. Lower management and the first line supervisory staff have the task of implementing the details of a maintenance program. The role of a technical specialist and that of the machine operator is performing the lubrication, tolerance testing, parts inspection, grit removal or similar tasks. Ideally each echelon should undertake a training function, be it formal or informal; check on the next lower echelon to see that the maintenance is being done; and a feedback of information should flow from lower to higher echelons.

The Importance of Maintenance

Several representative citations from the literature were adduced in Chapter II which indicated that (a) maintenance abilities are likely to be scarce in LDC's relative to industrial countries and (b) usually more maintenance will be required when producing with UM vis-à-vis a new alternative. By way of further introduction, three additional aspects of maintenance need to be mentioned.

1. Maintenance expenditures often constitute an important proportion of costs. The number of maintenance employees per one hundred employees has been estimated to range from six in the rubber and electronics instruments industries to fifty for chemicals.[2] In relation to the machine tool industry, Aleksandr S. Pronikov points out that expenditure on both repair and maintenance accounts for "a considerable proportion of production costs."[3] These

[2]United Nations, Industrialization and Productivity Bulletin, No. 4, p. 30, citing "Maintenance Management Practices Today," Factory Management and Maintenance (New York: McGraw-Hill, October, 1958), p. 138.

[3]Aleksandr S. Pronikov, "Repair and Maintenance of Machine Tools in the Developing Countries," Industrialization and Productivity Bulletin, No. 10 (New York: United

figures, however, undoubtedly underestimate the real expenditure on maintenance. If the time and effort of management, supervisory staff and production worker were taken into account, the maintenance proportion of costs would be even larger.

2. LDC's have a greater need for maintenance than developed countries.

The natural corollary of scarce maintenance skills and scarce capital is the greater need in LDC's for additional maintenance skills. This view is adequately expressed by the following excerpt:

> There is hardly need to stress the importance of maintenance and repair in under-developed countries where scarcity of capital is a major obstacle to industrialization. Investment in a piece of equipment--especially imported equipment--represents a considerably greater social cost in terms of resource input than is the case in developed countries.

Nations, 1966), p. 76.

According to Pronikov: "Research has shown that every year approximately 10 per cent of the stock of technical equipment undergoes major overhaul, 20 to 25 per cent intermediate overhaul and 90 to 100 per cent minor overhaul." Ibid.

Again: ". . . in an average-sized or small enterprise the cost of major overhaul alone is normally up to 60 per cent of the cost of a new machine in the case of medium-sized turning lathes, up to 40 per cent in the case of universal milling machines and up to 75 per cent in the case of capstan lathes." Ibid.

Further: ". . . the cost of maintaining and servicing a machine tool during one maintenance cycle (that is, up to and including the major overhaul) is greater than the cost of a new machine, and if maintenance and repair is badly organized can be several times greater." Ibid.

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> Under these conditions, waste of equipment which could be avoided by good maintenance practices or adequate repair is extremely poor industry practice; in fact, even more care is called for to ensure optimum performance of each piece of equipment.[4]

3. If maintenance is important in developed countries and even more important in LDC's, but there is a greater scarcity of skills in LDC's, one naturally asks what exists in the way of concrete knowledge or hard data on maintenance in LDC's? This is best answered, I think, in a letter from Professor Dr.-Ing. H. A. Havemann. Professor Havemann is the Director of the Research Institute for International Technical Cooperation in Aachen, Federal Republic of Germany, and a member of the managing committee of the United Nations Institute for Training and Research. I had asked Professor Havemann about the availability of hard data on the costs and returns of expenditures on maintenance and maintenance training in LDC's. His reply: ". . . we know from experience that there is at the moment no institution nor organization who could give you adequate relevant data."[5]

In spite of its importance, then it appears that we possess little empirical data on the economics of maintenance

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[4]Division of Industrial Development of the United Nations Department of Economic and Social Affairs, "Use of Industrial Equipment in Under-developed Countries; Problems of Maintenance, Repairs, Replacement and Obsolescence," Industrialization and Productivity Bulletin, No. 4, op. cit., p. 31. (Emphasis supplied.)

[5]Letter, April 12, 1967.

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in LDC's. Operating under the presumption that one prime function of economic theory is to pinpoint what needs to be measured, and further, that data gathering will usually follow when the theoretical framework is adequate, a model will be developed that represents the economics of the application and production of maintenance skills as a substitute for capital equipment. There follows a discussion which identifies (a) the variables in the model that are likely to differ significantly in LDC's compared to industrial countries and (b) the probable divergencies between social and private costs and returns to the economics of maintenance in LDC's.

The Economics of Substituting Existing Maintenance Abilities for Capital Equipment

Assuming a Fixed Amount of Installed Capital Equipment

The analysis will begin with an individual firm utilizing a fixed amount of capital equipment. The firm represents a small portion of demand for maintenance capability, thus it faces a relatively elastic supply for maintenance.[6] Maintenance exhibits diminishing returns per unit added, at least along the relevant portion of its demand curve.

As we have seen, maintenance activity is composed of several heterogeneous elements. In order to speak meaningfully of a "unit of maintenance," it will be defined as some fixed amount of dollar expenditure on any package or

[6]As implied by the greater shortage of such skills in LDC's, an industry, or the economy as a whole, is likely to face a more inelastic supply situation.

combination of maintenance inputs that will best complement capital durability in the short-run and substitute for it in the long-run.

The costs of maintenance consist essentially of (a) costs of materials, e.g., lubricants, minor tools, rags, manuals, etc., (b) additional wages, paid either at the external margin to hire more workers and/or at the internal margin to reward better performance, (c) net costs of spare parts,[7] and (d) costs of additional plant facilities and major equipment that might be needed for maintenance.

What are the returns to maintenance? As more maintenance is applied, capital is conserved in two ways:

1. Equipment downtime is reduced because of fewer breakdowns.[8] These savings can be ascertained by multiplying the reduction in downtime by the average productivity of the equipment per time period. The savings signify a conservation of capital in the sense of reducing the capital-output ratio.

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[7]Preventive maintenance is a substitute for repair, so it can reduce the rate of spare parts consumption. But one approach to preventive maintenance may be the application of a more stringent rule for disposing of a spare part, e.g., automatically replace it after six months use rather than nine months. The net result will be assumed to be a saving of spare parts since most forms of preventive maintenance prolong the life of parts. Also the higher costs of spare parts coupled with cheaper labor in LDC's would motivate expenditure on labor-intensive maintenance to <u>conserve</u> capital expenditures on spare parts.

[8]As in the case of spare parts, the greater application of preventive maintenance can be a complement of downtime (e.g., more frequent inspections or overhauls) or a substitute for it (e.g., fewer breakdowns of equipment). We will assume that the net result of more maintenance expenditure is the reduction of downtime.

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2. The physical and perhaps the economic life of the equipment is lengthened. Since it is assumed that capital equipment is installed, the durability engineered into it and the maintenance applied to it are complements in producing capital longevity. By lengthening the life of the equipment, increments of maintenance reduce annual capital costs.

The trade-off between costs and returns can be set up in a simple model. For simplicity we will assume that the cost of materials is negligible and maintenance activities can be expanded within existing plant facilities.

The following symbols will represent the relevant variables. Each is expressed in incremental terms and can be thought of as the value that will obtain due to a change of expenditure on maintenance by one dollar.

ΔO = The change in value added per year due to a change in downtime of the equipment.

ΔK = The change in capital costs per year due to extending the economic life of the equipment.

ΔW = The change in the annual wage bill.

ΔP = The net change in spare parts expenditure per year.

The gist of equating at the margin is to spend dollars on $(\Delta W+\Delta P)$ until it equals $(\Delta O+\Delta K)$. But what are the ways in which maintenance can be made more intensive? The following list includes some of the principle possibilities:

1. Assign more workers to operate a machine.[9]

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[9]For an interesting example of this technique, see David Granick, Soviet Metal-Fabricating and Economic De-

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2. Increase the number of hours devoted to managing, supervising or carrying out maintenance tasks.

3. Hire personnel with a higher level of embodied maintenance ability.

4. Switch brighter and more able personnel into supervising or performing maintenance.

5. Farm out maintenance problems by hiring consultants or other experts outside the firm.

6. Increase the frequency of inspections.

7. Increase the depth or precision of inspections.

8. Make specifications more rigorous, e.g., shorten the time span for automatically discarding a part.

All of these, of course, can be used in combination, e.g., an increase in, say, 6 or 7 might call for an increase in expenditures on 1, 2, or 3.

If there is a fixed amount of maintenance capability available to the economy as a whole, and all capital is installed, maintenance should be applied until the marginal social return on a unit of maintenance is equal to its marginal social cost.

Assuming a Variable Amount of Durability

If the assumption of having only installed capital equipment is relaxed, the entrepreneur can achieve capital

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velopment; Practice versus Policy (Madison, Milwaukee: The University of Wisconsin Press, 1967), pp. 104-10. It may also be a useful technique for learning maintenance routines, thus increasing maintenance capability.

longevity with a variety of maintenance-durability mixes. In the short-run maintenance complements durability; when capital replacement and a range of available techniques are assumed, maintenance and durability become substitutes.[10] Since the process of engineering more durability into capital is not free, it increases the initial cost of capital equipment.[11] The application of more maintenance will incur costs along the lines described earlier and reaps an additional return of reducing the capital costs required to reach a given target of physical life of equipment. The lengthening of the useful life of installed capital equipment yields short-run capital economies. These savings, ΔK, result from complementing a given amount of durability with additional expenditures on maintenance. As equipment changes occur in the long-run it is possible to achieve a given target of useful equipment life by choosing different proportions of maintenance and durability expenditures. When both maintenance and durability expenditures are variable, maintenance is a substitute for durability. We can introduce ΔD to represent the capital savings due to choosing less durability-intensive capital equipment. The equation for optimizing

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[10] For an excellent analysis see Rudolph C. Blitz, "Maintenance Costs and Economic Development," JPE (December, 1959), pp. 560-70. Some considerations of maintenance and durability had been developed in his earlier model appearing in "Capital Longevity and Economic Development," AER (June, 1958), pp. 313-29, but the later work is more general and aimed specifically at problems of LDC's.

[11] It may, and, indeed, should reduce the cost of capital per time period given the level of maintenance.

maintenance expenditures is now expanded to

$$\Delta W + \Delta P = \Delta O + \Delta K + \Delta D$$

where ΔD is the reduction in capital costs per year due to purchasing less durability.

Here again an optimal solution for the economy as a whole would entail the application of maintenance until the social returns and social costs are equated at the margin. The marginal cost and marginal product of using maintenance would be equal in all firms in all industries if we assume long-run equilibrium in a neoclassical world without externalities.

Assuming a Variable Amount of Maintenance Abilities in the Economy

The analysis will now proceed to a more complicated, but far more rewarding stage. It has been tacitly assumed that the supply curve of maintenance abilities for the economy as a whole is perfectly inelastic. In the very short-run this probably is a fair representation of reality. But through time the quantity and quality of maintenance skills can be varied. There are two dimensions to an expansion of maintenance capability. First, there can be an expansion in the size of the economy's maintenance force possessing roughly the same abilities and/or an upgrading of the abilities of the existing maintenance force.

Suppose expenditure on training can increase the effective supply of maintenance abilities. What is the optimal rate of such expenditure? The secret, of course, lies in identifying the marginal costs and returns involved. The marginal gross returns to producing and applying an additional unit of maintenance ability will be the difference between the marginal return and cost of applying it or

$$(\Delta O + \Delta K + \Delta D) - (\Delta W + \Delta P).$$

The difference can be designated as M_r. A discount rate should be applied when projecting this return into the future due to (a) the orthodox discount applied to any future flow of income, and (b) the likelihood that there will be attrition in the value of learned maintenance abilities as new techniques emerge.[12] Conceptually one might think of maintenance abilities as comprised of three components:

1. A component that depreciates very slowly if at all, e.g., the entrepreneurial commitment to the principle of maintenance, the habit or idea of maintenance, the technique and need for using manuals, principles of routinizing

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[12]The discounted revenue for any one year would be

$$\left(\frac{M_r}{M_r + (i+d)}\right)^t$$

where t is the relevant time period, i the interest rate and d the rate of depreciation of maintenance skills. If we allow T_r to represent gross present value after t years of use of the maintenance skills we get

$$T_r = \int_1^t (M_r)^{e - (i+d)^t} \cdot \partial t$$

maintenance activity, etc.[13]

2. One component of maintenance ability must be gradually adjusted to a flow of minor alterations in management control, equipment designs, new lubricants, etc. The rate of introduction of such change is assumed to be rather slow and steady in its overall impact.

3. A third component is subject to radical reduction in value because of abrupt changes in approaches to maintenance. In the switch from maintaining mechanical equipment to performing such services on electrical equipment, probably little is salvaged beyond those types of abilities classified in number 1 above.[14] The blow of such radical changes is softened somewhat if the older equipment is gradually phased out. In this case it more nearly

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[13]In one case an Asian expert was baffled because the language of an area had no word for the concept of maintenance. "Use of Industrial Equipment," op. cit., f.n. 10, p. 31.

We are assuming here that once certain basic principles of maintenance are learned, they, like swimming and riding a bicycle, are not forgotten.

[14]Scarcities of maintenance skills are created in developed areas by these technological leaps. A recent study prepared for the Office of Manpower Policy of the United States Department of Labor by the International Labor Office was inspired by the fear of scarcity of maintenance in highly mechanized and automated industries. International Labor Office, Training of Maintenance Workers, AUT/DOC/6 (Geneva: International Labor Office, 1967). The report concluded, however, that training facilities and methods had prevented severe scarcities from developing and had not prevented introduction of new technologies. Ibid., pp. 31-32. The study covered Belgium, France and The Federal Republic of Germany.

resembles number 2 above. The proper discount rates due to sudden change can be handled by introducing probability weights expressing the odds and extents of abrupt qualitative changes in maintenance requirements.

In any event, the present value of an expenditure on producing maintenance abilities should be calculated as the present value of a stream of revenue resulting from the application of the newly created amount.

The costs of producing maintenance abilities can involve (1) wages paid to the personnel while training, (2) the cost of fixed capital devoted to training, and (3) the cost of supervisory and teaching personnel. The <u>net</u> present value, R_n, can be calculated by subtracting the cost of producing the added maintenance ability, T_c, from the present value as shown below:

$$R_n = {}_1\int^{t} (M_r - T_c)^{e \; - \; (i+d)^t} \; . \; \int t$$

A firm should keep producing maintenance skills until its R_n on the added training is zero.

The Relevance of the Model to LDC's

In this section an attempt is made to catalog the variables in the model that are different for LDC's vis-à-vis developed countries. These differences will primarily center on divergencies between social and private costs and returns experienced in LDC's.

Revealed vs. Shadow Price Evaluation

Chapter VII elaborates on the effect of the revealed price of labor exceeding its real cost and costs of capital and foreign exchange being below their real costs. If the reader will patiently defer his demand for documentation until that point, a sketchy summary of the pertinence to the economics of maintenance is presented below:

1. The social cost of wages for training raw recruits is likely to be considerably below the wages paid by a firm. This point should not, however, be generalized beyond unskilled and semi-skilled workers.

2. The value of the capital equipment saved is likely to be underestimated even if it is all available domestically. To the extent that it is imported there is an additional deficiency in valuing the capital saved. The social opportunity value of capital is greater than its market price and is more so for imported capital or for capital with significant amounts of imported inputs.

By the same token, however, there will be a tendency to underestimate the value of the capital facilities used in training, since these can often be constructed by labor-intensive methods.

Results of the Scarcity of Existing Maintenance Skills

The dearth of maintenance abilities leads to economic rents in the upper ranges of expertise. Thus, the revealed costs are higher than their real costs. At the lower range of mainte

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of maintenance skills (perhaps a worker who knows how to lubricate his machine and has at least some appreciation of its importance) the divergence between revealed wages and real wages persists despite abundance. The imperfections of the market for unskilled and semi-skilled workers accounts for this phenomenon. At the upper range of maintenance expertise (perhaps a maintenance engineer or a good supervisor) the divergence occurs because of scarcity. The market mechanism, in the short-run allocation of scarce human resources, operates all too well. The allocation of maintenance skills gets the worse of two worlds. Several consequences of this scarcity are discussed below:

A. Despite the costs, the potentially high returns to using skilled maintenance personnel lead to a tendency of "piracy" in LDC's.[15] Several results obtain:

1. Piracy wastes entrepreneurial and managerial talents in competitive efforts to recruit and hold able supervisors and skilled workers.

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[15]"While the private concern can certainly institute its own training program . . . the danger of pirating remains an inhibiting factor. There is too much temptation to allow some other company to bear the training cost--which can often involve hundreds of dollars per trainee per year--and then entice the apprentice away with an offer of a wage somewhat above that promised by the firm undertaking the training. Therefore, at little extra cost, the pirating firm is spared making training outlays, as well as the uncertainty involved in the success of its efforts." Edward and Mildred Rendl Marcus, "Capital/Labor Ratios and the Industrialization of West Africa," in Norman N. Barish and Michel Verhulst, eds., Management Sciences in the Emerging Countries (Oxford: Pergamon Press, 1965), pp. 230-31.

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2. It forces the private wages of highly capable managers, supervisors and skilled laborers further from their social opportunity cost.

3. It leads to less production of such abilities because of (a) the resultant increase in labor turnover and (b) as the Marcus's citation in footnote 15 indicates, piracy offers a tempting substitute for training.

B. Scarcity encourages the <u>hoarding</u> of maintenance abilities.[16] When embodied abilities are hoarded in the sense described by the Marcuses, presumably resources are being wasted. Evidently the hoarding firm currently lacks complementary equipment, but assuming these exist elsewhere in the economy, waste is being incurred.

C. The high quasi-rent of especially able employees discourages the optimal allocation of maintenance as a substitute for capital.

D. Hoarding may be motivated by the desire to gain monopolistic profits in performing overhauls for smaller firms that cannot afford the fixed cost of maintenance and repair facilities.[17]

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[16] The Marcuses believe one advantage of taxing business to finance government sponsored training would be to alleviate hoarding of this sort: "The tax would not only help finance the educational program, but also lessen the temptation to hoard skills that are in short supply by putting the trained workers on jobs that require lesser trained personnel." <u>Ibid</u>., p. 231.

[17] ". . . small private firms are at the mercy of the large companies for practical assistance (for example, major overhauls requiring specialized tools) and must pay whatever price is asked." Quote from one response to a questionnaire

<u>Economic Deterrents to Producing Maintenance</u>

What specifically stands in the way of the production of maintenance skills in LDC's? There may be some attitudinal barriers, e.g., management may regard labor as an undifferentiated, uneducable "lump," there may be an engineering bias favoring the purchase of the maximum amount of durability, management may have a short time horizon which discourages projects that fail to show immediate returns, or the interfirm turnover of labor may be high in a particular area.

If individual firms will not undertake training projects, the alternative is for some industrial or governmental organization to do it, but it is unlikely that such programs can escape an increase in administrative costs. The scarcity of good administrative talent in LDC's and the decreased ability of such programs to focus on specific problems of a firm would cause difficulties. There are many considerations, however, which counter arguments against public sponsored maintenance training.

1. Whether or not something is wasteful in the sense of departing from optimal efficiency does <u>not</u> mean that it should not be undertaken. Getting rid of the waste is one issue; whether social returns will exceed those of

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on maintenance in LDC's, <u>Report of the Group of Experts on Maintenance and Repair of Industrial Equipment in Developing Countries</u>, I.D./1 (Vienna: United Nations Industrial Development Organization, April 21, 1967), mimeographed, p. 19.

alternative expenditures despite the waste is another.

2. There would be a net gain in rendering the supply of highly skilled workers more elastic which in turn reduces quasi-rent to such skills.

3. The wasted resources from pirating and hoarding maintenance abilities would be reduced.

4. Economies of scale may well be possible. Pierre Drouet says of training in vocational schools:

> This system of training also makes it possible to achieve marked economies of scale whenever the same facilities can be used for a number of different trades. At the national level further economies can be achieved by ordering equipment in bulk for public and private training schools and by devising programmes and courses for students throughout the country.[18]

5. A shadow price evaluation of the costs and returns of applying and producing maintenance skills would probably favor more of both.

6. Many cases of "bargain basement" or highly leveraged returns from training undoubtedly exist. When the requisite worker skills are rather simple, maintenance problems can be solved by focusing on one or more of the following: (a) creating or stimulating an appreciation by entrepreneurs of the benefits that obtain from proper maintenance (b) providing the training and motivation of management needed for them to set up appropriate routines and

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[18] Pierre Drouet, "Economic Criteria Governing the Choice of Vocational Training Systems," International Labor Review (September, 1968), p. 200. The article also discusses possible economies of scale for other types of training.

procedures within a workable organizational structure and (c) providing supervisory personnel with the knowledge enabling them, and incentives encouraging them to persistently see that maintenance work is accomplished. Compared to training workers, a training program for "key" personnel can influence a far greater amount of production and capital equipment without a proportionate increase in training cost.

7. Training could reduce the strain on foreign exchange necessitated by importing foreign technicians from abroad.[19]

8. A point especially appealing to small countries, the human material for maintenance training is likely to be far more homogeneous than the capital for which it substitutes. A small country like Honduras has a much better chance of rounding up capable trainees for an advanced maintenance course than it has of producing equipment for, say, an automated glass bottle plant.

9. To the extent that a greater supply of maintenance abilities permits the choice of technique to be less capital intense, there is a greater likelihood that more spare parts can be locally manufactured.

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[19]See Report of the Group of Experts on Maintenance, *op. cit.*, p. 31.

Methods of Producing Maintenance Skills

What are the various possibilities of producing maintenance abilities? A brief, but hopefully suggestive listing follows:

More Maintenance Abilities in Quantity or Quality

1. Learning while doing.
2. On the job training.
3. Formal training combined with production hours.
4. Formal training, full time.
5. Incentive programs rewarding superior or penalizing inferior maintenance.

More Efficient Use of Existing Skills

1. Work simplification and gradation.[20]
2. The adaptation of the proper level of maintenance organization within the plant.[21]
3. Centralization of some maintenance operations within industrial parks.

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[20]"There obviously is a need for repair simplification--analogous to work simplification--so that the desired steps can be made learnable. Again we have an opportunity for a gradation of skills, the more complicated tasks being reserved for the more experienced, with wages rising correspondingly." Edward and Mildred Marcus, op. cit., p. 229. In a footnote on the same page they state that "In the Northern Rhodesian Copperbelt, as a means of upgrading African labor, jobs formerly held by Europeans are broken into several simpler tasks which, taken together, are equivalent to the original job."

[21]For a detailed description of the methods of control, conditions for suitability, advantages, disadvantages and conclusions concerning five levels of maintenance organization, see Appendix I, "Use of Industrial Equipment in Under-developed Countries," op. cit., pp. 44-45.

Learning and Used-Machinery

Learning while doing has several important advantages over other methods of learning. First, the opportunity cost in terms of wages paid will be slight. Second, the salary involved in supervision attributable to training will be less. Third, the plant facilities need not have special areas for training set aside. Fourth, there is a large positive output during the learning period. Fifth, there is evidence that previous experience is a complement to formal training. Sixth, if combined with some on-the-job training ". . . the job has to be done correctly, and one quickly learns how important it is to work to high standards."[22] Seventh, some things can be better learned, or, in some cases *only* learned by actual experience.[23]

Learning while doing involves the accumulation of experience by exposure to a particular set of circumstances and variations on these circumstances over an extended period

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[22] *Report of the Group of Experts on Maintenance*, *op. cit*., p. 44.

[23] "The ability to anticipate and diagnose trouble on a piece of operating equipment . . . requires close association with that particular piece of equipment over a prolonged period of time." Michael T. Piore, "On-the-Job Training and Adjustment to Technological Change," *Journal of Human Resources* (Fall, 1968), p. 440.

Also "Many manufacturing processes, for example, are monitored by the sound, smell, and feel of the operating equipment: the operator 'senses' whether it is running smoothly and, if not, where the trouble is. In chemical processes, he sometimes tastes the product. Such 'skills' are developed over time through continual association with a process." *Ibid*., pp. 443-44.

of time. Gradually the rate of learning in one particular set of circumstances begins to slow as new knowledge is translated into routine responses. There have been several attempts to theorize on learning while doing and to quantify the economic results. Micro-studies have concentrated on empirical measurements of the behavior of some important variable as related to cumulative output. In these cases cumulative output is used to measure "experience."[24] Kenneth Arrow has developed a theoretical model which uses the economy's rate of capital accumulation as a proxy for learning on a macro-scale.[25]

Two conclusions emerge from the micro-data. First, if roughly the same set of production techniques are used, the gains from learning rapidly deplete themselves and

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[24]Of special interest to the purposes of this dissertation were Werner Z. Hirsch, "Manufacturing Progress Functions," Review of Economics and Statistics (May, 1952), pp. 143-55; Frank J. Andress, "The Learning Curve as a Production Tool," Harvard Business Review (January-February, 1954), pp. 87-97; and Winfred B. Hirschmann, "Profit from the Learning Curve," Harvard Business Review (January, 1964), pp. 125-39. For a useful critique of the learning curve as an analytical tool, see Kenneth Frederick Hammer, "An Analytical Study of 'Learning Curves' as a Means of Relating Labor Requirements to Production Curves," unpublished Master's thesis, Cornell University, September, 1954. Lester B. Lave has a useful bibliography in his Technological Change: Its Conception and Measurement (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966), p. 150. Mr. Charles Strong of the School of Business of the University of Texas at El Paso has prepared an exhaustive bibliography in mimeographed form.

[25]Kenneth Arrow, "The Economic Implications of Learning by Doing," Review of Economic Studies (June, 1962), pp. 155-73.

second, the rate of learning is more pronounced when the operations are less mechanized. The learning curves, progress curves, or Veerdourn effects as the phenomenon is alternately labeled, show a steep negative slope which rapidly approaches a limit when the proxy for "performance" is measured on the vertical scale, and that for "experience" is on the horizontal axis. Such curves have the general form $Y = y(X)^{-n}$ where the y and n are constants while Y represents performance and X represents experience. On a log graph the results, when plotted, have a constant negative slope. Examples are given on the following page which resemble the experience of aircraft assembly and petroleum refining.

A comparison of the slopes of the two examples indicates that the aircraft industry experiences a greater increase in efficiency due to learning while doing. At least this is the surmise by Hirschmann. Speaking of petroleum refining he says: "The line has a 'slope' of about 90%, as might be expected from a machine-paced operation which involves comparatively little direct labor."[26] The

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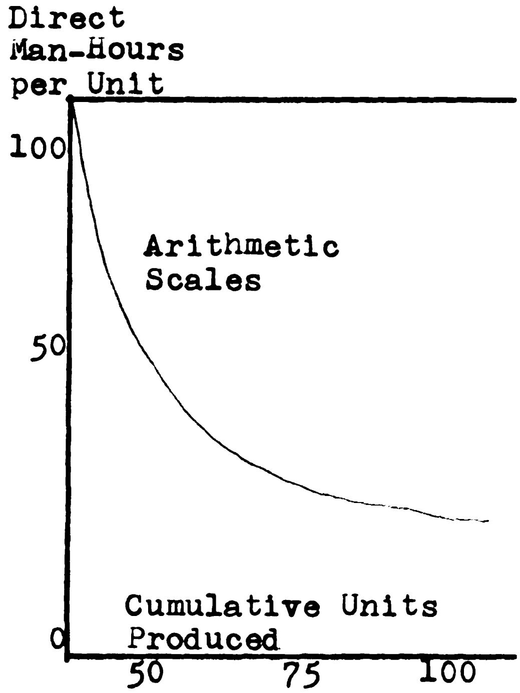
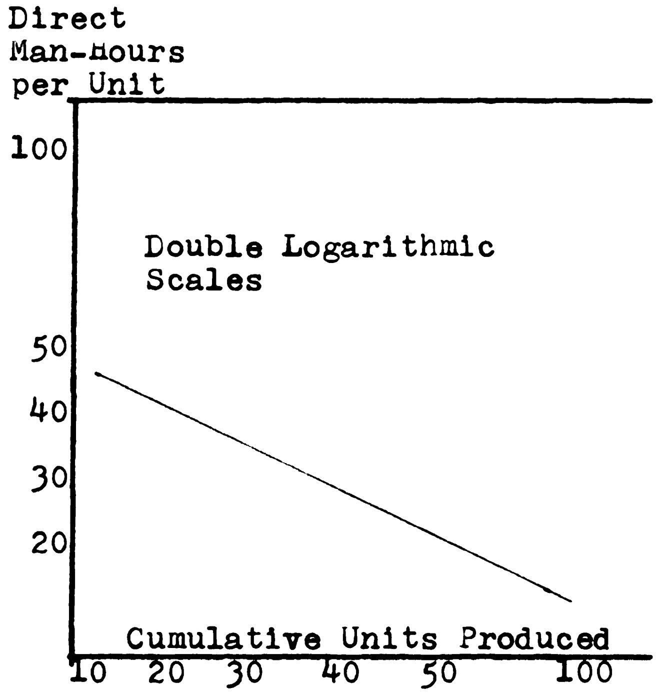
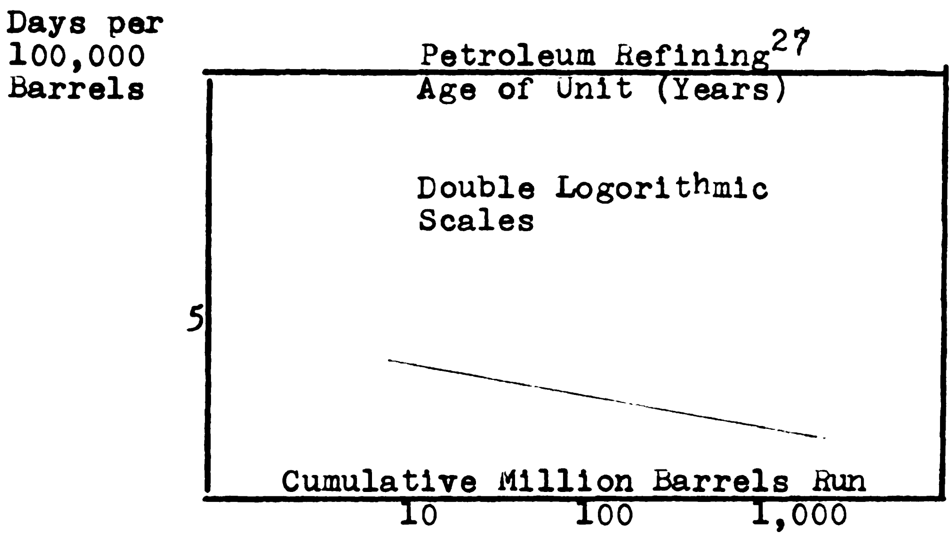
[26] Winfred B. Hirschmann, op. cit., p. 129.

THE AIRCRAFT INDUSTRY[27]







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[27]The original aircraft study and actual curve is found in Andress, op. cit., p. 90. The graphic approximation is from Winfred B. Hirschmann, op. cit., p. 126. The petroleum refinery case is also found in Hirschmann, pp. 129-30.

implication is that the greater the mechanization, the lower the incidence of learning. This view is shared by Andress. He is referring to aircraft assembly in the following remarks:

> Approximately 75% of the total direct labor input in the industry is assembly; the balance is represented by machine work. In assembly work there is a relatively large scope for learning; in machine work the ability to reduce labor hours is greatly restricted by the fact that the machines cannot "learn" to run any faster.[28]

Andress further finds that:

> Accordingly, when the proportion of labor input is less, the reduction of labor input is slower. For example, in the case of operations made up of approximately three-quarters machine time and one-quarter assembly time (the reverse of the usual situation in the aircraft industry), the approximate rate of learning has been found to be 90% rather than 80%. That is, the labor hours drop only 10% between doubled quantities, compared with 20% for the industry generally.[29]

Similar evidence had been uncovered by Hirsch's study of machining of parts and their assembly in the machine tool

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[28] Andress, op. cit., p. 89. In view of Hirschmann's findings on the petroleum refinery we cannot take the "any faster" of the quote literally.

[29] Ibid.

industry.

> In an attempt to gain a better understanding of the fields in which progress is made, the machining of parts as well as their assembly was analyzed. It was found that the assembling progress was much more rapid and more consistently so than the machining progress.[30]

What about changes in the productive technique? We not only have Arrow's suggestive treatment on a macro-level, but corroborating evidence at the micro-level as well. Hirschmann cites the temporary rise in the learning curve from which point it commences on a fresh descent:

> A rise in the curve can occur in the middle of a contract too, owing to a substantial interruption (such as that caused by introducing changes in a model, by moving operations to a new building, or by halting operations for a while so that forgetting occurs). Shortly after operations recommence and skill in handling changes is acquired, the curve declines rapidly to approach the old slope. Such a break in the curve occurs frequently enough to have acquired the descriptive term "scallop." In fact, if, instead of merely a change being made, a new model is introduced, or a new type of item is put into production, the scallop occurs initially and the curve essentially starts again.[31]

The analysis has now proceeded far enough to draw several self-evident, but important inferences about learning and UM. The employment of UM is likely to enhance the production of maintenance abilities for several reasons.

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[30] Hirsch, op. cit., p. 155. Of further interest, but not quite related to the point at hand, Hirsch attributed the progress to learning by direct labor, management, engineering department and material supplies.

[31] Winfred B. Hirschmann, op. cit., p. 126.

1. There is likely to be greater exposure to maintenance problems due to more frequent breakdowns or threats of breakdowns. Since learning appears to be a positive function of relevant experience, it will take place at a faster rate.[32]

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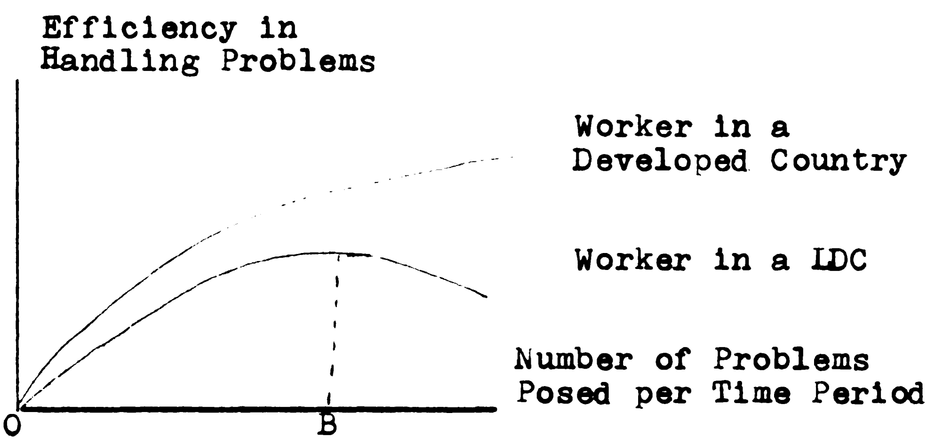
[32]An important caveat is in order. If the worker's frustration from the frequency and novelty of problems becomes too great, his efficiency may drop precipitously for psychological reasons. If the nature and number of problems posed become overwhelming to a worker who is not fully conditioned to an industrial environment, his consternation can prove disastrous. The results are illustrated below:



The point B on the horizontal axis represents the going "bananas" threshold of the worker. At this point he begins to give up, at best, or reacts in an even more detrimental way.

