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The Evidence on Appropriate Factor Proportions for Manufacturing in Less Developed Countries: A Survey*

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The question of appropriate factor proportions for less developed countries (LDCs) has emerged as an important area for research and for policy in the 1970s. High and rising rates of urban unemployment, the slow growth of employment in manufacturing, and high and rising capital-labor ratios are occurring simultaneously in many LDCs. It is frequently argued that the first two phenomena are caused by the last; that there are no efficient alternatives to the modern capital-intensive technology of the rich industrial nations; and that drastic, nonmarket solutions offer the only hope for the LDCs' employment and unemployment problems.

Though many economists believe that efficient alternatives do exist, there are still some skeptics within the profession (or at least some who believe that the alternatives are quite limited) and many noneconomist policymakers who believe that fixed proportions (i.e., current Western technology) describe the only efficient technology available for LDCs. Over the past 15 years there has been a significant accumulation of evidence bearing on this question, but there has been no systematic gathering and analysis of this evidence.¹ That will be the major task of this paper.

* An earlier draft of this paper was written for USAID under contract no. AID/CM/ta-147-526. I would like to thank Howard Pack and two anonymous referees for comments on earlier drafts. A reasonably complete bibliography pertaining to the evidence and issues discussed in this paper is available on request from the author.

¹ There have been a number of other surveys or summaries that deal explicitly with or touch on the problems of appropriate technology for LDCs, but none have focused primarily on the evidence. See David Turnham, *The Employment in Less Developed Countries* (Paris: OECD, 1971); Ronald G. Ridker, "Employment and Unemployment in Near East and South Asian Countries: A Review of Evidence and Issues," in *Employment and Unemployment Problems of the*

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The remainder of this paper will be organized as follows: Section I will briefly summarize the a priori arguments concerning the absence of choice in selecting efficient factor proportions and then will offer a survey of the available evidence. Section II briefly examines the evidence concerning the reasons that currently feasible appropriate factor proportions are not chosen. Section III explores the possibilities of developing new products and processes in LDCs to widen the range of technological choice and to increase the productivity of all resources over time. And Section IV will offer some conclusions from this paper.

A few points should be made at the beginning. First, by "appropriate" we mean factor proportions that are roughly in line with the overall factor availabilities in an economy. The poorer the LDC, the less capital (physical and human) relative to labor we expect to find and, hence, the more labor-intensive the "appropriate" factor proportions would be.² Appropriateness applies not only to factor proportions within an industry but also to the range of industries for LDCs; if an industry is unavoidably capital-intensive but imports are a viable alternative to domestic problems, the appropriateness of that industry for a LDC could certainly be questioned.

Second, there may not be a causal connection between high rates of urban unemployment and high capital-labor ratios. If the Harris-Todaro model is a correct description of LDC reality,³ it is the large

Near East and South Asia, ed. Ronald G. Ridker and Harold Lubell (Delhi: Vikas Publishing House, 1971), pp. 6–58; Sarah Jackson, *Economically Appropriate Technologies for Developing Countries: A Survey* (Washington, D.C.: Overseas Development Council, 1972); David Morawetz, "Employment Implications of Industrialization in Developing Countries: A Survey," *Economic Journal* 84 (September 1974): 491–542; Shankar N. Acharya, "Fiscal/Financial Intervention, Factor Prices, and Factor Proportions: A Review of Issues," Bank Staff Working Paper no. 183 (Washington, D.C.: IBRD, 1974); Edgar O. Edwards, "Employment in Developing Nations," in *Employment in Developing Nations*, ed. Edgar O. Edwards (New York: Columbia University Press, 1974), pp. 1–46; Henry J. Bruton, "Economic Development and Labor Use: A Review," *World Development* 1 (December 1973): 1–22; Larry E. Westphal, "Research on Appropriate Technology," in *Technology, Employment, and Development*, ed. Lawrence J. White (Manila: Committee for Asian Manpower Studies, 1974), pp. 7–29; Martin Brown and Mikoto Usei, "Review of Discussions," in OECD, *Choice and Adaptation of Technology in Developing Countries* (Paris: OECD, 1974), pp. 13–94; OECD, *Low Cost Technology: An Inquiry into Outstanding Policy Issues* (Paris: OECD, 1975); William R. Cline, "Distribution and Development: A Survey of Literature," *Journal of Development Economics* 1 (February 1975): 359–400; and A. S. Bhalla, "The Concept and Measurement of Labor Intensity" and "Lessons from Case Studies," in *Technology and Employment in Industry*, ed. A. S. Bhalla (Geneva: ILO, 1975), pp. 11–35, 309–24.

² Some authors have also included suitability for small-scale production, compatibility with other LDC cultures, and other desirable properties of technologies as part of "appropriate." For an example and critique, respectively, of this wider use, see Keith Marsden, "Progressive Technologies for Developing Countries," *International Labour Review* 103 (May 1971): 475–502; and Westphal.

³ See Michael P. Todaro, "A Model of Labor Migration and Urban Unemployment in Less Developed Countries," *American Economic Review* 59 (March

real-wage differentials between the urban modern sector and rural areas that are the major causes of much current LDC urban unemployment. To the extent that the artificially high urban wages also discourage the use of labor-intensive processes (see Sec. II), then urban unemployment and high capital-labor ratios are both parallel consequences of the high wages, but neither is the direct cause of the other.

Finally, in a normal, well-functioning economy we expect manufacturing employment to grow less rapidly than manufacturing output because of capital deepening and technological change.⁴ Thus the observation of a differential in growth rates should not by itself be a cause for concern. But the very large differentials that are observed⁵—much larger than could be accounted for by human-capital deepening and exogenous technological change—combined with the introduction of capital-intensive manufacturing facilities with capital-labor ratios far above the existing averages in the LDCs⁶ (at the same time that high urban unemployment rates indicate that physical-capital deepening ought not to be occurring) do indicate that the manufacturing sectors in many LDCs are not functioning properly.

But are there efficient alternatives to the high capital-labor ratios? It is to that evidence that we now turn.

I. Alternative Factor Proportions: The Evidence

The belief that capital-intensive manufacturing processes similar to those found in developed countries are the correct ones for LDCs was quite strong in the 1950s and 1960s, especially among engineers and even some economists. The major argument in favor of them was that they

1969): 138–48; John R. Harris and Michael P. Todaro, “Migration, Unemployment, and Development: A Two-Sector Analysis,” *American Economic Review* 70 (March 1970): 126–42; Michael P. Todaro, “Income Expectation, Rural-Urban Migration, and Employment in Africa,” *International Labour Review* 104 (November 1971): 387–413. See also E. M. Godfrey, “Economic Variables and Rural-Urban Migration: Some Thoughts on the Todaro Hypothesis,” *Journal of Development Studies* 10 (October 1973): 66–78; R. A. Berry, “Factor Proportions and Urban Employment in Developing Countries,” *International Labour Review* 109 (March 1974): 217–33; and Gary S. Fields, “Rural-Urban Migration, Urban Unemployment and Underemployment, and Job-Search Activity in LDCs,” *Journal of Development Economics* 2 (June 1975): 165–87. This hypothesis has been given powerful support by the finding that the rate of change of LDC urban unemployment is negatively related to LDC growth rates and is *positively related to the change in the ratio of urban incomes to economy-wide incomes* (see H. A. Turner and D. A. S. Jackson, “On the Determination of the General Wage Level: A World Analysis, or ‘Unlimited Labour Forever,’” *Economic Journal* 80 [December 1970]: 827–49).

⁴ Only if technological change were in a strong labor-using direction would employment be able to keep pace with output.

⁵ See, e.g., the data in Morawetz (n. 1 above).

⁶ See, e.g., the essays by David Morawetz, C. Peter Timmer, and Louis T. Wells, in *The Choice of Technology in Developing Countries* by C. Peter Timmer et al. (Cambridge, Mass.: Harvard University Press, 1975).

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were simply more efficient than more labor-intensive alternatives; the latter, it was claimed, would always use more labor *and more capital* per unit of output than would the process with the high capital-labor ratio. Thus, though alternatives might exist in a technical sense, they would always be found to be inferior.⁷ This could also be characterized as a belief in fixed proportions (as opposed to factor substitutability), since the efficient factor combination is fixed at the proportions found in developed countries.

The identification of efficiency with “productivity” (i.e., labor productivity) by many international study groups and productivity missions in the 1950s and 1960s helped contribute to this view.⁸ Though low labor productivity could be due to pure inefficiency (e.g., bad managerial supervision, bad organization of work tasks, etc.), it could also be due to the *efficient* combination of labor with low levels of capital in poor countries. The confusion of labor productivity with efficiency meant that high capital-labor ratios would be associated with efficiency.

Another strand of argument has claimed that efficient alternatives might exist for some processes but that the alternatives are limited, and hence in practical terms most LDCs are faced with little or no alternatives to high capital-labor ratios for most manufacturing processes.⁹ Or it is argued that high levels of mechanization are necessary to ensure high levels of quality (e.g., in machined products) or can substitute for managerial skills in organizing and supervising workers, skills which are even in shorter supply in most LDCs than is capital.¹⁰

⁷ Statements to this effect can be found in the comments of Nicholas Kaldor, as reported by Ronald Robinson, “The Argument of the Conference,” in *Industrialization in Developing Countries*, ed. Ronald Robinson (Cambridge: Cambridge University, 1965), pp. 5–53. See also Samir Amin, “Levels of Remuneration, Factor Proportions, and Income Differentials with Special Reference to Developing Countries,” in *Wage Policy Issues in Economic Development*, ed. Anthony D. Smith (London: Macmillan Co., 1969), pp. 269–93; Clarence L. Barber, “The Capital-Labor Ratio in Under-developed Areas,” *Philippine Economic Journal* 8, no. 1 (1969): 85–89; P. D. Ady, “Private Overseas Investment and the Developing Countries,” in *Private Foreign Investment and the Developing World*, ed. Peter Ady (New York: Praeger Publishers, 1971); and UNECLA, *Development Problems in Latin America* (Austin: University of Texas Press, 1970).

⁸ See, e.g., the ILO report cited in Peter Kilby, “Organization and Productivity in Backward Economies,” *Quarterly Journal of Economics* 76 (May 1962): 303–10; and K. Adusei-Poku and Z. Fiejka, “Fiscal Policy Aspects of Technological Changes in the Industrial Sector and Effects on Employment in Developing Countries,” in ILO, *Fiscal Measures for Employment Promotion in Developing Countries* (Geneva: ILO, 1972), pp. 295–312.

⁹ See Frances Stewart, “Choice of Technique in Developing Countries,” *Journal of Development Studies* 9 (October 1972): 99–121, and “Technology and Employment in LDCs,” in Edwards, *Employment in Developing Nations* (n. 1 above), pp. 82–132.

