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MULTINATIONALS AND APPROPRIATE TECHNOLOGY

Working Paper No. 179

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"Appropriate technology" has become a popular issue since we discovered that technology is a critical factor of production and an important ingredient in economic development. This working paper will make a preliminary examination of the role of multinational firms in the supply and use of appropriate technology in less developed countries, in view of further work in this area.

I. Definitions

"Technology" we shall define simply as knowhow and skills which may be technical or managerial. Our concern is with technology as it relates to economic performance so we shall ignore technologies in other aspects of culture, such as architecture, cuisine, or music.

Defining the "appropriateness" of technology is much more difficult and controversial. "Appropriate" means suitable or fitted for a particular purpose. In that sense, the appropriateness of a technology is determined by the purpose someone has in mind for it, and probably also by the circumstances in which it is used. If that is true, there may be no absolute and agreed upon definition of appropriate technology. Instead we might indicate various dimensions of appropriateness to be considered in evaluating a technology.

A. The World Bank lists four dimensions of appropriateness that can serve as a starting point.[1]

1. Appropriateness to Goal.

   Does the technology support the goals of development policy?

2. Appropriateness of Product.

   Is the final product or service delivered useful, acceptable and affordable to the intended users?

3. Appropriateness of Process.

   Does the production process make economic use of inputs?

4. Cultural and Environmental Appropriateness.

   Are the production processes, the products delivered, and the institutional arrangements compatible with the local environment and cultural setting.

That makes a pretty tough checklist for evaluating a technology. A technology might score well on some dimensions but poorly on others, such as nuclear energy in the U.S. Although the World Bank criteria are extensive, they are a bit imprecise so we shall briefly expand on various dimensions.

Appropriateness to Goals.

If nations have different goals, different technologies would be appropriate from one less developed country to another. Some goals might be:

1. Balance of payments equilibrium--the technology should cut imports and/or increase exports.
2. Expand employment--generally a labor intensive technology would be desired. Labor intensity is the most common dimension considered in discussions of appropriate technology.
3. Equality of income distribution--the technology should help to

achieve this goal. Sometimes the operations of multinationals are said to work against this goal, furthering income disparities.

4. Geographic dispersal--the technologies should help to prevent excessive unbanization and the urban-rural split.
5. General development strategy--three alternatives are possible here.
    a. An import substitution strategy with tariff protection.
    b. Import substitution without tariff protection.
    c. An export oriented industry.

    Presumably different technologies would be appropriate for each, including different scale of production and different quality or precision requirements.[2]

B. Other Aspects.

1. Energy use--today there is a lot of concern about the kind and amount of energy needed for technology exploitation.
2. Ecology--the environmental impact of a technology is increasingly considered by host countries.
3. Cultural fit--is the technology compatible with the religion, values, and life style of the people? The importance of this non-economic dimension is highlighted by the changes in Iran after the Shah's departure.[3]

C. The Market versus The Planners.

It is obvious that the search for an appropriate technology is very difficult with so many dimensions to be satisfied. Some dimensions may be incompatible with others so tradeoffs would have to be made, or some dimensions given priority over others.

In addition to that problem there is another one of practical importance to the change agent--the market test. It is not uncommon for development planners or multinational firms to design a technology that is "appropriate" by many of the indicators we have discussed and yet find failure because the market for which it is intended, doesn't cooperate. The planners' appropriate technology is not what the market wants.

II. The Role of Multinationals in Appropriate Technology

In the industrialized world multinationals are major generators and purveyors of technology. Many studies have shown that multinationals are characterized by a high degree of R & D intensity as compared with firms or industries that remain national or domestic operators.

The technology generating role of multinationals is recognized by Unctad in the NIEO where the call is for increased technology transfer, controls over multinationals, and for modification of the patent system. It is also implicitly acknowledged in the frequent demands by host countries for local R & D by multinationals. One final indicator of their technology generating capacity is the fact that the vast majority of patents in every country of the world--outside the communist block--are held by multinationals.

Because these firms are the major generators of economically relevant technology--as opposed to space or military technology--the question of their role becomes especially critical. In spite of its importance, however, limited empirical research exists on the question of how appropriate is the technology of multinationals to the needs of developing host countries.