The specifics of each case, of course, would depend upon (1) the degree of repetition, as opposed to true problems, contained within the maintenance and repair operations and (2) the degree to which workers have adjusted to the rigors of industrial production. Through time, presumably, more and more genuine problems will be converted to an "old hat" status as they are repeated. Also, through time, to the extent that more industrial experience is gained there will be a tendency for the LDCs' problem solving curve to gradually shift upward and for the "negative" problem solving portion of the curve to straighten. This process not only involves individual experience in learning procedures and techniques, but also experience at the cultural level. To use the term currently in vogue, the industrial labor force will develop a "commitment" to the industrial process.

2. The earlier technological vintage of UM implies less mechanization in the production process, thus allowing more scope for learning.

3. The earlier technological vintage implies a more labor-intensive method, thus the <u>breadth</u> of exposure is greater.

4. The shorter physical life of UM results in more frequent changes of capital equipment giving learning renewed impetus.

<u>Maintenance Awareness and the Compulsion to Maintain</u>

One vital prerequisite to a good maintenance program is not amenable to learning while doing, namely the appreciation of the importance of establishing, administering and checking a program for maintenance.[33] The lack of appreciation for the need of maintenance expenditure can take two general forms. In its severest and unadulterated form, returns and costs from maintenance expenditures simply do not enter into management's calculus. A few establishments, for instance, in reply to a UN sponsored questionnaire reported that their equipment replacement policy was geared to the belief that equipment ". . . was expected to last a number of years."[34]

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[33]"In both industry and government there is not sufficient realization of the need for more effective maintenance management and for the recognition of maintenance and repair as a function in its own right." <u>Report of the Group of Experts on Maintenance</u>, <u>op. cit</u>., p. 8.

[34]<u>Ibid</u>., p. 18.

A more common failing is that management cognitively realizes that preventive maintenance is important, but day to day pressures conspire to defeat its good intentions. Preventive maintenance is disadvantaged because it is postponable. Top management in LDC's, which is commonly plagued by a shortage of middle management, is forced to spread itself too thin. As a consequence, it focuses on (1) those aspects of business best known and (2) those which seem absolutely pressing. The harried manager is constantly preoccupied with putting out short-run fires.[35]

One condition which stimulates (or forces) management to do something about it is production by techniques for which preventive maintenance is absolutely necessary. Or put another way, the postponability of preventive maintenance is a matter of degree. The lower the probability of a malfunction and/or the lower the potential loss from a malfunction, the more postponable preventive maintenance becomes in the eyes of management.

Some writers have concentrated on a high potential loss from a malfunction as furnishing the impetus for a

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[35]"Top management . . . is literally forced to do not only the top management job, but also the jobs of their non-existent subordinates. The difficulty here is that no group, however talented, has time to accomplish all of these jobs well. Top management must necessarily in such cases ignore or overlook many crucial tasks. If the question of a critical bank loan comes up at the same time that an urgent parts order must be made, top managers will almost always attend to their banker first and parts second, if at all." _Ibid_., pp. 23-24.

"compulsion to maintain" in LDC's.[36] Albert O. Hirschman pointed to continuous-flow processes and airlines as examples.[37] The results of the UN study on maintenance agrees: "Large processing industries (sugar, oil, rubber) are generally among those industries with the most satisfactory repair and maintenance conditions."[38]

From my experience in Mexico there is an equally valid compulsion to maintain arising from the greater <u>probability</u> of malfunctioning of most UM in the absence of preventive measures. The dangers of generalizing from conversations with personnel from two dozen Mexican firms most of which operated in Mexico City, Toluca, Chihuahua City and Juarez is apparent. Nonetheless, in virtually every case, management showed a keen awareness of the importance of preventive maintenance by their (1) conscious attempts to acquire equipment needing less care (of which we will see more in Chapter V) and (2) emphasis on carrying out a preventive program.

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[36]The term "compulsion to maintain" is Albert O. Hirschman's <u>The Strategy of Economic Development</u>, <u>op. cit</u>., p. 142.

Incidentally, Hirschman appreciated the value of learning maintenance abilities. Choosing projects or techniques that require little maintenance only ". . . perpetuates the problem by considering the difficulty of <u>learning</u> maintenance insuperable." <u>Ibid</u>., (emphasis as in the original).

[37]<u>Ibid</u>.

[38]<u>Report of the Group of Experts on Maintenance</u>, <u>op. cit</u>., p. 13. The context makes it clear that these industries do not necessarily have the <u>easiest</u> maintenance problems, but tend to cope with them better.

Mexico aside, there is rarely a piece of literature on UM which does not caution against maintenance and spare parts problems. Sometimes it is pointed out that maintenance may be easier because UM is of a simpler design, but even here most studies carefully stipulate that these instances are exceptions.

With some exceptions preventive maintenance is less postponable when UM is employed. Bad things are likely to happen sooner if it is not applied.[39]

We see then that there is a two pronged learning effect from employing UM: first, more frequent exposure (if they are not so frequent that they become overwhelming) to maintenance and repair problems and more frequent changes to different vintages of equipment accelerate the learning of routines and skills. Second, management is prone to give

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[39]Undoubtedly, some maintenance awareness is not due to employing UM, but the reverse, i.e., the manager who can put together a good maintenance organization and program knows he has a good chance of keeping UM performing and drastically cutting his capital costs. Even here, however, learning would be experienced by observant colleagues through a demonstration effect.

Also, my Mexican experience did not reveal a perfect correlation of a compulsion to maintain and the employment of UM. The marginal firm that purchased UM because of a budget restraint is the chief exception. However, many of the established firms employing UM started as marginal firms. My suspicions are that in the case of the marginal firm, the top manager can observe the need for preventive maintenance (through learning while not doing), but he can ill afford to do much about it. Usually he not only takes over some middle management tasks, he, more often than not, is the management (and may also take a hand at first line supervisory tasks). He lacks the time and financial resources to learn about preventive maintenance, hire and train those with abilities and implement a program. If, preventive maintenance a high priority when employing UM, since the consequences of postponement are more sure and swifter.

Spare Parts

As the last chapter indicated, the spare part problem is frequently mentioned as one of the most formidable disadvantages of UM. Undoubtedly, the spare part problem is a real one but, as the following qualifications show, it is not unbeatable:

1. To the extent that preventive maintenance is improved, spare parts consumption will be reduced.[40] These savings are sometimes far greater than is the case in developed areas, not only because of the higher transportation costs and longer time involved, but because often whole units must be replaced when only one small component is defective.[41]

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however, he is lucky enough to eventually become established, and financial restraints are less binding, preventive maintenance will get high priority or, as Strassmann found, shift to using new equipment. W. Paul Strassmann, Technological Change and Economic Development, op. cit., p. 209.

[40] The only exception is in the case of earlier disposal of spare parts due to the application of more conservative standards.

[41] Regarding an example in a Middle Eastern country, the UN study says: "Instead of $8 replacement gears or $2 bearings, $140 transmissions were obtained. This type of aggregate parts replacement, instead of minor replacement, is a way of making up for unavailable skilled labour, but the price is far higher." Report of the Group of Experts on Maintenance, op. cit., p. 41.

2. Some crucial spare parts can be stocked. This will raise the effective cost of capital due to stocking, but it may be the most economical alternative.

3. Due to the earlier technological vintage of UM, spare parts are often much simpler in design and material composition. It is often feasible to manufacture them at the plant site or locally.[42] This process could be abetted by obtaining the blueprints in advance.

Local production saves transportation and customs charges, usually reduces the time involved in obtaining a part, and reduces inventory costs.[43] Domestic parts production and rebuilding would be more efficient if there were a larger demand for those types of parts that are simple to produce. The higher rate of consumption of spare parts by UM and the simpler design and composition of parts produces a strong backward linkage effect. A greater use of UM in LDC's would intensify the demand for locally produced and rebuilt spare parts. This is especially true when demand "converges," e.g., twenty-eight different types or sizes of

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[42]This has been true in virtually every case of UM use in LDC's with which I am familiar. It is surprisingly true of Mexico, where spare parts requisitions from original suppliers would presumably be relatively easy. Every observer with whom I have corresponded or conversed on the matter of spare parts in LDC's confirmed that local fabrication is common.

[43]One comparative cost study found that ". . . carrying inventory costs about 25 per cent of its landed cost per year, and a part costing $5, used four years later, really cost over $10. In many cases, local substitutes could be made for perhaps $8 or $9." Ibid., p. 51.

spare parts that can all be rebuilt by the identical process of grinding and resurfacing.

4. Due to UM's older technological vintage, the capital-equipment ordinarily is more divisible. One of thirty semi-automatic machines having a five-week downtime due to the lack of a spare part may not be nearly as costly as a fully automated plant having a downtime of three days.

5. When downtime does occur due to spare part deficiency, it need not be a total loss. Routine overhaul and repair can be performed that may have been needed anyway. Once again, the plant with thirty semi-automatic machines has the advantage over the fully automated plant. The fully automated plant may or may not need major maintenance, repair or overhauling; the semi-automated factory is virtually assured to have one machine in such a state. It is a simple matter to shift parts so that the needy machine is one out of action.

6. We must remember that it is the differential waiting time between UM and new-machinery parts that is a crucial variable. It appears the LDC's have spare parts problems regardless of the type of equipment.[44]

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[44] One entrepreneur in Mexico City told of seeking a part that was essential to his operations. He flew to New York, Florida and California before he returned in the space of three days with his spare part. This was for a part to one of his relatively new pieces of equipment. A businessman in Monterrey was told he would have a waiting period of two weeks for a spare part during which time his machine would have to sit idle. Two weeks later he reported to his dealer only to be told someone else needing the part happened by and it was sold to him.

The U.N. found that the waiting time for spare parts

7. Key to the spare parts problem is the more efficient stocking and dissemination of information about spare parts. For selected spare parts that have a wide and reasonably predictable rate of use, centralization and specialization of spare-parts distribution and manufacturing could be feasible on an industrial park, regional, national, and/or international basis.[45]

8. Red tape in the importing country often hampers the swift acquisition of spare parts. Even with proper communication with the original supplier and his rapid response in shipping the part, long delays in customs of the importing country are all too common. The net effect of these practices is undoubtedly detrimental to the national interest and should be the first target of any program designed to perfect the spare parts market.

9. Many firms stock parts for at least twenty years, thus the problems do seem to be largely those of communication

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ran ". . . up to a year if replacements had to be obtained by sea freight from abroad." Ibid., p. 17.

When points 3 and 6 are combined, an even stronger case can be made for local production of simpler UM parts rather than obtaining more sophisticated parts from abroad.

[45]The U.N. study on maintenance estimates the potential from specialization and centralization to be ". . . a 25-30 per cent reduction of expenses in equipment maintenance, cutting down idle time five or six times and supplying industrial enterprise with all kinds of spare parts for maintenance work, thus contributing to high quality repairs."

The study recognizes that specialization and centralization are not feasible under all circumstances, but ". . . will depend on the size of the enterprise and on the type of product made or service rendered." Ibid., p. 32.

and expediting the transfer of the part.[46]

Two Important Items of Miscellanea

Maintenance is Easier for Some UM

Thus far the analysis has proceeded under the assumption that maintenance costs will be greater when UM is employed. This is based on a "sound" generalization with which this dissertation has no quarrel. But, like most generalizations there are exceptions. When dealing in terms of roughly 2 1/2 per cent of United States UM sales that are exported to LDC's, even a small number of exceptions can have an enormous

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[46]A good deal of information on typical U.S. part stockage practice is found in Ralph M. Parsons Company Final Report: Used Equipment Study, conducted for the Agency for International Development, Job No. RMP 3677-1, Contract NO, AID/ csd-1060, November 30, 1965. For instance a minimum time for stockage of parts for metal working equipment, wood working equipment, and construction equipment is fifteen years (pp. 30-32, *passim*). For mobile handling equipment parts will be stocked a minimum of twelve years after a model has been discontinued, but: ". . . parts would be supplied as long as there is a demand, and if a need is generated, they would retool and manufacture spares." (P. 33.)

For road building and vehicular equipment: "Manufacturers state they will maintain spare parts as long as they are in demand and would retool to manufacture spare parts if the need was created." (P. 35.)

For electric power generating package units: ". . . spare parts are maintained for all models as long as they are in demand." (P. 36.)

For textile equipment and plants: "Spare parts for textile machinery can generally be obtained from manufacturers on short notice for equipment up to twenty years old. Machinery manufacturers also keep parts production prints and dyes for older machines and would retool to provide minimum quantities ordered." (P. 39.)

impact in percentage terms. The exceptions are at least as important as the rule.

Maintenance and Repair in LDC's Will Improve

The United Nations Industrial Development Organization has declared that the development of an optimum technology for LDC's should have first claim on the scientific and technical manpower devoted to economic development.[47] Of the five subheads under this goal, one is the ". . . repair and maintenance of industrial equipment whose inadequacy or complete lack is one of the major obstacles retarding the speed of industrialization in developing countries."[48] To help alleviate maintenance and repair problems, UNIDO ". . . launched a major campaign for the improvement of repair and maintenance facilities in developing countries."[49] The intention was to have six consulting firms in LDC's starting in late 1968 and experimental projects were to be initiated in 1969. A more comprehensive attack was intended for 1970.[50]

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[47] *Issues Proposed by UNIDO to the Advisory Committee on the Application of Science and Technology to Development for its Concerted Attack Programme*, ID/WG, 26/1 Rev. 1, Limited distribution (Vienna, Austria: UNIDO, November 21, 1968), p. 3. The paper was prepared for the Tenth Session of the Advisory Committee on the Application of Science and Technology to Development, Vienna, November 25-December 6, 1968. UNIDO took over the functions of the Center for Industrial Development in January, 1967.

[48] *Ibid.* (Emphasis as in the original.)

[49] *Ibid.*, p. 17.

[50] *Ibid.*

Judging from reports of UNIDO activity in various issues of their monthly UNIDO Newsletter, the overall program is proceeding on schedule.

The pressing need for better maintenance and repair in LDC's, the high priority assigned to improve the situation and the active leadership by UNIDO lends support to the expectation that improved maintenance is in the offing.

Conclusions

The employment of UM yields a social dividend in terms of learning while doing. This can be a substantial contribution considering the scarcity of maintenance abilities in LDC's, the reluctance of one firm to produce it, wasted resources tied up in pirating, the under-utilized skills due to hoarding and finally, the various capital costs which are due to inadequate maintenance.

Learning shifts the supply curve of maintenance abilities to the right and causes it to become more elastic. This facilitates the use of a less capital-intensive and mechanized method of production which, in turn, increases the rate and scope of learning. When learning is introduced as a dynamic variable, the choice of technique and the level of maintenance capability form a reinforcing interaction. UM also encourages the application of preventive maintenance because its need is more immediate and apparent.

The spare parts problem (a) in some cases favors UM by making local parts fabrication easier, (b) is less discriminatory against UM than the literature leads us to believe when the problems of procuring any parts is considered, and (c) can be largely solved by institutional changes designed to perfect the spare parts market.

The problems of maintenance and spare parts supply have been singled out for specific emphasis by UNIDO. To the extent that it and co-operating institutions are successful, it will, on balance, favor the employment of more UM in LDC's.

CHAPTER IV

FLEXIBILITY AND USED MACHINERY

Flexibility, like such attributes as elasticity, wears a "white hat" in the melodrama of economics.[1] Flexibility permits adjustment to unforeseen circumstances. In production it allows resources to be shifted into more favorable employment.

While there is general agreement that flexibility is desirable in economic undertakings, there is a tendency to use the term ambiguously. To compensate partially for the cavalier use of the term, some of the more important types of

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[1] "The ideal is a highly flexible economy which allows resources to be moved with a minimum of friction from declining to expanding industries where technical change is currently progressing the most rapidly." W. E. G. Salter Productivity and Technical Change (London: Cambridge University Press, 1966), p. 153.

"The limited ability of policy-makers to foresee changes in demand and supply conditions puts a premium on flexibility in the choice of development strategy." Hollis B. Chenery, "Comparative Advantage and Development Policy," in Surveys of Economic Theory: Growth and Development, II (New York: St. Martin's Press, 1967), 131.

"The economic importance of flexibility in the use of equipment is often underlined in the reports of technical assistance experts . . . ." "Adaptation of Processes, Equipment and Products," Industrialization and Productivity Bulletin, No. 6 (New York: United Nations, 1963), p. 18.

production flexibility are classified in the following section. There follows an analysis of three specific examples of flexibility in production. This brief chapter is similar to the previous one in that (a) the analysis can be generalized to new equipment which happens to have the requisite qualities of scale and physical life that are discussed below and (b) the bearing of the analysis on the feasibility of UM is readily apparent, so the explicit connection between the two can be briefly summarized at the end of the chapter.

Types of Flexibility in Production

A convenient taxonomy for flexibilities in production includes the four following categories: (1) flexibility regarding types of output (2) flexibility regarding types of inputs (3) flexibility regarding volume of output and (4) flexibility regarding geographic location.

Ability to Vary the Types of Output

In speaking of output versatility at the level of design economics the term "output" may have to be used rather loosely. At this level, the term "production task" is more appropriate, since some equipment can be utilized in several production processes, all of which are geared to the production of the same final product.[2]

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[2]It has been recommended, for instance, that the casing machine also be used for moistening tobacco leaves in order to cut costs in a cigarette factory. "Adaptation of Processes, Equipment and Product," op. cit., p. 18.

Chilton mentions the common center lathe as being a classic multi-purpose tool: "To some extent it can be made to take the place of a drilling machine, a boring mill, a milling machine for facing a flat surface or a polisher." Werner Leopold Chilton, "The Choice of Technology for United

At the plant level the relative ease of retooling for producing alternative products is the relevant aspect of flexibility. One would expect a considerable correspondence in the ease of shifting tasks on an intra-product basis and switching plant production to an entirely different product, since a general purpose machine would have better odds of being employed on the new product than a single-purpose machine. While the probabilities favor this tendency, it is not necessarily true in all cases. Both product A and B may use an identical or similar component which can be produced

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States Direct Investment in Latin American Manufacturing Industry and its Implication for Economic Development," (unpublished Ph.D. dissertation, Columbia University, 1962), p. 170.

Surely a contender for the flexibility championship is the Thomason Industries T/c Mill-Drill Table. It can serve for a contour edge mill, surface mill, drill, tap, ream counterbore, rout, stake, and insert. It can also be used for spot welding and applying adhesive as well as being portable. "Flexible Tooling Available at Bargain Prices," Modern Manufacturing (January, 1969), pp. 82-83.

A detailed comparative cost study on single-purpose and multiple-purpose woodworking machines was made by Boon. He concluded: "This study of costs of alternative processes in the wood-working industry under conditions of variable outputs and factor prices shows that at high interest rates and low wages, with relatively low output, a process of low capital intensity is likely to be economic, and that, under the same conditions, one multi-purpose machine is likely to be more economic than a combination of single-purpose machines. Gerard K. Boon, "Choice of Industrial Technology: The Case of Wood-working," Industrialization and Productivity Bulletin, No. 3 (New York: United Nations, March, 1960), p. 31. An earlier and even more detailed report of the findings can be found in Boon and Ph. B. van Harreveld, "Multi-Purpose versus Single Purpose Woodworking Machinery," Alternative Techniques of Production, Progress Report No. 3 (Rotterdam: Netherlands Economic Institute and the Research Institute for Management Science, November, 1958).

with the same specialized equipment. Similarly, a piece of equipment may be multiple-purpose, but happens not to be applicable to the new product. Thus, the output flexibility of the plant is partially, but not entirely dependent upon flexibility at the design level.

Ability to Vary Types of Inputs

At the machine design level input flexibility involves the degree of versatility of equipment in using different types, grades or sizes of fuels, raw materials, semi-finished or finished components. Flexibility in this sense hinges on the ability to handle materials with differing rates of flow, viscosity, specific gravity, combustability, granulation and numerous other physical characteristics. Flexibility in using a range of complementary human abilities is also important.

The relative ease of switching these types of inputs also applies to flexibility at the plant level. Two additional considerations at the plant level are (a) flexibility in changing managerial inputs, e.g., the manner in which the production process is organized and (b) the relative ease in shifting capital inputs from older to more modern vintages. This latter facet of flexibility is analyzed later in the chapter.

Ability to Alter the Volume of Output

Both at the economics of design and the plant level the flexibility of volume of output will depend on the ease of varying the <u>intensity</u> of use of the equipment. A level of flexibility more germane to the ensuing analysis is found at the external margin of the industry.

The industry level has not been mentioned in the two previously described types of flexibility since changing outputs at an industry level involves investment criteria rather than choice of techniques, and the industry's ability to alter inputs depends directly on the flexibility at the design and plant level. But the case of altering output at the industry's external margin does depend on which technique is chosen. To a great extent the degree of flexibility in altering the volume of output rests on the degree of divisibility of producing units. All other things being equal, the smaller the feasible scale of production of the individual plant, the greater the finesse of the industry in responding to a changing market size.

Flexibility Regarding Geographic Location

In large part the ability to produce a product in a number of geographic locations depends on other characteristics mentioned above, e.g., feasible scale of output, the level of human skills that can be employed and the range of material inputs that can be used. In view of the policy emphasis currently being placed on geographic decentralization of industry, community development, and overurbanization, it is mentioned here as a distinct category of flexibility. Because Chapter V places emphasis on practical examples, geographic flexibility is included there.

An Analysis of Three Aspects of Production Flexibility

The Feasible Scale of Output and Demand-Induced Import-Substitution

For the past two decades most Latin American and many African and Asian countries have attempted to encourage the substitution of domestically manufactured goods for imported goods through various policies which raise the price of imports.[3] Balance of payments deficits undoubtedly motivated a protectionist stance in LDC's, but for several decades, until recently, protectionist policy had been bolstered by the view that import-substitution could lead to sustained industrial growth.[4]

Currently there is a great deal of disillusionment with protection induced import-substitution.[5] After the

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[3] The advocacy of protection induced import-substitution has come to be associated with the writing and influence of Dr. Raul Prebisch. Perhaps the best rendition of his ideas can be found in "Commercial Policy in Underdeveloped Countries," AER, Papers and Proceedings, May, 1959, pp. 251-73.

[4] Referring to Latin America's situation in 1929, the ECLA says: "Import substitution thus represented, at one and the same time, an imperative requisite for the over-all development of the Latin American economies and one of the mainsprings of their industrialization process." Economic Commission for Latin America, The Process of Industrial Development in Latin America (New York: United Nations, 1966), p. 21.

[5] For representative citations evidencing the disillusionment of Dr. Prebisch and other former advocates of protection induced import-substitution, see Albert O. Hirschman, "The Political Economy of Import-Substituting Industrialization in Latin America," QJE (February, 1968), pp. 1-32.

commonly experienced spurt in import-substitution, the going has tended to become more difficult. Often this occurred so abruptly that it is common to speak of a "discontinuity" in the production function or a "kink" in the growth path of import-substitution.[6] Due to this well founded disillusionment, the policy emphasis has shifted to the advocacy that trade preferences be extended to the LDC's.

It may be, however, that import-substitution has not been given a fair chance. Hirschman, for instance, makes a convincing case for demand-induced import-substitution.[7] As imports grow, the domestic entrepreneur's risk is reduced as he observes the revealed demand and an existing distribution network for a product. Other advantages of the demand-induced import-substitution, according to Hirschman, are (1) domestic production initiated in a competitive environment (2) imports of luxuries, usually discouraged by protectionist approaches, which led to import-substitution would assist in "convergence" of demands for inputs that are also used in producing essentials and (3) more entrepreneurs would be recruited from indigenous ethnic and cultural groups.

In exploring the connection between demand-induced import-substitution and choosing techniques of production the

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[6] Ibid., p. 11.

[7] Ibid. Hirschman had recommended demand-induced import-substitution earlier in his The Strategy of Economic Development (New Haven: Yale University Press, 1958), especially pp. 120-25.

following assumptions will be made:

1. There are two production techniques, technique A and technique B, used to produce a particular commodity.

2. Excluding foreign exchange effects, the social marginal cost per unit of output is identical when the techniques are used at their maximum efficiencies.

3. Either the private marginal cost favors technique B, or nonmarket biases on the part of public officials, management or management advisors cause technique B to be chosen.

4. Technique A has a "feasibility threshold" of 12,000 units; technique B has one of 16,000 units. The feasibility threshold is that level of output associated with domestic[8] social cost per unit equal to the domestic price of the imported good.

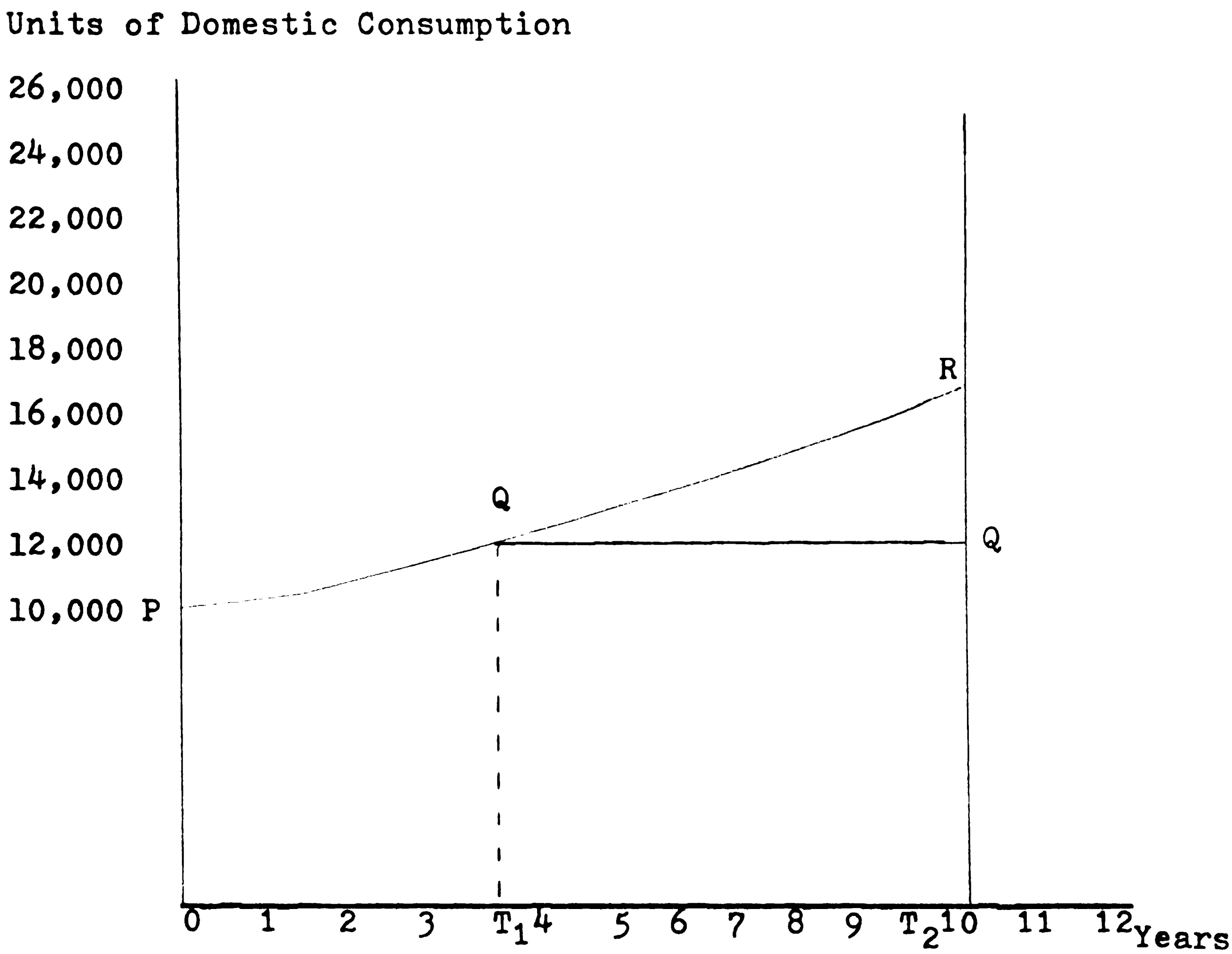
5. Import-substitution is a function of the "demonstration effect" on domestic producers, subject to the condition that the feasibility threshold is reached. For simplicity the import-substitution threshold and the feasibility threshold will be assumed to coincide.

6. The volume of the domestic demand begins in the base year at 10,000 units and grows at a compounded rate of five per cent per year.

These assumptions are stipulated to permit the analysis to focus on the foreign exchange effect (assumption 2)

8The adjective "domestic" is used here to maintain consistency with assumption number two which excludes foreign exchange effects.

due to differences in scale (assumption 4). Since B is assumed to be the technique chosen, the objective of the analysis can be couched in the following terms: by choosing the larger scale of production, is the supply of foreign exchange affected? A graphic representation of the situation is shown below.



Ten thousand units, the original size of the domestic market, compounded at five per cent per annum is plotted along the line PR.[9] At a five per cent annual growth rate, technique

[9]The figures are as follows:

A's feasibility threshold, 12,000 units, will be reached at T_1, or prior to year four. Technique B's feasibility threshold of 16,000 units shown by T_2, will be reached just prior to year ten.

Before domestic production begins with technique B, total foreign exchange expenditures is given by the product of $OPRT_2$, the number of units imported, and the average import price of the product. Had technique A been employed, imports from year zero to T_2 could have been reduced by T_1QST_2 units. Imports would have fallen to zero at T_1 after which they would resume their growth until another type A plant is warranted. The area T_1QST_2, times the unit price of the imported item is the loss of foreign exchange attributable to using technique B.

The importance of conserving foreign exchange need not be elaborated other than remarking that technique A would benefit static efficiency since the real value of foreign exchange is greater than its market price in most LDC's and growth would benefit by the relaxation of restrictions that foreign exchange availability places on the ability to import.

Year			
Base	10,000	5	12,763
1	10,500	6	13,401
2	11,025	7	14,071
3	11,576	8	14,774
4	12,155	9	15,513
		10	16,286

However, smaller scale of output implies a more labor-intensive technique. If this is the case what would be the effect on balance of payments? Would not a shift of income to a group with a higher propensity to consume increase total imports of consumption goods? The outcome depends, of course, not on marginal propensities to consume, but marginal propensities to import consumption goods out of changes in income. Given the notoriously high propensity to import luxury goods on the part of elite groups in LDC's no safe presumption can be made that consumer imports would rise. But, suppose we make such an assumption. The short-run effect of increased imports of consumer goods is bound to be unfavorable to the balance of payments. But, if the composition of the rise in imports is such that there is greater convergence of demand,[10] this would speed the process of import-substitution and conserve foreign exchange in the long-run.[11] Canned vegetables and simple stoves are usually easier to produce domestically in LDC's than are the equivalent of Nuits Saint George burgundy or Cadillac automobiles.

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[10]If, for instance, imports X, Y and Z all use a common domestically produced (or producable) input A.

[11]Future gains and losses could only be compared, of course, after applying some discount rate. Thus, a dollar foreign exchange lost in year 5 would be weighted more than a dollar of exchange saved in year 6.

The Physical Life of Equipment and the Rate of Embodied Technological Progress

The previous chapter dealt largely with human abilities as a form of technology which is not embodied in capital equipment.[12] Suppose we now hold disembodied technological progress constant and allow the rate of progress in technical efficiencies that are engineered into the equipment, embodied technology, to occur through time at a constant rate. In addition, the following set of assumptions will be made:

1. For the commodity under discussion two techniques are available, A and B.

2. The short-run social marginal cost per unit of output is the same for both techniques.

3. Technique A has an average physical life of 10 years; technique B has an average physical life of 20 years.

4. Equipment will be replaced at the end of its physical life.

5. Technique B is chosen either because its private marginal cost is lower or because of nonmarket biases on the part of public officials, management or management advisors.

A graphic representation of the situation is given on the following page:

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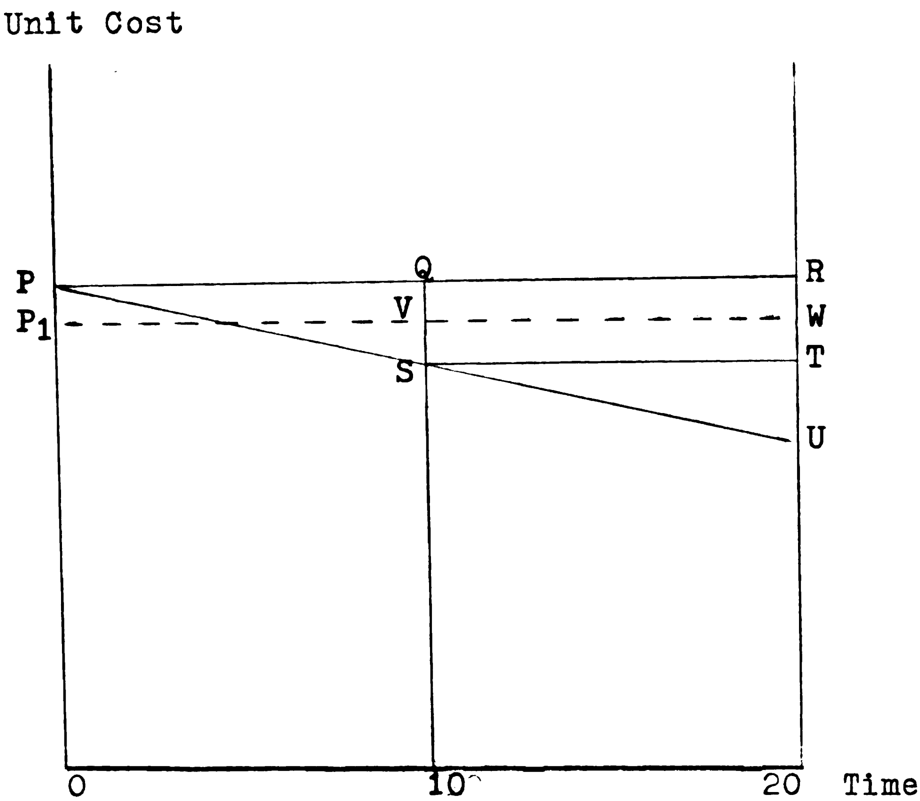
[12]The convention of using the terms "embodied" and "disembodied" with reference to capital and not to human resources necessitates some semantic acrobatics. In the last chapter the existing level of maintenance abilities was seen as embodied within human resources. When applied, these abilities become a form of disembodied technology to capital.