¹⁰ See Jack Baranson, *Industrial Technologies for Developing Economies* (New York: Praeger Publishers, 1969), chaps. 2 and 3, and “Bridging the Technological Gaps between Rich and Poor Countries,” in *The Gap between Rich and*

A completely different line of argument favoring capital-intensive technologies has rested on alleged saving and reinvestment rates by different economic groups. As argued by Galenson and Leibenstein, capital-intensive technologies would mean high returns to capital, and capital owners have higher saving and reinvestment rates than do workers.¹¹ Hence, even though there might be efficient labor-intensive methods available, capital-intensive methods should be chosen because reinvestment would be greater and the pace of industrialization would proceed faster. This argument clearly hinges on empirical evidence concerning saving rates by different groups, a topic to which we shall return later in this section.¹²

We now turn to the evidence. In one sense, it is easy to provide evidence that developed country capital-labor ratios are not the only alternatives available. A glance at any LDC industrial census which contains capital data will reveal capital-labor ratios that are usually a third of those in the United States.¹³ This is in spite of the fact that LDC rates of capacity utilization are frequently below that found in the United States, thus raising the LDC capital-labor ratios above what they would be with better capacity utilization (and hence more labor employed).¹⁴ But a believer in the superior efficiency of capital-intensive

Poor Nations, ed. Gustav Ranis (London: Macmillan Co., 1972), pp. 299–311; W. Paul Strassmann, *Technological Change and Economic Development* (Ithaca, N.Y.: Cornell University Press, 1968), pp. 92–102, 155–57; and Albert O. Hirschman, *The Strategy of Economic Development* (New Haven, Conn.: Yale University Press, 1958), chap. 8.

¹¹ See Walter Galenson and Harvey Leibenstein, "Investment Criteria, Productivity, and Growth," *Quarterly Journal of Economics* 69 (August 1955): 343–70.

¹² The argument also requires that the elasticity of substitution be greater than one (contrary to what many of the other proponents of capital-intensive methods believe) or that completely new capital-intensive technologies be developed.

¹³ See, for Chile, R. Luders and N. Cabero, "Employment and Technology in Industry: The Chilean Case," in ILO, *Fiscal Measures for Employment Promotion in Developing Countries*, pp. 313–36; for Kenya, ILO, *Employment, Incomes, and Equality: A Strategy for Increasing Productive Employment in Kenya* (Geneva: ILO, 1972), pp. 446–47; and for Mexico, Strassmann, pp. 316–17. Occasionally, authors have been able to find cases in which LDC capital-labor ratios are higher than developed-country figures (see Azizur Rahman Khan, "Capital Intensity and the Efficiency of Factor Use," *Pakistan Development Review* 10 [Summer 1970]: 232–63, and "Some Problems of Choice of Techniques in a Mixed Economy: The Case of Pakistan," in *Economic Development in South Asia*, ed. E. A. G. Robinson and Michael Kidson [London: Macmillan Co., 1970], pp. 199–212; Romeo M. Bautista, "Capital Coefficients in Philippine Manufacturing: An Analysis," *Philippine Economic Journal* 5, no. 2 [1966]: 205–27; and Gerard K. Boon, "Factor Intensities in Mexico with Special References to Manufacturing," in *Towards Balanced International Growth*, ed. H. C. Bos [Amsterdam: North-Holland Publishing Co., 1969], pp. 201–18).

¹⁴ For more discussion of capacity utilization rates and their causes, see Gordon C. Winston, "Capital Utilization in Economic Development," *Economic Journal* 81 (March 1971): 36–60, and "The Theory of Capital Utilization and

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methods would probably not be convinced by this kind of evidence. He or she might well argue that the LDC methods are inefficient (old, antiquated, improperly conceived) and/or that the overmanning of otherwise efficient capital equipment is occurring because of employment pressures in LDCs; protectionist policies in LDCs buffer these inefficient production units from more efficient competition from internal or external sources. Or a believer might argue that the LDC methods are efficient only for the small size of the LDC markets and that larger volumes could be produced more efficiently with more capital-intensive methods. (This scale argument is one to which we shall return below.)

Accordingly, a more systematic investigation than just a casual perusal of LDC industrial censuses is needed. We shall examine a number of different kinds of evidence.

Econometric Investigations of Factor Substitution

A large number of articles use LDC data, usually from industrial censuses, to try to measure the degree of substitutability between capital and labor. All of the efforts involve measurements of the elasticity of substitution in a CES production function involving capital and labor. Since the CES production function is nonlinear and cannot be estimated through ordinary least-squares estimation techniques and since data on capital is frequently not available or not considered reliable, an indirect method is used. If the logarithm of output (or, usually, value added) per worker is regressed against the logarithm of the wage, the coefficient on the latter variable is an estimate of the elasticity of substitution. Most studies use this form. (Some of the studies use a direct demand for labor formulation, in which labor is regressed against the wage, output, and other variables.) A few regress the output-capital ratio against the return to capital (both in logarithms), or they regress the capital-labor ratio against the wage alone or against the ratio of the wage to the return to capital (again in logarithms) to provide alternative estimates. These estimates have been made for the whole of manufacturing in single countries and for individual sectors within manufacturing, for both time series and cross sections, and for cross sections for sectors across different countries. As of this writing, these studies have been done for at least 25 LDCs.¹⁵

Idleness," *Journal of Economic Literature* 12 (December 1974): 1301–20; Ian Little, Tibor Scitovsky, and Maurice Scott, *Industry and Trade in Some Developing Countries* (London: Oxford University Press, 1970), pp. 93–99; A. R. Kemel and Alauddin Talat, "Capacity Utilization in Manufacturing Industries of Pakistan," *Pakistan Development Review* 13 (Summer 1974): 231–44; and William F. Steel, "Import Substitution and Excess Capacity in Ghana," *Oxford Economic Papers* 24 (July 1972): 212–40.

¹⁵ These countries include Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Egypt, Ghana, Greece, India, Iran, Israel, Jamaica, Kenya, Korea, Malaysia, Mexico, Nigeria, Pakistan, Panama, Peru, Philippines, Puerto Rico, Southern Rhodesia, and Turkey.

The estimates of the elasticity of substitution are, with only a few exceptions, positive, indicating (if one accepts the methodology as valid) that efficient factor substitutability is possible and that the fixed-proportions view of the world is incorrect.¹⁶ The estimates tend to clump between 0.5 and 1.2, but some studies find values appreciably above and below these values. Cross-section studies tend to find higher elasticities than do time-series studies.

The problems of these studies—in concepts, data, and econometric techniques—have been reviewed by a number of authors.¹⁷ The data are bad, the CES form may not be the correct one, the time-series studies may not include lags properly, the profit-maximization assumption may not be a good one, the assumption of competitive markets is surely not true, all firms may not be using the same technology, the cross-country studies may not use the correct exchange rates, the cross-section observations (especially across countries) may not be using comparable industries, the level of capacity utilization is usually not held constant, all labor and all capital are assumed to be uniform and to be the only factors of production. These are only some of the problems.¹⁸ It is easy to be skeptical of the results. Pack, for example, has argued that the time-series regressions may just be showing that value added per worker increases as capacity utilization increases and as simple technological improvements occur over time, and that wages increase as workers succeed in capturing some of that increase in productivity. Thus, rather than showing a causality between substitution away from labor and wages, the regressions may be showing a reverse causality between wages and increasing productivity.¹⁹ Cross-section regressions may be capturing a similar effect, as could the regressions using capital-

¹⁶ There is the problem of the possibility of selectivity of reporting: Only the favorable results may get published in journals.

¹⁷ See Richard R. Nelson, "A Diffusion Model of International Productivity Differences in Manufacturing Industry," *American Economic Review* 58 (December 1968): 1219–48; C. St. J. O'Herlihy, "Capital/Labour Substitution and the Developing Countries: A Problem of Measurement," *Bulletin of the Oxford University Institute of Economics and Statistics* 34 (August 1972): 269–80; Acharya (n. 1 above); Morawetz (n. 2 above); J. Gaude, "Capital-Labour Substitution Possibilities: A Review of Empirical Evidence," in Bhalla, *Technology and Employment in Industry* (n. 1 above), pp. 35–58; David Morawetz, "Elasticities of Substitution in Industry: What Do We Learn from Econometric Estimates?" *World Development* 4 (January 1976): 11–15.

¹⁸ There are also econometric problems of multicollinearity and simultaneous-equations bias.

¹⁹ See Howard Pack, "Employment and Productivity in Kenyan Manufacturing," *Eastern Africa Economic Review* 4 (December 1972): 29–52. But other authors have explicitly tried to test for this and reject it as an explanation (see John R. Harris and Michael P. Todaro, "Wages, Industrial Employment, and Labour Productivity: The Kenyan Experience," *Eastern Africa Economic Review* 1 [June 1969]: 29–46; and Gene M. Tidrick, "Wages, Output, and the Employment Lag in Jamaica," Research Memorandum no. 40 [Center for Development Economics, Williams College, 1970]).

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labor ratios. And Morawetz has shown that there is little consistency among the cross-section studies in their rankings of common industries by estimated elasticity of substitution.²⁰

Leaving aside, then, the data and econometric problems which are always present to a greater or lesser degree in any empirical work, one's evaluation of the worth of these regressions does hinge crucially on how one views the causality between wages and capital-labor ratios. If one already believes that capital-labor ratios are efficiently flexible and that entrepreneurs do respond to factor price incentives, then the results of the regressions provide additional support for this view; making labor more expensive and capital cheaper tends to cause factor substitution toward greater capital intensity. On the other hand, if one believes that efficient factor proportions are more or less fixed (and that observed differences are largely due to random elements or to pressures for increased employment) and/or that wages respond to higher levels of productivity, then the regressions may not support the claim of substitutability. In my view, both effects are probably occurring, and the econometric evidence probably does give some support for the position that efficient labor-intensive alternatives for manufacturing exist. But this is probably more an act of faith than a hard conclusion from incontrovertible evidence. The believers in fixed proportions are unlikely to be convinced.

Engineering or Process-Analysis Studies

In these kinds of studies, researchers investigate individual manufacturing processes or individual products. The investigators usually use engineering or other technical information to determine the inputs necessary to produce a given volume of products (or to process a given volume of manufactured items). A principal part of the investigation is to see if there are alternative means of producing that same volume; that is, if more workers and fewer machines (or, usually, simpler and cheaper machines) can produce the same volume as fewer workers and more machines. This is, of course, the heart of the substitutability question.²¹

Published evidence exists for only a dozen products and processes,²² but an important result emerges consistently: factor substitutability is possible, and the differences in factor ratios can be quite substantial. A

²⁰ See Morawetz, "Elasticities of Substitution."

²¹ Some studies present alternatives but then simply look at comparisons of unit costs. If these costs incorporate inappropriate factor prices, the conclusions from the costs may not be trustworthy. But one can usually re-create the original factor proportions so as to examine the technologically efficient alternatives.