The conventional wisdom--unsupported by solid empirical evidence--is that these firms tend to extend abroad the same product and process technology that they use at home. To the extent that this is true, it would represent a kind of technological imperialism. This idea was captured cleverly by some Frenchman who referred to the "Cocacolanization of Europe." Khomeini has made similar comments in Iran.

Conventional wisdom would seem to suggest that when in Rome, one should be like the Romans. One must question, however, whether that applies when one is in Sodom or Gomorrah. In any case, there are several reasons for expecting multinationals to extend abroad the same technology they use at home. For one thing, it is easier to continue doing what you do well rather than learning something new (inertia). There are knowledge gaps for the firm moving into a number of diverse host country environments. It is difficult to know just what products and processes are appropriate for each country. The cost of finding out can be high, so there is an economic barrier to getting the knowledge necessary for appropriate adaptation.

If the firm is successful in breaking through the knowledge barrier there are other barriers to adapting its products and processes. One is the economic and behavioral problem of getting product development staff, engineers, and production and plant design personnel to learn to do things differently. They are accustomed to designing the most advanced, sophisticated products and facilities for their industrialized, affluent home markets.

To do something less or different effectively places them at the bottom of a new leaning curve. This involves costs in time, retaining, and experimentation, and for markets that may be small and poor. The problem would be less if one technology would be suitable for all, or many, less developed markets.

A further barrier to adaptation is uncertainty. The firm has no assurance that any particular attempt at adaptation will be successful. (Some examples of failures will be given later.) It doesn't even have enough experience to posit probabilities of success. This uncertainty and fear of failure are probably major deterrents to attempts at adaptation by multinationals. Many presumably feel that it is better to take whatever sales and profits result from existing proven products and methods than to experiment with unknowns. Such an attitude is the more reasonable, the smaller the host country markets in question.

However, logical the preceding comments may appear, the important fact is that they are conjecture. There is too little empirical evidence on multinationals' foreign technology practices to speak with much assurance on this matter. What I will do now is give some partial evidence of multinational behavior in the developing countries, looking both at product technology and at process technology.

A. Product Technology of Multinationals

There is no doubt that many products sold by multinationals in developing countries are the same as those sold in affluent industrialized markets. Coca Cola and IBM computers are examples.

The fact that these products are not adapted, however, does not necessarily mean that they are inappropriate for those markets. It is interesting to note that when Coca Cola left India, for example, the response was the appearance of numerous imitative cola drinks. Nonetheless, as the critics allege, there are probably many products of multinationals which are not the most suited to the developing country markets where they are sold. Let us look at the efforts of some firms to try to find more appropriate products.

1. Nestle

An interesting example is Nestles' experience with its most most famous products, Nescafe. Nestle claims to have about fifty varieties or blends of Nescafe for different world markets, including developing countries. While this is not a critical product perhaps, it does show an example of corporate willingness to experiment and adapt to local preferences.

Nestle's infant formula provides a different and controversial example. It is not clear here, however, whether the question of appropriateness arises more in connection with the product or with the marketing technology used.

2. Ball Corporation

Ball produces packaging for goods and beverages, and home canning. Ball has developed a small scale canning system tailored to developing countries food needs. The system preserves foods that would otherwise go to waste in peak production seasons. The process, which is not completely

automated, is slower than that used in industrial countries --it puts out three tons a day versus 80 tons a day, for example.

Ball installations are found in a number of developing countries, such as Bhutan, Ecuador, Kenya, Mexico and the Philippines. Village cooperatives and other small commercial ventures are especially interested in it. The system is sold with a four day training course for national personnel. It is provided at a price which yields the firm little profit. Ball officials calculate the payoff is more likely to come in improved corporate image than in profits.

3. Quaker Oats

The company has had success developing a number of food products specifically for Latin American markets. In the 1960's Quaker was offered the license to produce and market Incaparina, a low cost, high protein food product developed by a government sponsored laboratory in Central America. Quaker accepted the license for several Latin American countries. The results? In Venezuela, the product failed for lack of raw material availability. In Brazil, the product made a promising start but was killed by inflation and government price controls. In Colombia, the operation ran in the red for several years but finally began showing a small profit.