OP represents the unit cost of production for A and B at zero years while the line PSU represents the "best-practices" cost of production through time.[13] The negative

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[13]The term "best-practices" is borrowed from W. E. G. Salter, op. cit., who in turn borrowed it from Anne P. Grosse, "The Technological Structure of the Cotton Industry," in Studies in the Structure of the American Economy, W. W. Leontief, et. al. (New York: Oxford University Press, 1953).

Salter defines the best-practice technique as follows: "The best-practice technique at each date is the appropriate technique having regard to both economic and technical conditions; it is the technique which yields minimum costs in terms of the production function and relative factor prices of each date." (P. 23.)

Our definition will be similar except the best practice technique is the technique which yields minimum social cost in terms of the production function and relative factor shadow prices of each date.

slope of PSU depicts the decline in the best-practices cost of production through time. According to our assumption, the entire burden of progress is thrown on embodied improvements.

Even though technique B is as efficient as technique A in terms of social cost per unit at year zero, the choosing of technique B will result in losses of efficiency through time. The loss, in fact, is shown by the area of the rectangle QRTS multiplied times the volume of output for the last ten years. The replacement equipment for technique A, say A', will produce at a cost of OP minus QS whereas the existing B plant still produces at OP.

This is merely a graphic expression of what many others have realized before[14] and, naturally, there are hosts of variations that can be made on this model. For instance, even if technique B is more efficient in year zero, the advantage of early replacement may still render technique A the best choice over a period of time. Suppose technique B can produce at OP_1. The unit efficiency advantage of technique B in the first decade is given by P_1PQV and the

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[14]"In choosing among techniques for performing the same service, it is normally preferable to choose the one which has the shortest life of capital equipment, other things being equal. This permits flexibility in the future, including the adoption of newly discovered techniques, without involving the abandonment of existing partially depreciated equipment." D. R. Campbell, "Choosing Techniques; An Indian Case: A Comment," *op. cit.*, p. 135.

Also see S. K. Bhattacharyya, *Capital Longevity and Economic Growth; An Analytical Study* (Calcutta: Basu Printing Works, 1965), pp. 22-27 and pp. 66-69; and Michael Gort and Raford Boddy, "Vintage Effects and the Time Path of Investment in Production Relations"; "Comments" by Anne P.

corresponding advantage of technique A in the second decade is given by SVWT. Therefore, long-run efficiency would depend upon the relative size of these two areas.[15]

If we expand our assumption number four to include economic as well as physical obsolescence, similar results would obtain. The probability is that the ratio of fixed costs to variable costs for the less durable technique A is lower than B's in the base year, and certainly the ratio will decline at a faster rate due to the more rapid depreciation. The lower ratio of fixed to total costs makes economic obsolescence less painful.

Capital Committed to Anticipating Market Growth

Given the prospects of a growing market, an entrepreneur should attempt to construct a plant to a scale that will minimize production costs over the anticipated economic life of the equipment. Basically this requires a trade off between the cost of expanding output at a later date versus carrying excess capacity for a period of time. In general, the more divisible the producing units, the cheaper it is to expand capacity in the future and the more pronounced the

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Carter and Peter A. Diamond, and "Reply" by Gort and Boddy in The Theory and Empirical Analysis of Production. Murray Brown, ed., (New York: National Bureau of Economic Research, 1967), pp. 395-430.

[15]Strictly speaking, future gains must be discounted. SVWT would need to exceed P_1PQV by enough to offset the discount "shrinkage" since A's gains are realized further in the future.

economies of scale, the cheaper it is to temporarily carry excess capacity.

The United Nations' Bureau of Economic Affairs has developed a formula for estimating the optimum plant size under conditions of a growing market.[16] The formula is constructed so the solution to the equation is in terms of the years of market growth that should be anticipated. Their formula for capital equipment expected to last ten years is given below:

$$(1-0.5\,\alpha)\,\lambda n^2 + [1-(1-\alpha)\,\lambda N]\;n-(1-\alpha)\,N = 0$$

Where

N = the lifetime of the equipment in years.

n = the number of years of market growth that plant capacity should anticipate.

λ = the growth rate of the market per year.

α = the capital outlay exponent. The annual costs related to capital are assumed to be proportional to capital outlay and to the α th power capacity.[17]

A close look at the elements in the formula will show that a larger amount of capital should be used to anticipate market growth (a) the faster the growth of the market (b) the more powerful the economies of scale (i.e., the lower

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[16]"Problems of Size of Plant in Industry in Under-Developed Countries," Industrialization and Productivity Bulletin, No. 2 (New York: United Nations, 1959), pp. 7-25. The mathematics is found in the "Appendix," pp. 24-25.

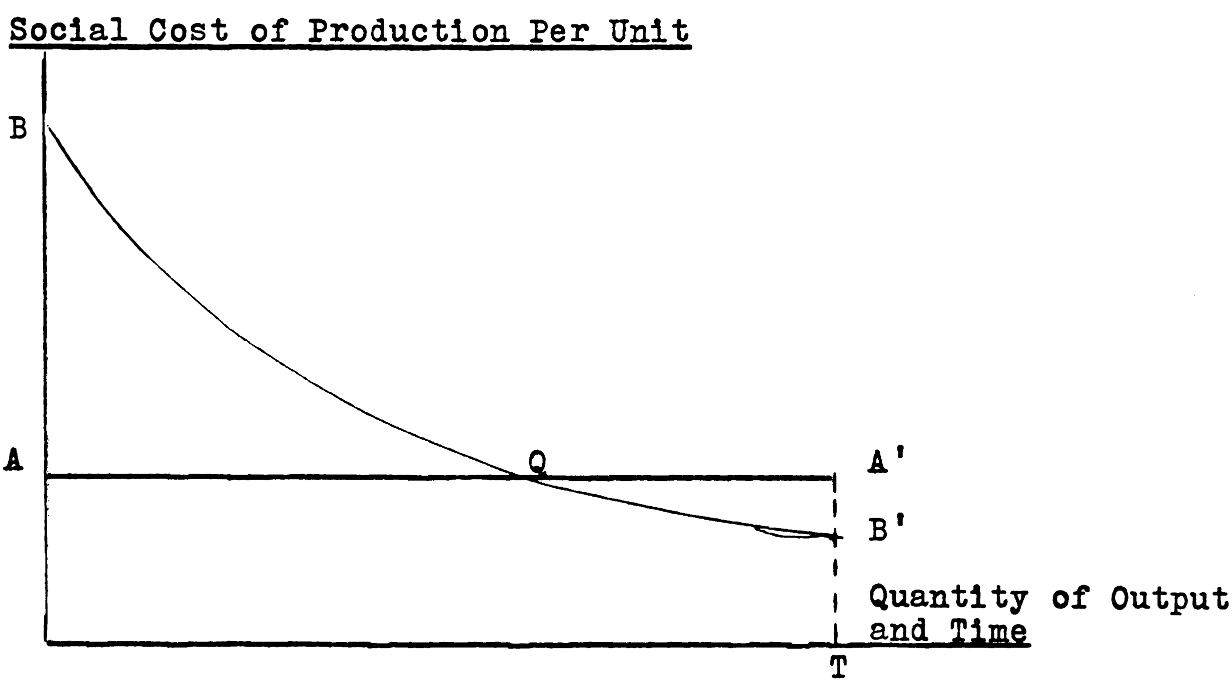
[17]For example the study assumed that capital investment outlay increases approximately as the 0.75th power of capacity in the glass container industry. Ibid., p. 13.

the capital outlay exponent) and (c) the longer the life of the capital equipment. We will assume that the growth rate of the market is independent of the choice of technique. The effect of a shorter life of the capital equipment has already been covered above. A faster replacement policy allows a closer "fit" to the best-practices curve and presumably one element in the evolution of best-practices is the influence of changes in scale. The analysis will, therefore, concentrate on economies of scale under conditions of equal life of the equipment.

Once again, there will be two techniques for producing the same product: Technique A and Technique B.

Technique A operates under constant cost conditions. Technique B operates under decreasing cost conditions.

The central trade offs can be shown graphically.



The vertical axis measures unit cost of production in social terms, while the horizontal axis measures quantity of output. Since the market grows by some compound rate, each output is uniquely related to a point in time. T is the level of the market after ten years' time.

The optimal choice of techniques would be obtained by comparing, ABQ, the initial gain from using technique A, with QAB, the loss in the later years for not using technique B. Note that a comparison of the absolute areas of the two geometric figures would not determine the optimum choice of technique. Future gains would have to be discounted. Since the benefits of technique A start immediately, while the efficiencies from B would begin at some later date, the discounting process would shrink the area ABQ by a smaller proportion than QAB.

This analysis can apply to a single plant in which technique A's inputs are all highly divisible while some input (presumably capital) of technique B's is not. It can also be applied at an industry level by allowing B to represent one large plant which is, in effect, the industry, while additions to capacity using technique A represent smaller plants entering into production. Such an industrial comparison would be over and above any competitive benefits that might result from a multi-plant industrial structure. Only the marginal plant in the multi-plant industry would anticipate market growth.[18]

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[18]The comments in this paragraph tacitly relax the assumption of perfectly constant costs for technique A.

In theory, then, the easier it is to accomodate a rising market by adding to plant capacity at the internal and external margins and/or the industry's external margin, the lower the cost of capital used in anticipating the growth of the market.

Flexibility and Used Machinery

The relevance of the foregoing analysis to the feasibility of employing UM is clear. We had assumed in Chapter I that the feasible scale of operation of older vintages of technology tends to be lower than more recent vintages, and the average physical life of used equipment will tend to be shorter. Moreover, older vintage equipment is more likely to permit marginal changes in plant capacity.

This does not justify a blanket endorsement for the massive employment of UM in LDC's. In many cases the *advantages* of economies of scale and durability will predominate. The analysis of flexibility does suggest, however, that in those instances in which UM shows comparable *static* efficiency with new machinery, its use should be encouraged. Perhaps less obvious, and more apropos to retrospectively appraising the static analysis contained in Chapter II, even if UM is at a mild *disadvantage* from the standpoint of static efficiency, the gains from flexibility can predominate in terms of long-run efficiency.

There is a temptation to think of the foregoing analysis in terms of risk since, in the real world, guessing the rate of technological advance and changes in the size of the market are risky undertakings. For this reason it must be emphasized that the conclusions drawn from this chapter do not depend upon risk. The same conclusions would be reached if the rate of technological advance and growth in the future is known with absolute certainty. We need only assume that best-practices production will lower costs at some known rate and the market will grow at some known rate.

Even though risk and uncertainty are matters that play little part in this chapter, they are relevant to the degree of flexibility. Risk and flexibility, like geographic flexibility, are reserved for a section in the next chapter which employs a less theoretical exposition.

CHAPTER V

SPECIAL SITUATIONS FOR EMPLOYING USED MACHINERY

This chapter describes a variety of characteristics of UM and environmental circumstances that enhances its appeal. Any one or any combination of these conditions may be a factor in choosing the best technique.

Exceptions to the Rules

Easier Maintenance with Some UM

Chapters II and III were written with the premise that LDCs' maintenance costs are higher for UM than for new equipment. Judging from the literature on UM, as well as from my correspondence and conversations with dealers and users of UM, this is a valid generality. The exceptions to the rule are sufficiently abundant, however, to justify further scrutiny.

As a case in point, in the early 1960's a dairy owner in Juarez, Mexico, purchased a used compressor in Lansing, Michigan. The compressor had been made obsolete in the United States by more sophisticated equipment which could cool the milk faster and increase capacity. The Mexican entrepreneur believes he made an exceptionally good buy since (1) he paid approximately 10 per cent of what new equipment would have cost, (2) the differential between transportation costs of the old and a new compressor was not a factor and (3) only moderate repairs were needed. The interesting aspect of his motivation, however, is that the attractive price was not his overriding consideration. He is convinced that the newer, more complicated compressors are much more difficult to maintain. The older and simpler model is durable, has few moving parts, and is free of complicated electronic controls. His expectation of lower maintenance expenses was his express reason for seeking the older equipment.[1]

Used computers may also have advantages including those of easier maintenance and training for maintenance activities. Mr. Wilson of Auerbach Corporation, while not in favor of LDC's acquiring first generation computers, believes some second generation computers have advantages over new models.[2]

Another illustration is found in a comparative cost study on used and new sole-stitching machines conducted by

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[1] Information was furnished by Mr. Carlos Borunda of Juarez. Mr. Borunda is the nephew of the dairy owner.

[2] "Another plus for the used system is the availability of good, tested support literature, programming manuals, maintenance manuals, training literature and a multitude of published articles, and technical papers offering descriptions,

the International Labor Organization. In LDC's, they concluded, the annual repair and maintenance cost would be 25 per cent less for UM than for new machinery.[3]

The UM literature cannot be faulted for neglecting instances of UM with lower maintenance costs. The failing has been the lack of emphasis on the importance of these cases. Entrepreneurs are not really encouraged to exploit these exceptional circumstances. The UN study on UM points out:

> There is no clear-cut difference in the magnitude and nature of maintenance problems between new and second-hand equipment. However, a knowledge of electrical control circuits, hydraulics, pneumatic systems and electronics is often necessary for the maintenance of modern machinery and such modern machinery may stand idle for long

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applications, maintenance experience and other useful information." Louis D. Wilson, "Use of Second-hand Computers in Developing Countries," Auerbach Paper 7500-107 (Philadelphia: Auerbach Corporation, n.d.), p. 5. Originally this was used by the UN Centre for Industrial Development as a background paper for the December, 1965 meeting of the group of experts on second-hand equipment.

Mr. Wilson goes on to say that ". . . of great value is the large group of people trained in the use and maintenance of the system, which has been in wide use for a number of years. Although these people may not be in the country in question, their very number will simplify the acquisition of adequate teachers as well as a nucleus of programming, operating, and maintenance personnel to get the developing country started in an effective programme smoothly as quickly as reasonable." Ibid.

[3]"Progressive Industrial Technology for Developing Countries," Development Digest (January, 1969), p. 58. The original study is contained in Human Resources for Industrial Development, Studies and Reports, N.S. 71, Chapter 7 (Geneva: International Labor Organization, 1967), pp. 201-17.

> periods of time in developing countries where these skills are still in short supply.[4]

The remainder of the section is devoted to pinpointing the difficulties of maintaining UM. Likewise, the pioneering Netherlands Economic Institute's study mentioned the greater robustness of UM.[5] The emphasis of the report, however, was on the problems of UM maintenance. Unusual as they may be, the instances of lower UM maintenance costs deserve more attention. We can reasonably hope that more light will be shed as the United Nations International Development Organization's investigation of maintenance problems in LDC's gains momentum.

UM with Long Physical Life

We have assumed that UM tends to have a shorter physical life than its new counterpart. This, of course, is not always true. Certainly, one can imagine rare instances of early vintage equipment with such brute indestructibility that it outlasts newer, more intricate vintages.[6] Or, more likely, one can imagine (and document) examples of UM that are so sturdy and/or easy to maintain that the ratio of its

[4]UN, Report of Expert Group on Second-Hand Equipment, op. cit., p. 9.

[5]Second-Hand Machines and Economic Development (Rotterdam: NEI, May, 1958), p. 3.

[6]The Mexican dairy owner cited in the previous section is convinced that given the level of maintenance skills at his disposal, his earlier vintage compressor will physically outlast a new model.

remaining physical life to that of new machinery is unusually high.

The specific ratio of the UM life remaining to new machine life depends upon such things as the age of the equipment, intensity of use of the equipment, and the quality of the maintenance prior to and after purchase. As a general rule, however, UM will last approximately one-half to three-fourths as long as new machinery. We have seen in Appendix A of Chapter II that the Netherlands Economic Institute assumed the physical life of UM was 10 years compared to 15 years for new machinery. The International Labor Organization's study of used and new sole-stitching machinery assumes a productive life of 5 and 10 years, respectively.

Some UM, however, has exceptionally long physical usefulness. Equipment such as drop hammers, forges and presses are classic examples. The Oneida silverware factory in Toluca, Mexico, uses an enormous drop hammer which is approximately 50 years old. Its enormous bulk (twenty tons) and the virtual absence of moving parts (it is mechanically elevated and the fall is gravity induced), make it virtually impossible to estimate its physical life. New innovations which allow faster metal shaping and reduce the time needed for workers to finish the silverware, has caused such a crude device to become obsolete in developed areas. The existing size of the market and the prevailing factor prices in Mexico (and perhaps real or imagined political risks) do not justify Oneida's investment in a modern device.

Further examples are cited by Chilton. The General Tire and Rubber Company transferred thirty and forty year old rubber mixing mills and calenders to Latin America.[7] The equipment was extremely durable and the rate of technological advance in equipment of this type had been exceptionally slow. In a similar move, Singer Manufacturing Company reconditioned some surplus equipment and, due to its simplicity of construction and sturdiness, the company was able to eliminate its age as a meaningful consideration while, at the same time, reducing maintenance problems abroad.[8]

UM which has been completely rebuilt will often have a physical life approximating or equaling new equipment.[9]

A physical life of UM approaching (or exceeding) that of its modern counterpart does not insure adequate efficiency. Greater speed, accuracy or reliability of new equipment will often decisively favor new machinery even when capital is costly and labor is cheap. But when the remaining physical

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[7] Chilton, op. cit., f.n. 1, p. 138.

[8] Ibid., f.n. 1, p. 156.

[9] Referring to metal working equipment, the Parsons Company study undertaken for AID reports that "Machines rebuilt to manufacturers' specifications have an average of eighty-five percent of the original new machine useful life expectancy." Furthermore, "Twenty year old machines rebuilt to manufacturers' specifications are as accurate and dependable as the new equipment of the same type." The Ralph M. Parsons Company, Final Report: Used Equipment Study, op. cit., p. 29. Similar results can be expected for rebuilt earth moving machines (p. 31), basic materials handling equipment (p. 33), heavy vehicular equipment (p. 34) and electric power generators (p. 35). The report makes an even stronger statement regarding textile equipment: "Used units have practically unlimited life expectancy if properly maintained." (P. 37.)

life is unusually long, UM can be an attractive buy, especially if accompanied by conditions of cheap maintenance, a slow pace of technological improvement or a smaller market size in LDC's.

Equipment With a Low Utilization Factor

The low initial capital cost of UM makes it attractive for situations that entail substantial idle equipment time. Furthermore, the idle time can be used to perform maintenance work without loss of output, i.e., "idle time" (the machine is not used because it is not currently needed) can be used to avoid "downtime" (the machine is needed but is either being overhauled or is out of order). Among the possibilities of low utilization situations are the following:

1. Ancillary facilities that are used intermittently, e.g., a plant's machine shop used for testing equipment, rebuilding or producing spare parts, and overhauling equipment.

2. In the event of technological discontinuities a perfect mesh of all machinery in a production line is unlikely. When the imbalances in capacity are pronounced, it may be more economical to operate the equipment with excess capacity at full blast part of the time, and shut it down completely when its production has sufficiently anticipated the remainder of the assembly line.

3. Standby equipment for increasing output for periods of peak demand.

4. Equipment subject to extreme seasonal demand, i.e.,

likely to stand idle for a considerable part of the year. For example, cotton gins, sugar refineries and food processing plants are frequently subject to such seasonal variations.

UM and Market Sizes

Optimal scales of manufacturing enterprises in LDC's are frequently smaller than those in advanced countries because of (1) smaller aggregate markets due to lower levels of income, (2) smaller individual markets for newly introduced products due to a highly inelastic demand (with respect to both price and income) for existing products, (3) high transportation costs relative to the value of output and (4) a limited or unreliable supply of some input. Since earlier vintages of technology usually have smaller scales than new equipment, the suitability of UM to LDC's market conditions has not gone unnoticed by the literature.[10]

But what of the future demand for UM in LDC's which is prompted by its smaller scale? Cannot we expect a far higher rate of market expansion in LDC's than in advanced

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[10] For instance, The Economist Intelligence Unit Limited, American Industry's Potential for Providing Used Machinery and Technical Assistance for Developing Countries (New York: EIU, January, 1962), p. 4; Waterson, op. cit., p. 9; UN, Report of Expert Group on Second-Hand Equipment, op. cit., p. 12.

Chilton also cites an example in which Industrias Kaiser Argentina produced cylinder blocks with UM at twenty-five blocks per hour rather than installing an automated line which would produce one hundred blocks per hour. Yearly outputs with new equipment would have been 250,000 per year, roughly double the saturation point of the Argentinian automotive vehicular market. Chilton, op. cit., pp. 161-62.

countries? In our optimistic moments we expect per capita incomes to grow and transportation facilities to improve in LDC's, but the truly impressive rates of market growth may come from regional trade cooperation among LDC's. Such groups, in various stages of operation or planning, already include the Central American Common Market, Latin American Free Trade Area, Caribbean Free Trade Area and Andean Common Market, in Latin America; the East Africa Common Market, Central African Economic and Customs Union, West African Customs Union, and industrial cooperation in the Magherb area, in Africa; and the Arab Common Market and regional Cooperation for Development, in the Middle East.

As markets within LDC's expand, however, UM will remain useful. Many of the special situations included in this chapter will still exist. Factor price differences in LDC's vis-à-vis developed areas will persist. Also, some manufacturing processes realize most economies of scale at a relatively low output. In addition, a larger scale of output can be achieved by adding more machines of the same vintage rather than drastically altering the capital-labor ratio.[11]

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[11]This is consistent with the findings of J. C. Sandesara who concluded: "For a country like India where capital-saving (i.e., in relation to output and surplus) considerations are paramount, as they ought to be in view of her factor-endowments, large-sized units and labour-intensive technologies seem to be appropriate, while small-sized units and capital-intensive technologies seem to be inappropriate." "Scale and Technology in Indian Industry," Bulletin of the Oxford University Institute of Economics and Statistics (August, 1966), p. 195. (The latter emphasis is supplied.)

This point is worth pursuing. The principal reasons

A more surprising result of the growth of regional markets will be to increase the desirability of employing UM in LDC's modernizing sector! This result will follow even if we assume the continuing success of regional trade groups in LDC's, a conclusion based on the fact that changes in the optimum scale of output depend on absolute growth within a market area as well as the rate of growth.

To illustrate what this means, we can consider the following figures: The Central American Common Market

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for economies of scale include (1) an increase in labor productivity due to greater specialization, (2) the ability to use more advanced technologies which, due to indivisibilities, are not feasible at a lower output, (3) increased managerial efficiency because of greater specialization and being able to apply an improved organization to a larger output, (4) being able to purchase material inputs in larger quantities, (5) applying "stochastic economies of scale" as the law of large numbers allows greater accuracy in ordering, inventory control, scheduling repair, delivery, etc., and (6) being able to borrow at a reduced interest rate. This closely follows G. Nguyen Tien Hung, "Economies of Scale and Economic Integration," Finance and Development (June, 1968), pp. 36-37.

What if we assume, however, that doubling of the scale of output will be due to expanding a 50 worker-50 machine enterprise to one with 100 workers and 100 machines. Notice that factors 3, 4, 5 and 6 (the latter depending more on the size of the firm) will very likely be present. Number 1 is "up for grabs" depending on the alternative to expanding the output. Automation, for instance, may require a technician to have a greater range of primary tasks than a machine operator. The main disadvantage to expanding through capital widening then is the absence of factor 2 above. This component of economies of scale is usually couched in terms of a "scale coefficient" which when multiplied times the percentage increase in capacity, yields the percentage increase in capital costs. The Sandesara results could be interpreted as meaning that the advantages of flexibility retained when expansion is accomplished through capital widening can predominate over the beneficial effects of a scale coefficient lower than unity when expansion is accomplished through capital deepening.

countries saw their market expand from an average GNP of around $400 million per country before the common market to approximately $2 billion for the entire region. Even if these figures (1) were translated into personal disposable income, (2) were adjusted to reflect transportation and communications barriers and (3) took into account a time lag in implementing the movement to a common market, the change from the small national markets of Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua to the current GNP of approximately $3.5 billion has resulted in an "eye opening" rate of expansion in the markets for many industrial products. Compare this, however, to a 4 per cent increase in the 1967 effective buying power of New York, New Jersey and Pennsylvania. On a base of $110 billion dollars,[12] a 4 per cent increase, or $4.4 billion would be greater than the combined Central American Common Market's current GNP.

If one can assume a rapid rate of growth in market sizes within less developed areas, coupled with a slower rate but superior weight of growth in advanced areas, these conditions will be ideal for the transfer of UM that becomes obsolete in industrial countries. This point is elaborated further in a later section on used automated equipment.

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[12] Sales Management (June 10, 1968), passim. Sales Management's concept of effective buying power is closely comparable to disposable personal income (p. C-6).

UM's Contributions to Human Resource Utilization and Development

Trading Current Output for Gains in Employment

A political decision may be made to sacrifice some current output in order to increase employment absorption. Certainly there is ample evidence that employment absorption is a major problem in LDC's. One estimate puts the unemployment equivalent of the economically active population of Latin America at approximately 25 per cent.[13] In recent years visible unemployment in various Latin American urban areas is estimated to have ranged from 5 to 18 per cent.[14] Furthermore, it appears that the gap between jobs and potential job seekers is growing in Latin America. Lederman included women of working age who were not economically active but wanted to work in his "labor force."[15] On this basis he estimated Latin American unemployment as a percentage of the "labor force" at 5.60 per cent in 1950, 6.90 per cent in

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[13] Latin American Institute of Economic and Social Planning and Latin American Demographic Center, "Elementos para la elaboración de una política de desarrollo con integración para América Latina" (Santiago; Instituto Latinamericano de Planificación Económica y Social, 1968), mimeographed, p. II-9. Their estimates are reproduced in Inter-American Development Bank, Socio-Economic Progress in Latin America; Social Progress Trust Fund Eighth Annual Report, 1968 (Washington: IDB, 1969), p. 365 and in Organization of American States, "The Unemployment Problem in Latin America" (Washington: OAS, October, 1969), mimeographed, p. 13.

[14] OAS, "The Unemployment Problem in Latin America," op. cit., pp. 3-4.

[15] See OAS, op. cit., p. 6.

1960 and 11.10 per cent in 1965.[16]

Latin America is not unique in this respect. At the beginning of the Fourth Five-Year Plan (1966-71) India's unemployment was estimated at around 9 to 10 million. During the five year period it is estimated that the number of unemployed will increase to around 13 to 14 million.[17] The number of laborers in India who are now working part time, but willing to undertake additional work has been estimated to be around 15 to 18 million.[18]

In view of the enormity of the problem a decision might well be made to increase employment for social and political reasons at the sacrifice of some current output.[19] If such a decision is made, the ideal would be to sacrifice a small efficiency differential for a generous increase in employment. UM should be used as an integral part of any such program. The fact that there are many instances in which UM is used efficiently despite a host of biases against it and the "nip and tuck" closeness of many hypothetical cost

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[16]Esteban Lederman, "Hacia una política de los recursos humanos en el desarrollo económica y social de America Latina" (Santiago: Instituto Latinoamericano de Planificación Económica y Social, July, 1968), mimeographed, p. 10. His results are reproduced in OAS, op. cit., p. 7.

[17]M. M. Mehta, "Industrialization and Employment with Special Reference to Countries of ECAFE Region" (Bangkok: Asian Institute for Economic Development and Planning, 1968), p. 10. Dr. Mehta was citing Government of India, Planning Commission, The Fourth Five-Year Plan: A Draft Outline (1966-71), pp. 106-108.

[18]Mehta, op. cit., p. 12, citing Government of India, Planning Commission, Third Five-Year Plan (Delhi, 1961), p. 158.

[19]Or to avoid possible drastic loss of output in the future due to social upheaval.

comparisons between new and UM,[20] leads one to conclude that at the margin little output would be sacrificed by substituting UM for new beyond the point of optimizing efficiency.

Employment would be increased because (1) on a given budget restraint of foreign exchange or domestic investment resources, more equipment can be purchased, (2) the earlier technological vintage of UM implies a higher ratio of labor to capital and (3) the earlier vintage permits and induces a greater substitution of maintenance.

Judicious application of UM can gain increased employment at bargain basement prices in terms of lost efficiency.[21]

UM and Rural Development

This section is similar to the previous one except it focuses on rural problems and efficiency in terms of current output is once again the overriding criterion for choosing the optimal technique.[22]

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[20]For instance my figures in the Appendix to Chapter II concerning textile equipment; the Netherlands Economic Institute, Second-Hand Machines and Economic Development, op. cit., pp. 8-15, and the International Labor Organization study on sole stitching machines as reported in "Progressive Technology for Developing Countries," Development Digest, op. cit., p. 58.

[21]The reader is reminded, unnecessarily it is hoped, that thus far this is the only section in dissertation which deals with the possibility of intentionally opting UM when it is less efficient than new equipment.

[22]This is for expository purposes only. One could assume a community welfare function which emphasized either rural employment absorption or geographic decentralization of industry to the extent that some current output would be sacrificed in order to further these goals.

Rural industrialization is deemed a desirable goal by LDC's because of a desire for social justice, a desire to decentralize production, a belief that migration from rural to urban areas exacerbates an already unstable political balance, a belief that over-urbanization requires excessive investment in social overhead and infrastructure capital or a desire to absorb wholly or partially fallow human resources.

UM is attractive for rural development projects in areas that experience seasonal unemployment or underemployment. Among the advantages are the following:

1. Since capital costs continue when equipment remains idle, the lower acquisition cost of UM is an advantage when a seasonal activity is involved.

2. Equipment which is amenable to a more labor-intensive factor mix and demands less sophisticated labor skills is in a better position to employ surplus rural labor.

3. UM can be selected from a range of past vintages and tailored to the feasible scale of production.

4. The labor employed would have a lower opportunity cost compared to labor transferred to urban areas. The problem of increased transportation and housing costs would be avoided, while per capita food production would remain essentially the same.[23]

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[23] If labor is transferred to urban employment and agricultural output drops by a smaller proportion than the agricultural labor force, food output per person remaining in agriculture rises. Policy makers then face the difficult task of holding down consumption per person in agriculture

5. UM maintenance problems could be reduced by using a skeleton crew to perform the major scheduled maintenance, overhauls, and spare parts rebuilding and replacement during the off season.

Of the industrial pursuits that are conducive to employing UM in rural community development, food processing is difficult to beat. The industry is closely tied to rural communities and is seasonal in nature. Improving the static efficiency of food processing in LDC's can reduce food spoilage, increase labor productivity through improved diets, and partially correct situations in which:

> The overall food balance sheet may look satisfactory in a particular country, [but] there are areas which suffer from severe shortages due to uneven distribution, lack of transport, storage and processing facilities.[24]

Many other industries can potentially be operated on a seasonal basis. Speaking of the rural sectors of developing countries in Africa, W. F. Johnson, Chief of USAID's Agricultural Division of the operations Mission in Liberia, says:

> In many of these countries local artisans,[and] local entrepreneurs, are able to move fairly quickly into the production of animal-drawn equipment, ploughs, wagons, carts, simple seeders to promote line-planting of plants and other types

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by creating proper incentives or the efficient administration of a tax which miraculously leaves farmers' incentives unchanged.

[24]United Nations, Report of the Asian Conference on Industrialization, Manila, Philippines, December 6 to 20, 1965 (New York: United Nations, 1966), p. 25.

> of improved equipment that can significantly increase productivity, but it is still not very costly and well within the reach of the local manufacturers, or potential manufacturers in the area.[25]

A study of the rural development in Western Nigeria corroborates these findings.[26] The authors found that of the agro-industries, food processing was the most feasible.[27] Proper training of local craftsmen and stimulation of entrepreneurial talents could lead to the establishment of other industries.[28]

UM and Training

Chapter III dealt with some advantages of UM in increasing and speeding the benefits from learning while doing. UM can yield similar results when used in more formal training programs since the trainee is exposed to a more mechanical process and more repetitions of problem situations for a given time period. If the number of problems presented do not overwhelm him entirely, the prevention of the problem *ex*

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[25]Quoted in *Rural Planning in Developing Countries*, Report on the Second Rehovoth Conference, Israel, August, 1963, Raanan Weitz, ed. (Cleveland: The Press of Western Reserve University, 1966), p. 96.

[26]P. Mueller and K. H. Zevering, "Employment Promotion through Rural Development; A Pilot Project in Western Nigeria," *International Labor Review* (August, 1969), pp. 111-30.

[27]*Ibid.*, p. 129.

[28]"This could lead to the development, particularly in the rural towns, of modern, small-scale indigenous businesses in certain promising trades like woodworking, metalworking and the manufacture of construction materials," *Ibid.*, p. 130.

ante or its solution ex post will be routinized at an earlier date.

Furthermore, UM can be chosen from a technological vintage representing a step toward more complicated equipment for trainees. The most modern equipment, with which few will ever work, can thereby be avoided. Professor A. D. Bohra of the Small Industry Extension Training Institute of Hyderabad, India, makes a similar point in describing the type of equipment that a prototype production and training center should produce for small industries. He asserts:

> . . . its equipment and machinery should not be of the very latest and most modern type. If they were, the training received would be of little use to the workmen upon return to their units. On the other hand, the Centre's equipment should be better than the substandard machinery usually available in small enterprises.[29]

Mr. Bohra is emphasizing the merit of training with what is loosely called "intermediate technology."[30] One convenient route to intermediate technology is UM.[31]

The durability and ruggedness of earlier vintages of technology is an advantage, because more mistakes are likely

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[29]A. D. Bohra, "Training for Industrial Production of Prototype Machinery," Industrialization and Productivity Bulletin, No. 6 (New York: United Nations, 1963), p. 44.

[30]A term popularized by E. F. Schumacher, a founder and director of the Intermediate Technology Development Group, Ltd.

[31]The other two avenues are (1) making adaptations and adjustments with new equipment and (2) "inventing backwards."

to be made when training than during actual production. Given the level of mistakes per time period, the cost per mistake will be lower because of (a) greater ruggedness and (b) lower replacement cost of the equipment in case of total disablement. If modern technological vintages reduce the probability of making a training error, a lower cost per mistake with UM must be traded off against a small number of mistakes with new equipment.

Indeed, there is evidence that the quality of training depends on the willingness to _accept_ the risk of trainee mistakes. Piore cites the example of a plant which canceled a summer training program because of complaints by shop foremen that the trainees were being "ruined."

> Apparently, machines and materials were the major "budgetary" constraints in the school programs, and the teacher had geared his instruction to minimize material wastage and machine damage. As a result, the trainees learned to work _too_ carefully and could not maintain the rate of production required in the shop.[32]

The greater sturdiness and lower acquisition cost of UM should at least diminish the practice of hyper-caution.