²² These include textiles, bicycles, paints, tires, sugar, cement blocks, metal cans, coir, grain milling, jute processing, metal machining, and woodworking. Recent abstracts indicate additional studies (see OECD, *Choice and Adaptation of Technology and Low Cost Technology* [n. 1 above]).

study by Timmer of rice milling and marketing systems found four efficient alternatives, of which the most capital-intensive required \$65,000 investment per worker and the most labor-intensive required only \$700 per worker.²³ An ECLA study of cotton textiles reported by the United Nations Industrial Development Organization (UNIDO) showed a choice of efficient techniques ranging from \$6,600 to \$21,500 investment per worker;²⁴ a later study by Pack argued that the lower limit is closer to \$1,100 per worker.²⁵ Further, Pack was able to relate the efficient factor combinations observed in operation to the wage rates and returns on capital also present and thus was able to calculate elasticities of substitution. Of six industries observed, all had positive elasticities of substitution, and five were above 1.0.

Of course, not all technically efficient factor combinations, even labor-intensive ones, would be economically efficient for LDCs. Just as a factor combination could be too capital-intensive, it could also be too labor-intensive. In fact, however, in virtually all cases, at realistic opportunity-cost wage and interest rates for LDCs, labor-intensive or intermediate alternatives are economically sensible. The LDCs do not appear to be limited to current developed country capital-intensive methods.

There are some limits to these studies and some unanswered questions, however. First, only two studies have investigated the relationship between economies of scale and optimal factor proportions; they find (for metal machining and for cement-block manufacture) that there are appreciable economies of scale and that capital-intensive methods are necessary to capture these economies.²⁶ Thus at low volumes there are efficient alternatives, and relative wage and interest costs should determine the proper technique. As volume increases, input levels grow more slowly so that unit costs fall (for any wage and interest rate), but this happens to a greater degree for capital-intensive processes. At very high volumes, the capital-intensive processes dominate so that at any wage or interest rate it makes economic sense to choose the capital-intensive process. The lower the wage, however, the higher the volume at which the switch from the labor-intensive to the capital-intensive processes should occur.

Why economies of scale should favor capital-intensive processes is unclear; this just seems to be a fact of technological nature for the par-

²³ C. Peter Timmer, "The Choice of Technique in Indonesia," in Timmer et al. (n. 6 above).

²⁴ UNIDO, *Textile Industry*, UNIDO Monographs on Industrial Development, no. 7 (UNIDO, 1969).

²⁵ Howard Pack, "The Employment-Output Trade-Off in LDCs: A Microeconomic Approach," *Oxford Economic Papers* 26 (November 1974): 388-404.

²⁶ See Gerard K. Boon, "Technological Choice in Metalworking, with Special Reference to Mexico," in Bhalla, *Technology and Employment in Industry* (n. 1 above), pp. 255-73; and Frances Stewart, "Manufacture of Cement Blocks in Kenya," *ibid.*, pp. 203-40.

ticular processes investigated. To what extent can this be generalized? Most of the investigators of product technology do not mention it, and this may well be a phenomenon restricted in significance to only some of the processes that go into manufacturing a product, like metal finishing, and flow processes involving liquids, pipes, and containers, like petroleum refining and chemical production. The importance of setting-up costs for a production run or of the surface area and volume relationship of containers dominates here.²⁷ For other manufacturing processes, scale effects seem likely to be much less important. (This appears especially true of the peripheral activities mentioned in the next section.) Clearly, though, much more needs to be known about the relationship between scale and factor substitutability.

For a product that does embody significant scale effects, LDCs face a dilemma.²⁸ The small-market LDC can achieve appropriate factor proportions but has high unit costs (but, it must be emphasized, the LDC would have yet higher unit costs if it switched to the capital-intensive method); the large-market LDC has lower unit costs but high capital intensity.²⁹ Only research leading to new technologies that would decrease the importance of scale effects or would have them apply equally to labor-intensive methods offers a way out of this dilemma.

A second open question in these studies is the problem of quality. Are capital-intensive processes necessary to ensure high quality? Stewart argues that this is the case for cement blocks.³⁰ This echoes the earlier arguments noted above that, particularly in metal-finishing processes, machines can substitute for skilled labor and foreman supervision in ensuring a high, uniform quality standard.³¹ Other process studies either claim that quality need not be affected by technique or neglect to mention the problem. Again, we need to know more in this area.

Finally, on this last point, the process studies do not tell us enough about the other inputs into the production process. A few studies do account for the differential efficiency in the utilization of raw materials

²⁷ The costs of containers and pipes tend to increase directly with surface area, which rises more slowly as dimensions increase than the volume enclosed (see Aubrey Silbertson, "Economies of Scale in Theory and Practice," *Economic Journal* 82 [suppl.; March 1972]: 369-91; and F. M. Scherer, *Industrial Market Structure and Economic Performance* [Chicago: Rand McNally & Co., 1970], chap. 4).

²⁸ This assumes that, despite the dilemma, it is still within the LDC's comparative advantage to produce the item rather than import it.

²⁹ And, of course, the small producer who expects volume to grow faces a yet crueller dilemma.

³⁰ Stewart, "Manufacture of Cement Blocks in Kenya."

³¹ See Baranson, *Industrial Technologies*, chaps. 2 and 3, "Bridging the Technological Gaps," and *Manufacturing Problems in India: The Cummins Diesel Experience* (Syracuse, N.Y.: Syracuse University Press, 1967); and Strassmann, pp. 93-102, 155-57.

by different techniques.³² But it is difficult to tell if this is a serious problem generally. Further, how valid is the argument that mechanization is an efficient substitute for management supervisory skills? Unfortunately, there is only one piece of quantitative evidence on this point. Clague has shown that the overall efficiency of Peruvian industries relative to that of comparable U.S. industries increased as capital intensity increased; machine-paced processes seem to offer less latitude for labor inefficiency.³³ The engineering and process studies have not thus far been able to quantify this, and so it must remain, with the exception of Clague's study, largely an open question. But Pack reminds us that high levels of mechanization will require skills necessary to repair the complex modern machinery, and these are usually as scarce in LDCs as the management skills that the machines are supposed to replace.³⁴ The repair skills to handle simpler machinery, however, usually are in greater supply. Pack argues that good management is also needed in order to recognize the possibilities for labor-capital substitution and to do the necessary innovations to adapt equipment rather than just accept completely the sales pitch of the traveling capital-goods salesman from the United States, Europe, or Japan.

In all, the engineering and process-analysis studies do provide powerful demonstrations of the feasibility of labor-intensive methods and are probably more convincing than the econometric studies in the previous section, but the difficult questions of scale, quality, and skill still remain.

Anecdotal Evidence

Under this category we group studies that report examples of labor-capital substitution but do not offer precisely quantified estimates of the frontier of efficient combinations in the way that the engineering studies do. These reports can nevertheless offer useful insights into the production processes.

The articles of Ranis and of Fei and Ranis have documented a number of ways in which labor could be efficiently substituted for capi-

³² See Howard Pack, "The Choice of Technique and Employment in the Textile Industry," in Bhalla, *Technology and Employment in Industry*, pp. 153-73; and C. B. Baron, "Sugar Processing Techniques in India," *ibid.*, pp. 175-202.

³³ See Christopher Clague, "The Determinants of Efficiency in Manufacturing Industries in an Underdeveloped Country," *Economic Development and Cultural Change* 18 (January 1970): 188-205. Diaz-Alejandro also tried to measure the effect, but his study focuses only on output per worker and thus ignores the effects of varying capital intensities (see Carlos F. Diaz-Alejandro, "Industrialization and Labor Productivity Differentials," *Review of Economics and Statistics* 47 [May 1965]: 207-14).

³⁴ See Pack, "Employment and Productivity," "The Choice of Technique and Employment in the Textile Industry," and "The Substitution of Labour for Capital in Kenyan Manufacturing" (*Economic Journal* 86 [March 1976]: 45-59).

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tal.³⁵ During Japan's early industrialization, when wages were comparatively low, machinery in textiles and other industries were run faster and more intensively (extra shifts); this meant more frequent halts for repair, but repair was a labor-intensive activity. The overall effect was greater labor intensity and greater efficiency in the use of all resources. Thus even in processes in which mechanization was necessary for quality reasons, double and triple shifts greatly decreased the overall capital-labor ratio. Greater use was made of older, used equipment from the West. Raw-material inputs were modified so that more labor-intensive processes could be used. Ranis reports that similar capital-stretching, labor-intensive techniques are currently being used in Korea and Taiwan in textiles, electronics, woodworking, and other industries. He further points out that, even for products in which there may be technical rigidity in some main production processes, there are always peripheral processes like materials handling and packaging which can be done efficiently with labor-intensive methods, so that the overall production of the product still has scope for labor-capital substitution.

Similarly, Pack reports examples of labor-capital substitution in consumer-goods manufacturing in Kenya.³⁶ He also indicates the possibility of factor substitution in peripheral activities but notes quality problems: human handling of fruit inputs into food manufacturing may lead to higher rates of spoilage or breakage. He also notes a scale-sensitive process: container filling. At high rates of volume, some container-filling processes would be worth automating, regardless of wage levels.

Many other anecdotal reports of LDC production processes that are more labor-intensive than those of developed countries are to be found in the economics literature.³⁷ But are the adaptations efficient? In

³⁵ Gustav Ranis, "Factor Proportions in Japanese Economic Development," *American Economic Review* 47 (September 1957): 594-607, "Output and Employment in the '70s: Conflict or Complements," in Ridker and Lubell (n. 1 above), pp. 59-76, "Industrial Sector Labor Absorption," *Economic Development and Cultural Change* 21 (April 1973): 387-408, "Some Observations on the Economic Framework for Optimum LDC Utilization of Technology," in White (n. 1 above), pp. 58-96, and "Employment and Labor Absorption in Development," in *Economic Growth in Developing Countries: Material and Human Resources*, ed. Yohanan Ramati (New York: Praeger Publishers, 1975), pp. 149-67; and John Fei and Gustav Ranis, "Less Developed Country Innovation Analysis and the Technology Gap," in Ranis, *The Gap between Rich and Poor Nations* (n. 10 above), pp. 312-35, and "A Model of Growth and Employment in the Open Dualistic Economy: The Cases of Korea and Taiwan," *Journal of Development Studies* 11 (January 1975): 32-63.

³⁶ Pack, "Employment and Productivity" and "The Substitution of Labour for Capital."

³⁷ See Strassmann (n. 10 above), chap. 6, and "The Causes of Technological Stagnation in Manufacturing during Early Industrialization," *Oxford Economic Papers* 19 (November 1967): 345-58; Donald W. Baerresen, *The Border Industrialization Program of Mexico* (Lexington, Mass.: D. C. Heath & Co., 1971); M. J. Sharpston, "Capital/Labour Substitution Possibilities: An Empirical Ap-

virtually all cases, the researchers report that the greater labor intensity has taken place in response to the lower volumes and/or the lower wage rates of the LDCs. This kind of response (as opposed to, say, a report that greater labor intensity seems to have occurred at random) does tend to support the notion that these are efficient adaptations. Also, Ranis's examples include firms that were facing substantial competition, either internally or in export markets; again, there is a presumption that this would tend to be forcing efficient adaptations. Finally, Ranis, Pack, the ILO, and Strassmann connect the adaptations with good, flexible management; again this argues for efficient adaptation.