Quaker's conclusion: conventional food products sell on taste appeal and consumers were not moved by Incaparinas' health appeal in spite of Quaker's extensive radio advertising and promotion through government health centers. People did not want

the product just because it was good for them.

4. Ford Motor Company

In recent years, Ford has made two major efforts at developing products especially for third world markets. The first was a Developing Nations Tractor (DNT). This was a small seven-horsepower walk-behind tractor designed for minimum maintenance and priced to be competitive with a pair of oxen. The product failed not because of inappropriate design but because local Latin American leading institutions refused to finance farmers' purchases of them.

There is an interesting sequel to the DNT story. Several years after Ford's pioneering attempt, a small Michigan company, Dowding Tool Products, picked up and expanded Ford's DNT idea. Dowding's tractor (called the Intec-77) has implements added to it enabling it to serve as a power source for both irrigation and electricity for a small village. This time development institutions are helping to solve the financing problem by purchasing tractors and testing them in countries, such as Bolivia, El Salvador, Kenya, Mexico and Thailand. If the tractors are found appropriate to local needs in these countries, the development agencies will provide financing. It would seem, however, that if Ford's original endeavor had the same support, the service capability of Ford would be much greater in these markets than that of Dowding Tool Products.

5. Ford Fiera

In the early 1970's Ford began design work on a "Model T for Asia". Ford's Fiera was to be a low cost, minimum

maintenance truck to be assembled by semiskilled labor with significant local content. With the addition of panels and accessories it could be adapted for use as a bus, truck, or family car. Unfortunately, Ford's idea was not considered better by Southeast Asian consumers who preferred a more expensive and sophisticated Japanese truck. As a result of this experience, Ford introduced the Fiera II, a bigger, more advanced vehicle. This has a better market reception than Fiera I and is still being sold in Southeast Asia.

6. General Motors

GM had an idea similar to Ford's at about the same time. Interestingly, GM's idea seems to have been born at an AID sponsored conference on the role of transportation in the development at Pakistan. The outcome was the BTV (Basic Transportation Vehicle). The BTV was similar to the Fiera I--a 1.2 liter engine, low cost, locally assembled truck. Sadly enough, the outcome for the BTV was also similar to that of the Fiera, though for different reasons. In GM's markets, which were generally not the same as Fords, a major form of competition was the common practice of making light trucks out of old sedans by cutting off the back and putting on wooden boxes.

Though the BTV is still sold in some Central American and Caribbean countries, GM doesn't consider it much of a success. Recently, in the Philippines, GM has introduced its own second generation BTV, called, logically, MTV (Medium

Transportation Vehicle). This is a heavier duty model, more costly and sophisticated.

7. Dow Chemical

Chemicals are products that would not appear to require adaptation to developing country markets. However, the experience of Dow shows that even in this area, the appropriate products are not always the same as those sold in industrialized countries. Dow has a major R & D facility in Brazil to serve the Latin American market. This operation, called "R & D South", is staffed largely by Latin Americans and its focus is on Latin American needs and applications for chemical products. "R & D South" has led to the development or modification of several products specifically for local market needs. Examples: Polyethelene film impregnated with insecticide used to protect bunches of bananas while still on the plant; a low toxicity organo-phosphate for a Latin American cash crop; a herbicide for pasture land developed by a team of fifty agronomists and technicians from Argentina, Brazil, Colombia, Mexico, Venezerala, Central America and the Caribbean.

8. Singer Company

Singer is one of the ealiest multinationals and its products have long found a market in less developed countries. In addition to the traditional manually powered sewing machines, recent specialized machines that allow embroidery or knitting have created growing cottage industries in a number of villages and towns in Mexico and Brazil. In Ibitinga, Brazil, in addition to

work in the home, factories with as many as eighty Singer embroidery machines were set up. Now Ibitinga exports embroidery work to major world markets, such as Japan and the United States. Important in these efforts were the easy credit terms and training lessons given by Singer to its customers.