The International Labor Organization (ILO) has recently taken an interest in vocational training with UM.[33]

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[32] Michael J. Piore, "On-the-Job Training and Adjustment to Technological Change," _Journal of Human Resources_ (Fall, 1968), f.n. 6, p. 440. (Emphasis as in the original.)

[33] See Technical Supporting Service of the Vocational Training Branch, International Labor Organization, "Classification of Second Hand Equipment for Vocational Training," Ref.: VTB/TSD-720, mimeographed (Geneva: ILO, 1967), pp. 1-4, and their "The Use of Second-Hand Equipment for Vocational Training Projects; Introductory Note," Ref.: VTB/TSD-721, mimeographed (Geneva: ILO, 1968), p. 1.

As indicated by the brevity of its two references (four pages and one page) the ILO is in the exploratory stage regarding UM. Nevertheless, two practical points are made in the brief reference notes:

First, even unserviceable UM can be useful in a training program in the following ways:[34]

1. It may be made serviceable in accordance with technical norms.[35]

2. It may be restored to working order below technical norms, but still be useful for vocational training.

3. Training in the repair of parts, study of the design of the machine, various tests and experiments, and study of the connections of a machine can be undertaken with complete, but unrestorable equipment.

4. From incomplete, unrestorable UM, training in specific tasks is possible (e.g., repair of motor bearings, gears, and shafts or assembling of machine parts).

5. Useful parts can be salvaged from scrap.

Second, and closely related, UM can lower capital cost without loss of training effectiveness for some types of demonstrations as well as serving as ". . . training

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[34] ILO, "Classification of Second Hand Equipment for Vocational Training," op. cit., p. 4. Some points are paraphrased for the sake of brevity, while some phraseology is taken verbatim from the original.

[35] Presumably this rehabilitation can involve trainee observation or participation as well as provide equipment for subsequent training projects.

objects for practical exercises (dismounting, winding or electrical motor, maintenance and repair training, etc.)."[36]

Short Term Production Tasks

When a particular production project is expected to be of a short duration, UM can be especially rewarding. The physical life of most UM compared to new machinery, will more closely correspond to the project.[37] This approach has most potential for (1) mining projects, (2) construction projects and (3) a one-time production run on an item for which future demand is uncertain. The more geographically isolated the production site, the more attractive this approach becomes, since transportation expenses are avoided if the useful life of the equipment is entirely exhausted and it can be scrapped rather than being moved for resale.

Lead Time and the Gestation Period

The advantage of shortening the gestation period of an enterprise was briefly touched upon in Chapter II (see pp. 60-62), but the introductory tone of that chapter dictated a superficial treatment. Lead time (the lapse of time from the date of equipment order to the date of its delivery) was tacitly included in the gestation period (the time between

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[36]ILO, "The Use of Second-Hand Equipment for Vocational Training Projects; Introductory Note," op cit., p. 1.

[37]Chilton cites an example of a firm ". . . with extensive experience in equipping and operating mining and manufacturing enterprises in Latin America . . ." that has employed UM in this manner. Chilton, op. cit., pp. 119-20.

The UM dealers in the U.S. are well aware of this the initial expenditure on a new production project and the attainment of full production). When one examines the pre-production time lags more carefully, it pays to separate the two since (1) a lead time need not be associated with a gestation period at all, if only replacement of equipment is involved and (2) the literature fails to distinguish properly between the economic impact of a longer lead time and a longer gestation period.

A great deal of emphasis is given to the attractiveness of UM because of a shorter lead time.[38] However, from both the entrepreneurs' and society's standpoint, a longer lead time will almost always be less penalizing than a longer gestation period. In normal circumstances a lead time can be at least partially anticipated by placing the order in advance. In addition, when the equipment is being ordered for

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special situation as a useful selling point. "Two . . . times when used equipment might be used are when a company has a short-term contract or is making a product with a relatively short life." "When to Consider Used Equipment," Iron Age (June 11, 1964), p. 186, quoting Mr. Raymond Pisano, sales manager for Perry Equipment Corporation of Philadelphia.

[38] "Often, the delivery periods for second-hand pieces of equipment are shorter, because the equipment is immediately available. If the difference between the delivery periods for new and second-hand equipment is considered in terms of product lost, the faster delivery of second-hand capital goods may mean a considerable economic advantage." Netherlands Economic Institute, Second-Hand Machines and Economic Development, op. cit., p. 4.

See also UN, Report of Expert Group on Second-Hand Equipment, op. cit., p. 7. Wiener cites an example of a public corporation in a LDC which purchased UM due to a shorter lead time, op. cit., p. 61.

replacement, the entrepreneur can often "make do" with his equipment on hand. Although this means temporarily incurring higher costs, the loss is not nearly as severe as foregoing the entire output. Finally, any lead time advantage for UM will sometimes be reduced by a rise in its price. If UM prices rise faster than those for new equipment, the incentives for avoiding lead time are diminished.[39]

The literature tends to exaggerate the real cost of lead time which in turn leads to overstating the advantages of opting for UM. By treating the cost of lead time as the product of (1) value added per time period and (2) the delivery time, one arrives at an overly pessimistic estimate. One can conceive of circumstances in which this method of calculation is appropriate, e.g., a machine crucial to the entire output of a plant unexpectedly breaks down beyond repair, but it must be admitted that this is an extreme situation.

Reducing the gestation period, however, will pay far more handsomely than shortening lead time. During a gestation

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[39] "The impact of Vietnam on top of a booming civilian economy has pushed lead times on new machines to unprecedented lengths." "The result is a boom in used equipment that has driven prices up 25% to 50% in the past year by some estimates. Other estimates run much higher; in extreme cases used equipment is selling at twice the level of a year ago." J. F. Barnes, "Second-Hand Machinery: Is the Price Right?" Iron Age (June 9, 1966), p. 25.

In unusual cases of late-model machines with six to ten months lead time (e.g., for chuckers and shears) UM has sold for more than its new counterpart. Ibid.

period, output is definitely postponed and real economic costs occur. The gestation period, then, is comparable to our <u>most extreme</u> case of lead time. And, the gestation period can be a major expense. The Latin American textile study estimated an installation period of fourteen months each for the 1950, 1960 and 1965 vintages of textile technologies.[40] Preoperational costs were estimated at $102,012, $131,241 and $151,821 respectively, while interest payments during the construction period were put at $490,341, $630,834 and $729,753 respectively.[41] A shortening of the gestation period would likely reduce the preoperational costs and would assuredly lower interest charges while construction is in progress.

Unfortunately, case studies commonly state how much sooner production can start with UM, but fail to distinguish between a saving in lead time from a reduction in a gestation period. Occasionally, these combined savings in time are substantial. A Kentucky synthetic rubber plant was producing in India a year sooner than if it were new.[42] If only one-half or even one-fourth of this period was attributable to shortening the gestation period, the economic rewards to both entrepreneur and society were clearly substantial.

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[40] UN, ECLA, <u>Choice of Technologies in the Latin American Textile Industry</u>, <u>op. cit.</u>, p. 16.

[41] <u>Ibid</u>., Table K, Item 1, Lines E and F, p. 64.

[42] This plant serves as the example in the next section on obsolescence due to a fuel change.

As mentioned in Chapter II (pp. 61-62) the gestation period can be shortened when the earlier vintage technology requires less specialized atmospheric controls built into the plant facility and when an entire plant can be acquired on a turn-key or packaged plant basis. Furthermore, even with no change in the length of the gestation period, costs can be reduced by achieving partial production at an early date due to the greater divisibility of the earlier vintage of equipment.

As with other attributes of UM, there will be varied experiences. Lead time in advanced countries during periods of surplus capacity will be short for new equipment. In addition, locating UM and arranging for its appraisal, inspection, reconditioning and exportation can be time consuming.[43] As the term "special instances" implies, there is no escaping the fact that the appropriate arithmetic will differ for each set of circumstances.

In summation, economic benefits from shorter lead time or gestation period cannot be automatically expected with UM, but the frequency and size of gains are sufficiently enticing to warrant entrepreneurial investigation. The literature tends to underestimate the savings from avoiding lead time, but fails to adequately stress the decided advantages of reducing the gestation period.

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[43]The Economist Intelligence Unit study makes a similar observation. Op. cit., p. 37.

Obsolescence Due to a Fuel Change

The development of a process permitting the use of refinery gases as raw material made a Kentucky synthetic rubber plant obsolete.[44] The older process, which used ethyl alcohol, was found to be feasible in India, where ethyl alcohol was plentiful and inexpensive, and the refinery gases were not expected to be available in the immediate future.

As in many cases of the successful employment of UM, other favorable circumstances were involved. The plant was fifteen years old but had only operated three and one-half years. The United States firm retained both an equity and royalty interest in the plant, thus it had a vested interest in its successful operation. Production records for the plant were available which revealed that, when operating, the plant consistently produced in excess of its designed capacity. The process was still in operation elsewhere in the United States, so arrangements were made for Indian personnel to observe the process in action. Technicians were available to supervise the dismantling and assembly of the plant. If all of this were not enough, as mentioned in the last section, the plant was put into operation one year before it could have been possible with new equipment.

UM and Risk

A high risk enterprise should consider employing UM. All things remaining equal, the greater the risk, the more

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[44]This example is mentioned in several studies on UM. The most detailed account is found in A. Wiener, op. cit., pp. 8-9.

desirable it is to have a lower ratio of fixed costs to variable costs. UM lowers this ratio in three ways: (1) the acquisition cost of the capital is lower, (2) a more labor-intensive method is used because of UM's earlier technological vintage and (3) the greater age of UM further increases labor-intensiveness by inducing higher maintenance expenditures. Furthermore, the ratios of fixed to variable costs will decline faster with UM than with new machinery, since (1) UM depreciates at a faster rate than new machinery and (2) the economically warranted expenditures on maintenance will increase at a faster rate for most UM. A few representative high risk situations follow:

1. High risks are routine for some economic undertakings. The mining industry is a classic example.[45]

2. A foreigner who has a direct investment in a concern which produces and sells in a LDC's market may suffer a loss if the LDC devalues its currency. If he continues his operations after the devaluation, the technique of production would not significantly affect the magnitude of his loss. If, however, the enterprise is forced out of business, the absolute

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[45]The reader will, I hope, pardon this and other minor violations of my stated scope of this dissertation, i.e., industrial pursuits. Several conditions which prevail in mining activities seem to justify at least a brief note. Mining is often characterized by (1) a high probability of failure; (2) the adverse effect of the remoteness of the typical mining operation, which "plays hob" with resale value of any equipment, regardless of age; and (3) the frequent occurrence of profitable but short term projects. All are circumstances which enhance the suitability of UM.

amount of fixed cost becomes crucial.[46] This point can, of course, be generalized to include political or social instabilities in LDC's.

3. Introducing a new product can be a risky business. W. R. Grace recognized this (apparently in the early 1960's from context).[47] They were planning to introduce toilet tissue to an area in Peru. In addition to their trepidation about consumer acceptance, the small size of the estimated market was a factor. The market figured to be about one thousand tons per year, far below the minimum capacity of new United States equipment. Grace and Company located a discarded paper mill in the United States and paid $20,000 for it on an "as is, where is" basis. Reconditioning, transportation and installation costs brought the total expense for the second-hand mill to about $100,000, but this compared favorably with the United States' price of $150,000 to $200,000 for a new mill. The company reported that the results have been most "gratifying."[48]

4. Suppose an entrepreneur has a fair idea of what

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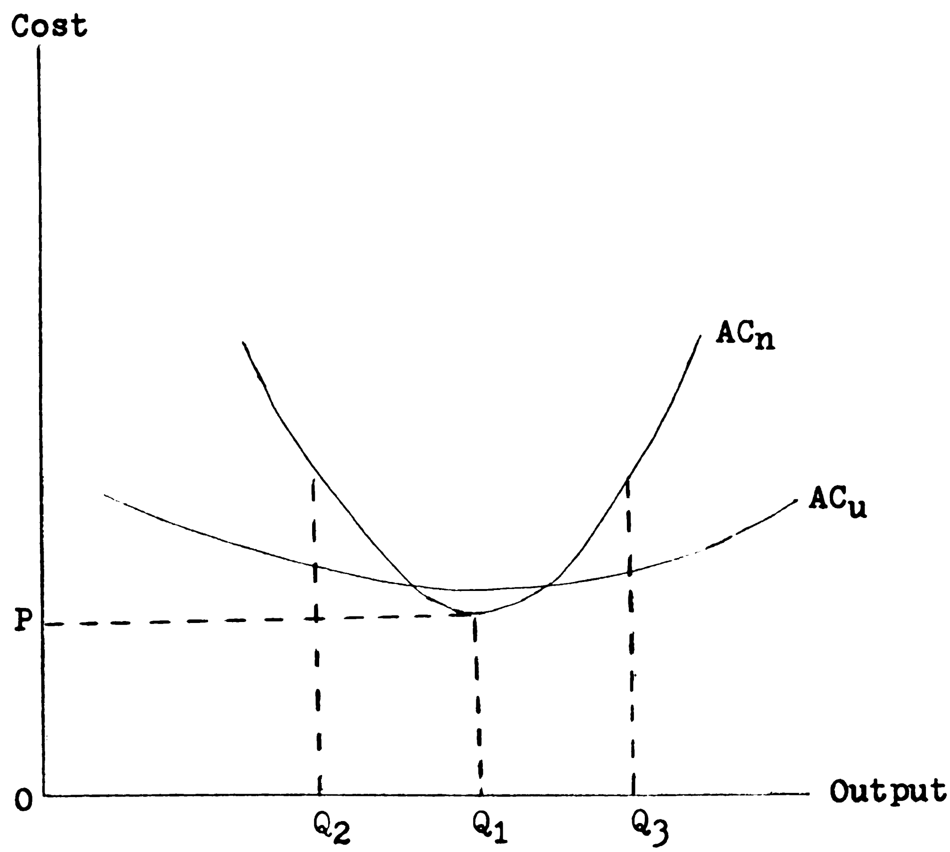
[46]"Concern with the stability of the hosts country's currency seems to rank high among economic considerations. The attractiveness of technological alternatives entailing relatively low initial cash outlays will be enhanced if management is seriously worried about the near-term possibility of currency depreciation." Chilton, _op. cit._, p. 193.

[47]_Ibid._, pp. 118-19.

[48]_Ibid._ At this point I shall make the utterly futile request that all Freudian punsters show great restraint and pass up this straight line, rare though they may be in doctoral dissertations.

the average size of his market is going to be during the life of his capital equipment, but he expects the demand for his product to show frequent and unpredictable deviations from the average. Put differently, he can predict the aggregate market over a long period with a fair degree of accuracy, but he cannot do so with any confidence for any given short period.

Consider the two situations depicted below:



Let AC_n represent the average cost curve for new equipment and AC_u the average cost curve for UM. The new technique allows the lowest cost of production attainable, at output Q_1, but if we figure that output will periodically fluctuate between Q_2

and Q_3, the technique that results the lowest unit cost over a range of demand cannot be determined a priori; it depends on the frequency, extent and duration of the departures from Q_1.

What justification do we have for depicting the cost situations as they are shown? The "flatter" UM curve implies greater flexibility in adjusting to different outputs. The characteristics of UM which permit less painful adjustments to change in demand have already been explored in Chapter IV when growth of the market could be envisioned with perfect foresight. Lower fixed costs (both absolutely and relative to variable costs), greater divisibility, and more frequent opportunities to replace equipment are also advantageous when demand fluctuates unpredictably.

Since the key is flexibility, and since UM will typically be more flexible regardless of the time interval or the production unit, the curves above can be applied to both the short-run or long-run and to the machine design, plant, or industry levels of production.

These examples of reducing risks by employing UM are not meant to be exhaustive. They do, however, serve to illustrate a simple conclusion: risk and uncertainty increases the desirability of reducing fixed costs as well as rigidities in equipment use; employing UM is one method of doing both.

Innovation and UM: Something New and Something Old

UM and Product Differences in LDC's

In advanced countries, increasingly rigorous product specifications will make older equipment obsolete. In addition gradual deterioration of equipment can render it incapable of meeting unchanged specifications. If, however, equipment failures are rather minor and buyers in LDC's are not so particular, the old machinery can still be productively used. Waterson tells of some used batch dyeing equipment in a Central American plant that could not reproduce the exact shade of color from batch to batch.[49] In spite of this deficiency, the plant operated profitably for the simple reason that the consumers were not disturbed by the variation in shade.

The development of new products expressly for LDC's offers additional opportunities for the employment of UM.[50] Simplification of the product's construction is one of the main objectives of "inventing backwards." Colgate-Palmolive, for instance, is introducing a washing machine that is ". . . hand-operated and vaguely resembles an old-fashioned butter churn."[51] Standard Oil of New Jerseyhas developed a

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[49] Albert Waterson, "The Use of Second-Hand Machinery in Developing Countries," revised (Washington: International Bank for Reconstruction and Development, October 4, 1962), mimeographed, p. 10.

[50] See Richard J. Howe, "Inventing Backwards; Some Firms Simplify Products for Markets in Poorer Countries," Wall Street Journal, Eastern Edition, May 27, 1969, pp. 1 and 32.

[51] Ibid., p. 1.

kerosene stove which costs about $2, and National Cash Register's Japanese subsidiary has developed a crank operated cash register.[52] There are already dozens of farm implements on the market which have been especially simplified for LDC's.[53]

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[52]Ibid.

[53]I have already had occasion (in Chapter I) to mention the Intermediate Technology Development Group, Ltd., of 9 King Street, Covent Garden, London. ITDG is a private, non-profit organization which encourages the development of new technology suited to LDCs' needs. As a glance through ITDG's Tools for Progress 1967/68; Guide to Equipment and Materials for Small-Scale Development will show, agriculture receives most of the organization's attention.

The Overseas Liaison Unit of the National Institute of Agriculture Engineering of Wrest Park, Silsoe, Bedfordshire, England, is also interested in new technologies for agricultural technologies. According to material supplied by Mr. D. H. Sutton, the Overseas Liaison Unit's development work ". . . results in the production of working plans for simple agricultural equipment which can be manufactured in the countries themselves." The Unit listed ten projects with which it is currently concerned, including a small portable rice thresher, a multipurpose animal drawn toolbar, a simple pump and a simple seeder. "Note on the Overseas Liaison Unit at the National Institute of Agricultural Engineering" (Bedfordshire, England: Overseas Liaison Unit, n.d., from context: late 1967 or early 1968), p. 1.

Modern Agricultural Company of Washington, D.C., designs and exports such products as a hand-operated thresher, the animal-drawn "Charlie Brown" shovel plow and the animal-drawn "Geronimo" potato planter. R. J. Howe, op. cit., p. 32.

LTV Aerospace Corporation has decided to begin production of its "Kid," ". . . an off-the-road multipurpose vehicle designed to meet the farming and transportation needs of Southeast Asian Nations." Through adaptation, it can serve as ". . . a mobile irrigation pump, fire fighter, insecticide sprayer, grain thresher, mobile power source, medical clinic or ambulance. . . ." "Ling-Temco Unit Production," Wall Street Journal, Southwestern Edition, July 16, 1969, p. 10.

But does simplification of the product imply a less sophisticated production process that favors an earlier vintage of technology? Not necessarily, but it will in many instances. Chrysler's solution to its Turkish marketing problem is a case in point:

> Chrysler faced problems. U.S. mass production methods weren't suited for Turkey's low-volume market, and skilled workers were unavailable. So Chrysler had to design a completely new truck that would be simple to put together. Among other things, this meant redesigning the cab, which in the U.S. is assembled out of pieces stamped by expensive dies. In Turkey, the cab is built from metal slabs cut by a crude hand-operated press that resembles a guillotine.[54]

To the extent that simplified products permit less sophisticated manufacturing processes, the advent of new technologies will have countervailing effects on demand for UM. The new, simplified machines will offer a substitute for UM, e.g., the animal drawn "Charlie Brown" shovel plow may offer a more efficient way to save capital than a more complicated, large second-hand tractor. On the other hand, the feasibility of using less sophisticated production methods to produce the new, simplified machines will cause a complementary increase in the demand for UM.

UM as a Prototype for New Technologies

The employment of imported UM can exercise a demonstration effect on LDCs' machine tool industry. The UN, speculating on this possibility, refers to UM in LDC's when it says:

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[54] R. J. Howe, op. cit., p. 32.

". . . they provide the prototype design of equipment embodying relatively more labour-intensive techniques for manufacture in under-developed countries."[55]

The idea is that LDCs' tool makers will observe certain features of UM design that could be incorporated into domestic machinery. I have been unable to discover an instance which follows this format precisely. More common is a deliberate research effort, usually undertaken by technicians in developed countries, which uses older model equipment as a prototype for new, followed by an attempt to instill a demand for the product in LDC's.[56]

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[55] UN, "Choice of Capital Intensity in Industrial Planning," Industrialization and Productivity Bulletin, No. 7, op. cit., p. 32.

[56] The hand-operated grain thresher mentioned in the previous section was inspired by ". . . century-old models displayed at the Smithsonian Institute. . . ." R. J. Howe, op. cit., p. 1.

A simple water pump has been developed along lines resembling an old Chinese model. Overseas Liaison Unit, "A Simple Hand-Operated Flap Valve Water Pump," Tropical Agricultural Engineering Information Bulletin, No. 1 (Silsoe, Bedfordshire, England: Overseas Liaison Unit of the National Institute of Agricultural Engineering, n.d.).

Chilton cites a further example: "In this instance, the recommendation was made to modify the proposed technology of a chemical project which was to be undertaken in Latin America. Mr. F. Shinagel [of the Research Division of W. R. Grace & Company] suggested that in lieu of the current U.S. technology a technique be adopted that was described in an old handbook published prior to World War I. The alternative process would have reduced the required investment outlay while satisfying the technical requirements of the new venture. In the end, this recommendation was not accepted, but its rejection was not attributable to any technical or economic shortcomings of the process." Werner L. Chilton, op. cit., f.n. 2, p. 102.

Rare as it evidently is, development of new technologies in LDC's due to the demonstration effect of UM would have three distinct advantages over the laboratory method of inventing backwards in developed areas. First, since the UM can be seen in action, weaknesses and strong points of various designs can be determined by observing the equipment's performance in the physical, economic and institutional environment of the LDC. Second, it would be more likely to encourage entrepreneurship among groups indigenous to the LDC's. Third, innovation within LDC's is more likely to become infectious, leading to further innovation. Fourth, since LDC's are not homogeneous, there would be merit in developing technologies more compatible with the peculiar conditions of each LDC.

Retrofit

"Retrofit," a contraction of "retroactive fitting," is the term applied to upgrading the performance of old machinery by means of modern attachments. Two illustrative examples follow.

Analim Electronics Corporation of Hialeah, Florida, produces a variety of retrofit items. Among these is its digital readout system employing a linear tape transducer. Since only two contact points are needed on any machine tool, the system can be installed in a few hours. One advantage is that the operator can reset the machine tool to its desired position even when the leadscrew is inaccurate, worn or otherwise damaged. No racks, pinions or gears are employed, thus problems of backlash do not arise. A complete two axis Model-A system sells for $2,975.[57]

Mr. Charles Penn, Public Relations Manager of Tyco Laboratories, Inc., doubts whether numerical control will be useful to LDC's on a large scale in the immediate future. He feels that Tyco's numerical control readout, called DigiPoint, is too expensive for most LDCs' entrepreneurs (over $2,000 without encoders). These devices are useful mainly in developed areas. According to Mr. Penn: "When large production runs under tight schedules and the labor costs are impinging heavily on the final piece price, the N/C is a help and a definite advantage."[58]

Tyco does, however, have other devices that are attractive to LDC's.

> Used machinery can be automated inexpensively and simply by employing what we at Tyco call Master Automated Control for presses and assembly machines. These types of production equipment, including such old dogs as 'a mechanical clutch press' can be operated safely at top speed and without fear of damaging the valuable dies and tools. . . . [This] inexpensive system runs in the vicinity of $350.00 per machine per central control. The accessories, such as end of material detector, transfer material detector, die shut height detector, parts counter and many other units can be attached in a matter of minutes to any old die stamping, assembly machine or press. This, we feel, is more in line with the needs of the less developed countries.[59]

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[57]Telephone conversation with Mr. Jay T. Malina, Sales Manager, July 11, 1969, and specifications and brochures furnished by Mr. Malina.

[58]Letter, April 29, 1969.

[59]*Ibid.*

There is no doubt that researching the retrofit market will throw additional burdens on entrepreneurs in LDC's, but restoring an older piece of equipment to its original performance, or adding to its versatility or accuracy at a fraction of the cost of buying a new machine is worth some time and expense. The following case study is in a sense an instance of retrofit on a grandiose scale.

UM and Automation

Automating UM: A Case Study of Papelera de Chihuahua, S.A.[60]

Upon entering the operating portion of Papelera de Chihuahua one is confronted with the "old" section of the plant. Scrap paper is converted into pulp and then pressed into a heavy corrugated cardboard for use in residential housing construction. Local construction needs absorb most of the output. Licenciado Gastone Guglielmina, who is the plant manager and one of the principal stockholders of the firm, estimates that the equipment is approximately seventy years old. He does not know its origin, since it was in Chihuahua when he arrived.

The most rewarding lessons, however, are to be found in the newer and larger part of the plant which has been under the control of Lic. Guglielmina since it was constructed and

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[60]Information is based on conversations with Gastone Guglielmina, in June of 1967, and an extended tour of the plant and an interview in August of 1969. Chihuahua City, Mexico, is located approximately 230 miles south of El Paso, Texas.

began operations in 1966. Various grades of wrapping paper are produced and sold in the Chihuahua, Monterrey and Mexico City markets. Maximum capacity is 40 tons per day; the plant averages approximately 35 tons per day. Some waste paper is used, but most of the raw material consists of baled sheets of cellulose obtained in the United States and from Celulosa de Chihuahua, S.A., which is located sixty miles southwest of the city of Chihuahua in the Anahuac Industrial Center.[61]

Most of the basic equipment in the new plant came from three sources: First, Mexican sources accounted for the equipment which converts the scrap paper or cellulose into pulp. Most of it was obtained second-hand in Monterrey with the important exception of the chemical agitator vats which had been used in Germany. In addition an hydraulic press which handles the heavy rolls of finished wrapping paper was purchased from a Chihuahua service station. Second, the bulk of the rolling mill was purchased in Germany when a plant was made obsolete by the growing size of the German market. Most of the equipment was made in 1950 by O. Dorries, A.G. Third, some of the equipment was made at the plant. Such was the case of the equipment for washing the larger impurities from the raw inputs and the vibrator screens that remove the small impurities from the liquified pulp. Of the rolling mill

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[61] Worthy of a passing note, the power for the Anahuac Industrial Center is provided by used thermo electrical steam generators from Milan. Wayne McClintock, "Pretty Clothing Evolves from Trees," El Paso Herald-Post (August 20, 1969), sec. B, p. 1.

equipment, both rollers and cylinders are made in the plant's machine shop as the need for new ones is anticipated.

In essence, Lic. Guglielmina, an engineer by academic training, took what amounts to the core equipment of a German paper plant and supplemented it here and there with Mexican second-hand equipment and equipment manufactured at the plant. The German plant had been manually operated and controlled; Lic. Guglielmina automated the entire operation! The chemical composition of the pulp is electronically controlled as is the temperature and humidity of the paper on the rolling mill. Photoelectric cells measure the quality and thickness of the paper on the rolling mill and feed back information which controls the speed of the throughput. The cutting machine and winder are automatically geared to the speed of the paper coming off the rolling mill.

In addition a variety of double checks and contingency devices have been engineered into the electronic controls. Power is provided from turbo electric output in the city of Chihuahua. In the event of power failure in Chihuahua, the plant automatically receives power produced hydroelectrically from nearby Lake Boquilla. The plant has an emergency lighting system. Standby generators automatically go into action if the primary machines fail. An air compressor purchased new in Monterrey is backed up by two second-hand German machines. Two photo electric cells register the thickness of the paper; information from one is reported to the main control board and the other provides information that can be read from a dial near the rolling mill itself.

Papelera de Chihuahua is a highly successful firm. Lic. Guglielmina believes it has the lowest unit cost of production of any producer of comparable products in Latin America, and the firm is able to compete successfully in the home markets of larger concerns in Monterrey and Mexico City. Several instructive lessons emerge from Papelera's operations.

Capital Costs Are Reduced

When comparing cost of UM to new machinery, Lic. Guglielmina believes the price of the UM must, as a rule, be no more than 75 per cent of the price for new equipment.

The durable nature of the equipment used in paper manufacturing, combined with an excellent program of maintenance and repair at Papelera, causes differences in the expected useful life of UM vis-à-vis new machinery to be a minor consideration. The seventy year old equipment in the old part of the plant corroborates Lic. Guglielmina's testimony on this point. The 25 per cent saving in initial capital outlays for UM is deemed a minimum because of (1) the greater risk in purchasing UM (although we shall see that Lic. Guglielmina takes measures to reduce the risk of obtaining poor equipment), (2) increased demands on the time of the entrepreneur in supervising the procurement, reconditioning[62] and

[62]Here I mean the managerial effort in putting the individual equipment in working order, and the supervision of changes necessary to synchronize the equipment with the rest of the production process. Lic. Guglielmina believed that the latter constituted the greatest tax on his time and ingenuity.

maintaining UM and (3) the direct outlays of money on reconditioning and maintenance of UM. Partially countering these cost considerations is the reduced lead time for UM which is important to Lic. Guglielmina's procuremant plans. He has, however, found that UM has resulted in no consistent saving in the gestation period.

Lic. Guglielmina has often been able to do considerably better than 75 per cent of the cost of new equipment in his UM acquisitions. The hydraulic press which moves the finished rolls of paper from the widening machine was procured from a service station in Chihuahua City for 15,000 pesos (approximately $1,200) compared with a 45,000 pesos ($3,600) price for a new one. The saving on the German winding machine was of a similar magnitude. The small German air compressor (used on a standby basis) was obtained as scrap iron. Several other minor pieces of equipment were obtained locally for the cost of hauling away. For most of the other UM, comprising virtually the entire complement of equipment aside from what was built new at the plant, the savings in initial capital outlay ranged from 50 to 75 per cent of comparable new machinery.

Access to Information on UM is Crucial

In responding to my question as to whether he used trade journals as a source of information on UM, Lic. Guglielmina replied in the affirmative. He does not fully trust them, however. He *always* personally inspects major pieces of equipment. This is after a precise cataloging of his needs (e.g., size and position of valves, volume of throughput, and accessibility of moving parts for maintenance) and a careful research for equipment that fits or approximates these specifications.

Trade publications are supplemented by a wide network of personal connections in the paper industry. Members of Lic. Guglielmina's ancestry were the first industrial producers of paper in Italy and approximately seventy relatives are now in the paper industry throughout Western Europe. Furthermore, in the course of setting up nine other paper plants in Italy, Austria, Switzerland and Monterrey, Mexico, and traveling in the United States, he has built up a long roster of personal and professional acquaintances in the paper industry. The end result is a superb information network. Although we cannot expect the typical entrepreneur in LDC's to be blessed with such valuable private sources of information, Lic. Guglielmina's situation does shed light on the benefits that would follow from improving the quantity, reliability and accessibility of information on the UM market.

UM, Automation and the Compulsion to Maintain

Continuous production is the key to Papelera's low unit costs. Thus the incentives mentioned by Hirschman are certainly felt.[63] That employing UM *adds* to the need of

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[63] "It is this *compulsion to maintain* that is, for instance, characteristic of the operations of integrated, 'continuous-flow' processes. . . ." Albert O. Hirschman, *op. cit*, p. 142.

formulating and implementing a maintenance and repair program has not been lost on Lic. Guglielmina. He has drawn up a complete set of standard procedures ("the Bible" in plant parlance) which includes instructions for proper preventive maintenance. Every machine or major component is assigned a number for maintenance purposes. These numbers are further coded by sections, e.g., building, warehouse, preparation, manufacturing, chemical engineering, etc. In the engineering department a card (approximately 340 of them) is kept on each major piece of equipment on which is recorded its maintenance history. The card projects the scheduled maintenance and replacement dates which are based on original manufacturer's specifications and modified according to actual experience at Papelera. Each card is checked daily.

Virtually all spare parts are made in the plant repair shop. Most of the equipment in the repair shop is secondhand and from Mexican and United States sources. The Papelera repair shop, unlike those of many plants, does not experience extensive periods of downtime. The accurate maintenance records described above allow an orderly scheduling of work. Some major components are built "from scratch." Rollers for shaping the paper have been made there and, at the time that I visited the plant, several large cylinders for the rolling mill were being manufactured in the machine shop.

Lic. Guglielmina weighs the relative ease of maintenance heavily in his equipment specifications and procurement policy. As we shall see next, among the many innovations that have been made at the plant, several have cut maintenance costs.

Continuous Innovations Are Possible

Aside from converting mechanical equipment to an electronically powered and controlled automated process, Lic. Guglielmina is constantly looking for less dramatic, but worth-while ways to improve efficiency. Some instances follow:

1. The Zeiss press, consisting of massive rollers that flatten the paper after the proper amount of moisture has been taken out, had no convenient aperture for checking the oil level. Either one waited until something went wrong or went through a time consuming process of dismantling part of the press to check the oil. An oil well was attached which could be inspected by sight.

2. The hydraulic press had no safety device. One was fashioned whereby any pressure applied around the edge of the hydraulic press pit would automatically shut off its power.

3. The water was originally suctioned away from the sheets of pulp as it traveled on the initial portion of the rolling mill by suction devices mounted on wooden frames which had to be replaced every few weeks. Teflon tops were substituted and experience has indicated that these are virtually impervious to wear.

4. One of the most serious bottlenecks presented by the mechanical equipment was the low throughput of the

chemical agitator vats. The agitation was originally performed by a series of blades that spun on axes arranged vertically in the vat. Lic. Guglielmina switched the arrangement to horizontal axes and added more blades to each shaft. Power costs were cut and rated capacity was increased from 25 tons per day to 40 tons.

5. The greater flow of pulp from the chemical agitator vats and the greater speed made possible by electronic controls necessitated complementary adjustments in the speed of the rolling mill. This was accomplished by increasing the number of cylinders and modifying their diameters slightly. The latter was done in the repair shop by refinishing the cylinders to add one-eighth of an inch to the rolling surface.

6. Papelera employs a "wet" production method which calls for exact levels of heat and humidity. These conditions are fulfilled by means of steam which rises out of the basement. The cost of producing the steam has been reduced by between 10 to 15 per cent by recycling the hot humid air back to the basement.

7. Modifications for differences in voltage requirements in second-hand generators have been frequently needed and have been accomplished at the plant.