The anecdotal evidence thus points in the same direction as the earlier evidence: Greater labor intensity is not only feasible but is in fact occurring in some LDCs. It does, however, seem to be closely tied to good management.

Big Firms versus Small Firms

It is widely acknowledged that small firms are more labor-intensive (lower capital-labor ratios) than large firms.³⁸ Many claim that the

proach," mimeographed (Washington, D.C.: IBRD, 1973); ILO, *Employment, Incomes, and Equality* (n. 13 above), pp. 141, 446–50; Louis T. Wells, "Economic Man and Engineering Man: Choice in a Low Wage Country," *Public Policy* 21 (Summer 1973): 319–42; G. K. Boon, "Technological Choice in Metalworking" (n. 26 above); Baranson, *Manufacturing Problems in India*, pp. 59–62, and *Automotive Industries in Developing Countries* (Washington, D.C.: IBRD, 1969), pp. 4–7; Hal R. Mason, "Some Aspects of Technology Transfer: A Case Study Comparing U.S. Subsidiaries and Local Counterparts in the Philippines," *Philippine Economic Journal* 9, no. 1 (1970): 82–108; and Armando Armas, Jr., "Implications of Legislated Minimum Wage on the Choice of Technique in the Agro-canned Pineapple Industry in the Philippines: A Micro Approach," *Philippine Economic Journal* 12, nos. 1 and 2 (1973): 294–309.

³⁸ The literature on small firms has become quite extensive. See Eugene Staley and Richard Morse, *Modern Small Industry for Developing Countries* (New York: McGraw-Hill Book Co., 1965); P. N. Dhar and H. F. Lydall, *The Role of Small Entrepreneurs in Indian Economic Development* (New York: Asia Publishing House, 1961); OECD, *Transfer of Technology for Small Industries* (Paris: OECD, 1974); IBRD, Economics of Industry Division, "Small Enterprises in Manufacturing: The Emerging Issues," mimeographed (Washington, D.C.: IBRD, 1973); Suzanne Paine, "Lessons for LDCs from Japan's Experience with Labour Commitment and Subcontracting in the Manufacturing Sector," *Bulletin of the Oxford University Institute of Economics and Statistics* 33 (May 1971): 115–34; Joseph E. Stepanek, *Small Industry Advisory Services* (Glencoe, Ill.: Free Press, 1960); Douglas Fisher, "A Survey of the Literature on Small-sized Industrial Undertakings in India," in *The Role of Small Industry in the Process of Economic Growth*, ed. Bert F. Hoselitz (The Hague: Mouton & Co., 1968), pp. 115–215; Miyokei Shinohara, "A Survey of the Japanese Literature on Small Industry," *ibid.*, pp. 1–113; Harry T. Oshima, "Labor-Force 'Explosion' and the Labor-intensive Sector in Asian Growth," *Economic Development and Cultural Change* 19 (January 1971): 161–83; Susumu Watanabe, "Reflections on Current Policies for Promoting Small Enterprises and Subcontracting," *International Labour Review* 110 (November 1974): 405–22; and Ram K. Vepa, *Small Industries in Japan* (Bombay: Vora & Co., 1967) and *Small Industry in the Seventies* (Delhi: Vikas Publishing House, 1971).

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small firms have adopted this greater labor intensity in response to the different factor prices that they face compared with large firms: cheaper labor and more expensive capital. This kind of response, they argue, shows that it is an efficient adaptation and hence that efficient factor substitution is quite feasible.

But are the small firms efficient? A counterargument would run as follows: The small firms may have lower capital-labor ratios, but they are inefficient in the sense that they use more labor and more capital per unit of output than do large firms. They are still able to sell goods in the same market as the big firms, however, because their wage costs are so much lower; that is, because the labor markets are imperfect.³⁹ Hence the greater labor intensity of the small firms is not necessarily an efficient adaptation.

The output-capital ratio of the small firms compared with the large firms is critical to deciding this point. But the evidence here is mixed, with different studies finding different results, even for the same country.⁴⁰

Unfortunately, truly valid comparisons between large and small firms are very difficult to construct. Not only must the same final product be produced by both firms, but they must be vertically integrated to the same extent. For example, suppose the large firms produce more of their own inputs or do more of their own distribution than do smaller firms. These extra activities probably involve different factor proportions than the main production processes that are being compared. Thus we could observe different capital-labor ratios and different output-capital ratios between large and small firms, even if the main production processes were identical, and might mistakenly conclude that these indicated differences in efficiency. None of the studies cited above has tried to correct for this problem. One corrective measure would be to recalculate the unit costs of both large and small firms, using social opportunity costs for all inputs; if small firms had lower unit costs measured in this fashion, we could then be confident that the greater labor intensity of the small firms was good evidence of efficient factor substitution. But these kinds of calculations are very difficult, and, of course, none of the studies has attempted them.

³⁹ Or one could argue that they sell different kinds of goods or different qualities, in which case the comparisons become largely irrelevant.

⁴⁰ For Pakistan, see Gustav Ranis, "Investment Criteria, Productivity, and Economic Development: An Empirical Comment," *Quarterly Journal of Economics* 76 (May 1962): 298–302; for the conflicting studies on India, see Dhar and Lydall; J. C. Sandesara, "Scale and Technology in Indian Industry," *Bulletin of the Oxford University Institute of Economics and Statistics* 28 (August 1966): 181–98, and "Size and Capital Intensity in Indian Industry: Some Comments," *ibid.*, 31 (November 1969): 331–34; and B. V. Metha, "Size and Capital Intensity in Indian Industry," *ibid.*, 31 (August 1969): 189–204; and for a number of countries, see Keith Marsden, "Towards a Synthesis of Economic Growth and Social Justice," *International Labour Review* 100 (November 1969): 389–418.

Overall then, we can learn little from the comparisons between large and small firms. The latter are surely more labor-intensive, and this is very likely a response to expensive capital and cheap labor, but in the absence of competitive markets we simply cannot conclude anything about the efficiency of small firms.

Used Machinery

Secondhand machinery is frequently recommended as a way for LDCs to reduce capital-labor ratios. The theoretical argument runs as follows: Profit-maximizing firms should find it worthwhile to replace existing machinery with new machinery either (a) when there is enough technological improvement so that the average total costs of output produced by the new machines are below the marginal costs of output produced by old machines, or (b) in the absence of technological improvement, when the future discounted maintenance costs of old machines exceed the price of the new machines plus their future discounted maintenance costs. In both cases, replacement depends on comparing one set of costs that have a heavy labor weight with another set of costs that have a heavy capital element. Thus a high-wage economy will find it economically rational to replace machinery much sooner than would a low-wage economy, and low-wage LDCs should find worthwhile the purchase of used machines that developed countries find marginal. In the developed country, if there is an active market in used machinery, the price of the used machine would have to fall by enough for a developed-country buyer to find it worthwhile to consider the used machine as an economic alternative to the new machine. At that price, the LDC buyer will surely find the machine more worthwhile (except for added transportation costs).⁴¹

The counterargument (often presented by those who believe in fixed proportions) is that good markets in used machines do not exist, used machines are a very risky proposition, spare parts may not be available, or the machinery is so technologically obsolete that the use of the machines is inefficient compared with new machines.

What is the evidence? First, it should be noted that organized markets in used machinery are present in the developed countries. Brokers, catalogs, and trade associations of used-machinery dealers do exist. Second, a number of studies have found efficient employment of used ma-

⁴¹ But if the productivity of the used machine falls so low that its price is simply its scrap value in the developed country, it may or may not be a good buy for the LDC. For further theoretical discussions concerning used machinery, see Amartya Kumar Sen, "On the Usefulness of Used Machines," *Review of Economics and Statistics* 44 (August 1962): 346-48; Sandra L. Schwartz, "Second-Hand Machinery in Development, or How to Recognize a Bargain," *Journal of Development Studies* 9 (July 1973): 544-55; and M. A. M. Smith, "International Trade in Second-Hand Machines," *Journal of Development Economics* 1 (December 1974): 261-78.

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chinery in LDC industries.⁴² The list is not long, but one suspects that there are many other instances of efficient use, yet researchers have not been told of it or have not considered the phenomenon interesting enough to ask about or report.

Buying used machinery is a risky proposition; it takes special skills to be able to tell which ones are the "lemons," and the original manufacturers' warranties have usually long since lapsed. Indeed, all of the studies stress the need for good management and engineering skills as a necessary adjunct to the proper choosing, adaptation, and use of second-hand machinery. But the studies do show that it can be done successfully.

The motor-vehicle industry provides an additional example of an industry in which active secondhand markets exist in developed countries, spare parts are available, and technological change has not been rapid. Large stocks of used cars and trucks are constantly available for sale in the United States and Europe. Prices depreciate faster than purely utilitarian considerations would dictate, especially for cars; spare parts are usually available; and technological change since World War II has been quite slow.⁴³ Many LDCs would do well to forego importing new vehicles or attempting the domestic production of these vehicles and instead buy and import large quantities of used vehicles.⁴⁴ Repair requirements would be greater for a fleet of vehicles bought used rather than new, but these skills are currently present to some extent in most LDCs, and their development should be further encouraged. Spare parts, if not available, could be manufactured locally. Both domestic and foreign-exchange resources would be saved for better uses, and effective capital-labor ratios in transportation would be lowered.

Again, the evidence on used machinery does show the possibilities of lower capital-labor ratios.

Multinational Corporations (MNCs)

The MNCs are frequently pictured as the special villains of the appropriate-technology effort. They are, so the argument goes, tied to their capital-intensive technology in the developed countries.⁴⁵ That is what

⁴² The areas covered include jute processing, cotton-textile manufacture, engine machining, paper manufacture, pineapple canning, consumer-goods industries in Kenya, and various industries in Mexico.

⁴³ For U.S. cars, see Lawrence J. White, *The Automobile Industry since 1945* (Cambridge, Mass.: Harvard University Press, 1971), chap. 13; for trucks, see Max Alth, "The Use of Old and Second-Hand Road Transportation Equipment" (paper presented at the seminar on the Establishment and Development of the Automotive Industry in Developing Countries, UNIDO, 1968).

⁴⁴ See John R. Meyer, "Transport Technologies for Developing Countries," *American Economic Review* 56 (May 1966): 83-90.

⁴⁵ See Frances Stewart, "Economic Development and Labour Use: A Comment," *World Development* 1 (December 1973): 25-28, and "Trade and Tech-

they are familiar with and what their product quality and trademark image are frequently based on. Efforts to change their technology for LDC conditions are too risky and costly. They ignore the possibilities of using local raw-material inputs. And, even if they were considering adaptations, they frequently pay higher wages than do locally owned firms and they can obtain their capital abroad at cheaper rates, so they would have less incentive to adapt.

The counterargument is presented by Pack.⁴⁶ As noted above, he argues that good management appears to be necessary to recognize and utilize the possibilities of labor-capital substitution. And the MNCs frequently have the best management around. Even if they pay higher wages than local firms, their wages are still considerably lower than those in the home country, and thus they have a strong incentive for adaptation.