9. Some Implications from these Experiences

The number of observations is too small for firm generalizations but some implications are suggested by the above examples.

a. Good intentions do not guarantee success. The Ford, GM and Quaker examples all show firms who tried to do good. Sadly they found out not only that they didn't do very well by trying to do good, they didn't do very much good either, in that the market gave a negative or lukewarm response to their labors. These examples discourage other firms from making similar efforts. Though not cited above, the experience of CPC International, Pillsbury, Swift, and other American companies corroborates that of Quaker with Incaparina.

b. Persistence may pay. Ford and GM were generally rebuffed by the market in their initial efforts--Fiera, BTV, and DNT. However, following up on these and moving down the leaning curve with Fiera II and MTV and the Intec 77 tractor seems to suggest better success with the second generation of products designed specifically for

developing country markets. These appears to be a learning curve at work.

Persistence also shows in the Quaker case. After several years of red ink in the Colombian market, the operation finally began to show a profit. The important question is whether the positive effects of the learning curve are sufficient to offset the negative influence of several years of red ink.

A developed country example of the rewards for persistence is Toyota in the U.S. After a costly, disastrous experience in the U.S. in the early 60's Toyota came back after a few years to be the leading import car in America.

c. A technically appropriate product is not sufficient for success. The Fiera, the BTV, the DNT and Incaparina all could be presumably called technically appropriate products. In the case of Incaparina and other high protein food products, the taste factor overwhelmed the health value and protein content. An executive in a major multinational food company told me his desire was to develop a "very high protein, vitamin rich product that would be bad for your teeth and sell like candy or snack foods". He felt that that was the only way people would buy such health foods. "They do not buy foods like medicines" he said.

With the DNT, the problem which killed the product

launch was a lack of financing for farmers' purchasing. With the Fiera, the problem was the market's desire for something bigger and fancier than the company's idea of appropriate technology. In part, this could be a failure of marketing research. However marketing research never can be an omniscient predicter, especially in such new and unfamiliar market/product areas.

In short, all these examples suggest that where consumers have some choice, desires for taste, style, or prestige can kill the market for products which are technically appropriate in a purely functional sense. Communist countries apparently avoid this problem by eliminating choice.

Also, a product is not only part of the technology of a culture, it is part of the total cultural system. If other cultural links, such as financing, distribution or attitudes don't mesh with the product, the failure can be called a system failure rather than a product failure. The Singer examples reinforce the idea that other things are needed for success than simply the technologically correct product. In speaking of agricultural equipment, Swannack-Nunn notes that "successful utilization of these technologies is based upon the recognition of local needs, agricultural extension to popularize the technologies, credit schemes

to enable purchase, and complementary innocations to insure raised productivity".[4] Again, the appropriate product is part of a system.

d. Local R & D can increase the probability of success.

The above examples and others not mentioned here indicate that when a firm conducts local R & D the products it develops will be more attuned to local market and cultural nuances. Nestle's success with Nescafe derives in large part from local testing and adaptation. While Quaker had great problems with Incaparina, it had significant success with its own locally developed food products. In industrial products, Dow Chemical has a number of successful applications in Latin American coming out of its R & D in Brazil.

On the other side, some of the failures in the utility truck and tractor area probably resulted from the fact that most of the development work was done far away from the market--a lot of it in Detroit. Conversely, the most successful second generation efforts (Fiera II and MTV) had more local market imput than the initial products.

e. The Public Relations Aspect of Multinationals' Product Adaptation.

There is some suggestion in the examples cited that the multinational's motivation in developing basic on appropriate products for developing countries was not

profits but public relations. In the food industry, for examples, U.S.A.I.D. money gave the impetus to some companies to do research on high protein foods. The Ball Company also expects rewards from enhanced image rather than increased profits.

Suppotting the evidence here is a survey of twenty-four food and phamaceutical firms regarding the motivation for their efforts in developing-country nutrition programs.[5] The ordering of the reasons given was as follows:

a. Relations with local government

b. Relations with the home government

c. Relations with the public (company image)

d. Product Profit

e. Competition (fear of not being in a market that could become important)

f. Social good (public need, public service)

Adam Smith would be pleased to find "social good" last on the list because he mistrusted any business that claimed to be trading for the public good. I would be more optimistic for the future of appropriate technology, however, if product profit were closer to the top of the list. I believe corporate efforts will be more skillful and diligent if they see profit opportunities to be more important than public relations benefits.