UM and the Marginal Value Product of Entrepreneurial Effort

In the case of Papelera de Chihuahua there is little doubt that employing UM places an extraordinary tax on entrepreneurial and managerial effort. It takes time for Lic.

Guglielmina to calculate the exact equipment needs; research the UM literature, correspond with friends in the paper industry and put feelers out among his relations who are in paper production; to sift out the equipment that appears to offer the best bet; travel in Mexico, the United States or abroad to personally inspect the equipment, supervise its crating for shipment; and finally mastermind the reconditioning and innovational adjustment needed to blend the equipment into the continuous-flow production process. Since top management in LDC's typically operates under severe time restraint, extra time and effort incur the cost of foregoing alternative applications of entrepreneurial and managerial ability.[64]

A valuable lesson emerges from Papelera at this point. Lic. Guglielmina is a man who calculates costs carefully. Before setting up the paper plant in Chihuahua, his tenth, he drew up fifty-one alternative combinations of equipment! In equipment procurement he prepares precise specifications and then shops for the needed item. The innovations mentioned above indicate the attention given to costs. He has a detailed knowledge of the procurement and rehabilitation cost of pieces of equipment and he can cite these figures from memory. He is acutely aware of competition in Monterrey.

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[64]Lic. Guglielmina usually puts in an eleven or twelve hour day at the plant. For a brief but excellent summary of the conditions in LDC's which place such great stress on top management, see UNIDO, Report of the Group of Experts on Maintenance and Repair, ID/1 (Vienna: United Nations Industrial Development Organization, April 21, 1967), mimeographed, pp. 21-24.

All of these indications lead one to believe that the engineer-manager is one who does weigh alternative costs and does so with some deliberation. He is aware of the problems of employing UM, but he consistently employs it for the simple reason that he feels that he can produce more efficiently with it.

What else are we to think? Lic. Guglielmina is free (and, indeed, in great demand) to move on and construct his eleventh paper plant, become technical assistant to a larger Monterrey or Mexico City firm, or to employ new equipment and devote more energy to other aspects of management. Yet, after quite obviously making conscious estimates of the various courses of action, he chooses to remain with Papelera and employ UM.

The moral is that even though entrepreneurial, managerial and supervisory capabilities are scarce in LDC's, "spending" some of this resource on employing UM may yield the most generous return available. The emphasis in the literature has been on saving these human abilities by means of using more expensive equipment with the tacit assumption that the marginal value product of these abilities will be great enough in alternative uses to more than compensate for the added capital costs. Our case study of Papelera indicates that up to a point reducing capital costs may have the highest return to a portion of these executive talents.

Used Automated Equipment in Less Developed Countries

Although Papelera de Chihuahua did not involve a transfer of automated UM, it affords a convenient point of departure for examining the feasibility of employing used continuous-flow equipment in LDC's.

For most products amenable to automated production, long-run unit costs can be lowered by enlarging plant scales. Feasible plant size is mainly governed by size of market demand for the plant output. As was mentioned earlier in this chapter, the superior growth in the <u>absolute</u> size of markets in advanced industrial countries will continually make such equipment obsolete. Although economically obsolete, many such plants will be in good physical order. Given the market growth in developed countries, it is reasonable to assume that an increasing number of automated plants will be thrown on the market or made available to foreign subsidiaries.

These second-hand plants will not be without advantage to LDC's. There are significant economies of scale in <u>securing</u> UM. Costs of obtaining appraisals and inspecting UM are inelastic with respect to the total cost of equipment.[65] When a complete plant is sold it represents one of the few cases in which the market <u>thinness</u> is conducive to efficiency. As we shall see in the following chapter, most firms treat sales of surplus machines as a marginal operation. When an entire plant is involved, however, pains are taken to give buyers the opportunity to inspect the equipment under power.[66]

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[65] Typical appraisal and inspection procedures are discussed in the following chapter.

[66] I have been unable to trace the original reference, but I recall reading of a multimillion dollar plant being auctioned while the prospective buyers made their bids in

Furthermore, arrangements can be made for bringing key personnel from abroad and training them under the current staff of technicians. Frequently an equity position or a royalty is retained by the selling firm thus giving it a vested interest in the success of the project.

When a complete plant is purchased it is more feasible for one organization to dismantle, package, transport, reassemble and rehabilitate the equipment. As will be seen in Chapter VI, the current pattern of specialization in the UM market makes this a rarity for individual pieces of equipment.

The most obvious advantage of an automated plant is that it has production decisions "built into" it, thus freeing entrepreneurial, managerial and supervisory talent for alternative application. Used plants do this <u>and</u> reduce capital costs.

We can expect less resistance within LDC's to the importation of second-hand automated plants than is the case with nonautomated UM. While not representing <u>the</u> most modern technology, such plants are of recent vintage and retain some

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air-conditioned lounges in two large metropolitan areas of the U.S. Closed circuit TV and two-way communications enabled the viewers to see the plant under power and request that the camera "zumar" in to get a closer look at a particularly sensitive (and suspicious) looking moving part. These elaborate lengths indicate (1) the importance that buyers attach to seeing the equipment in operation and (2) the economies of scale in marketing expensive equipment (albeit the expense was in this instance borne by the sellers).

of the aura of modernity. This tends to reduce engineering biases and political fears of an intentional plot to dump old equipment in LDC's.

The advantage of cheap labor, of course, is sacrificed and the goal of employment absorption is not greatly furthered by employing automated equipment. Nor is it entirely clear whether, on balance, maintenance problems would ease. The transfer of automated plants, then, offers no panacea for LDC's. As with all other cases of employing UM, there is no substitute for carefully reviewing alternative productive methods. The results will differ according to variations in the age and condition of the equipment, size of the market, available skills of the labor force and a variety of other circumstances.

Conclusion

The existence of special situations for employing UM in LDC's makes the difference between the real world and the literature on UM more intelligible. In the real world UM accounts for a substantial amount of capital formation in LDC's despite anti-UM biases. In the first approximation to cost comparisons in Chapter II, using assumptions that represented ordinary cost conditions it was seen that only in rare instances would UM be feasible.

The explanation to this seeming paradox lies in the term "ordinary." If only 1 per cent of UM situations have lower maintenance costs; only 1 per cent have unusually long physical lives; only 1 per cent involve abnormally high risk;

only 1 per cent involve market sizes too small for new machinery; only 1 per cent involve substantial idle time, etc.; the cumulative total is impressive. In addition the number of UM situations that will have <u>slight</u> advantages in <u>several</u> points of comparison (e.g., maintenance costs are only slightly higher, the life of the equipment is fairly extensive, and the risks are slightly greater than the usual project) will swell the total. It is in best "filling the bill" for a variety of such situations that UM makes the greatest contribution to economic welfare in LDC's.

PART III

CHAPTER VI

ORGANIZATION OF THE UM MARKET

This chapter has four purposes: (1) to make a rough estimate of the contribution of UM imports to capital formation in LDC's, (2) to determine the effect of increased demand for UM by LDC's on UM prices, (3) to review the market organization for transferring United States UM to LDC's and (4) to examine the degree of marginality and pattern of specialization of the UM transfer mechanism.

The Contribution of UM to Capital Formation in LDC's

Virtually the only hard data on UM transferred to LDC's are figures on a few categories of United States exports. Even these are not available prior to 1965. Despite this paucity of statistics an attempt will be made to give a very rough idea of the contribution which UM imports make to capital formation in LDC's. This is admittedly akin to an archeologist estimating the base of a pyramid from several random pieces of the apex. One can, however, take comfort in that (1) a calculated estimate is probably better than none (I know of no previously existing estimate) and (2) an estimate accurate enough to be "in the ball park" will be sufficient for present purposes. If we know that the probabilities favor an estimate of UM's contribution to LDC's investment in fixed durable equipment which is closer to one-half of 1 per cent, 10 per cent or 20 per cent, a good deal of insight will have been gained.

Four categories of used equipment which are directly related to core equipment for manufacturing are separately reported in the export statistics of the United States Department of Commerce. Each category includes both rebuilt and nonrebuilt used equipment. The four types of equipment and their respective Schedule B Commodity numbers are (1) metal-cutting machine tools, 7151072, (2) metalworking machine tools, 7151088, (3) industrial sewing machines (except shoe sewing machines), 7173040 and (4) pulp mill and paper mill machines, 7181130.[1]

The relevant figures and percentages are found in the appendix to this chapter. As one would expect, UM as a percentage of total imports of United States equipment is consistently larger for LDC's than for developed areas. The ratio of imported UM to total machinery imports for LDC's has ranged from a low of 25.7 per cent in 1968 to a high of 46.6 per cent in 1965. This compares to a 11.5 per cent low in the first seven months of 1969 and a 19.0 per cent high in 1965 for developed areas. The UM total machine ratio for LDCs' imports has ranged roughly from double to triple the ratio for developed countries.

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[1] Schedule B numbers for the new counterparts are (1) 7151070, (2) 7151086, (3) 7173030 and (4) 718110 and 7181120 (the new pulp mill and paper mill exports are reported separately).

The used metal-cutting and metalworking machine tools have been particularly heavy as a proportion of total LDCs' imports. This is especially important in view of the projected need for these and similar metalworking equipment in LDC's. It is estimated that machine tools and metalworking machinery will constitute 27.4 per cent of equipment requirements of manufacturing industries in LDC's in 1975.[2] This is by far the largest category of equipment in the projection with the exception of a catch-all classification called "special industrial equipment."

Suppose that we assume that the four years, seven months (January, 1965 through July, 1969) totals for all four categories of UM are fairly representative of all UM exports from the United States. We could infer that approximately 35 per cent of the value of equipment exported to LDC's was second-hand. If we apply this proportion to LDC's imports from all developed areas and assume that imports will account for two-thirds of LDC's needs,[3] we arrive at a figure of 23 1/3 per cent of industrial equipment formation accounted for by importation of UM.

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[2]UN, "Projection of Demand for Industrial Equipment," Industrialization and Productivity Bulletin, No. 7 (New York: United Nations, 1964), Table IV, p. 21.

[3]The UN projection assumed imports would satisfy two-thirds of the LDCs' requirements for "manufacturing equipment proper" in 1975. They are referring to most of the SITC 71 group of commodities, total nonelectrical machinery. Ibid., f.n. 25, p. 16.

This first approximation very likely overstates the contribution of UM for the following reasons:

1. Mexico purchases a large amount of UM from the United States. The geographic proximity to a developed country, level of labor and management skills, and the rate of Mexican industrialization may cause Mexico to be atypical with respect to UM importation. If Mexico imports an unusual amount of UM relative to the remainder of LDC's, using United States figures as representative of the developed countries overstates the results.

2. The Soviet Union and Eastern European countries, as of the mid-1960's, did not include significant amounts of UM in their exports to LDC's.[4] This would have the same effect as 1 above, i.e., using the United States as representative of the developed countries tends to overstate the results.

3. Some LDC's have growing machine tool industries (e.g., Argentina, Brazil and Mexico), thus the assumption that two-thirds of industrial equipment is imported may be too high.

4. Using the four year, seven months totals may overstate the current importance of UM. Over this period there has been a tendency for the composition of LDCs' equipment imports to change to a lower UM-new machinery mix. This tendency is reversing itself in 1969 and the period of

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[4]Wiener, op. cit., p. 13.

observation is too short to confidently speak of a "trend." The data, however, at least suggests such a possibility.

Even assuming that the first approximation as stated above overstates the role of UM in LDC's by 50 per cent, UM imports would account for approximately one-eighth of their industrial equipment. As a rough guess, the contribution of UM ranges from between 10 and 20 per cent of their supply of industrial equipment. We are, then, dealing with a marginal factor, but it is marginal to industrialization of LDC's in the same sense that an arm or leg is a marginal part of the body.

Demand of UM by LDC's Relative to UM Supply

Is the flow of UM being made obsolete in developed countries sufficient to supply the future demand for it in LDC's? The answer is definitely in the affirmative. Exports of used machine tool sales in the United States are approximately 5 per cent of the total.[5] The figures in the appendix to this chapter indicate that slightly over 50 per cent of United States UM exports go to LDC's. If these two pieces of data can be taken as representative of all UM, approximately 2 1/2 per cent of UM sold in the United States goes to LDC's.

Estimated sales by members of the Machinery Dealers National Association in 1965 was approximately $380 million.[6]

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[5]Machine Dealers National Association, "News from MDNA" (Washington: MDNA, April 3, 1967), p. 2, quoting Richard L. Studley, executive director of MDNA.

[6]Wiener, op. cit., p. 35.

Wiener estimated that sales by members of this organization comprised about 75 per cent of all sales of such equipment in the United States (including government surplus bought and sold by dealers).[7] This puts the total 1965 metal-cutting and metal-forming machinery at about $500 million. He estimates that the United States supply of metalworking UM is about one-half of the world total[8] and that demand of LDC's for new and used equipment of this sort was approximately $1.2 billion in 1965.[9] Under these assumptions the supply of UM in developed countries could satisfy over 80 per cent of the LDC's demand for metalworking equipment. As we have already seen, the indications are that somewhere between 10 and 20 per cent is a fair guess as to the actual amount.

Wiener goes on to conclude, however, that:

> In practice, the entry of developing countries into the second hand market in strength would undoubtedly push up the price of second hand versus new equipment.[10]

It is undoubtedly true that, say, a sudden doubling of LDCs' demand for UM would raise its price relative to new equipment, at least in the short-run. The long-term price effect would, however, be hardly discernable! First, the LDCs' demand, as

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[7] Ibid.

[8] No global figures are available on UM trade. "No data are available on the magnitude of the world trade in second-hand equipment, either in terms of units sold and bought or in terms of value." UN, Report of Expert Group on Second-Hand Equipment, op. cit., p. 5.

[9] Wiener, op. cit., p. 39.

[10] Ibid.

far as we can estimate, would still constitute only about 5 per cent of the total sales in developed areas. Second, a short-run rise in UM prices would increase the quantity supplied by making it more profitable to replace equipment earlier. Third, an increase of usable UM would occur at the "scrapping margin" by justifying greater rehabilitation expenditures on equipment that would otherwise have been junked. Fourth, a large increase in demand for UM by LDC's could induce the Soviet Union and Eastern European countries to supply UM for either political or economic reasons. Fifth, and a point to be pursued later, an increase in the size of demand for UM would make the UM market more efficient.

Even under rather extreme assumptions an increase of LDCs' demand for UM would have little long-run price effect. Let us assume (1) an instantaneous doubling of the purchases of UM by LDC's which would increase demand by 2.5 per cent, (2) a perfectly inelastic supply of UM and (3) a price elasticity demand of -.5. Consider the general equation for a linear demand function, p = a-bu where

p = 100 = The equilibrium price before the increase in demand.

u = 100 = The units of UM offered at all prices.

b = -2 = The slope of the demand function, i.e., $\Delta p/\Delta u$. This means that price elasticity of demand is -.5 in the vicinity of equilibrium.

a = 300 = The ordinate if u were zero; a is uniquely determined by assigning the values for p, u and b.

The original situation is given, then by $p = 300 - (2 \cdot 100) = 100$. Now let demand for UM rise by 2.5. The demand curve shifts to the right but u remains at 100. The result is determined by the slope of the function, i.e., for each unit rise in the demand for UM, the ordinate will rise by 2. The new equation is $p = 305 - (2 \cdot 100) = 105$.

Since new machinery is a very close substitute for UM it would be surprising if the price elasticity of demand is not elastic. Furthermore, if we permit time for supply to adjust, there is bound to be some response in the amount of UM offered to changes in price. For purely illustrative purposes suppose we assume that equilibrium is once again at p = 100 and u = 100. Price elasticity of demand will now be assumed to be -2.0 and elasticity of supply .5. The linear equations are expressed below:

$p = 150 - .50 = 100$ (Demand)

$p = -100 + 200 = 100$ (Supply)

Now allow demand to rise by 2.5 units. Given a slope of -.5, the ordinate of the demand function rises by 1.25 making our set of equations as follows:

$p = 151.25 - 50$

$p = -100 + 200$

Solving these simultaneously we get

p = 101, a rise of 1 per cent

u = 100.5, a rise of .5 per cent.

For most types of UM one can safely conclude that a substantial increase in employment of UM by LDC's can be accomplished without significantly affecting its long-run price.[11]

The Organization of the United States Used-Machinery Market: Sources of Supply

UM comes into the market for a variety of reasons. The equipment may have physically deteriorated to the point where replacement is advisable.[12] Economic obsolescence can come before physical obsolescence due to the advent of new equipment able to perform the same task more efficiently, the introduction of an entirely new process, economies of scale coupled with growing market demand, a change in materials used, or a shift in the demand for a product. Corporate reorganization (e.g., liquidations or mergers) also accounts for the marketing of some surplus equipment.

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[11]This conclusion should be distinguished from a cyclical increase in demand in developed countries for both UM and new machinery. UM prices do climb far and fast under these conditions.

[12]The UN Report of Expert Group on Second-Hand Equipment says of this type of equipment: "It should not be considered for possible use in developing countries." (Op. cit., p. 4.) While this is sound generally, several important exceptions should be noted. First, scrapped equipment can be a source of good spare parts. "Spare parts" here may mean the entire "shell" say, of an electric generator that can house new "guts." Second, in some cases scrap can be rehabilitated in LDC's. An example was mentioned in the case study of Papelera de Chihuahua in the previous chapter. Third, and perhaps the most important, there are a variety of uses in training to which scrap equipment can be put. These were mentioned in Chapter III in citing the International Labor Organization's interest in UM for training purposes.

Sales by Original User

Most large corporations have centralized departments for handling surplus equipment. Regularly published lists are circulated among company departments who get "first crack" at it. It is not unusual for United States firms to transfer used equipment to their subsidiaries or branches in LDC's. Several instances were mentioned in Chapter V. Strassmann noted the practice in Mexico and Puerto Rico.[13] In 1965 United States companies transferred $356 million to foreign affiliates, some of which had presumably been used by the parent.[14]

Few equipment manufacturers have standard trade-in policies for UM. Waterson mentions, however, that firms who do accept trade-ins and recondition their own equipment are "good bets" for buyers since there is usually a better guarantee and service agreement as well as a more assured spare parts supply.[15] An example of such an operation is the Goldberg-Emerman Corporation, a subsidiary of Giddings & Lewis, Inc., which supports the parent company in the area of used machine tools:

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[13] Strassmann, op. cit., p. 211.

[14] Marie T. Bradshaw, "U.S. Exports to Foreign Affiliates of U.S. Firms," Survey of Current Business (May, 1969), Part I, p. 47.

It is impossible to guess the exact amount of UM within this total since, "We regret that the questionnaires which provided the data for our May 1969 article, did not call for a breakdown of capital equipment exports into new and used machinery." Letter, November 5, 1969, Marie T. Bradshaw.

[15] Waterson, op. cit., p. 13.

> In our capacity we participate with each division of Giddings & Lewis in trade-ins against new machinery sales. This activity is carried out throughout the world, as Giddings & Lewis has manufacturing facilities both in Germany and the United Kingdom.[16]

Goldberg-Emerman also rebuilds and repairs any of the parent company's equipment on a contract basis with any division of the parent company.[17]

In addition many manufacturers allow trade-ins which are applied only to certain types of equipment or are decided in each individual case. Dorr-Oliver, Inc., provides an example: "In rare instances, we have taken back equipment which was in use less than one year."[18]

Brown and Sharpe Manufacturing Company

> . . . does not have a trade-in policy on old equipment except in the case of Automatic Screw Machines. In this instance we offer a flat $500.00 allowance against the purchase of a new Brown and Sharpe Automatic Screw Machine, providing all of the main parts are with the old machine.[19]

It is more common for distributors of new equipment to accept trade-ins of UM on their own terms. For instance Bucyrus-Eric Company, a firm engaged in manufacturing construction equipment,

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[16] Letter, February 20, 1969, Mr. Marshall Goldberg, President, Goldberg-Emerman Corporation.

[17] <u>Ibid</u>.

[18] Letter, January 8, 1969. Mr. D. C. Gillespie, Marketing Director, Industrial Process Systems, Dorr-Oliver, Inc.

[19] Letter, January 7, 1969. Mr. George A. Hawkins, Sales Director Machine Tool Division, Brown & Sharpe Manufacturing Company.

> . . . sells its products to the construction industry both domestically and in the export markets through well-qualified distributors who operate as independent business people. They purchase new equipment from us, and in turn sell this equipment to customers, taking in used equipment on trade. These distributors either repair the machinery or sell it in an "as is" condition.[20]

Firms also dispose of equipment through auctions, but most UM is sold directly to UM dealers.

AID and UM Transfers

As a general rule AID does not permit its funds to be used for the procurement of used equipment.[21] Under certain circumstances, however, AID can assist in transferring UM to LDC's. Section 217 of the Foreign Assistance Act of 1961 authorized the President to conduct a study to determine the feasibility of establishing aid programs for furnishing UM to friendly LDC's.[22] This study (presumably the Used Equipment Study performed by Ralph M. Parsons Co.)[23]

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[20]Letter, January 8, 1969, Mr. F. B. Shew, General Sales Manager, Construction Machinery Division, Bucyrus-Erie Company.

[21]Letter, Dennis M. Leen, Chief, Industrial Resources Division, Office of Procurement, AID, September 13, 1968.

Also AID Regulation 1, section 201.11 (a) says, "Unless otherwise authorized by AID/W [Washington] in writing, the commodity shall be unused, and may not have been disposed of as surplus by any governmental agency." Federal Register, Vol. 32, No. 101 (May 25, 1967), p. 7673.

[22]AID, Manual Circular No. 1454.3, "Procurement of Rebuilt or Reconditioned Machine Tools and Metalworking Equipment," attachment B (March 28, 1967), p. B-1.

[23]Contract No. AID/csd - 1060, November 30, 1965.

was completed late in 1965. It led to the belief that "The simplification of rules may encourage increased utilization of those types of used equipment that are selected and should provide products of acceptable quality at significant savings."[24] AID after consultation with representatives of the Machine Dealers National Association implemented ". . . standard criteria that could appropriately be applied to used equipment, and [selected] the types of equipment to which the standards might be most easily applied."[25]

Used machine tools and metalworking equipment were chosen as the UM to be covered on a pilot project basis under the new simplified procedures. This equipment was chosen because ". . . (a) adequate supplies of such equipment appear to be available, and (b) most firms in this industry operate under established quality standards."[26]

The conditions under which machine tools and metalworking equipment may be authorized for procurement are set forth in AID's Manual Circular 1454.3, effective date March 28, 1967. The equipment must be rebuilt or reconditioned.[27] An adequate supply of replacement parts must exist at the time of the procurement and the supplier agrees to a period of

[24] AID, Manual Circular No. 1454.3, op. cit.

[25] Ibid.

[26] Ibid.

[27] Ibid., sec. III.A.l.a., p. 2.

time during which, upon request, ". . . the supplier will render assistance in the procurement of replacement parts in accordance with U.S. industry practices prevailing at the time of the request."[28]

English language copies of operation and spare parts manuals must be supplied for each piece of equipment.[29] An AID Regional Bureau could specify additional requirements pertaining to procurement, but essentially the transfer will be undertaken if all parties are satisfied with the condition and price of the equipment, as evidenced by an inspection report completed by an independent inspecting firm mutually agreed upon by supplier, AID and buyer. In late 1967 AID tightened its control over the inspection process as will be seen presently in a section on inspection and appraisal.

The following three major programs exist for the acquisition of excess government equipment:

1. The advance Acquisition Program is authorized by Section 608 of the Foreign Assistance Act of 1961, as amended, and operates by using a revolving fund of $5,000,000. AID selects, overhauls and warehouses excess equipment. The United States General Service Administration circulates a catalog to LDC's which contains descriptions of surplus equipment. For approved uses the equipment can be acquired

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[28] Ibid., sec. III.A.2.c-d, p. 2.

[29] Ibid., sec. III.A.2.e.

for 15 per cent of the original acquisition cost which reimburses the revolving fund for transportation, rehabilitation and storage costs incurred by AID. Only government agencies or wholly owned government development agencies of LDC's are eligible. The LDC can reserve the equipment after which the Government Service Administration turns the equipment over to AID to be overhauled, crated and shipped to the LDC.

2. The Direct Acquisitions Program is authorized under Section 202 and 402, Federal Property and Administrative Services Act of 1949 as amended. AID acquires excess property directly from the government agencies. The LDCs' recipient defrays the actual cost of any service associated with acquiring and transporting the equipment to the point of use.

3. The Non-AID-Financed Program allows eligible recipients to acquire excess equipment directly from owning government agencies as authorized under Section 607, Foreign Assistance Act of 1961, as amended. With certain exceptions concerning transportation costs, the recipient defrays the cost of acquiring and transporting the property to the point of use.

The original acquisition value of surplus United States government property channeled through AID in fiscal 1965 and 1966 is shown below in terms of original acquisition costs.[30]

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[30]From figures supplied by AID and obtained by me from the office of Congressman George H. Mahon.

Type of Program

	Advance Acquisition	Direct Acquisition	Non-AID Financed	Total
Fiscal 1965				
Domestic	8.9	6.6	1.5	17.0
Foreign	9.9	10.1	.4	20.4
Total	18.8	16.7	1.9	37.4
Fiscal 1966				
Domestic	15.7	1.7	1.3	18.7
Foreign	19.3	21.3	2.5	43.1
Total	35.0	23.0	3.8	61.8

Additional amounts of surplus government equipment do not go through AID, but are sold by soliciting competitive bids. Much of these sales, under the auspices of the Defense Industrial Equipment Center, is purchased by United States dealers.

The Federal Republic of Germany also has a foreign program involving financing, tax incentives, and government supervision to insure an adequate condition of the UM and a future supply of spare parts.[31]

Private Non-Profit Organizations

The Tools for Freedom program operates as a part of the Pan American Development Foundation. Its activities are

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[31]For a description of the regulations under which the German program operates, see Untersuchung der Möglichkeit, gebrauchte deutsche Werkzeugmaschinen für Produktions- und Reparaturunternehmen in Entwicklungsländern einzusetzen,

directed at equipping training schools in Latin America with tools donated by United States firms at no cost to the receiving institution. As of late 1968, 143 schools and technical training centers had received equipment from Tools for Freedom with over 100,000 students in attendance at day and night sessions.[32] As of this writing there is no detailed data on Tools for Freedom program.[33]

Self Help, directed by Mr. Vern Shield, transfers used equipment (mainly for agricultural and small industry use) to LDC's at below market value. The equipment is reconditioned by Self Help and sold abroad. In 1968 the amount shipped was over $500,000.[34]

Professor Strassmann has suggested that, as desirable as these programs are, they may suggest a lack of organization

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Band 3 (Aachen: Forschungsinstitut für Internationale Technische und Technisch-Wirtschaftliche Zusammenarbeit, n.d., but from correspondence, late 1968 or early 1969).

The Federal Republic government made a complete study analyzing the role of UM in their aid program. At this writing it has not been released to the public, nor have I been able to learn further details. Correspondence with individuals connected with the Research Institute for International Technical Co-operation, leads me to assume that the study will eventually be made available.

[32] "Action, Pan American Development Foundation" (November, 1968), p. 1.

[33] A doctoral dissertation for Boston University concerning Tools for Freedom by Sister Mary Garnier Fenton of Regis College is now in progress. Presumably it will contain statistical data on the amounts and types of equipment donated. Letter, November 17, 1969, Nathaniel C. Williams, Director, Tools for Freedom.

[34] "Action, Pan American Development Foundation" (July, 1969), p. 1.

of the regular market channels for UM.[35]

UM Dealers

Most UM sold in the United States is not sold directly to the final user by the original owner, but goes through UM dealers. Many firms prefer to sell to dealers because of the quickness of the transaction and lack of administrative expense.[36] Machinery to be replaced is usually considered a nuisance anyway and not worth the time and effort needed to turn a profit on it, thus the dealer is an attractive alternative for disposal compared, say, to arranging an auction.[37] UM dealers also obtain equipment at auctions resulting from liquidations, those arranged by surplus equipment departments of corporations, and those for disposing of government surplus.

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[35]Strassmann, op. cit., p. 218.

[36]Leesona Corporation is typical. They dispose of used metal working machines ". . . by calling in used machinery dealers, usually three (3) and accepting the highest price offered for machines in 'as is' condition." Letter, January 23, 1969, Mr. J. N. Krieger, Supervisor of Estimating and Manufacturing Research, Leesona Corporation.

[37]"It cannot be too strongly stressed that companies in the United States do not regard used equipment as a profit-making commodity, but as a by-product of their main operation. As a result they are not willing, save in exceptional cases, to spend a large amount of time and effort in maximizing the return they receive from their used equipment. The first essential in selling used equipment for the great majority of firms interviewed was for the greatest convenience in its disposal; the possibility of a better price was a secondary factor." The Economist Intelligence Unit Limited, op.cit., p. 43. Emphasis in the original.

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The United States UM market is well organized. Specialization in certain types of equipment is frequent when the volume of demand is sufficient. The Machine Dealers National Association members, for instance, deal mainly in metalworking equipment and machine tools. Wiener lists several major dealers in used welding equipment and used electrical equipment.[38] The construction equipment trade organization, Associated Equipment Distributors, has a subsidiary group known as the Used Equipment Research Group.[39] Dealers also specialize in coal mining machinery.[40]

UM dealers range from those to whom UM sales are a side-line to their new machinery sales to firms highly specialized in a few specific types of equipment. Most dealers have some facilities for warehousing, cleaning and making minor repairs on equipment. Almost all dealers without complete rehabilitation facilities have arrangements with independent contractors who perform such work.

Very few, if any, UM dealers specialize in the overseas market. Wiener turned up only one firm that did as much as 30 per cent of its sales in exports and most of this was

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[38]Wiener, op. cit., pp. 33-34.

[39]Letter, January 8, 1969, Mr. F. B. Shew, General Sales Manager, Construction Machinery Division, Bucyrus-Erie Company.

[40]Letter, February 10, 1969, Mr. C. W. Schrock, District Manager, Mining Machinery Division, Joy Manufacturing Company.

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concentrated in Europe.[41] The Economist Intelligence Unit, Ltd., study agrees:

> To our knowledge, there are no second-hand dealers who concentrate on moving used equipment abroad. Some companies have, of course, been active in this area, but they have not limited their operations to overseas sales.[42]

The lack of UM dealers with sizeable concentrations in foreign markets means that export firms are usually the agencies handling the physical transfer of the equipment. In the foreign country the majority of the equipment is handled by a licensed importer who purchases the UM on his own account as a dealer, for the account of a dealer, or for the final user. Some UM goes directly to the final user in the foreign country.

Additional Elements in the LDC-UM Market

Six other elements in the transfer process that deserve attention are: (1) inspection and appraisal, (2) financing the transfer, (3) the information network of the UM market, (4) rehabilitation of the equipment, (5) the physical transfer of the equipment and (6) service and guarantees. Financing and the information network have, or are said to have, imperfections which make it appropriate to include them in the next chapter. The remaining four elements are discussed below.

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[41] Wiener, *op. cit.*, p. 31.

[42] EIU, *op. cit.*, p. 45.

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Inspection and Appraisal

Two factors account for the importance of appraisal and inspection in the UM market. First, the market for any specific type of equipment is likely to be rather thin, especially so for entire plants. Second, the differences in ages, conditions and makes of the same type of equipment cause the product to be even more heterogeneous than new machinery. Under these conditions the market will automatically result in a trustworthy price only for equipment that is (1) fairly standard, (i.e., amenable to accurate grading or classification) and (2) in heavy demand. In all other cases, the alternative is to accept the stated price and condition of the UM on faith or to hire an impartial expert to estimate the marginal productivity of the equipment.

Equipment that is relatively inexpensive is not usually subjected to inspection and appraisal since (a) it is more likely to have a high volume of demand and (b) the cost of appraisal (as we shall see) is prohibitive. In these instances the buyer is guided by the market, the reputation of the seller, a hope that he will be lucky,[43] or some combination of these. When dealing with most core equipment and all complete plants, inspection and appraisal should be considered a necessity.[44]

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[43]Similar to those in the United States who buy a major appliance in cut-rate sales outlets, but who get no service agreements in the bargain.

[44]The reader is reminded of Lic. Guglielmina's practice of always personally inspecting major pieces of equipment (Chapter V).

We can get some unusual insights into the practical aspects of appraisal and inspection from information received from Mr. Earl E. Burkhard, a professional property appraiser.[45] He outlines three methods of appraising UM:

1. Audit appraisal. After a physical examination the original cost is obtained from the accounting records, the original cost is converted to current dollars, usually by using indices from trade sources, then applying depreciation, usually according the useful life allowed by the Internal Revenue Service.

2. Canvassing the UM market. The market is felt out from UM firms such as those that exist on Lafayette Street in New York or from prices quoted by large UM dealers such as Boturnnik Brothers of Hamden, Connecticut.

3. Original cost. The original cost is secured from the manufacturer when no longer obtainable from the owner. Also the manufacturer can furnish the current cost of the new machine and occasionally the current estimated cost of a used machine.

In the process of inspection and appraisal, the appraiser must obtain the correct name of the machine, the year of manufacturer, the type and model, the base cost and the additional cost for added "gadgets and gimmicks."

It is usual for appraisers to charge a fee per day

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[45] Letter, December 14, 1968. The information is a paraphrase of his letter.

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plus expenses. Mr. Burkhard's fee is $100 per day. Larger companies, he says, charge as high as $250 per day.

The Export-Import Bank of the United States[46] does not have

> . . . specific regulations regarding sales of second-hand equipment, other than the . . . "Used Equipment Questionnaire" . . . which must be submitted by applicants for medium-term credit coverage under either the Eximbank guarantee or FCIA [Foreign Credit Insurance Association] insurance programs.[47]

Some UM, however, on credit terms of up to 180 days, ". . . may be covered under an FCIA short-term policy without submission of this special form."[48] While appraisal is not explicitly mentioned, the Used Equipment Questionnaire does ask, "How is the value of the used equipment to be determined?"[49]

In 1967 the United States Agency for International Development stiffened its provisions regarding inspection.[50] An inspection report is required by an inspection firm designated and paid by AID.[51] Furthermore, AID will stipulate the

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[46]The name was changed from the Export-Import Bank of Washington in March of 1968.

[47]Letter, November 26, 1968, from Mr. John W. Corbin, Assistant to the Vice President for Program Planning and Information, Export-Import Bank of the United States.

[48]*Ibid*.

[49]Used Equipment Questionnaire, question no. 7.

[50]Information is from AID, *Small Business Memo*, December 12, 1967.

[51]"At the time that AID approves for financing used equipment, AID will designate an inspection firm to examine and appraise the equipment which the supplier proposes to sell under AID financing." (*Ibid*., sec. 1.) "Payment for inspection services will be made directly by AID to the inspection firm pursuant to these contract arrangements and will not be included within the commodity price." (*Ibid*., sec. 3.)