What is the evidence? Here we must be very careful in evaluating it. A number of interview and questionnaire surveys of MNCs have concluded that only a modest amount of technological adaptation has taken place, mostly in response to lower volumes and not to local factor costs.⁴⁷ This evidence has been widely cited by those who see the MNCs as villains.

But there is an interesting paragraph in a recent study by Boon that is worth recounting at some length.⁴⁸ He describes an interview at an engine plant owned by an MNC in Mexico. At the beginning of the interview, the management assures Boon that the Mexican plant uses exactly the same technology as that used in the parent plant in the developed country. But as the interview proceeds and Boon tours the factory, it becomes clear that in many respects the factor proportions are

nology," in *Trade Strategies for Development*, ed. Paul Streeten (New York: John Wiley & Sons, 1973), pp. 231–63; Paul Streeten, "The Multinational Corporation and the Nation State," in *The Frontiers of Development Studies*, ed. Paul Streeten (New York: John Wiley & Sons, 1972), pp. 223–38, and "The Multinational Enterprise and the Theory of Development Policy," *World Development* 1 (October 1973): 1–14; and Constantine Vaitsos, "Foreign Investment and Productive Knowledge," in *Beyond Dependency*, ed. Guy F. Erb and Valeriana Kallab (Washington, D.C.: Overseas Development Council, 1975), pp. 75–94.

⁴⁶ See Pack, "Employment and Productivity" and "The Substitution of Labour for Capital."

⁴⁷ See Lloyd G. Reynolds and Peter Gregory, *Wages, Productivity and Industrialization in Puerto Rico* (Homewood, Ill.: Richard D. Irwin, 1965); W. A. Yeoman, "Selection of Production Processes for the Manufacturing Subsidiaries of U.S. Based Multinational Corporations" (Ph.D. diss., Harvard University, 1968); Helen Hughes and You Poh Sing, eds., *Foreign Investment and Industrialization in Singapore* (Canberra: Australian National University Press, 1969); Jack Baranson, *International Transfer of Automotive Technology to Developing Countries*, United Nations Institute for Training and Research, Research Report no. 8 (UNITAR, 1971); and Grant L. Reuber, *Private Foreign Investment in Development* (London: Oxford University Press, 1973).

⁴⁸ Boon, "Technological Choice in Metalworking" (n. 26 above), p. 270.

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different. The main machinery processes are automated, but secondhand equipment is used. And all of the auxiliary processes, like packaging, handling, transporting, and storing, are done much more labor-intensively. Perhaps interviewers get told what the interviewees wish to believe!

Contrary to these surveys, any researcher who sticks his head into an MNC facility in an LDC and looks around is likely to find substantial adaptations of capital-labor ratios, particularly in auxiliary processes.⁴⁹ These adaptations occur in MNC export operations as well as MNC manufacture for local LDC markets.⁵⁰ Of course, not all MNCs adapt. Pack cites an example of a home office insisting that capital-intensive processes be maintained, even though the branch manager recognizes that more labor-intensive methods would be more profitable.⁵¹ And not all of the MNCs in Strassmann's sample of MNCs in Mexico adapted their technology, but a higher fraction adapted their technology than did locally owned firms. And a higher fraction were buying and using secondhand machinery. Again, parallel to Pack's argument, the importance of good flexible management possessed by MNCs is stressed by Strassmann and by the ILO mission to Kenya.

It appears, then, that both locally controlled firms and MNCs can and do adapt their factor proportions. But which group is more likely to adopt the more labor-intensive methods? In examining comparative evidence, it is necessary to exclude economy-wide comparisons. Here, we will always find that MNCs are more capital-intensive than locally controlled firms. This is to be expected, since the MNCs do have a comparative advantage in capital-intensive products. The critical question concerns comparisons within an industry in which both groups are present. Strassmann, Pack, and the ILO mission to Kenya all find the MNCs to be more labor-intensive; they explain this on good management grounds. Mason finds that, for a group of matched pairs of firms, U.S.-controlled firms tend to be somewhat more capital-intensive than locally owned Philippine or Colombian firms; he explains this on the grounds that the U.S. firms pay higher wages and have access to cheaper

⁴⁹ See *ibid*; Pack, "Employment and Productivity" and "The Substitution of Labour for Capital"; Baranson, *Manufacturing Problems in India*, pp. 59-62; Strassmann, *Technological Change and Economic Development* (n. 10 above), chaps. 5 and 6; Mason (n. 37 above); ILO, *Employment, Income, and Equality*, pp. 446-50; Wells (n. 37 above), and Armas (n. 37 above).

⁵⁰ See Baerresen (n. 37 above); Ranis "Output and Employment in the '70's," "Industrial Sector Labor Absorption," "Some Observations on the Economic Framework," and "Employment and Labor Absorption in Development," all in n. 35 above; and G. K. Helleiner, "Manufactured Exports from Less Developed Countries and Multinational Firms," *Economic Journal* 83 (March 1973): 21-47, and "Manufacturing for Export, Multinational Firms, and Economic Development," *World Development* 1 (July 1973): 13-21.

⁵¹ Pack, "Employment and Productivity."

capital.⁵² Radhu also finds foreign firms to be more capital-intensive than locally owned Pakistani firms.⁵³ But Cohen finds no significant differences between foreign and Korean firms producing for export markets.⁵⁴ The evidence is clearly mixed.

Although the MNCs may not be the heroes of appropriate technology, they are far from the villains that many make them out to be. They have the management expertise, and they are frequently willing to use it to adapt to labor-intensive processes. Again, there is adequate evidence of factor substitutability.

Factor Proportions and Savings Rates

An argument cited earlier in favor of capital-intensive methods is that they would raise the income share of capital owners who are supposed to have higher rates of saving and reinvestment than do workers; the pace of industrialization would thereby be quickened. This kind of argument, of course, presupposes that government taxation of labor incomes for savings purposes is not feasible. But ignoring this, what do we know about savings rates?

The evidence reviewed by Mikesell and Zinser does indicate that saving out of labor income is very low; the marginal propensity to save rises with income, and the saving rate out of profits is high.⁵⁵ But Oshima argues that added income to low-wage workers might reduce the dissaving of many.⁵⁶ If we turn to the saving rates of firms of different capital intensities, Ranis provides evidence that medium-size (less capital-intensive) firms have higher savings and reinvestment rates per unit of output than do large firms.⁵⁷ Appavadhanulu argues that small firms in India have higher saving rates than large firms.⁵⁸

The evidence thus is somewhat mixed. And given the possibility of government taxation as a form of saving, the income distribution, saving, and reinvestment argument appears to be a weak reed on which the case for capital intensity might rest.

⁵² See Mason, "Some Aspects of Technology Transfer" and "Some Observations on the Choice of Technology by Multinational Firms in Developing Countries" (*Review of Economics and Statistics* 55 [August 1973]: 349–55).

⁵³ Ghulam M. Radhu, "Some Aspects of Director Foreign Private Investment in Pakistan," *Pakistan Development Review* 12 (Spring 1973): 68–80.

⁵⁴ Benjamin I. Cohen, "Comparative Behavior of Foreign and Domestic Export Firms in Developing Economy," *Review of Economics and Statistics* 55 (May 1973): 190–97, and *Multinational Firms and Asian Exports* (New Haven, Conn.: Yale University Press, 1975).

⁵⁵ Raymond F. Mikesell and James E. Zinser, "The Nature of the Savings Function in Developing Countries: A Survey of the Theoretical and Empirical Literature," *Journal of Economic Literature* 11 (March 1973): 1–26.

⁵⁶ See Oshima (n. 38 above).

⁵⁷ Gustav Ranis, "Production Functions, Market Imperfections, and Economic Development," *Economic Journal* 72 (June 1962): 344–54.

⁵⁸ V. Appavadhanulu, "Firm Size and Saving Rate in India," *Indian Economic Review* 9 (October 1974): 183–88.

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Product Substitution

Some researchers have argued that in addition to the wrong factor proportions being used the wrong products are being consumed.⁵⁹ Consumer durables like automobiles, air conditioners, and washing machines have capital-intensive production technologies. More appropriate products and services, like bicycles, air coolers, and launderers, would be more labor-intensive. (We will leave the issue of the development of new products for LDCs for Sec. III.) Frequently it is claimed that this is the result of an inappropriate income distribution in LDCs—too heavily skewed toward the rich—and that a radical redistribution of income is necessary.

Though this last suggestion may be recommended on ethical grounds, it appears likely that income redistribution would have only a tiny effect on employment. This is the clear conclusion of the general equilibrium macroeconomic models that have recently been constructed for a number of LDCs.⁶⁰

A less radical alternative would be simply to levy excise taxes on capital-intensive goods which have labor-intensive substitutes. For example, Indonesia taxes “modern” manufactured cigarettes more heavily than traditional *kretek* clove cigarettes.⁶¹

Another way of encouraging the production of appropriate products is to orient the economy toward exports. Here, labor-intensive goods and processes will have a comparative advantage in world markets and hence will be the natural choice for LDCs. This is the path that the “success stories” of the East and Southeast Asia—Korea, Taiwan, Hong Kong, and Singapore—and, to a lesser extent, Colombia, Brazil, and Mexico, have followed.⁶²

⁵⁹ See Paul Streeten, “Technology Gaps between Rich and Poor Countries,” in Streeten, *Frontiers of Development Studies*, pp. 381–400; Stewart, “Trade and Technology,” and “Technology and Employment in LDCs” (n. 9 above); and Helen Hughes, “The Scope for Labor-Capital Substitution in the Developing Economics of Southeast and East Asia,” in White, *Technology, Employment, and Development* (n. 1 above), pp. 30–57.

⁶⁰ For reviews of these models, see Cline; and Morawetz, “Employment Implications,” both in n. 1 above.

⁶¹ See Mohammad Sadli, “Application of Technology and Its Employment Effects: The Experience of Indonesia,” in Edwards, *Employment in Developing Nations* (n. 1 above), pp. 363–72. But India maintains price *ceilings* on capital-intensive white sugar (as compared with the less refined *gur*), which would otherwise encourage its consumption, except the ceilings also discourage production and limit supplies (see Baron [n. 32 above]).

⁶² See the references in n. 42. See also Little et al. (n. 14 above); R. Porter, “Transfer of Technology: The Hong Kong View” (paper presented at the meeting on the Transfer of Technology to Developing Countries through Subcontracting and Licensing Agreements, with Special Reference to the Automobile Industry, UNIDO, 1972); Bela Balassa, “Industrial Policies in Taiwan and Korea,” *Weltwirtschaftliches Archiv* 106 no. 1 (1971): 55–77; Fei and Ranis, “A Model of Growth and Employment” (n. 35 above); and Michael Sharpston, “International Subcontracting,” *Oxford Economic Papers* 27 (March 1975): 94–135.

