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ANNUAL RESEARCH REPORT

Technology Choice and Employment in Developing Countries

Contract No. AID/otr-C-1326

A. GENERAL BACKGROUND

This research is addressed to technology choice and employment in developing countries. Previous Growth Center research on unemployment in developing countries, as well as the research of others on issues of technology, suggests that designing government policies to increase employment demands a fuller understanding of the behavior of individual firms. In particular, we intend to study firms' technology choice and adaptation behavior at the micro level, in terms of both standard economic variables and the backdrop provided by institutional and non-standard components of the environment.

B. STATEMENT OF PROJECT OBJECTIVES AS STATED IN THE CONTRACT

Our purpose is to try to understand how public policies can affect employment in the society as a whole by changing the environment in which individual firms choose technologies and the direction of change in technology. Four industries will be closely scrutinized, including the collection of data at the micro level on technology choice via a survey of a sample of firms within the four industries. There will be close collaboration with indigenous scholars and research institutes in the four countries selected for work during all phases of the project.

C. CONTINUED RELEVANCE OF OBJECTIVES

The general outline of project objectives remains unchanged.

D. ACCOMPLISHMENTS TO DATE

During the past year we have made good progress in three spheres. First, we have refined our objectives and have decided on the industries and countries which would be of prime concern (the "core module"). Second, we have established working arrangements with collaborators and institutions in each of the countries of our "target set" (Brazil, Colombia, Japan, and Taiwan) as well as outside of the set. Third, we have reviewed economic and related literature on technology choice and innovation, as well as more specialized, secondary data having a bearing on our core module and further narrowed the topics to be explored in the course of our work.

(1) In selecting components for the core module, several factors were weighed. To obtain results which would be generalizable, we wished to investigate a wide variety of industries, all of which exist under widely differing LDC environments. We have chosen industries of some importance in which there exists scope for substitution between relatively capital-intensive and labor-intensive techniques of production: cotton spinning, men's leather upper shoes, ploughs, and either bread or bricks.

(2) Working arrangements with collaborators in the four countries have been established. Each of the four groups has already begun evaluating various aspects of our core module.

Our collaborating institution in Brazil is FIPE (Fundacao Instituto de Pesquisas Economicas) at the University of Sao Paulo. This group, composed of J. R. Mendonca, J. A. Savasani, and H. D. Cruz, has received local funding for the project from the State government. In part because

FIPE's initial research suggested that there is little scope for technological substitution in the production of fruit juice and because of severe seasonality problems, this industry, which was previously considered for inclusion, will not be studied under the project.

In Colombia, the collaborating institution will be FICITEC (Fundacion Para el Fomento de la Investigacion Cientifica y Tecnologica), an interdisciplinary group providing technical assistance to small and medium-sized firms. FICITEC has experience in obtaining information on their clients' technological choices and how they were made. In 1972, they prepared a study of the export prospects of the leather footwear industry.

In Taiwan, our association will be with the Economic Planning Council of the Republic of China (EPC). In addition to Shirley Kuo, whom John Fei has worked with before, the EPC has one economist assigned to each of the four industries, and has provided some local funding. During this past year, they have been collecting both economic and technological secondary data on the industries chosen. They may, in addition, analyze the PVC (polyvinyl chloride) industry in which they are interested.

In Japan, two economists, R. Minami and Y. Kiyokawa, both at the Hitotsubashi University, are interested in an analysis of the Japanese cotton spinning industry. Professor Minami has spent the current year as a visitor at the Growth Center (under separate funding) when the modalities of the collaborative effort were worked out.

Preliminary arrangements on collaborators outside our target set are being made, with the ultimate aim of increasing possibilities for cross-country comparisons. These include Peter Kilby at Wesleyan University and James Pickett at the University of Strathclyde. Kilby will be studying

technology transfer issues at the micro level for the ILO. He is currently planning to consider two industries, in Nigeria and Malaysia, two in our core module, as well as planning to use some of the survey questions we are developing. Cardwell has discussed with the Strathclyde group the possibility of our having access to their extensive work on footwear technology.