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specifications for the inspecting firm.[52]

It is generally conceded that inspection and appraisal is highly advisable when expensive equipment is involved. We can, however, infer that the temptation to omit this step is very great. In the first place, it is expensive (as the fees cited above demonstrate). Also, the fact that AID has seen fit to require and control the process of inspection indicates that many prospective purchasers were prone to risk the buying of UM without proper appraisal.

The Physical Transfer of the Equipment

Careful attention must be given to the requirements of disassembling, packing, crating, loading, unloading and reassembling UM. With a simple piece of equipment that is complete, difficulties are not terribly great, but

> . . . when the second-hand machinery or equipment is a complex grouping composed of multiple units, such as a blast furnace, a rolling mill, chemical equipment (other than separate units, like stainless steel vessels, vats or tanks), the task of appraising, dismantling, packing, shipping, rehabilitating and reassembling it becomes a major operation surrounded by greater risks than most buyers in underdeveloped countries should undertake. The blast furnace or

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[52]"The inspection firm will examine the equipment with particular regard to the physical condition and performance capability of the equipment <u>in accordance with the instructions which AID</u> shall issue to the inspection firm." (<u>Ibid</u>., sec. 1. Emphasis supplied.)

For a critical examination of the problems that might arise under these provisions, see Julius Kaplan, "AID and the Used-Equipment Syndrome," <u>Worldwide Projects and Installations Planning</u> (May/June, 1968), pp. 48-50, 52, 54-55. A copy of the AID <u>Small Business Memorandum</u>, December 12, 1967, is included on page 55.

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> rolling mill may require major rebuilding; the chemical equipment may be corroded; and in order to salvage the coffee-roasting plant, the building in which it is housed may have to be partly torn down and rebuilt after the plant is removed. These examples are not hypothetical; all of them have actually happened.[53]

The most crucial step in the physical transfer (in the sense that more mistakes are likely to occur), is the original disassembling and packing. If a reliable party can be charged with this responsibility or if the purchaser can adequately supervise or perform the task, equipment damage and loss of parts will be reduced. Ideally the entire physical transfer process would be done by a single organization.[54] There are three circumstances under which this would be more likely to happen: first, if the UM dealer has a vested interest in seeing that the equipment arrives in good shape because he values the client's future business; second, if the seller retains an equity or royalty position in the equipment and third, if the purchase is of sufficient magnitude to warrant supervision by the purchaser.

A single organization usually does not handle the physical transfer because (1) few dealers in UM are exporters and (2) there is a lack of strong vested interest by transferring organizations. These conditions are perpetuated by the smallness of the LDC-UM sales (a) in the aggregate and

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[53]Waterson, op. cit., p. 14.

[54]Strassmann agrees. Op. cit., p. 216.

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(b) to each firm selling UM. A later section of this chapter deals more thoroughly with these matters.

Rehabilitation of UM

Almost inevitably something must be done to get UM in its top working order after it is bought. If only cleaning, parts replacement, minor repair or minor overhaul is required, no great problem is encountered. Most sellers of UM can perform tasks of light rehabilitation of this sort and most buyers are capable of doing so if they prefer.

No serious bottleneck is encountered for more involved rehabilitation tasks ranging from repair of major parts to complete rebuilding of the machine. Larger UM dealers have these capabilities, some original manufacturers perform these tasks, firms engage in these activities on a contractual basis in the selling countries and in the LDC's, and in varying degrees the buyer of the equipment can rehabilitate the equipment himself.[55]

One incentive for self rehabilitation of the equipment on the part of the buyer is the high mark-up on rebuilt equipment. The Parsons Company study found the following figures on the actual cost of rebuilding and the sale price of rebuilt equipment. Both are shown in terms of the percentage of replacement costs.

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[55]Strassmann found that to the extent of their capabilities, Mexican and Puerto Rican entrepreneurs preferred to do their own repair work. From context, however, it appears that he was not necessarily speaking of initial repair work. Strassmann, op. cit., p. 213.

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COSTS AND SALES PRICE OF REBUILT UM AS A PER CENT OF ORIGINAL COST OF THE EQUIPMENT[56]

Category	Dealer Cost of Rebuilt UM	Sale Price of Rebuilt UM
Construction (Earth Movers)	26%	60%
Materials Handling	28%	58%
Generating Plants	26%	40%
Metalworking	30%	66%
Woodworking	21%	47%

Guarantees and Service Agreements

Most United States companies selling UM will guarantee it, but most do not offer these guarantees outside the United States. The Parsons Company study found

> Of the companies interested in participating, seventy-five percent issued unconditional guarantees on their used equipment, ranging from ninety days to one year. They did, however, firmly state that their existing domestic guarantees would not apply to equipment purchased for overseas shipment.[57]

The study did, however, find that "Several of the larger companies engaged in overseas used equipment trade issued unconditional guarantees which they honor anywhere in the world."[58]

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[56]Ralph M. Parsons Co., Final Report: Used Equipment Study, op. cit., p. 24.

[57]Ibid., p. 22. This particular comment refers to a survey in the Los Angeles area. Forty-two businesses dealing in used equipment were contacted. Thirty-six companies who were willing to participate in an AID sponsored program involving UM formed the basis of the above citation.

[58]Ibid., p. 23. This remark applies to dealers in Houston, Detroit, St. Louis, Pittsburgh and New York and other areas not identified.

Fabick Tractor Company of St. Louis, for instance, sells with an unconditional guarantee. In addition, at the time of the survey, Fabick provided engineering and technical assistance in advance of the purchase, service facilities after the purchase and a twelve-week training program for shop apprentices. Tippins Machinery of Pittsburgh and Morey Machinery of New York are examples of larger firms with similar guarantees, pre-purchase assistance and service arrangements.[59]

It is not customary nor is it good business to give guarantees on equipment sold "as is, where is," and, as we have seen, very few firms give unconditional guarantees where the equipment is completely rebuilt by them. But, between these extremes there are

> . . . all kinds of guarantees given with used equipment, such as the guarantee that the equipment conforms to specifications 'to the buyer's satisfaction,' or that the defective parts will be replaced, etc.[60]

The UN study says that original manufacturers who recondition their old equipment usually offer a warranty or guarantee.[61]

The United States Machinery Dealers National Association (MDNA) give a 30-day money back guarantee on most UM sold if the buyer pays the transportation cost of returning it.[62]

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[59] Ibid., pp. 25-26.

[60] UN, Report of Expert Group, op. cit., p. 17.

[61] Ibid.

[62] MDNA members agree to ". . . accept within 30 days from shipment any merchandise sold with a guarantee, freight prepaid, for refund of the purchase price, if mechanically unsatisfactory." MDNA, Membership Directory 1967, p. 1.

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Even when warranties, guarantees and service agreements are part of the deal, distance conspires with the lack of interest in maintaining lasting business relations (the seller doesn't really "need" the buyer or vice versa) causing problems after the purchase. Recipients of UM in LDC's complain of slowness, incompleteness or total failure in living up to guarantee and service agreements. The guaranteeing and servicing organization also has its problems in identifying valid claims.

The area of guarantees and servicing agreements is one of the least satisfactory aspects of the UM market organization. The causes include long distances involved, poor communications, the marginality of the LDC purchases from developed country dealers, as well as actual and imagined bad faith on both sides of the markets.

The Marginality of the LDC-UM Market and the Prevailing Pattern of Specialization

One of the most striking features of the UM market in general, and the LDC-UM market specifically, is the marginality of the operations. Marginality crops up in several places. First, the disposal of equipment by the user is typically a marginal operation. Second, there are many distributors and new equipment dealers that merely "dabble" in UM as a sideline. Third, the foreign market, and more particularly the LDC demand for UM, is a tiny fraction of the total UM market. Fourth, the marginality of the total LDC-UM demand is reflected in the micro-makeup of the UM market

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in that individual firms do not tend to specialize in exporting UM to LDC's. Finally, many importers and LDC's dealers carry UM as a sideline.

Naturally the lines of specialization in the UM market in developed countries are geared to their domestic markets. Volume of demand permits some specialization in individual pieces of equipment, but not specialization in transferring equipment to LDC's. The ideal would be a number of firms <u>specializing</u> in exporting UM to LDC's and <u>generalized</u> in all of the functions needed to get it done, i.e., capable of performing, supervising or arranging the proper dismantling of the equipment; rehabilitation; packing and crating; shipping; and reassembly and servicing of the equipment. Such an arrangement would have two advantages. First, servicing the LDC-UM market has different requirements than the domestic market in developed industrial societies. It takes know-how in dealing with administrative red tape, requires greater stress on communications, greater care in crating and packing, etc. Second, there would be greater vested interest. The firm's success would depend <u>entirely</u> on maintaining a reputation for adequate or superior performance in selling to LDC's. This coupled with responsibility for all (or most) of the steps of the transfer process would increase incentives to avoid errors.

All of this, of course, assumes an ideal situation which does not exist. In short, it is wishful thinking. It does, however, represent a policy goal. If we can assume

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away the theoretical anomalies of the "second best" argument, any movement toward such a pattern of specialization and functional scope would improve the efficiency of the LDC-UM market.

APPENDIX B

APPENDIX B

UNITED STATES EXPORTS OF SELECTED TYPES OF EQUIPMENT (IN THOUSANDS OF DOLLARS)[a]

	Exports of Both New & Used Equipment			Exports of New Equipment			
	(1) To All Countries	(2) To MDC's	(3) To LDC's	(4) To All Countries	(5) To MDC's	(6) To LDC's	(7) % to LDC's
1965							
Metal-Cutting[b]	14,626	8,390	6,236	5,091	4,261	830	16.3
Metalworking[c]	26,510	17,174	9,336	17,931	13,991	3,940	22.0
Sewing[d]	17,221	11,958	5,263	15,316	10,901	4,415	28.8
Paper[e]	11,881	7,334	4,547	11,561	7,199	4,362	37.7
Total	70,238	44,856	25,382	49,899	36,352	13,547	27.1
1966							
Metal-Cutting	13,077	8,588	4,489	5,101	3,884	1,217	23.9
Metalworking	24,799	18,507	6,292	19,932	15,923	4,009	20.1
Sewing	19,903	12,809	7,094	18,268	11,734	6,534	35.8
Paper	10,730	7,256	3,474	9,351	6,712	2,639	28.2
Total	68,509	47,160	21,349	52,652	38,253	14,399	27.3
1967							
Metal-Cutting	11,260	6,820	4,440	4,792	3,768	1,024	21.4
Metalworking	22,095	16,126	5,969	17,058	13,205	3,853	22.6
Sewing	18,523	12,404	6,119	17,282	11,688	5,594	32.4
Paper	11,908	6,433	5,475	10,270	5,995	4,275	41.6
Total	63,786	41,783	22,003	49,402	34,656	14,746	29.8
1968							
Metal-Cutting	10,130	6,365	3,765	4,992	3,262	1,730	34.7
Metalworking	25,382	17,370	8,012	21,785	15,874	5,911	27.1
Sewing	20,711	13,628	7,082	19,390	13,173	6,217	32.1
Paper	9,424	6,812	2,612	8,619	6,526	2,093	24.3
Total	65,647	44,176	21,471	54,786	38,835	15,951	29.1
1969 (7 mos.)[f]							
Metal-Cutting	5,721	3,462	2,259	2,904	2,354	550	18.9
Metalworking	16,269	12,041	4,228	13,558	10,284	3,274	24.1
Sewing	15,197	11,435	3,762	14,575	11,253	3,322	22.8
Paper	4,640	3,223	1,417	3,972	2,798	1,174	29.6
Total	41,827	30,161	11,666	35,009	26,689	8,320	23.8
Grand Total	310,007	208,136	101,871	241,748	174,785	66,963	27.7

APPENDIX B--Continued

	Exports of Used Equipment				UM as a % of Total Imports of US Eqp.	
	(8) To All Countries	(9) To MDC's	(10) To LDC's	(11) % to LDC's	(12) To MDC's	(13) To LDC's
1965						
Metal-Cutting	9,535	4,129	5,406	56.7	49.2	86.7
Metalworking	8,579	3,183	5,396	62.9	18.5	57.8
Sewing	1,905	1,057	848	44.5	8.8	16.1
Paper	320	135	185	57.8	1.8	4.1
Total	20,339	8,504	11,835	58.2	19.0	46.6
1966						
Metal-Cutting	7,976	4,704	3,272	41.0	54.7	72.9
Metalworking	4,867	2,584	2,283	46.9	14.0	36.3
Sewing	1,635	1,075	560	34.2	8.4	7.9
Paper	1,379	544	835	60.6	7.6	24.0
Total	15,857	8,907	6,950	44.2	18.9	32.6
1967						
Metal-Cutting	6,468	3,052	3,416	52.8	44.8	76.9
Metalworking	5,037	2,921	2,116	42.0	18.1	35.4
Sewing	1,241	716	525	42.3	5.8	8.6
Paper	1,638	438	1,200	73.3	6.8	21.9
Total	14,384	7,127	7,257	50.5	17.1	33.0
1968						
Metal-Cutting	5,138	3,103	2,035	39.6	48.8	54.1
Metalworking	3,597	1,496	2,101	58.4	8.6	26.2
Sewing	1,321	456	865	65.5	3.3	12.2
Paper	805	286	519	64.4	4.2	19.9
Total	10,861	5,341	5,520	50.8	12.1	25.7
1969 (7 mos.)						
Metal-Cutting	2,817	1,108	1,709	60.7	32.0	75.7
Metalworking	2,711	1,757	954	35.2	14.6	22.6
Sewing	622	182	440	70.7	1.6	11.7
Paper	668	425	243	36.3	13.2	17.1
Total	6,818	3,472	3,346	49.1	11.5	28.7
Grand Total	68,259	33,351	34,908	51.2	16.0	34.3

APPENDIX B--Continued

[a]United States Department of Commerce, United States Exports, Schedule B, Commodity by Country.

[b]Metal-Cutting machine tools, used, 7151072, and new, 7151070.

[c]Metalworking machine tools, used, 7151088, and new, 7151086.

[d]Industrial sewing machines, except shoe sewing machines, used, 7173040, and new, 7173030.

[e]Pulp mill and paper mill machines, used, 7181130, and new, 7181110 (Pulp mill machines) and 7181120 (paper mill machines).

[f]For seven months through July, 1969.

CHAPTER VII

MARKET IMPERFECTIONS

One would not expect the market transfer of UM to LDC's to be a frictionless paragon of a neoclassist's ideal. The market for UM is small compared to the LDCs' demand for new equipment; industrial equipment has a low degree of homogeneity, a characteristic even more pronounced in the UM market; there is a dearth of dealers and exporters who specialize in servicing the LDC market; the available information concerning UM is inefficiently transferred or inadequately used; LDC factor markets are imperfect; and extra-economic attitudes affect the demand for UM by LDC's. This chapter seeks to elaborate on these and other imperfections whose net effect reduces the purchase of UM by LDC's.

Engineering Bias

Although it is impossible to speak with precision about the degree to which an engineering bias favors modern equipment, such a bias is commonly thought to exist. When confronted with an important, but nonquantifiable variable, a descriptive, qualitative analysis will have to suffice.

As a beginning we can explore the causes of an engineering bias. In its more primitive form an engineering bias results from a lack of proficiency in economics leading to the substitution of engineering standards for economic criteria or the overemphasis of a single economic criterion. Productivity per man hour, production per time period, and energy produced per unit of fuel consumed are all economically important, but for LDC's to attain a level of performance comparable to developed economies for any of these criteria does not necessarily constitute good economics. But a technical expert is prone to apply what he knows best, and since most engineering expertise emanates from mature industrial areas, a bias naturally develops which favors modern, capital-intensive production.[1]

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[1]A good little survey of engineering biases (although economists do not escape unscathed) can be found in Robert Sadove's "Economists, Engineers and Development," Finance and Development (June, 1967), pp. 125-32. Mr. Sadove cites the following instance of engineering bias: ". . . the design of a water supply system for a large Far Eastern city included the use of an advanced electronic control system for checking water levels. It was found that the job performed by the control system could be done adequately by a man with a pencil and paper and a bicycle to carry him from one check point to another. The engineers had obviously allowed their desire for technical perfection to run away with them, and in fact recommended a solution to the water supply problem that was not the least costly." Op. cit., p. 128.

"It is convenient for a foreign investor to use the same technology as in the home country and to pay high wages, despite the fact that labor is abundant." Charles P. Kindleberger, Economic Development (2nd ed.; New York: McGraw-Hill Book Company, 1965), p. 257.

A second reason for the engineering bias is the comparative ease of obtaining information on late vintage equipment. At one's disposal are technical journals displaying

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"The American engineer is familiar with and trained in the current technology of the United States; he is, generally, not familiar either with previous technological practice in the U.S. or with current practice in other countries. If he is called upon to blueprint an industrial construction project, his advice must generally reflect what he is familiar with." Charles Wolf, Jr. and Sidney C. Sufrin, Capital Formation and Foreign Investment in Underdeveloped Areas (Syracuse: Syracuse University Press, 1958), p. 42.

"Few international divisions or subsidiary international holding companies seem to have their own technical or production staffs. What technical help or evaluation that is needed in analyzing or developing foreign projects is recruited from the operating divisions of the parent company. Such persons are almost invariably domestically oriented and preoccupied with their own technical and production problems. There is, therefore, an apparent inclination to evaluate or plan a foreign project on the American pattern without much concern for environmental differences. . . ." Statement by Richard D. Robinson, Lecturer, Harvard Graduate School of Business Administration as quoted by Werner Leopold Chilton, "The Choice of Technology for United States Direct Investment in Latin American Manufacturing Industry and Its Implications for Economic Development" (unpublished Ph.D. dissertation, Columbia University, 1962), p. 87.

"At the microeconomic level, undue deference is commonly given to the views of engineers, who by the very nature of their training are utterly averse to using machinery that does not combine all the most advanced techniques available." ECLA, Choice of Technologies in the Latin American Textile Industry, op. cit., p. 2.

The prevalence of the primitive engineering bias was forcefully brought to my attention during a meeting of businessmen, educators and government officials from El Paso, Texas; Juarez, Mexico and Chihuahua City, Mexico. I had delivered a paper entitled, "The Economic Impact of the Mexican Border Industrialization Program." The Mexican BIP, an offshoot of the Mexican National Frontier Program, seeks to attract industry to the Northern Mexican border by allowing the importation of machinery and materials tariff free, if the product is eventually exported from Mexico. The

the latest producer goods. The technical advisor is more apt to be familiar with the standard references on specifications for installing, operating and maintaining modern equipment. The use of readily available information by the engineer, technical advisor or entrepreneur does not necessarily manifest irrational behavior. Information of this type is inexpensive in terms of cash outlays and time. If information can only be acquired through time consuming research or correspondence and is of questionable reliability, the cost and risk may not be economically justifiable. The economic costs and returns of information on UM elicit two comments:

1. The rewards can be extremely attractive! Mr. Charles Stokes of Stokes Brothers and Company was concerned with setting up wool processing facilities in Bolivia during the early 1960's. His firm served as contractors to Servicio Agricola Interamericano, the agricultural affiliate of USAID. Funds had been provided by AID for wool washing machinery to be used by a Bolivian government project intended to establish a producers' cooperative. By researching the UM market, Mr. Stokes was able to purchase not only a washing plant, but an entire yarn producing mill!

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attraction to United States businessmen is clearly cheap labor. In spite of this, during an ensuing discussion, an engineer colleague unleashed a spirited advocacy for the use of the most modern automated productive techniques. Businessmen, and for the most part, educators and government officials, were not impressed.

> I found that by buying good used equipment, we could provide not just a washing plant but a complete mill for the production of sheepswool, alpaca, llama tops and finished yarns . . . the project is producing yarns, especially alpaca yarns . . . in a plant with just a fraction of the capital investment that would have been required had new machinery been installed.[2]

The wool scouring equipment, centrifuge, boiler, top cutter and bales were obtained in Peru; the carding, drafting and combing machinery in Argentina; the twisting and spinning machinery from Wanskuck Mills in Rhode Island and the equipment for winding the yard into skeins for retail sale was purchased new in Germany.[3]

It is apparent from the diversity of equipment and sources that a great deal of research effort went into the project; it is equally apparent that the results were rather spectacular.

2. Despite complaints that potential customers in LDC's are experiencing difficulty in getting facts about UM,[4] much information on UM is readily available, inexpensive, and reliable. When contacted through a United States Embassy, the United States Department of Commerce will furnish the names of reliable dealers in the types of UM specified. The United States Government Service Agency and AID are also sources of information on surplus government

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[2]Letter, September 17, 1968.

[3]*Ibid*.

[4]See W. N. Schultz, "World Used Machinery Market Suffers Communications Lack," *Iron Age* (February 24, 1966), p. 27.

equipment. Various trade publications list the UM currently available.[5] Trade associations such as the Machinery Dealers National Association (used, rebuilt and reconditioned metal working machine tools) and the Electrical Apparatus Service Association are useful sources of information.

The real failing is not the absence of an abundance of facts and figures on UM or an adequate referral system to place buyers in contact with sellers and exporters. The problem is one step removed, i.e., the lack of knowledge about the existence of such a network of information. This is not to say that there are no gaps in our knowledge about UM that can only be answered by painstaking research, but

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[5]For instance the Used Equipment Directory, published monthly by the Used Equipment Directory, Inc., at 70 Sip Avenue, Jersey City, New Jersey. Subscription costs $10 per year in the United States with rates for other countries quoted on request. Contents include a "Geographic Dealers Directory," a "For Sale" section, and a free "Wanted" section. Perhaps the most significant recent improvement in the UM information market was the instigation of a card file system on UM in connection with the company's free "equipment finding service." Each issue of UED contains business reply cards on which equipment needs may be placed. This information is circulated to UM dealers.

The Equipment-Guide Book Company, 3980 Fabian Way, Palo Alto, California, issues a monthly Equipment Guide-Book Reporter for $1 per year which has a classified section containing UM ads. While this company specializes in construction equipment, much of it (e.g., air and gas compressors) is of interest to manufacturers. The company also sells a comprehensive library on construction equipment specifications and estimates of market values for old and new equipment. This service is not inexpensive (from $45 to $105 per year depending on the volume desired), by LDC standards, but may be feasible if the cost could be spread over a number of users.

it does mean that the information barrier can largely be overcome by arming entrepreneurs, technicians and engineers in LDC's with a handful of central sources. In the immediate future enabling LDC's to tap the extant network of communications will lead to the greatest degree of improvement in the UM market. The costs are modest when gauged by potential gains.

The Future of the Engineering Bias

Suppose we can assume away any fatal difficulty caused by lack of knowledge of the market. We are still faced with the more primitive type of engineering bias. An entrepreneur, technician or engineer, who avidly believes that the latest technological vintage is *ipso facto* the most efficient, is not likely to take the pains to contact the Machine Dealers National Association or subscribe to *Used Equipment Directory*. Nor is he likely to make a detailed cost comparison between UM and new machinery, even if he does go to the trouble of obtaining the raw data. What can be done about this type of mentality?

Fortunately, the answer to this question is: keep doing what we are already doing. The engineering bias, narrowly defined,[6] has been slipping badly in recent years

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[6]The person imbued with an engineering bias derives no psychic income from recommending the latest vintage of technology. He simply believes that the chances for an earlier technology to prove the most economically efficient are so remote that the inclusion of UM in a comparative cost

and is still rapidly retreating. There has long been an awareness that LDC's may require different technologies from those used by mature industrial economies, but lately "the word" has <u>really</u> been "getting around." We have already mentioned that (1) UNIDO has singled out the development of optimal technologies for LDC's as deserving the top priority of technical and scientific agencies concerned with development and (2) some organizations, most notably the Intermediate Technology Development Group, Ltd., which are devoted to developing and popularizing appropriate technologies for LDC's.[7] Academia is getting into the act as the University of Pittsburgh conference mentioned in the last footnote attests. The University of California at Los Angeles is offering two five-day courses for engineering and science graduates entitled "Engineering Economics in Developing Countries" and "Optimization Techniques with Application to

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study would constitute wasted effort. If he were confronted with the comparative data which convinced him of the superiority of UM in a particular instance, he would feel that his welfare had improved. In the following section we will confront extra-economic biases for which economic efficiency is not the exclusive basis for choosing techniques of production.

[7]"The ITDG is also encouraging the formation of groups similar to itself in developing countries--groups are active in India (The Appropriate Technology Development Group), Ghana (Kumasi Technology Group), Kenya and the Caribbean and one is likely to be formed in Pakistan soon." George McRobie, Chief Executive of ITDG, from a statement prepared for the International Conference on the Interdisciplinary Aspects of the Application of Engineering Technology to the Industrialization of Developing Countries, School of Engineering, University of Pittsburgh, Pennsylvania, October 20-25, 1968, p. 5 as quoted in "Intermediate Technology Development Group," <u>Development Digest</u> (January, 1969), p. 48.

Developing Countries."[8] At least four trade books are available to those interested in the subject.[9] Various reports on international conferences also display an awareness that techniques used in developed areas may not do for LDC's.[10] Worldwide Projects and Installations Planning, a bimonthly publication which describes itself as "a journal for multinational management with engineering, financing, purchasing, construction and operations responsibility," regularly has articles emphasizing the dangers of applying unmodified United States methods in LDC's.

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[8]Engineering 885.20 and 885.21, offered September 8-12, 1969, and September 15-19, 1969, respectively.

[9]Amartya Kumar Sen, Choice of Techniques (Oxford: Basil Blackwell, 1960; Gerard Karel Boon, Economic Choice of Human and Physical Factors in Production (Amsterdam: North-Holland Publishing Company, 1964); Jack Baranson, Technology for Underdeveloped Areas: An Annotated Bibliography (Long Island City, New York: Pergamon Press, 1967) and Baranson's Industrial Technologies for Developing Economies (New York: Frederick A. Praeger, 1969).

[10]"The real problem is to develop in India technologies which are appropriate to India, i.e., technologies which are the very best in the context of India's circumstances, situations and resources," R. N. Jai, "Introduction," Appropriate Technologies for Indian Industries, papers presented at the meeting of a working group held at the Small Industry Extension Training Institute on January 2-4, 1964 (Hyderabad, India: Yuva Press, 1964), p. 1.

"It is significant to note that out of the replies received to our questionnaire . . . , the responses from mills in the less developed areas gave greater emphasis to the need for equipment flexibility than did the replies from large mills in North America, running a limited product mix." United Nations, Report of Expert Group Meeting on the Selection of Textile Machinery in the Cotton Industry, ID/WG.8/1 (Vienna: UNIDO, 1968), p. 53.

Perhaps the most revealing indications come from engineers with experience as technical advisors in LDC's. I had asked Professor A. O. Schmidt, of the Department of Industrial Engineering, Pennsylvania State University, if it is customary to take the cheaper costs of labor and higher capital costs into account in LDC's when setting up production of machine tools. Professor Schmidt, who has had experience as a technical advisor in LDC's, replied: "The answer is 'yes.' This often is the only way to introduce economical production in the so called developing countries."[11]

The engineering bias is not holding up well in the light of day. On balance the continued deterioration of this bias will increase the demand for UM.[12]

An Asian Conference recommended: "That countries of the region promote industrial design in their territories, taking note of the difference in the social and cultural background and the habits of the prospective users and consumers of their products; and encourage industrialists to take account of industrial design in their production and development plans." United Nations, <u>Report of the Asian Conference on Industrialization</u>, Manila, Philippines, December 6-20, 1965 (New York: United Nations, 1966), p. 37.

"Another question discussed . . . was that of adapting techniques and equipment obtained from abroad to the particular conditions prevailing in the country where the investment was effected, from the standpoint of relative costs of capital and labour, plant sizes and installed capacity, and adjustment of the quality and characteristics of the product concerned to the requirements of local markets." United Nations, <u>Report of the Symposium on Industrial Development in Latin America</u>, Santiago, Chile, March 14-25, 1966 (New York: United Nations, 1966), p. 41.

[11]Letter, March 11, 1969.

[12]This statement deserves a caveat if a long-run outcome is considered. The wider understanding of the technological needs of LDC's is leading to the development of new equipment with features usually found in UM, e.g., smaller

Used Machinery and Infavoidance

Infavoidance, as used here, is the desire to avoid the appearance of inferiority.[13] A person who attributes superiority to those who develop and manufacture the latest technological innovations, and who psychologically identifies with the "superior" group by using the modern equipment, will be willing to pay a premium in the form of sacrificed efficiency. The amount of the premium he will pay to use new equipment (or the size of the efficiency "bonus" that he will demand from UM) depends partly on his financial circumstances and partly on the strength of the psychological benefits he derives from identifying with superiority.

Infavoidance can take several forms:

1. It can affect the choice of technique because the entrepreneur himself derives psychological satisfaction from using the fruits of modern science.[14]

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scale, simplicity of operation or greater flexibility. The long-run effect of the demise of an engineering bias could be a reduction in the demand for UM due to the greater use of these new technologies. What will happen when this technology eventually appears on the used equipment market, I leave to the imagination of some future scholar and doctoral dissertation.

[13]According to one definition "infavoidance need" is ". . . the need to avoid shame, to escape failure or humiliation." A Comprehensive Dictionary of Psychological and Psychoanalytical Terms (New York: David McKay, Inc., 1958), p. 260.

[14]This can explain such phenomena of which the following is an example: "In a textile factory in Medellin the company had a brand new IBM 1420 computer although the work could easily be done by hand with a considerable financial saving." Letter from Professor Robert M. Eastman, February 28, 1969. Dr. Eastman, a member of the Industrial Engineering

2. In some cases the entrepreneur may be free of the direct influences of infavoidance, but because _others_ associate UM with inferiority, or because the entrepreneur _thinks_ they do, he automatically opts for new equipment. He may know costs can be lowered by employing UM and he may suffer no psychological loss from doing so, but he feels that the image of his business will suffer.[15] Given his view of the

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faculty of the University of Missouri at Columbia, Missouri, has considerable first-hand experience with Latin American industrial engineering problems. Professor Eastman makes it clear, however, that "The bias towards the shiny new machine is far from unique to newly developing countries. A major example in this country is the executive who has to have a bigger and better computer for his company than does his competitor, even though the economics of the computer definitely does justify a smaller unit." _Ibid_.

Waterson supports the prevalence of entrepreneurial infavoidance:

"Furthermore, while a plant may be found where used equipment is pointed out to visitors, most operators take much greater pride in managing factories with the most up-to-date production facilities. This human frailty is frequently encountered in underdeveloped countries."

"Indeed, in some underdeveloped countries, there is such a strong aversion to the use of anything but new machinery that entrepreneurs have been known to settle for lower financial returns in order to enjoy the psychological satisfaction derived from ownership of the latest equipment." Albert Waterson, "The Use of Second-Hand Machinery in Developing Economies," revised (Washington: International Bank for Reconstruction and Development, October 4, 1962), p. 4.

Strassmann, however, found that ". . . when second-hand equipment is rejected the basis is usually a calculation, possibly pessimistic and incomplete, but not a prejudice." W. Paul Strassmann, _Technological Change and Economic Development_ (Ithaca, New York: Cornell University Press, 1968), p. 213.

[15]"The view has also been expressed that the corporate image (e.g., progress) is incompatible with used or

institutional setting, he practices rational, enlightened selfishness by purchasing new equipment.

3. When influential or elite groups affect national policy due to infavoidance, a "political bias" favors modern equipment. In such a case an ideology or mistique affects the choice of techniques used in production.

Speaking of Brazil, Leff says: "The 'industrial mentality' stressed the glamorous achievements of modern technology."[16] Furthermore, "This ideology also expressed a strong preference for industries that were considered the embodiment of both national development and modern technology."[17] Although Leff is referring to an "industrial mentality" in Brazil, which began to become prevalent among engineers in the 1920's and 1930's, this is not an instance of engineering bias as we have used it above. It was ideological and influenced political decisions.[18]

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obsolete equipment." Chilton, <u>op. cit</u>., p. 117.

Earlier in his dissertation Chilton had cited a relevant example: ". . . there is the problem of national pride. We would find it very difficult to convince any partners in a foreign country or a foreign government that it was at all desirable to install anything but the most modern and efficient flour mill. This is true of our Venezuelan project and I know it is also true of any other flour mill project that we might propose in any other country in the world." Mr. Ben Greer, Executive Vice President, The Pillsbury Company, letter, February 18, 1960, as quoted in Chilton, <u>ibid</u>., p. 80.

[16]Nathaniel H. Leff, <u>The Brazilian Capital Goods Industry, 1929-1964</u> (Cambridge, Massachusetts: Harvard University Press, 1968), p. 17.

[17]<u>Ibid</u>., p. 18.

[18]"Strongly nationalistic, they also stressed the importance of import substitution as a means toward national economic and political progress." <u>Ibid</u>., p. 17.

The existence of a political bias favoring new equipment is well supported in the literature on UM and it, rather than prejudices of the engineer or entrepreneur, constitutes the most formidable threat to UM.[19]

Other Variations of the Political Bias

Exploitation of the Political Bias

Suppose you are an entrenched entrepreneur in a LDC who is blessed with substantial monopoly profits. Word

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19"It seems clear that this practice [of using new equipment] results in part from the desire of many of the leaders of the developing countries to have nothing but the best. There is well-documented evidence that many of the developing countries are unwilling to buy used equipment for prestige reasons." The Economist Intelligence Unit, Limited, American Industry's Potential for Providing Used Machinery and Technical Assistance for Developing Countries (New York: EIU, Ltd., January, 1962), p. 37.

"Anyone who advises a developing country to acquire used machinery runs the risk that his motives will be suspected, and that he may be accused of wanting to saddle a country with the 'castoff' equipment which another country wishes to scrap." Waterson, op. cit. p. 4.

In April, 1969, I presented a paper in Juarez, Mexico, before a meeting of the International Students Association entitled "New Technologies for Latin America." Delegates were present from most Latin American countries. Although the paper covered a whole range of possibilities for adapting or developing technologies, I had mentioned, as an aside, the possibility of employing UM. The subsequent discussion of the paper was completely dominated by objections to my assertion that UM could be useful. One Latin American delegate was afflicted with the most extreme form of political bias against UM, the "plot syndrome." In short, "The United States is dumping obsolete, useless equipment on Latin America in order to keep these countries in a state of technological backwardness." My rejoinder was that since only about 2 1/2 per cent of UM sold in the United States is exported to the entire less developed world, the execution of the "plot" is a model of ineptitude.

reaches you that a competitor is authorized to build a plant to compete with your product, and further investigation reveals that a second-hand United States plant is to be used. What political weapons are at your disposal? The political bias, of course. This variety of market friction can be dubbed the "exploitation of the political bias."