A Summary on Factor Proportions

This section has summarized the available literature on the possibilities of labor-capital substitution in LDC manufacturing. Each subsection has presented one aspect of the evidence. By itself, each subsection may not appear entirely convincing. But together they paint a rather impressive picture. There seem to be plenty of opportunities for more labor-intensive methods to be used. And there seem to be opportunities for a more appropriate product mix. The ranges of choice are far from complete on both the production and product sides. The economist's smoothly curved production isoquant is rarely present. It is the task of research and development to increase the range of choice, a topic we shall tackle in Section III. But the claim of fixed coefficients, or even of a severely limited choice of efficient factor proportions, simply does not offer a satisfactory explanation for the introduction of production methods embodying inappropriate factor proportions in most LDCs.

II. The Causes of Inappropriate Factor Proportions

The evidence of Section I suggests that there are efficient labor-intensive alternatives for the capital-intensive production methods that have been installed or have been proposed for most LDCs. If fixed factor proportions are not the reason for LDC capital intensity, what explanations can be offered?

First, the relative prices of capital and labor are frequently badly out of line with their true social worth: A wide variety of government policies have made capital artificially cheap in capital-short economies, while labor has been made artificially expensive in many of these same economies.⁶³ Capital is made cheaper through government-subsidized low-interest loans, favorable exchange rates or low tariffs for imported capital goods, tax holidays on new investments, and accelerated depreciation on capital goods.⁶⁴ Labor in urban manufacturing has been made more expensive through minimum wage legislation, mandated fringe benefits, restrictions on the ability to lay off workers, and government-encouraged union pressures. These labor provisions are most likely to be enforced in the government sector, in large firms, and in MNCs. As we argued earlier, they are a major factor in encouraging high urban unemployment. Real urban wages are frequently two or more times

⁶³ See Little et al.; and Efrén Cordova, "Labour Legislation and Latin American Development: A Preliminary Review," *International Labour Review* 106 (November 1972): 445-474.

⁶⁴ Exchange control and overvalued exchange rates make smuggling a highly profitable activity. Smuggling via overinvoicing on the import of hard-to-value (by customs officials) capital goods provides yet another incentive for entrepreneurs to favor capital-intensive processes (see Gordon C. Winston, "Overinvoicing, Underutilization, and Distorted Industrial Growth," *Pakistan Development Review* 10 [Winter 1970]: 405-21).

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rural wages.⁶⁵ In a number of countries, the relative distortion of labor and capital prices, rather than getting better, has become worse during the years since the Second World War. Witte estimates that the wage/capital-rental ratio for all of Mexican manufacturing rose from an index of 100 in 1954 to 280 in 1964; for Peru, the same factor-price ratio for a number of industries rose from 100 to 1958 to a range of 190–270 in 1966.⁶⁶ Roemer reports that the same ratio in Ghana rose from 100 in 1960 to 124 in 1966 (but subsequently fell to 90 in 1970).⁶⁷ Krueger reports an appreciable rise in Turkey for the period 1955–70.⁶⁸ In a contrary case, Williamson reports a falling ratio in the Philippines for 1955–66.⁶⁹ But generally the pattern reported is rising real wages in manufacturing in most LDC countries, while capital remains cheap or becomes cheaper.⁷⁰

The rising real wages in LDC manufacturing sometimes receives two defenses; both should be put to rest. First, it is argued that wages should rise with the increases in productivity in manufacturing. Besides mixing cause with effect, this argument is wholly inappropriate for an economy with widespread un- and underemployment. As long as there is substitutability, greater capital shallowing should be encouraged through low wages; only when labor grows scarce should real wages rise in line with rising productivity. Second, it is argued that in a world of monopolistic MNCs which escape LDC taxes through internal transfer pricing vis-à-vis the parent company, high wages may be the only way that the LDC can capture some of the profits. But the obvious solution to this is to improve government taxation and customs procedures and to reduce the MNC's monopoly power by introducing more competition

⁶⁵ E.g., for the Philippines, see George L. Hicks and Geoffrey McNicoll, *Trade and Growth in the Philippines* (Ithaca, N.Y.: Cornell University Press, 1971), p. 91.

⁶⁶ Ann Dryden Witte, "Employment in the Manufacturing Sector of Developing Economies: A Study of Mexico and Peru," *Journal of Development Studies* 10 (October 1973): 33–49.

⁶⁷ Michael Roemer, "The Neoclassical Employment Model Applied to Ghanaian Manufacturing," *Journal of Development Studies* 11 (January 1975): 75–92.

⁶⁸ Ann O. Krueger, *Turkey* (New York: Columbia University Press, 1974), p. 235.

⁶⁹ Jeffrey G. Williamson, "Relative Price Changes, Adjustment Dynamics, and Productivity Growth: The Case of Philippine Manufacturing," *Economic Development and Cultural Change* 19 (July 1971): 507–26. This is confirmed by Hicks and McNicoll and by Robert E. Baldwin, *The Philippines* (New York: Columbia University Press, 1975), p. 148.

⁷⁰ See Anthony D. Smith, ed., *Wage Policy Issues in Economic Development* (London: Macmillan Co., 1969); Elliott J. Berg, "Wages Policy and Employment in Less Developed Countries," in *Prospects for Employment in the Nineteen Seventies*, ed. Ronald Robinson and Peter Johnston (London: HMSO, 1971); Peter Gregory, "Wage Structure in Latin America," *Journal of Developing Areas* 8 (July 1974): 557–80; and J. B. Knight, "Wages in Africa: What Should a Foreign Firm Do?" *Oxford Bulletin of Economics and Statistics* 37 (May 1975): pp. 73–90.

(via imports, if necessary) into the domestic economy in which the MNC sells or by opening up for wider bidding the extraction and export concession that the MNC has. Using wages to try to capture those profits is a distinctly inferior and potentially quite harmful policy.

The cheap-capital and high-wages policies have laudable goals—to encourage investment and to raise worker incomes—but their inevitable result is to encourage entrepreneurs to substitute away from labor- and toward capital-intensive processes. The econometric studies of the elasticity of substitution, if they are to be believed, certainly point in this direction. The engineering and process analysis studies tell the same story. And much of the anecdotal literature, analysis of small firms, and discussion of MNC adaptations do link changes in capital-labor ratios to relative factor prices.

Further, inappropriate factor prices make capital-intensive goods cheaper and labor-intensive goods more expensive, thus discouraging consumption of the latter. Not only wrong processes but also the wrong products are encouraged.⁷¹

But factor prices do not seem to offer a complete explanation of the existence of inappropriate factor proportions. A second reason seems to be the strong tendency for entrepreneurs and especially engineers to think in terms of developed-country mechanized technology as the ideal, regardless of factor prices. The confusion between high labor productivity and efficiency enters here. If markets are noncompetitive, entrepreneurs seem willing to sacrifice some of their potential monopoly profits in order to achieve this goal of mechanization. Wells has labeled this the phenomenon of “engineering man.”⁷² This appears to be a widely held notion. But there has been only one attempt formally to test the proposition. White found that greater competition in Pakistani product markets forced industrialists to adopt more labor-intensive methods relative to the U.S. “ideal”; industrialists in less competitive markets were freer to pursue their engineering goals.⁷³

Third, even in instances in which firms might be interested in more labor-intensive methods, and those methods do exist, information about them is frequently difficult to obtain. Search is costly, the firms are familiar with the capital-intensive processes, and the absence of compe-

⁷¹ See Charles Cooper, “Science, Technology, and Production in the Underdeveloped Countries: An Introduction,” *Journal of Development Studies* 9 (October 1972): 1–18.

⁷² See Wells (n. 37 above). The argument also appears in Bruton (n. 1 above); Ranis, “Some Observations on the Economic Framework”; and James Pickett, D. J. C. Forsyth, and N. S. McBain, “The Choice of Technology, Economic Efficiency, and Employment in Developing Countries,” in Edwards, *Employment in Developing Nations* (n. 1 above), pp. 209–21.

⁷³ Lawrence J. White, “Appropriate Technology, X-Inefficiency, and a Competitive Environment,” *Quarterly Journal of Economics* 90 (November 1976): 575–85.

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tion may reduce the incentive to search. Or even with search, they may simply fail to find out about the labor-intensive methods.⁷⁴

Fourth, not all MNCs adapt their technologies. There are plenty of “engineering men” in MNCs, and, if permitted by noncompetitive markets, they too will mechanize beyond socially optimal levels.

Fifth, inappropriate government policies, beyond the labor and capital pricing policies and the failure to encourage competition mentioned above, are another contributing cause. Badly conceived, capital-intensive public projects are a waste of resources and surely do not provide a good example to the private sector. The mystique of high productivity and modernity pervades the public sector as much as it does the private sector.⁷⁵ Other poor policies include a frequent negative attitude toward the import of used machinery and used vehicles, sometimes taking the form of outright bans.⁷⁶ This is based on the belief that used machines are inferior and private entrepreneurs are mistaken in their purchases or that used machinery may be an easier vehicle for smuggling (through overinvoicing to smuggle funds out of the country or underinvoicing to reduce tariff duties, since the customs officials may be less familiar with the true value of the machinery). As argued above, such policies are sacrificing potential major improvements in labor-capital ratios.⁷⁷ And the unwillingness to tax or otherwise discourage the consumption of capital-intensive consumer goods and the unwillingness of many governments to encourage the development of export markets for manufactured goods further push their economies toward capital-intensive methods.

In short, LDC government policies can go a long way in explaining the inappropriate factor proportions observed.

III. The Evidence on Research and Development in LDCs

Although plenty of opportunities for more appropriate factor proportions exist in LDCs, the range of choice is far from complete, and in

⁷⁴ For a description of a can manufacturer who simply failed to find out about the availability of a lower cost labor-intensive method of production, see C. Cooper et al., “Choice of Techniques for Can Making in Kenya, Tanzania, and Thailand,” in Bhalla, *Technology and Employment in Industry* (n. 1 above), pp. 85–121.

⁷⁵ See David Morawetz, “Import Substitution, Employment, and Foreign Exchange in Colombia: No Cheers for Petrochemicals,” in Timmer et al. (n. 6 above), pp. 95–107.

⁷⁶ See Kurt Rethswisch, “Prohibitive Tariffs on Used Vehicles: Aid or Obstacle to the Development Process?” *Journal of Development Studies* 10 (April/July 1973): 395–402.

⁷⁷ But reliance on used machinery may still tie LDCs to a pattern of increasing capital-labor ratios over time, since it has been the past pattern in the developed countries from which the used machinery comes (see Michael P. Todaro, “Some Thoughts on the Transfer of Technology from Developed to Less Developed Nations,” *Eastern Africa Economic Review* 2 [June 1970]: 53–64).

many instances a serious need exists to develop new processes and products for LDCs that will be more labor-intensive and, of course, that will increase the overall productivity of all factors generally.⁷⁸ This is technological progress, with research and development as the main generating agent. Unfortunately, technological progress and R & D are only imperfectly understood in the developed countries, and the data there are still poor and spotty.⁷⁹ Much less is known about this area in LDCs.

