AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY
Economics

B. SECONDARY
General Economics

2. TITLE AND SUBTITLE
Production characteristics in foreign enclave and domestic manufacturing: the case of India

3. AUTHOR(S)
Leipziger, D.M.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1976	22 p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Bureau for Program and Policy Coordination, Agency for International Development, Washington, D.C. 20523

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In AID discussion paper no.33) Copies available at no cost from Naomi Copeland, Agency for International Development, PPC/EMS, Room 3665 NS, Washington, DC 20523

9. ABSTRACT

An estimation of Cobb-Douglas production functions for U.S.-owned and Indian-owned manufacturing affiliates. It was discovered that U.S. firms in the sample of manufacturing affiliates employ a less capital-intensive technology but a higher fixed capital intensity than Indian firms. Abstracting from possible differences in the age of capital between samples, the inference is that the technology imported by or developed for Indian firms would be more capital-using to produce the same bundle of output produced by the U.S.-owners. Also, it was found that U.S. firms in India face a higher wage-interest ratio than domestic firms and thus adjust the ex ante technology, so that on the average they utilize more fixed capital per man ex post than counterpart Indian firms.

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-AAC-193	
12. DESCRIPTORS	13. PROJECT NUMBER
	14. CONTRACT NUMBER AID/PPC
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

DEPARTMENT OF STATE

AGENCY FOR INTERNATIONAL DEVELOPMENT

Washington, D.C.

Bureau for Program and Policy Coordination

A.I.D. Discussion Paper No. 33

PRODUCTION CHARACTERISTICS IN FOREIGN ENCLAVE AND DOMESTIC MANUFACTURING: THE CASE OF INDIA

Danny M. Leipziger

A.I.D. Discussion Papers are circulated for the information of the addressees and their staffs. These papers are intended to serve several functions: to improve knowledge of analytical studies, research results and assistance policies among Agency personnel; to encourage the careful recording and analysis of Agency experience and problems by persons currently engaged in them; and to share such experience and ideas with interested persons outside the Agency. These papers are designed to stimulate and serve as background for discussion. They represent the views of the authors and are not intended as statements of Agency policy.

June 1976

TABLE OF CONTENTS

		Page
	Introduction	1
I.	Methodology	1
II.	The Data	3
III.	Results	5
IV.	Summary	9
	Footnotes	11
	References	14

Introduction

The issue of technology choice by foreign-owned manufacturing firms in less developed countries (LDCs) has received considerable attention from development economists.[1] Although empirical work has been limited, and results mixed, there is some evidence that foreign affiliates of multinational corporations (MNCs) select technologies which may not be as labor-intensive as economic theory would predict on the basis of factor endowments.[2]

The purpose of this paper is to compare the production characteristics of domestic Indian manufacturing firms with those of U.S.-owned manufacturing affiliates in India. This analysis allows us to examine the hypothesis that domestic firms are more responsive to the relatively lower wage-interest ratios prevailing in LDCs and that they therefore employ more labor-using technologies. Such an hypothesis is a logical extension of Reuber's /9/ finding that a higher degree of local equity participation or managerial control is associated with an increased probability that the firms choice of technology will reflect comparative factor costs. The converse hypothesis would support Strassman's /11/ finding; namely, that foreign firms are more responsive in adapting technology to local conditions than are local firms.

I. Methodology

We posit Cobb-Douglas production functions for the respective manufacturing sectors.

(1) $VA = AK_i^a L^b$; $i=T,F,W$

where VA = value added defined to include wages, pre-tax profits, interest, depreciation and net indirect taxes.

A = constant term

K_i = proxy for the flow of capital services

T = total capital assets

F = fixed capital assets

W = working capital defined to include inventories and cash

L = persons employed

a,b = respective output elasticities for capital and labor.

The production functions are estimated in logarithmic form for a matching sample of Indian-owned and U.S.-owned manufacturing firms. By matching sample, we mean that the Indian firm data is adjusted so that it corresponds to the industrial breakdown of the U.S. manufacturing sample in terms of the value added accounted for by each two digit industry. Therefore, we are comparing the technology employed by U.S. firms to produce a bundle of output in India vis-à-vis the technology that would have to be employed by Indian firms to produce the same bundle. If the estimated coefficients of the respective equations are shown to be statistically different using Chow's /1/ test, then we calculate the average capital-labor ratio resulting from the least-cost tangency of an isoquant and the factor-price constraint. We distinguish between diverse capital-labor ratios resulting from disparate technologies (i.e. production functions)

and diverse capital-labor ratios resulting from different factor price relations. In other words, we believe in both ex ante and ex post substitution, where a particular technology (e.g. plant design and machinery) is employed, yet where substitution possibilities exist between labor and capital in sub-processes or peripheral operations of the plant.[3] In Figure 1 therefore, an isoquant estimated for sample data depicts a particular technology (rather than a shelf of technologies) and the elasticity of substitution is assumed to be positive.

In Figure 1, k^{US} and k^{I} can be viewed as the average observed capital-labor ratio which U.S. and Indian firms have selected when facing their respective wage-interest relations. Assuming that the U.S. firm were confronted with the same wage-interest ratio facing the Indian firm, however, it would choose k^{US*} as its optimal capital intensity.[4]

We therefore are interested in the following analyses: a) comparing the production functions utilized by the U.S.-owned and Indian-owned manufacturing firms i.e., isoquant I versus isoquant US on Figure 1; b) if the production functions differ, comparing the technology differences which cause capital intensities to differ given equal factor price relations facing all firms i.e., compare k^{I} and k^{US*}; and c) comparing the actual observed capital intensities given diverse factor prices i.e., k^{I} and k^{US}.