B. Process Technology

Here again the conventional wisdom is that multinationals use the same technology abroad as at home--meaning that their production processes are too capital intensive for labor rich developing countries. Skinner, for example, says that "scope for substitution of labor for capital by multinational companies is considerably greater than is typically put in practice".[6] Though empirical evidence is limited, it does not appear to support that statement. Of course, Skinner's study was one of the earliest. Let us look at some of the evidence.

There may be companies who make conscious, careful efforts to study labor intensive production techniques for their developing country plants but I know of only one clear example. That is Philips, the Dutch electronics giant. They have a pilot plant in the Netherlands where they experiment with making radios and other Philips' products without all the expensive capital equipment used in their European factories. They even bring workers from developing countries both for training purposes and to make the techniques more appropriate.

The BTV should also be cited as an example of process technology adaptation. GM designed this, not just as a basic vehicle but also as one that could be assembled in simple facilities with extensive local content. It was estimated by GM that it would take only $250,000 investment to set up a BTV factory. The Fiera is similar on this count.

Robinson cites the example of Gillette who introduced the notion of the mini-plant, a plant specifically designed to produce

the lowest volume possible at a feasible cost.[7] Small is beautiful. Is it also economic?

C. Empirical Studies

1. Yeoman

Yeoman studied the foreign subsidiaries of thirteen U.S. firms and found little difference in the amount of capital per worker in plants in developing countries as compared with those in developed countries.[8] Where the cross elasticity of demand is low and where manufacturing costs are low relative to selling price, there is little incentive to adapt technology. This condition holds in the pharmaceutical industry.

On the other hand, where cross elasticities of demand are high and where manufacturing costs are a large fraction of the selling price, it was found that process adaptation was more extensive. More labor was employed in developing country plants. This was the case for home appliance producers.

2. Mason

Mason studied fourteen U.S. subsidiaries compared with fourteen closely matched local firms in the Philippines and in Mexico.[9] Mason's findings:

a. Techniques did not vary much between the Philippines and Mexico, i.e. value added per worker and capital per worker were about the same.

b. U.S. subsidiaries employed more capital per worker than national firms.

c. U.S. firms had higher value added per worker and paid a higher wage rate. The higher wages of U.S. firms resulted in a wage bill to capital service ratio similar to that of local firms.

d. A larger proportion of U.S. firms employment is in the factory, i.e. fewer salaried personnel. The skills mix differs also. U.S. firms use relatively more executive, technical and unskilled workers. Local firms use more skilled workers and accountants. One explanation for this: U.S. firms have more experience and well defined procedures and thus can use more unskilled workers. Local firms have less experience and less well developed procedures and thus use more skilled workers and accountants.

e. U.S. firms have a lower cost of capital and can use different production techniques and still remain competitive.

Mason concludes that U.S. subsidiaries can't be singled out for blame for the inappropriate factor proportions problem. He said national policies make labor too expensive and capital too cheap, affecting the production function of both national and foreign firms.

3. Baranson

Baranson did a detailed study of a Cummins diesel engine plant in India. He concluded that "For developing countries, it is not an either/or choice between automation and handicraft

technology. Technology should be viewed as a continuum of production techniques, with choices depending on the one hand on the scale and precision of production, and on the other on wage rates relative to capital costs--within the emerging framework of manpower skills and industrial capabilities."[10]

4. Chudson

In a U.N. sponsored study, Chudson found that "in many if not most large scale manufacturing operations, the opportunity for choosing from among the available technologies more economically efficient and at the same time labor-intensive technique is extremely limited... A significant number of replies to the UNITAR questionnaire indicate that foreign firms have looked into the possibilities with reasonable care and have made adaptations mainly in materials handling operations and in construction operations as well as in the simpler repetitive operations in technologically unsophisticated forms of food processing, pharmaceutical packaging and the like.[11]

5. Wells

Wells conducted a study on Indonesia and found that foreign firms tended to use the same capital intensive technology as used in their home markets which had very different factor costs.[12] Wells suggested a number of possible explanations.