Most investigations of R & D in developed countries involve tests of the Schumpeterian hypotheses that large absolute size and market power are necessary to encourage R & D. The evidence from these tests is definitely mixed. But in LDCs the data are so scanty that writers on the subject are generally content if they can just quantify R & D expenditures; there have been only a few empirical tests of hypotheses.⁸⁰ The LDCs perform only 2% of all R & D conducted in the non-Communist world, and LDC manufacturing firms appear to spend only 0.1%–0.2% of their sales on R & D.⁸¹ In contrast, manufacturing firms in the United States on average spend 2% of sales from their own finances on R & D.⁸²

⁷⁸ See Marsden, "Progressive Technologies" (n. 2 above); and E. F. Schumacher, "Employment Possibilities of Different Types of Technologies," in Robinson and Johnston, pp. 134–42, "Industrialization through 'Intermediate Technology,'" in *Developing the Third World: The Experience of the Nineteen Sixties*, ed. Ronald Robinson (London: Cambridge University Press, 1971), pp. 85–94, "The Work of the Intermediate Technology Development Group in Africa," *International Labour Review* 106 (July 1972): 75–92, and *Small Is Beautiful* (New York: Harper & Row, 1973).

⁷⁹ For recent surveys, see Charles Kennedy and A. P. Thirwall, "Technical Progress: A Survey," *Economic Journal* 82 (March 1972): 11–72; and Morton I. Kamien and Nancy L. Schwartz, "Market Structure and Innovation: A Survey," *Journal of Economic Literature* 13 (March 1975): 1–37.

⁸⁰ For general discussion, see Sussex Group, "Science and Technology in Less Developed Countries," in *Third World Employment*, ed. Richard Jolly, Hans Singer, and Fiona Wilson (Baltimore: Penguin Books, 1973), pp. 354–61; Stewart, "Technology and Employment in LDCs" (n. 9 above); Strassman, *Technological Change and Economic Development* (n. 9 above), chap. 7; Richard S. Eckaus, "Notes on Invention and Innovation in Less Developed Countries," *American Economic Review* 56 (May 1966): 98–109; Amiliar Herrera, "Social Determinants of Social Policy in Latin America," *Journal of Development Studies* 9 (October 1972): 19–37; Richard R. Nelson, "Less Developed Countries—Technology Transfer and Adaptation: The Role of the Indigenous Science Community," *Economic Development and Cultural Change* 23 (October 1974): 61–78; Robert Solo, "The Capacity to Assimilate an Advanced Technology," *American Economic Review* 56 (May 1966): 91–97; G. K. Helleiner, "The Role of Multinational Corporations in Less Developed Countries: Trade in Technology," *World Development* 3 (April 1975): 161–89; and Lawrence W. Bass, "The Role of Technological Institute in Industrial Development," *World Development* 1 (October 1973): 27–32.

⁸¹ See Sussex Group; Herrera; ILO, *Employment, Incomes, and Equality* (n. 13 above), p. 148; and Mark Frankena, "The Industrial Trade Control Regime and Product Designs in India," *Economic Development and Cultural Change* 22 (January 1974): 256.

⁸² See Scherer (n. 27 above), p. 349.

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Katz, in one of the few detailed studies of LDC R & D, found that the R & D expenditures as a percentage of sales of Argentine firms in nine industries were only a fifth of the relative amounts spent by domestic U.S. firms in the same industries.⁸³

The reasons for the low levels of spending are many: low levels of income; shortages of trained personnel; the small sizes of firms in LDCs; the ready availability of developed-country technology and the low risks involved in transferring it intact rather than trying to adapt it; the absence of competitive pressures to innovate; and the practice of MNCs, if they do any R & D relevant to LDCs, to do it mostly in their home countries.⁸⁴

As a consequence of the low levels of R & D, many argue that labor-intensive processes are not developed for LDCs and that new products which would be more labor-intensive and aimed at the mass markets of low-income consumers are not developed.⁸⁵ Further, there is probably a close connection between process adaptation and product adaptation. In many cases adaptation of the processes requires product adaptation, to make fine tolerances less critical and frequently to lower the general quality of the product. The MNCs come in for their share of criticism here, since their reputations are frequently based on the quality of their products and they are reluctant to tamper with that image.

Still, it is instructive to remember that some invention, innovation, and adaptation does occur in LDCs. The anecdotes in Section I were all largely instances of firms innovating: taking developed-country machinery or processes and altering them to suit the LDC conditions. Three stories of individual innovations in LDCs—the development of a lift pump in Vietnam and of a bamboo tube well in India and the adaptation of machinery for paper manufacture in Mexico⁸⁶—definitely

⁸³ Jorge M. Katz, "Industrial Growth, Royalty Payments, and Local Expenditures on Research and Development," in *Latin America in the International Economy*, ed. Victor L. Urquidí and Rosemary Thorp (New York: John Wiley & Sons, 1973), pp. 197–232.

⁸⁴ See Katz; Frankena; and Jack Baranson, "The Drive toward Technological Self-Sufficiency in Developing Countries," in *Latin America—U.S. Economic Interactions*, ed. Robert B. Williamson, William P. Glade, Jr., and Karl M. Schmitt (Washington, D.C.: American Enterprise Institute, 1974), pp. 201–12.

⁸⁵ See Stewart, "Choice of Technique in Developing Countries" and "Technology and Employment in LDCs" (n. 9 above); Streeten, "Technology Gaps between Rich and Poor Countries" (n. 59 above); and Vaitzos (n. 45 above).

⁸⁶ See, respectively, Robert L. Sansom, "The Motor Pump: A Case Study of Innovation and Development," *Oxford Economic Papers* 21 (March 1969): 109–21; Arthur J. Dommen, "The Bamboo Tube Well: A Note on an Example of Indigenous Technology," *Economic Development and Cultural Change* 23 (April 1975): 483–89; and Dilmus James, "Used Automated Plants in Less Developed Countries: A Case Study of a Mexican Firm," *Inter-American Economic Affairs* 27 (Summer 1973): 31–46.

fit the patterns that have been described for developed countries.⁸⁷ Strassmann provides examples of products and processes developed in Mexico.⁸⁸ The International Rice Research Institute (IRRI) has an active program in the design and manufacture of small-scale agricultural improvements for LDCs.⁸⁹ Even a few of the MNCs have research operations in LDCs and adapt items like cars and tires to local conditions and currently seem to be interested in providing new high-nutrition food products for LDCs.⁹⁰

But clearly the flow of new products and processes that are appropriate for LDCs is not fast enough. Efforts should be made to encourage more R & D and, of course, to make sure that it is aimed at the right targets. Here, the question of incentives arises again. First, a number of articles note that the innovations in Latin American construction methods have tended to be labor saving, and rising real wages for construction workers have been a primary cause; the labor-saving innovations have been adopted more slowly where real wages were lower.⁹¹ Second, Pack argues that labor-intensive methods may encourage more rapid technological progress, since new processes do not have to be embedded in expensive capital goods.⁹² Third, Cooper notes the connection between the research and consulting of the Engineering Faculty at the University of Nairobi and their teaching.⁹³ The government sector in Kenya wants capital-intensive "modern" methods on its projects; it wants to hire engineering graduates and faculty consultants who know these methods. Therefore the faculty must teach these methods and do most of their research on projects relating to them. Fourth, research on appropriate products will not be encouraged if inappropriate factor prices

⁸⁷ See John Jewkes, David Sawers, and Richard Stillerman, *The Sources of Invention*, 2d ed. (New York: W. W. Norton & Co., 1969).

⁸⁸ Strassmann, "Causes of Technological Stagnation" (n. 37 above), and *Technological Change and Economic Development* (n. 10 above), pp. 172-73 and chap. 7.

⁸⁹ See Amir U. Khan, "Appropriate Technologies: De We Transfer, Adapt, or Develop?" in Edwards, *Employment in Developing Nations* (n. 1 above), pp. 223-33; and Amir U. Khan and Bart Duff, "Agricultural Mechanization: Technology Development at the International Rice Research Institute," in White, *Technology, Employment and Development* (n. 1 above), pp. 97-125.

⁹⁰ See USAID, Office of Science and Technology, "Appropriate Technologies for International Development: Preliminary Survey of Research Activities," mimeographed (Washington, D.C., 1972).

⁹¹ See Paul W. Strassmann, "Innovation and Employment in Building: The Experience of Peru," *Oxford Economic Papers* 22 (July 1970): 243-59, and "Construction Productivity and Employment in Developing Countries," *International Labour Review* 103 (May 1971): 503-18; and David Greene and W. Paul Strassmann, "Peruvian Construction Statistics and Productivity Changes," *Journal of Development Studies* 7 (January 1971): 189-95.

⁹² Pack, "Employment and Productivity" and "The Substitution of Labour for Capital."

⁹³ Charles Cooper, "Science Policy and Technological Change in Underdeveloped Countries," *World Development* 2 (March 1974): 55-64.

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or exchange rates make domestic production unprofitable. One USAID report gives the example of a Pakistani research institute developing a new pesticide, but the report's author is then puzzled as to why the institute could get no entrepreneur interested in producing it.⁹⁴ Small wonder, when Pakistan had a badly overvalued exchange rate and pesticides could come in duty free. Fifth, Frankena notes that India's foreign-exchange-control regime meant that there was less competitive pressure to design new products and processes; Baranson has similarly argued that Brazilian firms do little R & D because of the absence of competitive pressures.⁹⁵ Frankena also points out that the control regime encouraged dependence on foreign technology, since a domestic firm with a foreign collaborator to provide foreign exchange could more easily get governmental approval for new projects. Finally, prestige factors also play a part in assessing what kind of R & D is worth encouraging. Katz, for example, describes the research potential of firms in Argentina's electrical-goods industry and writes in disparaging terms of the small firms that make simple transistor radios for the domestic market.⁹⁶ Katz's views would probably be shared by government officials deciding on the allocation of research funds. Yet these firms may have made the best adaptations of product and process for the bulk of the market.

Research institutes in LDCs are frequently seen as a way of encouraging appropriate R & D and of transmitting new and existing knowledge of techniques to LDC firms, especially small firms. There are plenty of examples of successful research institutes (the Korean Institute of Science and Technology, Instituto Mexicano Investigaciones Technologicas (IMIT), IRRI, the International Maize and Wheat Improvement Center of Mexico, the Madras Leather Institute), but also of institutes which are not.⁹⁷ The leadership of these institutes appears to be critical to their success. The decision by an institute to solicit contracts to solve problems and to do applied research is also important.⁹⁸ The contrary decision to do basic research and try for published papers in developed-country journals will mean another research institute spinning its wheels. Finally, confidentiality of information is a problem, since many firms fear that publicly sponsored research institutes will reveal confidential information to the tax authorities or politicians.⁹⁹

⁹⁴ See USAID (n. 90 above).

⁹⁵ Frankena (n. 81 above); Baranson, "The Drive toward Technological Self-Sufficiency" (n. 84 above).

⁹⁶ See Katz (n. 83 above).

⁹⁷ See the sources noted in nn. 72, 81, and 82.

⁹⁸ Since LDC industrial firms do not undertake much applied R & D, basic R & D by research institutes is wasted (see Khan).