(3) Obviously the specification of technology is important. In reviewing the literature on technology choice and innovation, plus the secondary data on the core module, in order to study the choice of technique, we have chosen a level of detail intermediate between the economist's measures of total capital and labor and the engineering approach of a complete listing of minute machine subprocesses. We will select a classification scheme, based on a linear graph description of the technology. The technological classification need not be the same for each of the sectors that we have chosen to study. Shoe production, for instance, allows the possibility of subcontracting soles, whereas spinning is more likely to be part of a larger spinning and weaving operation. Brick firing can be either in a discrete process chamber or a continuous process tunnel kiln. We will gear our survey questionnaires to the nature of the particular industrial technology.

Designing such specialized surveys demands the services of an engineer-consultant in each industry, plus a collaborator in each country. They will be able to give us information on the factors which limit technological flexibility. For example, after getting an overview of the general state of the art in the industry in each country, we can focus on such issues as the structure of its information network and the nature of its chief suppliers and then compare these with the other countries in our sample. Given the

importance of understanding the local technical conditions, we hope to use some of the money originally budgeted for outside consultants to hire consultants in the respective LDC's.

We are preparing guidelines for the initial interviews for the three Growth Center researchers who will be spending time in the field. We have also prepared a preliminary questionnaire for firms in each industry. In our surveys, as well as other phases of this project, the focus will be on six areas of special concern.

(i) Factor Market Imperfections and Capital Intensity

Many have argued that factor market imperfections provide an explanation for observed patterns of technology choice, but there has been little empirical research to document this. We plan to look at the structure of capital and labor markets, going beyond the usual description of the cost of capital and labor to incorporate institutional aspects such as the role of the extended family in providing credit, and the impact on labor costs of legislation on firing and layoffs.

We have found considerable interest in this topic in the collaborating institutions. The provision of credit to the industrial sector, particularly to small and medium-sized firms, is an important government policy objective In Brazil, FIPE has already initiated some research on capital and labor markets which will form a base for further research. In Colombia, tentative contacts have been made with sources in the Banco de la Republica which will be pursued and which may lead to cooperation with respect to data availability and research focus.

We plan to gather information on the structure of factor markets, particularly the capital market, using the usual sources of financial data, direct contacts with lending institutions, and existing studies to get a

detailed picture of how these markets work. We than intend to modify the conventional economic models of firm behavior in the light of the specific conditions found to represent the effects of the total structure on firms' technology choice.

Of course, we do not expect that factor prices, even when very broadly interpreted, will be able to provide a full explanation of the pattern of technology choice, but intend to move into less conventional and non-economic areas as well.

(ii) Scale of Production and Capital Intensity

It has become almost commonplace to argue that capital intensity tends to vary positively with scale of output. But most studies have not succeeded in disentangling the effects of scale from the effects of relative factor prices, other non-price government policies and market distortions, entrepreneurial behavior or various statistical problems.

In addition to such economic studies as Diaz's, Berry's, and Strassman's, there is a large, engineering type literature on the "optimal" process at various levels of output. This literature, however, rarely considers market variables and economic decision making. Therefore, it is difficult to distinguish hypotheses concerning changes in micro production processes with scale of output that are valid only in the United States from those that are more generally true.

If we should find that large firms tend to be significantly more capital intensive than small firms, then it is important for policy purposes to know whether the choice is due to underlying technological considerations, to different relative prices in a segmented market, or to entrepreneurial behavior. If it appears to be the first, controlling for both market conditions

and entrepreneurial background, we still have to answer what determines the range of firm sizes. The question of scale, then, cannot be treated as simply one of technological data, or of market incentives, or of personal preferences. Our stratified sample, using both market and institutional variables, should help us to disentangle these effects.

(iii) Innovation and Diffusion

The literature on technical change can generally be placed in one of three categories: (1) a macro theoretical approach to explain how innovations are induced, in essence a theory of the demand for innovations; (2) a historical, somewhat anecdotal approach at the firm level, using micro evidence of particular innovations, which usually looks at the supply side of innovations more than the demand and (3) the theory and empirical testing of technological diffusion through an industry.