The actual objective of the game is the avoidance of competition, but the campaign should be formulated along the "plot syndrome" lines, i.e., "depleting precious foreign exchange while playing into the hands of those who would keep us perpetually dependent on their technological superiority." An attempt to influence the body politic for private gain can be expected of vested economic interests. It just happens that competition with UM is especially vulnerable when the spectre of technological imperialism is raised.[20]

Exchange Controls and the Political Bias

One reason that the national administrations of LDC's harbor distaste for UM has nothing to do with pride.

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[20] In the early 1960's a textile mill had been given administrative authority to set up in Peru. The United States equipment was boxed and the United States entrepreneurs sold their New Braunfels, Texas, plant in order to free themselves for the Peruvian venture. At this point a Peruvian presidential decree reversed the earlier administrative approval and the boxed equipment had to be sold to a firm in Argentina for a fraction of its cost. Judging from conversations with one of the entrepreneurs involved, it appears that Peruvian textile interests indulged in a highly successful exploitation of a political bias against UM.

Due to the heterogeneous nature of the UM, it is difficult to determine a fair market price. It is therefore possible for entrepreneurs in LDC's to make a deal with UM exporters in developed countries, overprice the equipment and thereby get scarce foreign exchange out of the country.[21]

This possibility not only results in policy measures which discriminate against UM; Mr. John W. Shotwell, a USAID official with lengthy experience in Latin America, observed:

> . . . today to avoid exchange controls takes a much smoother method than that involving the type of transaction using used equipment. The buyer is nearly <u>automatically suspect</u>, therefore <u>few wish to expose themselves</u> in such a way, even in the most underdeveloped of the Latin American Countries.[22]

The legitimate use of UM, then, can in some instances be thwarted because the entrepreneur fears that officials will *think* he is avoiding exchange controls by purchasing UM. Official scrutiny in LDC's is usually a good thing to avoid.

Poor Business Practices and the Political Bias

If you converse or correspond with anyone with experience in the transfer of UM to LDC's, the odds are you will be exposed to at least one "horror story." Especially from the LDC's one hears of the wrong equipment arriving, equipment arriving in an incomplete condition, equipment arriving which does not function properly, or when the

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[21] See UN, *Report of Expert Group on Second-Hand Equipment*, *op. cit.*, p. 15.

[22] Letter, May 30, 1969. (Emphasis supplied.)

equipment is imported in satisfactory condition, there are often subsequent complaints about sellers who renege on guarantees and service agreements. Three categories of poor business practices can be distinguished.

1. Poor communications. All too frequently UM dealers in developed countries receive orders which are woefully short of specific information. As Waterson says,

> When a dealer in used machinery receives a request from abroad for "a metal-working lathe" or when the U.S. Department of Commerce receives a request from a North African country for "equipment to process dates for exports" neither one is able to proceed without more specific information.[23]

As the context of the whole Waterson article indicates, however, some UM dealers do send equipment when they receive orders of this caliber. They may (a) feel they are justified since the customer has brought any possible misfortune on himself, (b) see sales to LDC's as "gravy" since they are a marginal part of his operation or (c) a combination of these two conditions.

2. Unscrupulous dealers. Like any other selling activity, some dealers are willing to misrepresent the claims about equipment or substitute different equipment for that which was stipulated. Here again, the marginal nature of orders from LDC's will play a part. The deal is treated by the seller as a "windfall gain" with no attempt to establish lasting business relationships.

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[23] Waterson, op. cit., p. 11.

3. "Penny wise; pound foolish." The informed entrepreneur in LDC's can avoid most unhappy transactions in UM. The literature on UM urges that orders from LDC's be complete and specific.[24] Reliable dealers can be contacted through the United States Department of Commerce and there are firms who will inspect the equipment while in operation (if possible) and appraise its value. Why, then, do some entrepreneurs in less developed countries continue to purchase UM on a "sight unseen," and "where is, as is" basis or hire brokers or finders (who, incidentally, often locate the equipment by telephone and never see the equipment themselves)? And why do vague or even cryptic descriptions of equipment continue to accompany some UM orders?

Most LDC entrepreneurs who indulge in such practices are attempting to cut corners. In an earlier section it was pointed out that considerable information about the UM market can be obtained, but doing so does take some time and effort on the part of the entrepreneur. The same can be said of researching his precise equipment needs. When an order is sent requesting "a metal-working lathe," he is, in effect, gambling that the possibility of incurring a cost due to receiving inadequate equipment will be less than the

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[24]For instance, "The first requirement in the acquisition of machinery (whether new or used) is to know the exact specifications required to meet specific needs of the buyer." UN, Report of Expert Group on Second-Hand Equipment, op. cit., p. 16.

opportunity cost of time and money spent on engineering and market research. Similarly, when he purchases on a "sight unseen," and "where is, as is" basis, he is wagering that the savings of inspection and appraisal fees will outweigh equipment deficiencies.

When standard individual machines are ordered (as opposed to entire basic production units or packaged plants), the expense of an inspection and guarantee may not be justified. In all other cases, however, researching the specific needs and obtaining inspection and appraisal services should be considered as an integral part of the cost of obtaining UM. The _effective_ price of UM, i.e., capital cost per unit of output, will be lowered as a consequence.

Financial Biases

The Budget Restraint Bias

Many entrepreneurs in LDC's buy UM because they cannot afford new equipment. Unlike the other market imperfections reviewed in this chapter, the budget restraint favors the employment of UM. It affects importers of equipment in LDC's as well as final users. Wiener says of importers dealing in UM:

> Frequently, as they [LDC importers] grow larger and more prosperous, they sell their second hand equipment and purchase new. Having limited capital and credit, they cannot afford new equipment and buy second hand out of necessity.[25]

[25] Wiener, _op. cit._, p. 60.

Probably the budget restraint is not a serious bias from an economic standpoint. First, although we cannot say precisely how much, it is clear that a great amount of UM transferred to LDC's is done by financially strong parent companies in a developed country to LDCs' subsidiaries. Second, many entrepreneurs in LDC's are able to arrange the financing of new equipment.[26]

When manufacturers in LDC's are forced to purchase UM, several analytical elements can be distinguished:

1. Real capital is allocated to entrepreneurs who are apt to be marginal in terms of experience, size of firm or financial strength.

2. The budget restraint adds to the roster of entrepreneurs (or keeps the current number from shrinking). This does not necessarily mean that entrepreneurship is increased. Presumably most of the financial resources would have been made available to entrenched entrepreneurs, if the marginal entrepreneurs were eliminated. The long-run effect depends on whether the gains from expanding entrepreneurship at the external margin predominates over increased entrepreneural activity at the internal margin.

3. The marginal entrepreneur is excluded from choosing

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[26]My own estimate based on conversations and correspondence with UM dealers is that approximately one-half of UM purchases involve a budget restraint. Since these purchases are usually small, however, they probably constitute closer to 10 per cent of the total dollar volume of UM transferred to LDC's. These estimates must be regarded as based on impressions rather than hard data.

new machinery. This departure from efficiency is reduced to the extent that a careful cost comparison by the entrepreneur would have favored UM, and is further countered to the extent that the budget restraint neutralizes imperfections that are unfavorable to the employment of UM.

Risk Avoidance by Public and International Development Agencies

Public development corporations of LDC's, foreign aid agencies of advanced countries, and international lending institutions operate in a political arena which places a high penalty on the absolute number of failures. Critics of development policy can effectively use examples of failure even when the overall results of a group of projects is more beneficial than an alternative set of undertaking with no failures.

Projects involving UM are especially vulnerable to political attack since the blame for failure is easily transferred to the equipment rather than a failure to hedge inventories during a fall in prices, excessive nepotism, poor supervision, evils of absentee ownership, a sudden shift in demand, or any number of other conditions which can spell failure for a fledgling enterprise. In view of these political realities the agency influencing the choice of technique tends to discourage the employment of UM.[27]

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[27] Kaplan points out that some have interpreted AID's Small Business Memorandum of December 12, 1967, as encouraging the consideration of UM by foreign entrepreneurs and development agencies. The policy calls for AID to finance

Risk avoidance may account for the fact that it is rare for an LDC development agency to import UM[28] and could explain why centrally planned countries have not exported UM.[29]

UM sales only if AID chooses the inspector, stipulates the inspection criteria and names his fee. Kaplan disagrees with this interpretation. "Actually, AID is more reluctant than ever to associate its funds with used equipment. The Small Business announcement seems to be an attempt by the Agency to pull together effective control devices for those occasional situations where arguments are compelling in favor of financing used equipment." Kaplan, op. cit., p. 48. (Emphasis as in the original.)

Two individuals with experience inside development agencies further corroborate the point on risk avoidance. Albert Waterson of the International Bank for Reconstruction and Development says:

"One must further note that the Export-Import Bank and other agencies which finance development projects in underdeveloped countries generally shy away from providing funds for the acquisition of used equipment for the projects they finance. They feel the use of second-hand machinery and equipment introduces the unnecessary uncertainty in a situation which already has many difficulties." Waterson, op. cit., p. 3. Later he states, "If anything goes wrong in a factory which has installed second-hand machinery, the blame may be placed on the used equipment instead of on possible management or on other causes unrelated to the used machinery." Ibid., p. 4.

Mr. John Shotwell of USAID similarly writes, "In general the foreign assistance agencies will not go to bat for a change in host government regulations in a particular project or case." Letter, May 30, 1969. Also in this connection he comments that "Failure assessments are unwelcome at everybody's door whatever the cause, both with host agencies or banks or foreign assistance organization or the particular technicians involved." Ibid.

[28]Ibid., and Wiener, op. cit., p. 61.

[29]"The USSR and the newly industrialized countries of Eastern Europe are also intensifying their export of new machinery and complete plants to the developing countries. Thus far, it has not included second hand equipment." Wiener, op. cit., p. 13.

It should be made clear that this form of risk avoidance is not irrational behavior on development agencies' part; it is a reaction to the irrational tendency to blame UM for failure "willy nilly." Under existing circumstances their risks of impairing the carrying out of their long-run functions are greater in the case of UM. Attitudinal change toward UM in LDC's is a prerequisite to development agencies' routine use of UM.

Credit Terms and UM

It is tougher to obtain financing for UM compared to new machinery and the interest charges are apt to be higher when UM is used as collateral.[30] But the direct impact of

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[30]"Account must be taken of the possibility that manufacturer's credit or a bank loan may be available to finance the purchase of new machinery but not available to finance the purchase of old machinery." Waterson, op. cit., pp. 8-9.

The Economist Intelligence Unit's study refers to UM when it remarks: "It was commonly suggested that price was a secondary consideration compared to the availability of credit." Op. cit., p. 13.

Both the Economist Intelligence Unit and Wiener take issue with the Netherlands Economic Institute's application of the 10 per cent rate of interest to UM and new machinery. ". . . it seems entirely possible that a considerably lower rate of interest would be available for purchases of new equipment than for the purchase of used equipment." Economist Intelligence Unit, Ltd., op. cit., p. 32. "The slight advantage of the second-hand equipment in this [NEI] comparison is open to question. The rate of interest on second-hand equipment may well be higher than for new." Wiener, op. cit., p. 53.

A section of the UN study is devoted to problems of financing the purchase of second-hand equipment. UN, Report of Expert Group on Second-Hand Equipment, Chapter X, op. cit., p. 18.

the conditions of credit availability do less economic damage than the UM literature would lead one to think. This is true for the following reasons:

1. No one knows exactly what proportion of UM is transferred to LDC's by a parent firm to a subsidiary, but we have indications that it is sizeable.[31] These transactions, by and large, require no outside financing.

2. Because of the budget restraint many marginal firms are priced into the UM market despite the interest rate difference and because of the various attitudinal biases against UM, many of the larger firms in LDC's opt out of the UM market. As a result the composition of the firms who must purchase the UM and use it for collateral tends to be skewed toward smaller, riskier enterprises.[32] From the standpoint of economic efficiency, these firms should receive harsher terms in the financial market regardless of the equipment being purchased. Thus, a good portion of an interest rate differential rests on other grounds besides the involvement of UM.

3. There is some gross gain in the efficiency of the financial market from the practice of compartmentalizing

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[31]A far higher proportion of foreign subsidiaries in Puerto Rico and Mexico use second-hand equipment than do locally owned firms. See Strassmann, op. cit., p. 211.

[32]Strassmann found preference for second-hand machines to be associated with small scale enterprises in Puerto Rico and Mexico. Ibid., Table 16, p. 209.

borrowers into certain broad categories. Compartmentalization of this sort is akin to economies of scale in production. If a lending agency made it a practice to investigate each loan made on UM and determine the financing terms on the basis of each individual case, the economic gain from better rationing of financial and real capital would have to be reduced by the additional resources consumed through more intensive financial research.

4. Some discrimination against UM evidences itself in credit provisions, but actually is the result of some of the more fundamental biases, e.g., the political, engineering or risk avoidance (by development loan agencies). There is no reason to suppose that bankers are immune to these attitudes when technicians, the general public, management and political leaders are not.

5. The size of the typical loan for UM will be smaller than a loan on new machinery. This is true because of (a) the aforementioned tendency of smaller firms to borrow on UM and (b) the lower initial capital costs for UM. Since there is little difference in the cost of processing small and large loans,[33] the financial agency must charge a higher rate of interest on smaller loans in order to make a rate of return commensurate with those on large loans.

The foregoing should not be taken as a stance against improving the existing institutions involved in UM financing,

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[33]The Economist Intelligence Unit, Ltd., <u>op. cit</u>., p. 13.

but it is an argument that the harm to economic efficiency is not as great as the literature implies and to the extent that UM financing discriminates against second-hand equipment, it partly reflects the network of attitudinal biases against it.

Social and Tax Legislation in LDC's

Some forms of social legislation tend to discriminate indirectly against earlier vintages of technology by discouraging labor-intensive techniques. Particularly damaging are job tenure provisions which make it difficult for employers to discharge workers or require an indemnity payment to the worker.[34]

New firms or firms which have not hired beyond the point of no return (until the cost of discharge is prohibitive) will tend to mechanize sooner than would otherwise be the case.[35] For all firms not caught in the "indemnity trap," the logical policy is to become capital-intensive and even then to chronically under-hire.

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[34]The Brazilian document, Consolidação das Leis do Trabalho, Article 492, provides that an employee with more than ten years of service in the same firm cannot be dismissed without cause which must be proven. Sometimes employers are driven to pay a worker a lump sum to get rid of him when courts are unsympathetic to the firm. Robert J. Alexander, Labor Relations in Argentina, Brazil and Chile (New York: McGraw-Hill Book Company, Inc., 1962), p. 121.

Argentina has a provision for indemnity to be paid to workers under certain conditions upon dismissal. Some claim this has led to a "dismissal industry." Ibid., pp. 201-202.

Strassmann cites similar labor laws in Mexico and India. Op. cit., p. 135. Also, see Wendell Gordon, "Capitalism and Technological Adaptation in Latin America," Journal of Economic Issues (March, 1969), p. 73.

[35]Strassmann, op. cit., pp. 136-37.

In addition to labor legislation, tax incentives sometimes favor capital-intensity. When tax savings accrue to reinvested profits, but not to using profits to hire more workers, the asymmetry favors the choice of a more capital-intensive technique.[36]

Trade Restrictions on UM

Many LDC's have embargoes or tariff provisions that exclude or discourage the importation of UM. In many respects these provisions can be thought of as the legal and economic manifestations of a political bias unfavorable to UM although other reasons will often be adduced.

Such restrictions, according to the UN study exist in ". . . some of the latin [*sic*] American countries, India, Iran, Iraq, Somalia, Turkey, etc."[37]

The EIU study speaks of ". . . strict regulations banning or restricting the entry of used equipment in certain countries, as for example in Argentina."[38]

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[36] *Ibid*., pp. 127-28.

[37] UN, *Report of Expert Group on Second-Hand Equipment*, *op. cit*., p. 15.

The Centre for Industrial Development of the UN made a survey of such import restrictions of LDC's which included questions about the reasons that they were in force. The information obtained was used as part of the background material for the December 7-22, 1965, meeting of the group of experts on second-hand equipment in New York. If a complete set of the original survey replies exist, I have not been able to find it. They are not available through UN offices and I have written every member of the expert group for whom I could obtain a mailing address. Unfortunately, none whom I contacted has preserved the material.

[38] EIU, *op. cit*., p. 38.

Sometimes UM is subject to the full importation duties new machinery pays. This is true in the case of many specific tariffs and even when an ad valorem tariff is involved some customs officials refuse to take the purchase price as a base and substitute a price close to that of a new unit.[39] Peru, for instance, requires duty payment equivalent to new on some used equipment imports.[40]

Shadow Prices and UM

Literature on choice of technique and investment criteria commonly contains some comment on the disparity between market costs of factors of production and their social opportunity costs.[41]

No one doubts that there are vast chunks of the population in LDC's that are working or are capable of working, but who contribute nothing or next to nothing to total output. There is heated controversy as to the extent and location of

[39]Chilton, op. cit., f.n. 3, pp. 198-99.

[40]Ibid.

[41]Representative references are as follows: Jan Tinbergen, "Choice of Technology in Industrial Planning," Industrialization and Productivity Bulletin, No. 1 (New York: United Nations, 1958), pp. 25-26; United Nations Bureau of Economic Affairs, "Capital Intensity in Industry in Underdeveloped Countries," ibid., pp. 7, 9, 18 and 21-22; G. K. Boon, Economic Choice of Human and Physical Factors in Production (Amsterdam: North-Holland Publishing Company, 1964), pp. 80 and 108; D. R. Campbell, "Choosing Techniques; An Indian Case: A Comment," Oxford Economic Papers (March, 1967), p. 135; Everett E. Hagen, The Economics of Development (Homewood, Illinois: Richard D. Irwin, 1968), p. 396; Charles P. Kindleberger, Economic Development, 2nd ed., (New York: McGraw-Hill Book Company, 1965), p. 93.

The most sophisticated analysis of shadow prices and surplus labor. For instance Hansen,[42] Schultz,[43] and Paglin[44] would deny that it exists on a massive scale in agriculture. Other studies do claim that large amounts of underemployment exist in agriculture albeit much exists for a few hours a day due to the lack of enough complementary inputs (mainly land), or, they say, it exists seasonally.[45]

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methods of calculating them is found throughout Ian M. D. Little and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Vol. II (Paris: Development Centre of the Organization for Economic Co-operation and Development, 1969).

[42]B. Hansen, "Marginal Productivity Wage Theory and Subsistence Wage Theory in Egyptian Agriculture," Journal of Development Studies, 2 (July, 1966), pp. 367-99.

[43]Theodore W. Schultz, Transforming Traditional Agriculture (New Haven: Yale University Press, 1964), and Economic Crises in World Agriculture (Ann Arbor: The University of Michigan Press, 1965).

[44]Morton Paglin, "Surplus Agricultural Labor Development: Facts and Theories," AER (September, 1965). Pp. 815-34.

[45]See for instance the figures cited from a study by the Latin American Demographic Center and Latin American Institute for Economic and Social Planning in the Inter-American Development Bank's Socio-Economic Progress in Latin America, 1968 (Washington: Inter-American Development Bank, 1969), p. 365.

Also, M. M. Mehta, Industrialization and Employment with Special Reference to Countries of the ECAFE Region (Bangkok: Asian Institute for Economic Planning, 1968), pp. 8-13.

Mueller and Zevering found considerable part-time idleness and seasonal variation in demand for rural labor in Western Nigeria. P. Mueller and K. H. Zevering, "Employment Promotion through Rural Development; A Pilot Project in Western Nigeria," International Labour Review (August, 1969), pp. 111-30.

Regardless of the extent of labor surplus in rural areas, no one doubts that it exists in the cities. Visible unemployment of the urban labor force in Latin America has been estimated to range from 5.2 per cent (Lima-Callao, Peru: April-May, 1969) to 18.4 per cent (Barranquilla, Colombia: 1967).[46] In addition the labor surplus contains those who have dropped out of the labor force because of discouragement, those (mainly younger women) who would enter the labor force given sufficient labor demand, and those working part-time who desire to work more. Furthermore, the social opportunity cost of redeploying those shining shoes, selling lottery tickets, engaged in petty retailing, those hired as menial servants, etc., is bound to be quite low.

For our present purposes we will gloss over the disagreement on the location of surplus labor in LDC's and merely assume that there exists additional hours of labor that can be redeployed at a social opportunity cost considerably below the actual money wage which the redeployment would entail. The ensuing analysis will assume a shadow wage for unskilled labor of 50 per cent of the actual wage.[47]

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[46]OAS, "The Unemployment Problem in Latin America," op. cit., p. 4, Table 1.

[47]This was the figure that Little and Mirrlees calculated for Pakistan and used in a case study of a rayon plant. Ian M. D. Little and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Vol. II, op. cit., pp. 222-31.

In extraordinary circumstances unskilled labor may justifiably be considered free in terms of social opportunity cost, but the 50 per cent shadow price appears more realistic due to one or some combination of the following: (1) transportation costs or additional social overhead or infrastructure costs may be involved in transferring labor from one sector to another; (2) the raw labor may have had a very low, but not a zero marginal product; (3) the labor may have been only seasonally underemployed in their original occupation; (4) the new industrial occupation may cause their food consumption to rise; (5) if a transfer of labor from subsistence agriculture is involved, it may cause those remaining in agriculture to increase their consumption of food; (6) additional administrative costs could be incurred and (7) some minimal training may be necessary for even unskilled industrial occupations.

A shadow wage of 75 per cent of actual wage will be used for semi-skilled labor reflecting the belief that many of the tasks performed by such labor can be learned rather quickly with moderate training costs.[48]

There is also fairly wide agreement that the rate of interest in LDC's is lower than the marginal productivity of capital and that foreign exchange is cheaper than it would

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[48]This also follows Little and Mirrlees who speaking of unskilled labor say ". . , and in that category we can also include many grades of semi-skilled labour, and even skilled labour, where the skills required are easily and quickly learnt on the job." Ibid., p. 154.

be in a neoclassical world. Accordingly, we will assume a range of increases of one, two and three percentage points in the cost of capital. Each of these increases reflect a hypothetical result of the combined impact of arriving at higher shadow interest rates and foreign exchange rates.[49]

In the appendix to this chapter (Appendix C) the adjustments in lower wage costs and higher capital costs have been applied to the unit costs of production of the three technological vintages of textile equipment that were originally shown in Appendix A to Chapter II. It will be recalled that the ECLA study[50] presented detailed costs associated with using new equipment of the technological vintages of 1950, 1960 and 1965. We adjusted the unit cost of production for the 1950 and 1960 vintages by associating a range of increased maintenance costs and decreased capital costs with

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[49]This would seem roughly in line with Schmedtje's estimate that the actual cost of riskless capital in Pakistan in the 1950's was around 5 1/2 per cent whereas the real cost of capital was somewhere around 7 to 8 per cent.

Jochen K. Schmedtje, "On Estimating the Economic Cost of Capital," Report No. EC-138, mimeographed (New York: International Bank for Reconstruction and Development, October 21, 1965), pp. 6-7. Note that (1) his base of 5 1/2 per cent is lower than the base of 12 per cent assumed by the ECLA study, (2) the cost of capital in the ECLA study was not riskless and (3) our hypothetical increases include the foreign exchange impact whereas Schmedtje was concerned only with the domestic rate of interest.

[50]ECLA, "Choice of Technologies in the Latin American Textile Industry," op. cit.

the use of UM.[51]

Two important points emerge from the data:

1. In Appendix A, 1960 UM that had an annual capital cost of 75 per cent was the most efficient technique only for the case which assumed the lowest rise in maintenance costs. The shadow price data shows with this ratio of UM to new machinery costs the 1960 vintage is most efficient for the majority of cases.

While this roughly doubles the number of _hypothetical_ cases that are feasible for the 1960 vintage (at various maintenance and UM cost assumptions) it represents a _much more_ significant increase in terms of real world _availability_ of UM on these terms. Given (a) the usual case of shorter life of UM and (b) the relatively recent vintage of 1960 compared to 1965 technology, one would rarely encounter 1960 available UM cheap enough to allow _annual_ costs to be 50 per cent of that for new equipment. The shadow price figures greatly expand the feasible employment of UM due to the increased probability of purchasing UM at the requisite lower initial price.

2. The use of shadow prices shows UM to be a much better bargain than new machinery in trading off some static efficiency for some gain in employment. For instance, while

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[51]One set of figures was associated with a 10 per cent decrease in the annual cost of capital due to employing UM. These cases are excluded from Appendix C, since they add little to the analysis at this point.

the 1950 vintage of technology is in no instance the most efficient regardless of our assumptions, the difference in the loss of static efficiency narrows considerably.[52]

For example, if new 1950 equipment is employed rather than new 1965 equipment, the difference in unit cost is 2.1 cents per meter of yarn. This difference is reduced to 1.1 cents if we compare costs of (1) new 1965 and (2) 1950 UM that is associated with a 100 per cent rise in variable maintenance costs and a 50 per cent reduction in annual capital costs. We can go further and compare these 1950 UM costs with those of 1960 UM[53] that are associated with a 50 per cent rise in variable maintenance costs and a 25 per cent decrease in annual costs. After applying shadow wages and a shadow cost of capital of 14 per cent to each process, the cost disadvantage of the 1950 vintage shrinks to .766 of one cent per meter.

If a normative decision is made to achieve a higher level of employment at some loss of static efficiency, the use of shadow pricing further enhances the attractiveness of employing UM.

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[52]The levels of employment for the 1950, 1960 and 1965 vintages of technology are 668, 446 and 315, respectively. Ibid., Table 1, p. 9.

[53]We use a 1960 example here, since it is more efficient than the 1965 method after shadow price adjustment.

Conclusion

The material in this chapter should speak for itself. Although there are biases that favor the employment of UM (e.g., a budget restraint) there are severe imperfections in the market which discourage its use. It is ironic that a political bias in LDC's takes its most extreme form in the belief that UM exports from developed countries to LDC's is a plot to perpetuate technological inferiority, while at the same time development agencies who do or could facilitate such a transfer are also afflicted with a bias (risk aversion) against UM.

The conclusion must be that LDC's could reasonably absorb much more UM than they currently do. The exact amount cannot be estimated with precision any better than the exact amount of UM currently being transferred to LDC's. But, the number and intensity of the attitudinal biases and certainly the implications of imperfections in factor prices in LDC's would lead to the conclusion that a substantial increase would be compatible with the goal of maximizing static efficiency. Even more could be utilized if employment absorption were to be given a high priority as an economic goal.

APPENDIX C

APPENDIX C

COSTS OF PRODUCTION PER METER OF YARN 1950, 1960 AND 1965 VINTAGES OF EQUIPMENT[a]

1. New Machinery, Market Prices[b]

Technological Vintage	Cost per Meter (in cents)
1950	20.744
1960	19.067
1965	18.541

2. New Machinery, Shadow Prices[c]

Technological Vintage	Cost per Meter (in cents) Assumed Shadow Rate of Interest		
	13%	14%	15%
1950	20.121	20.394	20.667
1960	18.868	19.167	19.465
1965	18.571	18.885	19.200

APPENDIX C--Continued

3. Used Machinery, Shadow Prices: Costs per Meter (in cents)

Rise in Variable Maintenance Costs	UM/NM Cost = 50%[d] Assumed Shadow Rates of Interest			UM/NM Cost = 75% Assumed Shadow Rates of Interest		
1950 Technology						
	13%	14%	15%	13%	14%	15%
50%	18.953	19.158	19.364	19.588	19.829	20.069
100%	19.060	19.267	19.472	19.696	19.936	20.176
150%	19.168	19.374	19.580	19.804	20.044	20.284
200%	19.276	19.482	19.687	19.912	20.152	20.392
1960 Technology						
	13%	14%	15%	13%	14%	15%
50%	17.496*	17.714*	17.933*	18.247*	18.506*	18.765*
100%	17.625*	17.843*	18.062*	18.375*	18.634*	18.893*
150%	17.753*	17.972*	18.190*	18.504*	18.763*	19.022*
200%	17.882*	18.100*	18.317*	18.632	18.892	19.151*

[a]Based on figures from ECLA, "Choices of Technologies in the Latin American

APPENDIX C--Continued

Textile Industry," E/CN, 12/746, mimeographed (Santiago: ECLA, January 13, 1966) and calculations in Appendix A of this thesis.

[b]ECLA, _op. cit._, Table 13, p. 36. I have carried the computations to two more decimal places beyond that of the original.

[c]Based on shadow wages of 50 per cent and 75 per cent of the market wages of unskilled and semi-skilled workers, respectively, and shadow rates of interest as indicated. For wages of various skill categories see _ibid._, Table L, pp. 65-66. Investment figures and the bases for costing investment are found in _ibid._, Tables K and M, pages 64 and 67.

[d]UM/NM cost refers to the ratio of annual capital cost of UM to that of new machinery. Decreases in capital costs and increases in variable maintenance costs were calculated at market prices and then the adjusted costs were subjected to shadow pricing.

*Indicates those costs per meter that are more efficient than its counterpart of 1965 machinery.

PART IV

CHAPTER VIII

CONCLUSIONS AND POLICY IMPLICATIONS

The contribution of UM to LDCs' investment in industrial equipment is marginal, but it is marginal to the same degree that expenditures on research and development constitute a marginal part of total investment in the United States or that purchases of automobiles are a marginal component of total consumption expenditures. It is useless to attempt to identify a point of demarcation between marginal and nonmarginal. We merely need say that UM probably constitutes a minimum of 10 per cent of LDCs' investment in industrial equipment; if the transfer of UM dried up overnight, a noticeable change in the pattern of capital formation would result.

Most comparative cost studies, including the calculations of Appendix A of this thesis, cannot explain the extent to which UM is employed in LDC's. Such comparisons lead us to believe that only cases of exceptional bargains in the UM market merit the attention of entrepreneurs. Moreover, the LDC-UM market is fraught with imperfections which, on balance, favor the selection of new machinery.

The explanation of this seeming paradox is simple. Most purchases of UM involve one or more special circumstances and thus do not fit into the mold as portrayed by the figures in Appendix A. Using such a first approximation, based on sound generalizations, merely explains why most equipment imported into LDC's is new. Bargains do occasionally crop up, but more important are a host of exceptional special situations that enhance the appeal of UM.

Although not usual, in a substantial minority of cases the maintenance cost of UM approximates or even falls below that for new equipment. Occasionally high risks stemming from political unrest, the threat of devaluation or the introduction of a new product will sway the entrepreneurial decision in favor of UM. Once in a while one finds UM that is so sturdy that its expected physical usefulness is comparable to that of new equipment, thus magnifying any advantage in the initial purchase price of UM. Sometimes a limited market size favors the use of UM. Here and there, a switch in fuel supply will make a plant in developed areas obsolete, but not in LDC's. The list could be extended, but the point is obvious. The "substantial minority of cases," "occasionalies," "once in a whiles," "sometimes," "here and theres," etc., while not impressive individually, mount up to an impressive total of UM sales. Nor need UM be heavily blessed by a single special situation; a tinge of several such advantages can yield the same result.

Occasionally the literature on the LDC-UM market emphasizes the proposition that under ordinary circumstances for any given project UM should not be used. While true, for the vast majority of production tasks in LDC's, UM should <u>always</u> be considered. There is nothing incompatible about these two statements. It is analogous to a dice player who cannot expect to roll a six on any given cast of the dice, but should not disregard such a possibility.

Of more fundamental importance are the indications that a substantial expansion of the volume of UM transferred to LDC's would enhance their economic welfare. Moreover, an extensive increase in the UM purchased by LDC's could be accomplished without experiencing any significant rise in its long-run price because of (1) the miniscule proportion of all UM going to LDC's, (2) the high cross elasticity of demand between UM and new machinery, (3) earlier retirement of equipment in response to a rise in price of UM, (4) increased incentive to rehabilitate equipment otherwise headed for scrapping as the value of UM rose and (5) improvement in the efficiency of the LDC-UM market due to the rise in demand.

Social Benefits from UM Employment

It is impossible to guess the level of additional UM that LDC's could profitably absorb. Our analysis in Appendix C suggests that the application of shadow price adjustment could easily double the amount. If market imperfections could be removed, or more realistically, ameliorated, static efficiency would improve. In addition several other less obvious social rewards would be forthcoming that complement the goals of growth or employment absorption. The four most potent of these advantages are reviewed below.

Savings in Foreign Exchange

Compared to new equipment, UM will, with rare exceptions, have lower annual capital costs per unit of output. Usually, this can be attributed to a low initial purchase price although other factors, e.g., a shorter gestation period, a better fit to market size, greater flexibility, etc., can contribute to the same result. To the extent that lower capital costs apply to imported equipment, outlays of foreign exchange are reduced. Moreover, lower production costs due to increased efficiency will encourage import substitution and export expansion.[1] Aside from cost competitiveness, the smaller scale of earlier vintage machinery encourages demand-induced import-substitution at an earlier date.

Three additional savings in foreign exchange which could materialize are:

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[1] Both the manager of Papelera de Chihuahua, Gastone Guglielmina, and the Head of the Department of Economics and Statistics of the State of Chihuahua, Mexico, Lic. Jaime Caraveo, estimate that close to 100 per cent of Papelera's wrapping paper output has substituted domestic production for United States imports.

A Calcutta firm purchased a second-hand semi-automatic machine for making wood screws from its British associate. It undersells the British affiliate in India and also exports to neighboring countries. Waterson, op. cit., p. 2.

A Cleveland, Ohio, firm established a foundry in South America with used steel casting equipment. Steel for the castings could be shipped from the United States 7,000 miles round-trip, including 700 miles of inland transportation, and still castings could be produced and delivered to Cleveland at a cost advantage over modern equipment in the Cleveland plant. Ibid.

1. Greater domestic production and rebuilding of spare parts induced by (a) a larger volume of demand and (b) the less complex nature of the parts.

2. A reduction in the need to import highly skilled technicians to service late vintage equipment.[2]

3. With the proper inducements, the demonstration effect of UM can encourage local production of new equipment incorporating some of the desirable technical features often found in earlier vintages of technology.[3]

Naturally, adequate foreign exchange is an ingredient in achieving static efficiency, an ingredient which presumably would be taken into account by proper calculations of shadow prices.[4] Convincing empirical evidence exists, however, that the shortage of foreign exchange is a far more formidable obstacle to growth than to static efficiency.[5] In this light official objection to importation of UM into LDC's, inspired by fears of illegal circumvention of foreign

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[2]"However, it must be realized that the necessary repair operations should not be beyond the capacity of the prospective maintenance men. Otherwise there arises a built-in need for expensive expatriate mechanics or engineers." Edward and Mildred Marcus, "Capital/Labor Ratios and the Industrialization of West Africa," op. cit., p. 229.

[3]For instance, smaller scale, simpler operation and maintenance, greater ruggedness and more flexibility.

[4]It will be recalled that the range of increases in capital costs in Chapter VII and Appendix C were attributed to the combined imperfections of the domestic and foreign capital markets.