a. The impact of engineering objectives (that is, technical efficiency and the prestige associated with technical sophistication and modernity).

b. Greater flexibility of output in the face of uncertain

market data (that is, rapid increase or decrease of labor is difficult; adding shifts for a machine-intensive operation is relatively easy, so likewise its shutdown).

c. Greater ease of managing machines than local labor, coupled with shortage of managerial skills, especially at the foreman and superior levels.

d. Response to government policies which bestow greater rewards on more capital intensive enterprises (for example, the greater ease of getting loans for fixed assets than for working capital; also the impact of tax incentives such as accelerated depreciation).

e. Greater consistency and higher quality of output.

f. The cost of developing a new, more labor intensive technology.

g. Low productivity of labor, thereby making cost per unit of output relatively high.

i. Desire to avoid "sweat shop" conditions where men do the work of machines.

6. Morley and Smith

These economists asked the direct question: "Do multinationals adapt their production processes when they move to a less developed country?" The somewhat surprising answer, which contradicts the conventional wisdon is: Yes, the production adaptation is significant and substantial, though it may not be optimal. They studied and visited U.S.

facilities of multinationals and their subsidiaries in Brazil. They present three kinds of evidence to support their conclusions.[13]

The first kind of evidence concerns fixed capital per employee. In six major industry categories in which U.S. multinationals are involved in Brazil the fixed capital per employee in Brazil is consistently far below that found in the U.S. It ranges from the food processing industry where capital per worker in Brazilian subsidiaries is less than one-fifth than in the U.S. to a high of about two-fifths in the fabricated metals industry.

The second kind of evidence relates to value added per employee. Here again facilities in the U.S. are way ahead of the same firms' plants in Brazil. The value added per employee in the U.S. exceeds that in Brazil by a ratio of 1.5 to 1 on the low side in the rubber industry to a high of 3.35 to 1 in the food processing industry.

The third evidence relates to the use of automatic versus non-automatic machinery in the factories. Here again, the average use of non-automatic machinery in Brazil is three times as great as in the firms' U.S. facilities. The lowest ratio is in motor vehicles where U.S. facilities use 18% non-automatic machinery as compared with 48% non-automatic machinery in Brazil. Two reasons given for this outcome were the shorter production runs in Brazil and the high set up costs for automatic machinery.

Morley and Smith also have an observation about output volume and the choice of technology. They note that mechanization can profitably occur only if the volume of output exceeds some threshold limit. If Brazilian plant output is below that limitwhile that of U.S. plants is above the limit, one would expect different production functions in the two countries. If both Brazilian and U.S. plants were above that threshold limit, one would expect similar production functions in each country and there should be no criticism of failure to adapt. The authors' visits to multinationl's facilities in both Brazil and the U.S. suggest that adaptation of production techniques was done only where economically profitable. They note for example that subassemblies can take advantage of economies of scale, and hense greater automation. Final products, on the other hand, suffer diseconomies of scale if there is product differentiation.

In-plant services are another area of difference. In Brazil, the plants use far more labor in materials handling, for example hand carts in preference to conveyor systems. In ancillary services, such as accounting, inventory control and production scheduling, further differences are found. In the U.S. these activities are accomplished primarily with computers. In Brazil they are generally done manually or with simple accounting machines.

7. Lipsey, Kravis and Roldan

In a 1978 NBER working paper,[14] these economists asked two questions: Do multinationals firms adapt to labor cost differences

by using more labor-intensive methods of production in LDCs than in developed countries? and Do multinationals firms' affiliates in LDCs use more capital-intensive methods than locally owned firms?

They concluded that both U.S.-based and Swedish-based firms do adapt to differences in labor cost, using the most capital-intensive methods of production at home and the least capital-intensive methods in low wage countries. Among host countries, the higher the labor cost, the higher the capital intensity of production for manufacturing as a whole, within individual industries and within individual companies.