The last is probably the most straightforward and empirically manageable of the three, since it is not concerned so much with the generation of new techniques as with the implementation of techniques new to the firm. Our discussions with engineers at MIT have helped us to isolate several major innovations--such as open end spinning or the elimination of the of the picking stage in cotton spinning; the consolidation of lasting into two rather than three machines in shoe production; the tunnel kiln as compared with a chamber kiln in bricks. From detailed information on market conditions and input costs, we should be able to determine under what conditions each innovation is profitable. To the extent that firms do not implement what appear to be profitable techniques, we can then use our analysis of the information structure and institutional constraints to explain the lack of diffusion.

These major innovations are generally developed outside the firms we will be interviewing and are of the "white collar" variety--innovations which occur as a result of a conscious effort on the part of a technically trained person engaged in an organized R & D effort. Small adaptations made within the firm, often on the shop-floor--i.e., "blue collar" innovations--are more difficult to quantify. Through our discussions with LDC engineers, we intend to isolate several representative subprocesses which are capable of within-firm adjustment.

(iv) Quality Variation

At a high level of abstraction, we can argue that quality variation is no different from product variation. Standard theories have focussed on national comparative advantages, so that at given world prices, a country should export those commodities intensive in the use of the relatively abundant factor of production. We can refine the theory to include the choice of quality. The difficulty comes in getting a grip empirically on the problem, since there is a large potential array of qualities for each commodity, and for each quality, an array of production techniques. We propose to isolate several crucial subprocesses to study the variation in technique with quality. Quite important will be the standardization and quality of the raw material and product. We do not want to prejudge the question by suggesting that there is an inverse relation between quality of product and labor intensity. For a commodity like shoes, for instance, labor intensity is likely to decrease with the transition from cut tires to plastic shoes, then increase again with the transition of low quality leather shoes and still more to high quality leather shoes. Our sample questionnaire includes some of the quality variation for three of our sectors.

A greater range of variation will have to be obtained through other information. such as existing studies on plastic shoes, cement blocks, and synthetic fibres.

(v) Information Networks

Instead of thinking of the firm as having perfect information about existing technology, it is more realistic to think of it as having very limited a priori information and being required to make decisions under uncertainty on the acquisition of additional information at significant cost. It seems natural to think of the cost and reliability of the technology information as depending on the structure of the information network and where the firm is "plugged" into the network. For example, firms whose managers belong to certain ethnic groups with natural contacts abroad are in a position to acquire high quality information at a much lower cost than those who do not have these contacts.

There has also been considerable interest in this question in collaborating countries. There are other studies in the general area of the transfer of technology emphasizing the role of information, but they tend to be more interested in formal channels--such as through licensing and patents. We will be looking at more informal channels and focussing on a detailed description of these channels for specific industries.

We plan to explore the nature, quality and relative costs of sources of information as perceived by spokesmen for the industries. We will use this information in conjunction with other information on specific techniques and on factor costs to determine whether certain techniques would be profitable for individual firms, and then to ask whether their pattern of technology choice is in accord with the postulated information structure.

(vi) Longitudinal Study

The Japanese cotton-spinning experience will be the only component in our core module which lends itself to both longitudinal as well as cross-sectional analysis.

Our ability to examine this industry over time is particularly apt not only because it reflects the ideal phases underlying the Kuznetsian transition of a "typical" developing society in its drive for economic maturity, but also because of the existence of detailed and accurate statistics which should provide us with a much fuller understanding of such changes at the industry level. We can note, for instance, a declining K/L ratio in cotton spinning during Japan's export-substitution subphase (1890 to 1910) giving way to capital deepening, as we would expect, once the labor surplus condition has disappeared (after World War I) and labor-saving innovations take over.