[5]See Chenery and Strout, op. cit.

exchange restrictions, is especially ironic.

Absorption of Labor

Increased employment of UM would absorb more labor for three reasons.

1. An earlier technological vintage implies a higher ratio of labor to initial capital costs.[6]

2. There is more incentive and compulsion to apply labor-intensive maintenance to lengthen the physical life of the equipment.

3. On a given investment and/or foreign exchange budget, more equipment can be obtained, thus requiring more complementary labor.[7]

If an improvement in static efficiency is made by perfecting the LDC-UM market we can, then, expect a "bonus" or a "dividend" in the form of employment absorption. But beyond some level of employment, these two goals are likely to be incompatible due to a combination of (1) population growth, (2) scarcities and indivisibilities of capital goods and (3) scarcities of complements to labor or capital (e.g.,

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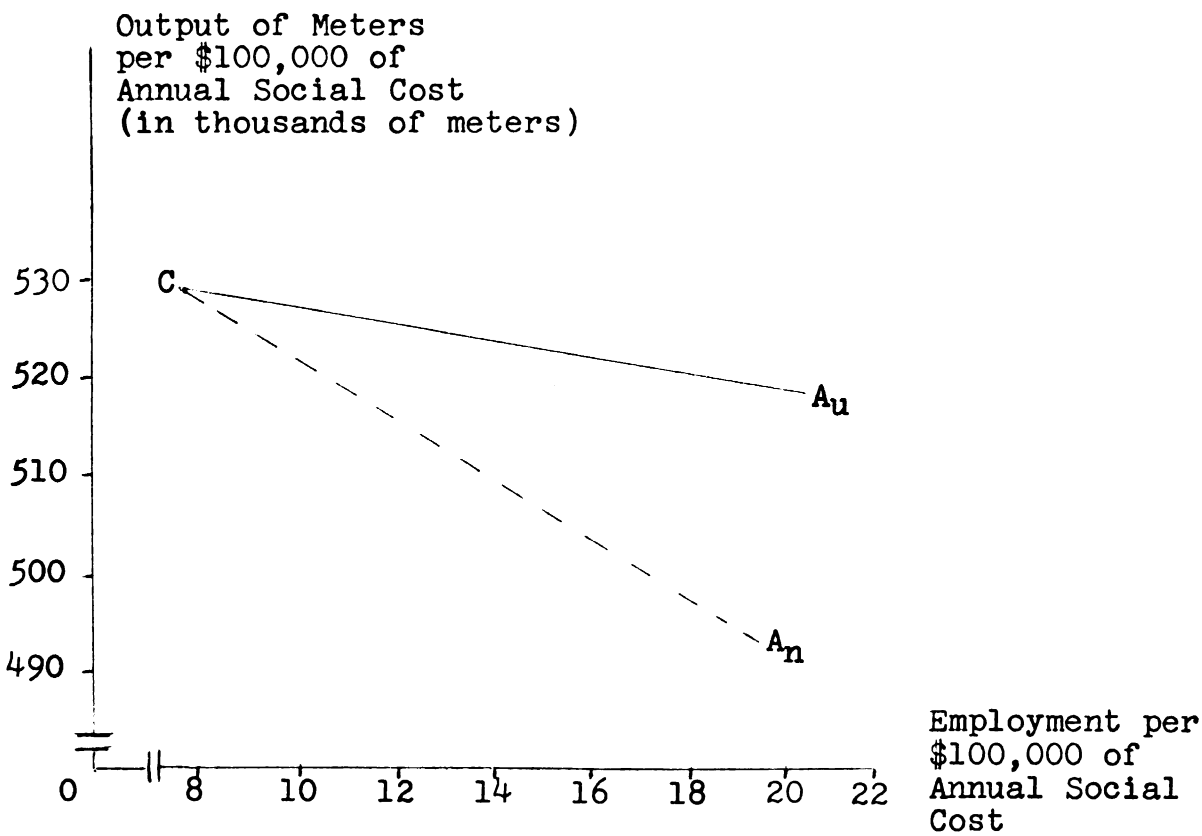
[6]This is sufficiently illustrated by the ECLA textile study. For technological vintages of 1950, 1960 and 1965, total investment was $4,453,340, $5,658,542 and $6,507,633, respectively, while employment was 668,446 and 315, respectively. ECLA, Choice of Technologies, op. cit., Table 1, p. 9 and Table K, p. 64.

[7]This was amply illustrated by Mr. Stokes' (Chapter V) purchase of an entire wool yarn processing plant with a budget originally earmarked for the purchase of wool washing equipment.

It is worth pointing out that although much of the advantage of reducing surplus labor through the effects of points 1 and 2 above is lost when a used automated plant is imported, the effect of the third point still applies.

efficient financial markets, entrepreneurial talent, a functional distribution system, etc.). If a political decision is made to increase employment at the expense of some current output, production with UM would be one of the least painful methods of accomplishing such a goal.

Data based on the Latin American textile study can be used to illustrate this point.[8] The amounts of output and employment per $100,000 of social cost[9] are shown graphically below for 1965 new equipment (C), 1950 new equipment (A_n) and



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[8] Figures are based on ECLA, op. cit., as adjusted in Appendix A and Appendix C of this thesis.

[9] Shadow adjustments consist of a reduction of wages of unskilled and semi-skilled labor by 50 and 75 per cent, respectively, and raising capital costs by two percentage points.

1950 used equipment (A_u).[10]

A movement from C to A_n represents a gain of 11.83 men employed at the expense of 35,800 meters of yarn, a ratio of approximately one man to 3,000 meters.[11] By comparison, a gain of 12.84 men employed and a loss of 10,500 meters, a ratio of approximately one man to 800 meters, results from moving from C to A_u. If policy dictates that a "price" in terms of current output be paid in order to "purchase" additional employment, A_u is a bargain vis-à-vis A_n.

The comparison would probably be even more favorable for A_u. If the assumed increase in variable maintenance cost resulted in additional hiring of unskilled workers (a) shadow price calculations would reduce the real cost of added maintenance expense and (b) the number of workers per $100,000 cost would rise.

Increased Learning

Learning by the labor force is augmented by employing UM in four ways. First, the larger number of workers

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[10]For the 1950 used equipment variable maintenance costs are assumed to rise by 100 per cent; annual equipment costs are assumed to decrease by 50 per cent.

[11]The relevant figures are given below:

Basis for Calculation	Employment per $100,000 of Annual Social Cost	Output of Meters per $100,000 of Annual Social Cost
C	7.76	529,500
A_n	19.59	493,700
A_u	20.60	519,000

associated with the earlier vintage technology increases learning at the external margin. More workers get exposure to the industrial process than would have been the case had UM been eschewed. Second, "learning while doing" is faster and more pronounced when using a mechanical method of production as opposed to an automated method. Third, the more frequent maintenance and repair problems of older machines increase worker experience. Fourth, the more frequent replacement of UM increases worker exposure to different vintages of technology.

Induced learning at the managerial level is somewhat different. When employing UM it is usually more obvious that postponing maintenance activities is a costly practice. The entrepreneur using second-hand equipment must operate under a compulsion to maintain if he expects to stay in business for long. Those who do not are likely to find it necessary to trade in their hatband reading "entrepreneur" for one reading "ordinary member of the labor force." Some anthropologists claim that associating pain with tribal puberty rites is an effective means of increasing the learning and retention of the cultural norms that older members of society seek to impress upon the discomfited initiates. The compulsion to maintain when using second-hand equipment is closely analogous.

Expansion and Utilization of Entrepreneurial Talents

Employing UM expands the ranks of entrepreneurs. Because of budget restraints many face the alternatives of producing with UM or not producing at all. This effect resembles the exposure of a larger number of workers to industrial production. Using second-hand equipment swells the roster of persons getting experience in risk-taking, decision-making and, hopefully, innovation. Keener competition can also result.

The effect on the supply of entrepreneurship at the internal margin is not symmetrical with the impact on the external margin. On balance, there appears no doubt that the employment of UM <u>absorbs</u> the time, energy and ingenuity of the existing entrepreneurs. The case study involving Lic. Gastone Guglielmina serves as an example. It was clear that more of his entrepreneurial abilities were needed to research, inspect, purchase, renovate, synchronize and maintain his second-hand equipment than would have been true of new equipment. The statements of Hirschman, Meier, and others, claiming that greater capital-intensity offers a substitute for entrepreneurial and managerial abilities, are correct if we confine their inferences to the supply of entrepreneurship at the internal margin. Capital intensity can increase the <u>effective</u> supply by freeing such abilities for alternative application.

But the key phrase is "freeing such abilities for alternative application." There is no a priori reason to suppose the marginal product of entrepreneurs' time will exceed their returns from researching, inspecting, purchasing, renovating, synchronizing, maintaining and producing with UM.

The case study in Chapter V featured an entrepreneur who consciously weighed costs and alternative techniques of production. Furthermore, he operated within an impressive network of information about the paper industry. Are we to assume that Lic. Guglielmina, and entrepreneurs in general who employ UM, knowingly or through ignorance dissipate their entrepreneurial talents? It hardly seems likely.

Economies of Scale in the LDC-UM Market

Barring further hostile political action against UM by LDC's, the absolute amount of UM transferred to LDC's can be expected to rise in response to (a) increased needs for all types of equipment, (b) more used automated plants being thrown on the market and (c) improved levels of maintenance in LDC's. Any alteration of policy which favored UM would, of course, reinforce these trends. If the Chapter VII and Appendix C analysis is close to reality, policies implementing shadow pricing could at least double the amount of UM employed in LDC's.

In Chapter VI we saw that under the pessimistic assumptions of a -.5 price elasticity of demand and a perfectly inelastic supply with respect to price, a doubling of the LDC-UM market would result in a 5 per cent increase in the long-run price of UM. Allowing for (a) normal growth in the UM market in developed countries and (b) a price elasticity of supply above zero, a large increase over a reasonable length of time (say, 10 years) would raise price even more moderately. If we have reason to believe that the LDC-UM market is subject to economies of scale, a rise in demand for UM will at worst dampen a price rise in UM and could result in a net decrease in price.[12]

Specifically what efficiencies can be identified which would be a function of a larger LDC-UM market? Suppose the letters A through K represent an array of types of UM:

A, B, C, D, E, F, G, H, I, J, K.

Furthermore, suppose as we move from type A toward type K that (a) the number of units sold per time period falls, (b) the equipment becomes more specialized and (c) the unit price rises. A, B, C and D can be used to symbolize those types of UM that have a market demand which permits accurate classification as to make, age, condition, and specifications. Market price gives a fairly accurate picture of the marginal productivity for these types of UM.[13] E, F, G and H symbolize individual pieces of specialized equipment.

I, J, and K represent a set of core equipment or an entire plant facility. These types of UM enjoy advantages such as (1) a lower inspection and appraisal fee relative to the purchase price (compared to E, F, G and H), (2) greater likelihood of observing the equipment perform under power,

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[12]Notice that the increase in the supply of UM in response to a price rise and a fall in the price which LDC's entrepreneurs pay are not incompatible if efficiencies occur in various phases of the transfer process.

[13]The price will, of course, reflect the marginal productivity in the developed country since the bulk of sales are domestic.

(3) a better chance of obtaining the operating and maintenance history, (4) more likelihood that key personnel from LDC's can be trained by technicians of the selling firm, (5) a better probability that the original owner will retain a vested interest in the proper operation of the equipment (i.e., royalty or equity) and (6) an enhanced incentive to appoint a single organization to accomplish the physical transfer of the equipment.

Now assume there is a significant increase in the dollar volume of demand for UM which results from the combined effect of (a) a rise in demand for all types of UM and (b) a disproportionate increase in demand for the more expensive types of equipment. Two margins would be affected. First, the "classification" margin could be feasibly extended, say, to type E equipment. Second, the demand for an expensive, automated plant can be extended out to a type not heretofore on the UM market, say, to L.[14] Efficiencies inherent in a viable market are extended at the "classification" margin while the aforementioned benefits of large purchases are extended to larger, more expensive plants at the "trade-up" margin.

Since the LDC-UM market constitutes such a small per cent of total UM sales, the effect at the "classification"

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[14]This tacitly assumes market forces that encourage "trading-up" to more and more modern (but not necessarily the most modern) vintages of technology. One rationale offered in Chapter V was premised on a faster rate of market growth in LDC's coupled with a faster growth in the absolute size of the market in developed countries.

margin will probably be of slight importance.[15] No such verdict can apply to the "trade-up" margin. The addition of one $7 million plant to 1967 imports of SITC 71 equipment from member countries of the Organization for European Co-operation and Development would have represented approximately 70, 20 and 10 per cent increases for Costa Rica, Nigeria and India, respectively.

Additional efficiencies would follow an expanded LDC-UM market. The high cost of carrying inventory is one reason for the high markup on UM by dealers. The stochastic effect of larger sales volume would permit the ratio of inventories to sales to shrink.

The most advantageous possible (but not certain) by-product of an expanded LDC-UM market would be a shift in the pattern of dealers' market orientation. The ideal would be firms that specialize in servicing LDC's and are generalized in all, or most, of the stages of the transfer process. Such a market pattern would lead to the following desirable results:

1. The specialized firms would have a vested interest in establishing and maintaining a reputation. Most orthodox price theorists tend to frown on the implications of "reputation" in a market and, indeed, consider it an imperfection. But, in an otherwise very imperfect market, a "reputation" can be a blessing to the customer. Orthodox price theorists

[15]In the next section I suggest that the classification margin be extended through subsidy.

usually assume omniscience about the market is obtainable at a zero cost. In the UM market this is especially misleading. Paying a little extra for "reputation" and receiving honest descriptions of the equipment can be a bargain.[16]

2. A firm specializing in servicing the LDC-UM market is more likely to be in a position to handle all of the steps in the physical transfer of the equipment.

3. Greater expertise will accrue to specialization *à la* Adam Smith, e.g., an improved ability to negotiate goods through customs, carry on business in several languages, deal in foreign currencies, knowledge of special equipment problems of tropical countries, etc.

4. New equipment dealers offer *detailed* technical advice to LDC's in setting up new facilities; UM dealers ordinarily do not. A vested interest in maintaining lasting relations with entrepreneurs in LDC's would encourage the incorporation of pre- and post-sale technical assistance into any sizeable UM contract.

Toward a UM Policy

The "Keep Doing What We Are Doing" Department

Four lines of investigation, that on balance will encourage the employment of UM, are well under way. The momentum of research combined with the number and/or prestige

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[16] I am following Stigler who in turn was following a suggestion by Milton Friedman. George J. Stigler, "The Economies of Information," *JPE* (June, 1961), p. 224.

of the organizations involved warrants the view that the findings will be useful. These fields of endeavor are as follows:

1. Improving maintenance in LDC's.[17]

2. Improving the availability of spare parts in LDC's.[18]

3. The use of shadow prices.[19]

4. Increasing interest in labor-intensive technologies.[20]

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[17]The United Nations Industrial Development Organization has given this high priority. See their "Report of the Group of Experts on Maintenance and Repair of Industrial Equipment in Developing Countries," op. cit. Several teams were to have been sent to ten LDC's and to have been in the field by November, 1968. Experimental projects were to have been implemented in 1969 and if the program is on schedule a concerted attack on the problem began in 1970.

[18]Here again, UNIDO has taken a keen interest. See UNIDO, "Issues proposed by UNIDO to the Advisory Committee on the Application of Science and Technology to Development for its 'Concerted Attack Programme'," ID/WG. 26/1 Rev. 1, mimeographed, November 21, 1968, pp. 15-16. From time to time the announcements of newly initiated field studies concerning spare parts have appeared in UNIDO's Monthly Bulletin.

[19]The most sophisticated techniques known to me are found in Ian M. D. Little and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Vol. II (Paris: Organization for Economic Cooperation and Development, 1969).

[20]The number of institutions interested in labor-intensive technologies is growing as is the literature. For bibliographical material see UNIDO "Selected Bibliographical References," ID/WG. 3/BP.3, mimeographed, May, 1967, pp. 1-3; the bibliography to A. K. Sen's "Choice of Technology: A Critical Survey of a Class of Debates," ID/WG.3/DP.7, mimeographed (Vienna: UNIDO, May 1967), pp. 27-31 and Jack Barranson, Technology for Underdeveloped Areas; an Annotated Bibliography (Oxford: Pergamon Press, 1967).

For a statement that is representative of most international development organizations see UN, World Economic Survey, 1968, Part I, "Some Issues of Development Policy in the Coming Decade: Population, Employment and Education," preliminary edition (New York; UN, June 4, 1969), pp. 7-20.

Reducing Anti-UM Bias

The most significant perfection of the LDC-UM market would entail the elimination of prohibitions or less severe impediments to importing UM. Here, we are once again confronted with the political bias. There are, as we have seen, other anti-UM biases, but the political bias is the most damaging since:

1. Political decisions have sweeping effects. A single businessman may get a rotten deal and foreswear any future purchase of UM. A political response may be an embargo on that type of UM which precludes <u>all</u> producers from employing it. Furthermore, business decisions tend to be easier to reverse while political decisions on trade barriers are far easier to enact than to remove.

2. Many of the other types of bias are partly attributable to the political bias. The entrepreneur may avoid UM imports because he thinks the government will think he is purchasing UM to circumvent foreign exchange restrictions. International development agencies, development agencies of wealthy nations and even development agencies of LDC's shy away from UN because of the political hostility toward it.

3. The political bias is further removed from exposure to the relevant learning process. Engineers and businessmen in LDC's catch on through experience that UM can be profitable under the right conditions. "Horrible examples" occur with UM, but enormous amounts are still imported into

LDC's. Importers and businessmen gripe about UM, but continue to import it and use it.[21]

Reducing Political Bias:
The Pressures

Although the political arena is not exposed to learning situations in the same sense that management and engineers are, learning can be induced by the pressure to solve related problems. The shortage of foreign exchange, for instance, is a chronic problem for most LDC's and the judicious employment of UM can, as we have seen, help alleviate the problem. By far, however, the strongest compulsion to change current policy stems from the political social and economic effects (and fears of further effects) of surplus labor in LDC's.

One can justifiably argue how much and in what forms true underemployment exists in LDC's. But, as Lewis suggests, when hoards of visibly unemployed are sleeping on the streets and burgling homes, the precise definition of surplus labor becomes academic.[22] The problem is already so acute

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[21]See Strassmann, op. cit., pp. 212-13.

In the spring of 1968 I read a paper on "Used Machinery and Industrial Development in Less Developed Countries" at a meeting in Chihuahua City, Mexico, which was sponsored by the government of the state of Chihuahua. In the formal discussion period which followed, one Mexican businessman was particularly pronounced in his comments on the difficulties of producing with UM. Later in an informal discussion I learned that he was currently employing UM in his forestry products firm, had done so for years and intended to continue to do so. His reason was unassailable; he could "make more money by doing so."

[22]W. Arthur Lewis, "A Review of Economic Development," AER, Supplement (May, 1965), p. 14.

that a reorientation of the weight that employment absorption should be given is already taking place.[23]

The growing urgency to use more labor productively can, under proper conditions, encourage policy changes favoring the employment of UM. Among the more obvious would be lifting embargoes on UM, adjusting tariff provisions and/or their implementation so UM is not placed at a disadvantage to new equipment, use of shadow pricing on public projects and encouraging public agencies to examine routinely the UM market when purchasing equipment from abroad. The elimination of tariffs on spare parts and, above all, elimination of red tape in getting them through customs are worthy goals in their own right. A movement toward such a policy should gain momentum as the connection with employment absorption is made clear. Finally, there is a mounting recognition that a variety of domestic policies in LDC's unwittingly encourage capital-intensive means of production.[24]

An alteration of taxes, subsidies, lending agency policies and labor laws to encourage labor absorption would favor UM.

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[23]". . . successful development is best defined in employment (or employment and output) terms rather than in terms of output alone." Lloyd Reynolds, "Economic Development with Surplus Labour: Some Complications," Center Paper No. 133 (New Haven: Yale University Economic Growth Center, 1969), p. 90.

[24]See, for example, Strassmann, op. cit. Chapter 4 "Labor-Capital Substitution: Relative Scarcity Signals and their Interpretation," pp. 112-48; OAS, "The Unemployment Problem in Latin America," op. cit., p. 15; and Wendell Gordon, "Capitalism and Technological Adaptation in Latin America," Journal of Economic Issues (March, 1969), pp. 66-86.

Thus far, however, this section on policy has merely pointed out that (a) there are several lines of investigation being pursued that will eventually favor UM and (b) severe pressures are being exerted on the body politic to come up with some solution to the growing pool of surplus labor in LDC's. Attention will now be directed at some concrete actions that would facilitate and reinforce these forces that are already in motion.

Reducing Political Bias: Propagandizing UM

Most literature on UM that might find its way to LDC's is aimed at technicians and technical advisors rather than the broad spectrum of those influencing policy. This information certainly has its place, but literature is sorely needed that can reach the power elite and get across the idea that (a) UM is not a part of a plot to perpetuate technological backwardness and (b) UM, when properly selected and used, can contribute to economic welfare.

Skillful writers can counterbalance the plot syndrome by driving home such points as:

1. Almost all machine shops in the United States use some second-hand equipment.

2. Almost all of the UM sold in the United States stays there, and of the small fraction exported, one half goes to other developed areas.

3. Mexico, a country with a fine "track record" regarding industrialization and growth over the past thirty-five years, is one of the largest importers of UM.

4. Rather than attempting to force or beguile LDC's into accepting UM, development lending agencies are _themselves_ reluctant to finance it.

Also helpful would be popularization of the operating histories of well known firms that have used second-hand equipment. The competitiveness, foreign exchange impact and employment absorption of such companies as Altos Hornos (iron and steel) of Mexico and Industrias Kaiser Argentina (automobiles) of Argentina are attractive targets for such an exposition.

Reducing Political Bias: Assimilating UM into the Technical Literature

Technicians and technical advisors, as Galbraith has reminded us, are not totally ineffective in moving the center of gravity of policy. The more complex a problem becomes, in fact, the greater their influence is likely to become. There is, then an important indirect route to policy influence. How has UM fared in the literature aimed at the professional? To my knowledge there is only one article in a leading economics journal which is entirely devoted to the topic.[25]

The only studies by major national or international development agencies that are generally available are the UN's _Report of Group of Experts_ and the Netherlands Economic Institute's _Second-Hand Machines_.[26] Both are superficial. So there is a dearth of such literature on UM. _Specifically_, what is needed?

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[25]A. K. Sen, "On the Usefulness of Used Machinery," _Review of Economics and Statistics_, _op. cit_.

[26]UN, _op. cit._, and NEI, _op. cit_.

1. The four categories of United States exports of used industrial equipment that appear in the statistics are pathetically inadequate. The major exporters of industrial equipment should instigate a separate reporting of UM exports by types of machinery and countries of destination or, at the very least, gather the data and make it available to scholars on a cost basis. Much meaningful investigation can still be done with qualitative analysis and micro-studies, but one entire dimension to useful research rests on adequate availability of statistical data on the LDC-UM market.

2. The literature could use good, descriptive research on production with UM in the tradition of the ECLA study on choice of techniques in the cotton textile industry which has been so prominently featured in this thesis.

3. The marvelously detailed statistics on the quality and quantity of inputs and their costs that are emanating from UNIDO[27] and OECD[28] should include some comparative costs on UM commonly employed in LDC's.

Desirable Interferences in the Market

The basic underpinnings of the LDC-UM market are exceptionally strong. It has to contend with a variety of

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[27] UNIDO, Profiles of Manufacturing Establishments, Vols. I-II (New York: UN, 1967-68) and Estimation of Managerial and Technical Personnel Requirements in Selected Industries (New York: UN, 1968).

[28] Manual of Industrial Project Analysis in Developing Countries, Annex to Volume I, "Industrial Profiles" (Paris: OECD, 1968).

attitudinal and market biases, a marginal status, relative neglect in the literature and occasional abuses of the "horror story" variety, yet businessmen in LDC's continue to use it. Still, there are some relatively inexpensive measures that could be undertaken, most involving subsidization of access to information, which would increase efficiency in the LDC-UM market. Five such measures are presented below:

1. In Chapter VI we saw that there is an enormous body of information on UM already available from trade sources. A "bargain basement" improvement in efficiency can be gained by merely plugging LDC's into the existing information network through subscriptions to such publications as Used Equipment Directory.[29] Libraries of branch offices of wealthy countries' development agencies, LDCs' development corporations, appropriate technical advisory services and central offices of industrial parks should consider such publications as standard acquisitions. The cost, when spread over several users or an entire community of firms, would be nominal as would the cost of subsidization and free distribution to appropriate libraries and offices.

2. Between the types of UM with a large enough sales volume to generate a dependable market price and the types for which inspection and appraisal should be considered a

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[29] Especially useful because of its card locator service. The subscriber merely fills out a card stating the specific equipment desired and UED sends reproductions of the descriptions of suitable equipment that listing dealers have on hand.

necessity lies a portion of the market that is amenable to improvement. The volume of sales may be substantial, but not quite large enough, or perhaps the volume for the general type of equipment is large enough, but differentiation of vintages, makes, conditions and slight structural variations preclude its inclusion in the high volume, dependable price market.

For these types of equipment the subsidization of the development of a classification scheme would pay generous dividends in efficiency. Without such guidelines expenses connected with inspection and appraisal must be borne, or worse, the eventual expense from failing to have it inspected and appraised will be incurred. Neither of these costs is small. A good classification system developed by government, trade associations, or both would extend the margin of that portion of UM sales for which the market performs adequately.

3. A central, global information and referral service is needed. The potential instrument is already at hand in the form of the Industrial Inquiry Service of the United Nations Industrial Development Organization. Recently, however, UNIDO has not been giving much attention to UM.[30] Furthermore, since its initiation of the service, its facilities have been strained by a phenomenal increase in the number of

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[30]"I am sorry to inform you that the interest expressed by United Nations member-nations has not warranted the continuation of our project on used equipment in developing areas and that, therefore, it is not included in our current work programme." Letter, I. D. Radović, Industrial Development Officer, Technological Division, UNIDO, May 16, 1967.

inquiries. Nevertheless, resources should be found for accomplishing at least two UM programs. First, inquiries about UM should be considered an integral and legitimate part of its service and second, UNIDO should operate as an information clearing house on the availability of and need for complete second-hand plants.[31]

4. Most UM dealers do not have the ability or desire to furnish detailed technical information on synchronizing a major piece of machinery into an existing plant. As we saw in the case study of Papelera Chihuahua, the detailed pre-acquisition planning and making adjustments to fit it into the production process absorbed a great deal of management's time and energy. In that instance it happens that the top manager is an engineer. What of firms in LDC's without direct access to high level professional knowledge? The need for outside advice is even more pressing.

Undoubtedly some of the projects that have been suggested above would help, i.e., a UM equivalent of <u>Profiles of Manufacturing Establishments in Developing Countries</u>, an inquiry answering service, and a referral service. While

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[31]This would revive one of the functions of the Industrial Coordination Board which has ". . . practically stopped its activities related to the sale of used machinery to the developing countries." Letter, Hans Hangenskiöld, Director, Industrial Coordination Board, Stockholm, Sweden, May 11, 1967. The ICB had attempted a more heroic role than the one envisioned above. It actively sought out plants, participated in its financing and arranged for technical assistance. Given a softening of political bias, a growth in the UM market in general and the growth in demand specifically for used automated equipment, such services may be put to good use in the future.

these would help, the problem would still be bothersome and it can be identified by asking ourselves "to whom would such a referral service refer?" The most commonly used source of detailed advice on setting up and integrating equipment into the plant is the seller of new equipment. Strassmann has suggested that governments ". . . can hire sellers of new machinery as consultants in sales and servicing, thus allowing these to contribute without much risk to their reputation."[32]

5. Some administrative policies guarding against the most flagrant failures of the LDC-UM transfer are desirable. Trade associations, government agencies of exporting countries or a combined private-public group could maintain a roster of dealers in good standing.[33] The purpose would be to reduce the incidence of delivery of the wrong equipment or equipment that is totally unusable.

If the importing country interferes at all in the LDC-UM market, it should stress the following requirements:

a. Evidence that the purchaser has taken measures to ascertain the suitability of the equipment to his precisely specified needs.

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[32] Op. cit., p. 217.

[33] Such a suggestion has come from within the ranks of UM dealers. "Mr. O'Brien suggests a formal license plan to assure that transactions were through reputable dealers. This would prevent unscrupulous dealers from exporting inferior equipment as in the past. Licensing would be regulated by the Commerce Department, and could be removed for cause." "World License Plan Aid Foreign Sales?" Iron Age (November 1, 1962), p. 106. Mr. O'Brien, Jr., was the President of O'Brien Machinery Co. of Philadelphia.

b. The general condition of the equipment is represented fairly by the supplier.

c. Assurance that an adequate supply of spare parts are stocked or will be readily available.

In short, the importing countries could model their actions along the lines of AID's export requirements. This is far more desirable than eliminating the problem by embargoing UM completely.[34]

Specific Gaps in Our Knowledge: Suggestions for Further Research

1. Current trends in research funding relegate descriptive research to a nonprestigious level. This is hardly justified when proper analysis awaits the emergence of careful and detailed descriptive studies. No one appreciates better than I the difficulty of obtaining cost information from entrepreneurs in LDC's; they tend to be "tight lipped" about business practices of any kind. Nevertheless, the stature and expertise of international research and development organizations have enabled them to produce some excellent comparative cost studies involving new equipment, and the same presumably can be done for UM. Case studies should not only be aimed at comparing static efficiency, but should also

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[34]As I have hinted before, if it were not for political bias and political recriminations against UM the LDC-UM market would thrive notwithstanding the occasional abuses. Experienced businessmen in LDC's take measures to reduce risks; those who fail to do so will not be businessmen for long. The ideal program, then, is one that is aimed <u>solely</u> at the prevention of <u>flagrant</u> failures, not because <u>their</u> economic cost is so burdensome, but because they feed the fires of anti-UM sentiment.

examine the foreign exchange impact, labor absorption, effect on learning and the reinvestment rates.

2. Good use could be made of macro-studies attempting to project the amounts and varieties of UM that will become available in developed areas and estimating the volume that could be absorbed by LDC's assuming various rates of economic growth, technological change, growth of market sizes, rates of improvement in skill levels, and changes in factor prices.

3. The range and versatility of retrofit equipment is staggering. A technical manual tailored specifically to LDC's (i.e., concentrating on those devices more inexpensive, durable, and requiring lower levels of skills to mount and operate) establishing guidelines for retrofitting equipment would be of immediate practical value. I am assuming that UNIDO is now in the process of developing similar manuals on (1) maintenance and (2) spare parts design and repair in connection with their ongoing programs mentioned several times previously in this thesis.

4. Mexico purchases more UM from the United States than any other LDC. To what extent does the explanation lie in (a) the economics of transportation, (b) a higher level of labor skills and managerial abilities, (c) better access to information (including a possible demonstration effect), (d) unusual tariff provisions or the large United States direct investment? If we knew the answer, light would be shed on the returns to increased information in more remote areas, we could guess at the consequences of raising skill levels in countries less advanced than Mexico and suggest alternative trade regulations to other LDC's.

5. A study related to number 4 above would be of interest. While no researcher has turned up a dealer in used manufacturing equipment that specializes in transferring UM to LDC's, there are firms dealing in construction and mining equipment that do a significant share of their business with Mexico. The question arises: Do all of the good things claimed for this arrangement really happen? Do communications include specific needs? Are lasting relations between purchaser and buyer maintained? Are the needs for inspection and appraisal minimized, and does the selling firm offer a package deal including the physical transfer, rehabilitation, financing and servicing? Only a comparative study of the operation of these firms vis-à-vis the usual UM dealer (usual in that he depends on LDC sales to a small extent) will provide the answer.

6. Can UM contribute to the domestic production of new equipment with characteristics of earlier vintage technology? We saw in Chapter V that it has occasionally served as a model, but usually the research and production takes place in developed countries. As a matter of course, every research institute concerned with choice of technique and developing new technologies for LDC's should routinely include investigation of UM as a part of their program. This is especially true for research institutes located in LDC's themselves.

7. A pilot project employing UM in a seasonal agro-industry in rural communities would, if successful, open

a whole new dimension for UM in LDC's.

Limitations to the Study

Efficiency and Growth

Throughout the study I have assumed that the complementary effects of static efficiency and growth are more important than any trade-offs between the two goals. If (1) LDCs' growth rates can be significantly improved by moving to a more capital-intensive method at the expense of current output, (2) this method of achieving a higher rate of growth is more efficient than government taxation and reinvestment and (3) a high priority is accorded growth, the case for increasing the transfer of UM to LDC's would be weakened.

Infrastructure and Rate of Urbanization

Differences in costs for services provided by infrastructure have been assumed to be independent of the labor-capital ratio of directly productive activity. Aside from an analysis of the suitability of UM for use in seasonal industries in rural community development programs, no connection has been made between rate of urbanization and choice of technique.

Since a large proportion of LDCs' capital stock and annual investment is in infrastructure, any cost differentials associated with various factor intensities and/or technological vintages would be an important consideration.

Mexico

Every attempt has been made to draw conclusions that apply to LDC's in general. It is true, however, that all of my personal observations of UM in LDC's have been confined to Mexico and most of my relevant interviews have been with Mexicans. My conclusions may unconsciously favor what will work in a Mexican setting rather than LDC's as a whole.

Lack of Data

The results of this thesis depend mainly on qualitative analysis and on gleaning examples and opinions from literature, interviews and correspondence. The estimate that UM comprises approximately 10 per cent of LDCs' investment in industrial equipment was made by extrapolating from the scant data available and then somewhat arbitrarily cutting that figure in half to remedy several biases inherent in the extrapolation. Errors are to be expected and it is only hoped that the estimate is "in the ball park."

Conclusion

UM already makes a marginal contribution to the economic development of LDC's, but its role should be substantially increased. Achieving this goal need not be costly since (1) it can be done with little or no increase in the long-run price of UM, (2) the crush of mounting surplus labor and the pinch of foreign exchange shortages will encourage a policy more favorable to UM and (3) the bottlenecks of maintenance abilities and spare parts availability are becoming less serious.

Furthermore, there is no need to replace the LDC-UM transfer mechanism, nor must it undergo sweeping reorganization. Although beset with numerous frictions, the basic underpinnings of the UM market are solid. Improvement in the availability and use of knowledge and filtering out the most egregious abuses of the LDC-UM market should be the dual focal points of policy.

While a methodical policy of eschewing UM may yield some psychological satisfaction, infavoidance carries a high price tag, a price which poor countries can ill afford to pay. Continuing to do so seems especially lamentable when simple and inexpensive changes in policy could accomplish a sizeable move toward the optimal employment of UM.

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