When they attempted to separate the capital-intensity differences into choice of technology and method of operation within a technology they found that firms appeared to choose capital-intensive technologies in LDCs but then responded to low wage levels there by substituting labor for capital within the technology. Similarly, U.S. affiliates appeared to use technologies similar to those of locally owned firms but to operate in a more capital-intensive manner mainly because they faced higher labor costs.

8. Implications from Empirical Studies

The studies cited do not give a definitive answer about the appropriateness of multinationals' production techniques in developing countries. As White pointed out in a 1978 survey of this subject "the evidence is clearly mixed."[15] Perhaps more mixed than clear. The studies do suggest, however, that multinationals are doing much more economically appropriate adaptation

than Skinner apparently found in the mid-'60s. The important issue remaining is how much more adaptation could or should be done by multinationals?

III Conclusions

Technology is important to economic development. Multinationals are major suppliers of product and process technology. In a preliminary way we have looked at the appropriateness of the technology supplied by multinationals to developing countries. Some efforts are being made by multinationals in product and process adaptation. More could probably be done but we need more research before we have unambiguous guidelines as to what and how. As an example of the "more," Swannack-Nunn's study indicates "an untapped potential and a desire among agricultural equipment firms in the U.S. to participate in the development and production of intermediate technology agricultural equipment in the developing countries."[16]

What research should be done? From the viewpoint of this paper, there are two major participants--host countries and multinationals and research must be done on each. A number of the empirical studies cited mentioned several kinds of host country constraints: policies, objectives, and economic, cultural and behavioral variables. The more clearly these can be identified and evaluated, the better the technology supplier can react and adjust to them. We need to identify more explicitly what we call the absorptive capacity of developing countries.

We also need more research on the role of the multinationals. Given that developing countries have greatly different factor endowments and prices from those in the multinationals' home countries, why aren't these being exploited by the firms in an appropriate profit maximising manner? Or are they? Wells suggests that many firms overautomate their foreign plants[17] but some others cited seem to disagree. Is the firm behaving optimally given the host country situation or are there knowledge gaps and behavioral problems that keep the firm from using more appropriate technologies? Such are the kinds of questions with which this working paper must end. Perhaps, readers will suggest some answers--or avenues of investigation to find them.

FOOTNOTES

[1]"Appropriate Technology in World Bank Activities," IBRD, July 19, 1976, p.19.

[2]Conversation with my colleague, C.K. Prahalad, on this point.

[3]See also "Appropriate Technology-Legitimized!" by Seneviratne, Development Forum January-February 1979, p.3, He lists eleven factor endowments or constraints similar to those we have.

[4] Swannak-Nunn, "U.S. Business and Transfer of Intermediate Technology," Journal of International Business Studies, Winter, 1978, p. 123.

[5]"World Malnutrition," Alan Berg, Harvard Business Review, January-February, 1972, pp. 130-141.

[6]Skinner, cited in Robinson, International Business Management, 1978, p. 149.

[7]Robinson, Ibid., p. 147.

[8]W. Yeoman, "Selection of Production Processess in U.S. Manufacturing Subsidiaries," Dissertation at Harvard, 1968.

[9]Mason, The Transfer of Technology and the Factor Proportions Problem, UNITAR, 1970.

[10]Baranson "Automated Manufacturing in Developing Countries," Finance and Development, vol 8. No.4, 1971.

[11]Chudson, The International Transfer of Commercial Technology to Developing Countries, UNITAR, 1971, pp. 25,26.

[12]Wells, "Economic Man and Engineering Man: Choice of Technology in a Low Wage Country," Public Policy, Summer, 1973.

[13]Morley and Smith, "The choice of Technology: The Multinationals in Brazil," Economic Development and Cultural Change, January, 1977, pp. 239-264.

[14]Lipsey, Kravis, and Roldan, "Do Multinationals Firms Adapt Factor Proportions to Relative Factor Prices?" NBER Working Paper No. 293, October, 1978.

[15]White, "The Evidence on Appropriate Factor Proportions for Manufacturing in Less Developed Countries: A Survey," Economic Development and Cultural Change, October, 1978, pp. 27-53.

[16]Swannack-Nunn, op. cit., p. 123.

[17]Wells, "Don't Overautomate Your Foreign Plant," Harvard Business Review, January-February, 1974, pp. 111