The phases even occur in terms of technology transfer. In the domestic capital goods industry, in particular for cotton weaving, we can see the transition from a foreign-machinery import substitution stage to an export-substitution stage, as epitomized by the export of the Toyota Automatic Loom. In the 1880s, spinning machinery was operated by Japanese workers who had been trained by foreign technicians. Later, the Japanese were themselves creating knowledge, as symbolized by the establishment of the Textile Industry Laboratory in 1918.

In our comparison of Japanese spinning with the U.K., we intend to focus on the areas of concern mentioned previously, with particular attention to information networks. The Japanese network seems particularly suited to technology transfer. According to Gary Saxonhouse's 1971 Ph.D. dissertation,

fully 87% of all spindles in Japan in 1909 had been supplied by a single English manufacturer, Platt Brothers of Oldham. This manufacturer, because it could draw on the entire range of U.K. experience, was thus uniquely qualified to serve as an information source. Throughout the history of Japanese cotton spinning, the Boren, an industry-wide trade association, controlled 97% of the spindleage. It had influence not only in technology transfer and technology choice, but also in the control of output. The individual Japanese firm's information network further differed from its British counterpart because of the former's tendency to be vertically integrated, and affiliated with many other companies through the zaibatsu system. The impact of this network relative to indigenous private and public R & D and engineering education activities will be examined in this context.

E. DISSEMINATION AND UTILIZATION OF RESEARCH RESULTS

Plans for dissemination and utilization of our findings relate mainly to the final year of the project and remain the same as in the original proposal. It should be noted, however, that we have an active collaborative group in three LDC's, plus in Japan, and the assurance of additional budgetary support from at least the Brazilian and Taiwanese governments.

F. STATEMENT OF EXPENDITURES AND OBLIGATIONS AND CONTRACTOR RESOURCES

	Contract Budget 1974-75	Actual Expenditures 1974-75	Obligations Incurred 1974-75
SALARIES AND WAGES	$41,543	$40,807	-0-
FRINGE BENEFITS			
TIAA, 24%	3,173	2,889	-0-
Non-TIAA, 17%	5,065	4,222	-0-
INDIRECT COST, 66% Salaries	27,418	26,933	-0-
OVERSEAS ASSOCIATES	18,750	2,387	427
CONSULTANTS. U.S.	2,200	1,100	-0-
PUBLICATIONS	500	-0-	-0-
TRAVEL	7,000	7,260	-0-
SUPPLIES & EQUIPMENT	3,500	3,388	150
DATA PROCESSING	2,000	-0-	-0-
	$111,149	$88,986	$577

Underspending reflects a postponement of work by overseas associates until the second and third years of the project; heavy use will be made of these funds while investigators carry on extended field research in Brazil, Colombia, and Taiwan during 1975-76. Data processing and publications expenditures are also being postponed for use during the next two years.

G. WORK PLAN AND BUDGET FORECAST FOR COMING YEAR

Lucy Cardwell and Mary Ann Baily will be spending the second half of 1975 in Brazil and Colombia, respectively. John Fei will be in Taiwan for a year beginning August 1975. After having conducted open-ended interviews with people in the four industries (some in connection with factory visits), with our local engineer-consultants, and with host collaborators this summer, they will prepare the final analytical statement of the hypotheses to be tested as well as the questionnaire required for the survey to elicit the necessary information.

The actual field survey will begin in January of 1976, following our final modifications during a dry-run period in December 1975/January 1976. By July 1976, the survey data will have been tabulated and "cleaned." In the summer of 1976, with the full analysis of our findings about to begin, Cardwell and Baily will probably return to the field to coordinate the final phase of activities with our LDC collaborators.

The projected budget for 1975-76 for these activities follows:

SALARIES & WAGES	$46.961
FRINGE BENEFITS	
TIAA, 22.3%	2,955
Non-TIAA. 17.9%	[illegible],034
INDIRECT COSTS, 75.5% W & S	34,516
OVERSEAS ASSOCIATES	43,400
CONSULTANTS	6,600
PUBLICATIONS	1.000
TRAVEL	8.000
SUPPLIES & EQUIPMENT	4,000
DATA PROCESSING	4,000
	$157,466