⁹⁹ See Strassman, *Technological Change and Economic Development*, pp. 43-48.

Pressuring the MNCs to do more R & D in the LDCs is another approach. Countries might make this a condition of entry by the MNC. Again, appropriate factor prices and product taxation would certainly encourage this process, as would more competition in product markets. Indeed, much of the problem that LDCs face in paying too much for the transfer of technology (through excessive royalties, improper transfer prices on inputs, etc.) would disappear with a combination of tougher bargaining and a procompetitive (via import competition) policy that would reduce the potential profits that the MNCs could siphon away. The frequently described picture of helpless LDCs at the mercy of a handful of monopolistic MNCs is largely false.¹⁰⁰ Alternative suppliers of technology to achieve similar ends almost always exist, and LDC policymakers can and should be able to take advantage of this.¹⁰¹ Even in the world automobile industry, which exhibits tight oligopoly in domestic production in every developed country, there are more than a dozen producers capable of LDC production.

Finally, the question of patents in LDCs combines the problem of incentives and MNCs. Patents provide a property right in an idea and thereby encourage the investment of resources (R & D) in the production of new ideas that would otherwise be copied at low or zero cost. But they do convey a monopoly on the idea. In LDCs the vast majority of patents are granted to foreigners, and only a tiny fraction of them are ever used in production in the LDC.¹⁰² Essentially, the patents largely protect foreign inventions from being copied domestically rather than encourage domestic invention. But the patent system does encourage some MNCs to produce in LDCs, which they otherwise would not do if they could not protect their products and processes.¹⁰³ Although the publication of the patent in the developed country reveals the basic invention, nonpatentable proprietary confidential information is usually necessary to make the invention work. This is what the MNC frequently brings to the LDC, and the protection of the patent also protects this proprietary knowledge. The critical question, then, concerns the worth

¹⁰⁰ See the references in n. 37 and Richard J. Barnett and Ronald E. Muller, *Global Reach* (New York: Simon & Schuster, 1974).

¹⁰¹ The Brazilian engineering industry has been successful in obtaining foreign technology at reasonable costs (see Nathaniel H. Leff, *The Brazilian Capital Goods Industry, 1929-1964* [Cambridge, Mass.: Harvard University Press, 1968], chap. 4). The recognition that LDCs can be effective bargainers is found in Streeten, "The Multinational Enterprise" (n. 45 above); and G. K. Helleiner, "Transnational Enterprises in the Manufacturing Sector of the Less Developed Countries," *World Development* 3 (September 1975): 641-50.

¹⁰² See Constantine Vaitsos, "Patents Revisited: Their Functions in Developing Countries," *Journal of Development Studies* 9 (October 1972): 331-49; and Peter O'Brien, "Developing Countries and the Patent System: An Economic Appraisal," *World Development* 2 (September 1974): 27-36.

¹⁰³ See Edith Penrose, "International Patenting and the Less Developed Countries," *Economic Journal* 83 (September 1973): 768-86.

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of a broad patent system that possibly encourages some domestic invention and some MNC investment but that also prevents domestic firms from using foreign-owned patented inventions that the foreigners are not using. There is simply no evidence to support strongly any conclusions. It is probably the case that a more selective system—for example, one that voided foreign-held patents after a period of domestic nonuse—would be more worthwhile.¹⁰⁴

For R & D in LDCs, then, though the picture is far from bleak, it is also far from rosy. Though some R & D is done, more is needed. But again, incentives are important, and policies should be shaped carefully. It is too easy to throw away large sums of money on ill-conceived R & D.

IV. Conclusions

The evidence summarized in this paper suggests strongly that greater labor intensity in LDC manufacturing is feasible and would be efficient. The possibilities are not unlimited; plenty of room still exists for the discovery of intermediate technologies through well-directed R & D. But a view that LDCs are currently condemned to high capital-labor ratios, because there are no efficient alternatives, simply is not consistent with the evidence.

The evidence also suggests that incentives matter. Appropriate factor prices are an important spur to the discovery and profitable use of appropriate factor proportions and appropriate products. Effective competition in product markets can also provide an important push in the right direction by leaving less scope for engineering instincts to dominate efficient factor use.

Large gaps, however, still remain in our knowledge of appropriate factor use. The microeconomic studies of efficient alternative factor proportions have been completed for only a handful of industries. It would be reassuring to have many more studies showing that alternatives exist. Also, these kinds of studies could profitably be focused on the auxiliary handling, packaging, transporting, and storage processes that figure prominently in the anecdotal examples of substitutability; again, it would be reassuring to have more precise estimates here. Further, we still do not understand very well the connection between scale effects and mechanization or the extent to which it is a genuine problem. The connection between quality standards and mechanization and the extent to which mechanization serves as a substitute for skilled processing labor and/or management supervisory skills are still largely unknown; most evidence here is still qualitative rather than quantitative. (But it cannot be emphasized too frequently that better utilization of existing capacity—

¹⁰⁴ This might have one unfortunate effect, if done in isolation. It would provide easier access to foreign capital-intensive technology by local entrepreneurs and might bring out further the “engineering men” among them.

multiple-shift work in particular—would greatly economize on existing and future capital investments,¹⁰⁵ and that export markets can supplement small internal markets so as to achieve possible scale economies.) Finally, the connection between good management and the ability to recognize and utilize the opportunities for labor-capital substitution needs much greater exploration.

The conclusions of this paper point directly to a number of policy implications. First, the establishment of proper factor prices is terrifically important. This has been a familiar refrain from economists over the past 10 years, but it can still bear repeating. The subsidies to capital use must be ended; an important part of this would be the replacement of exchange controls and overvalued exchange rates with realistic exchange rates. If wages in the urban modern sector cannot be decreased, at least their rates of increase must be substantially moderated in many countries. This is difficult to advocate since these wages are low by developed-country standards, but they are high by comparison with the incomes of the bulk of the remaining population in the LDCs, and the wage increases in the urban sector must necessarily reduce the potential for improving the incomes of the poorer majority. If these policies of altering relative factor prices are combined with procompetitive policies and more effective taxation policies, they need not imply a decrease in labor's share of output relative to capital's share.

With respect to the small-firm versus large-firm problem, efforts to provide special facilities or subsidies to small firms are probably unwise. It is easy to waste funds on unproductive projects in this area,¹⁰⁶ and it would be a serious mistake to compound the current incentive errors by subsidizing capital for small firms. Rather, it would probably be quite adequate simply to give small firms unhindered access to resources; that is, to stop current discrimination against small firms and to let the processes of competition sort out the efficient and inefficient sizes.¹⁰⁷ The current exchange-control- and capital-funds-control regimes usually do quite the opposite.¹⁰⁸ The establishment of an industrial extension service

¹⁰⁵ But recent analyses of shift work have pointed out that, at a given relative wage, the long-run capital-labor ratio in an industry could increase or decrease, depending on the elasticity of substitution and on any shift-work wage differential. The ambiguity occurs because multiple shift work lowers the effective costs of capital relative to labor, thus encouraging substitution of capital for labor as new facilities are built (see Gordon C. Winston, "Capital Utilization and Optimal Shift Work," *Bangladesh Economic Review* 2 [April 1974]: 515–58; and Roger Betancourt and Christopher Clague, "Multiple Shifts and the Employment Problem in Developing Countries," *International Labour Review* 114 [September–October 1976]: 187–96).

¹⁰⁶ See Dhar and Lydall, and Watanabe, both n. 38 above.

¹⁰⁷ See Kathleen Di Tullio, "Small Enterprises in Manufacturing: The Emerging Issues," in OECD, *Transfer of Technology for Small Industries* (n. 38 above), pp. 78–100.

¹⁰⁸ See Lawrence J. White, *Industrial Concentration and Economic Power in Pakistan* (Princeton, N.J.: Princeton University Press, 1974), chaps. 2 and 7.

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that would provide information on techniques and help solve problems for small businesses would probably be the best action that an LDC government could take.¹⁰⁹ But, like research institutes, effective extension services are easy to describe in principle and difficult to make work in practice.

The policy toward used machinery should also be relatively neutral. Neither a strongly pro- nor anti-used-machinery policy seems warranted. Rather, reliance on the judgments of entrepreneurs—provided that the appropriate factor price and procompetition policies are pursued—is warranted. Again, an information service to help on those judgments would be worthwhile.

The appropriate factor price and procompetition policies, backed by some tougher bargaining by LDCs, would limit many of the possible abuses by MNCs.¹¹⁰ Taxation policies on inappropriate products and an outward-looking orientation that stressed labor-intensive exports would also help. And pressuring the MNCs to do more R & D in the LDCs is probably worthwhile.

Research institutes and information services, both national and international, are probably fruitful ways of encouraging more appropriate R & D by and for LDCs. But, again, describing the good research institute is much easier than operating it.

If the connection between good management and appropriate factor proportions is as crucial as much of the evidence suggests (with good management meaning that entrepreneurs can recognize and utilize the opportunities for appropriate factor proportions and also that supervisory skills may be able to substitute for mechanization in the maintenance of quality standards), then appropriate management-training institutes may be as (or more) important as appropriate R & D institutes for discovering and applying efficient labor-intensive methods.

Finally, a few words of caution: Appropriate technology is currently a fashionable topic of research and interest. There is, however, a serious risk. Appropriate technology is sometimes touted as a quick and easy way of raising LDC incomes to developed-country levels. Five or 10 years from now, after some (but not all) measures to encourage appropriate technology have been taken, many current enthusiasts will look around and notice that most of the people in LDCs are still very poor by devel-

¹⁰⁹ See Ross W. Hammond, "Technology Transfer Systems for Small Industries," in OECD, *Transfer of Technology for Small Industries*, pp. 190–200.

¹¹⁰ For example, ending the tax concessions that make capital cheaper for MNCs would improve factor utilization and increase taxes at the expense of profits. The questionnaire data (if it is to be believed) indicate strongly that MNC location decisions are not affected by tax concessions (see Reuber [n. 47 above], p. 128; Streeten, "The Multinational Corporation and the Nation-State" [n. 45 above]; Helen Hughes, "Conclusions," in Hughes and Seng, *Foreign Investment* [n. 43 above], pp. 177–210; and Jordan Schreiber, *U.S. Corporate Investment in Taiwan* [Cambridge, Mass.: Harvard University Press, 1970], p. 75).

oped-country standards. They may then decide that appropriate technology was a fraud and will search for some other quick and easy solution. This would be unfortunate. Appropriate technology does not offer a simple solution to LDC problems; it cannot. There are no quick and easy solutions, short of a radical change in the relative supply-demand conditions for most natural resources, comparable with that which has occurred in oil.¹¹¹ But appropriate technology can mean an improvement in the allocation of resources in LDCs, perhaps a slightly more equitable internal distribution of income, and more and better employment opportunities. The game should not be oversold, but it is definitely worth the candle.

¹¹¹ And even then, LDCs would still face serious political, social, cultural, and income-distribution problems. Saudi Arabia is not everyone's ideal of what an LDC that becomes rich should look like.

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