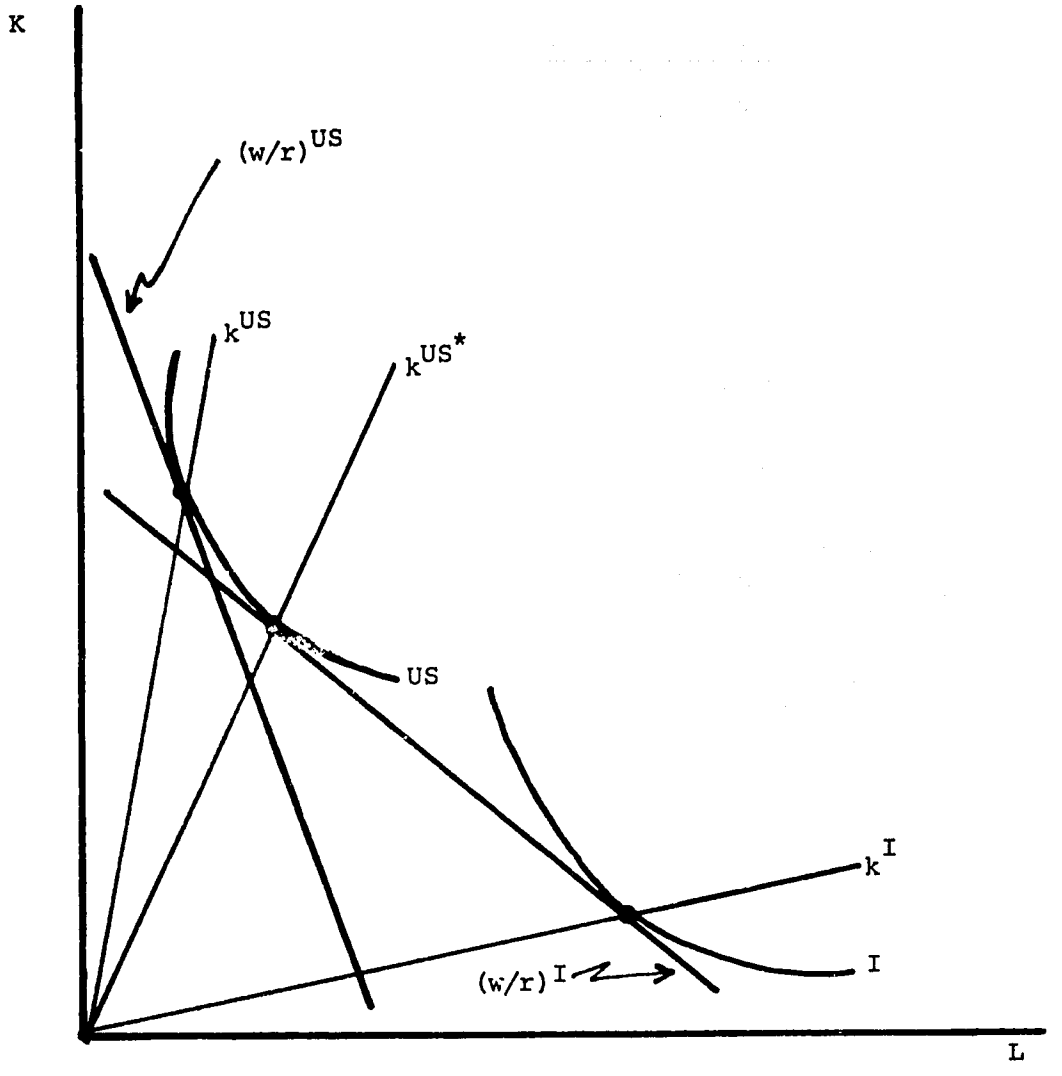
II. The Data

The Indian firm data as of 1964-65 is reported in the United Nations Industrial Development Organization's Profiles of Manufacturing Establishments and it includes fixed capital assets after depreciation (K_F) and

working capital (K_F) which sum to total capital assets (K_W) which sum to total capital assets (K_T); employment in terms of men on the payroll (L); and value added (VA). The 80 firms included are primarily single-establishment firms, with a few branch observations being aggregated into single data points. The data was converted to dollars at then current exchange rates. Comparable data for Indian affiliates of U.S. MNCs was reported for 1966 in the U.S. Commerce Department's Special Survey.

In order to compare the production characteristics of the U.S.-owned and Indian-owned manufacturing samples, adjustments are required to compensate for the fact that the industrial breakdown of the U.S. enclave is different from that of the domestic manufacturing sample. Therefore, while we first estimated production functions for domestic Indian manufacturing, we then proceeded to re-estimate the equations weighting the observations to match the industrial breakdown weights in the U.S. subset. In other words, if chemicals accounted for 25% of total value added in the U.S. subset, we reweighted the domestically-owned set so that chemicals account for 25% of total value added in domestic manufacturing. The effect of this adjustment is to compare the production characteristics of U.S.-owned firms producing a certain bundle of manufactures with the production characteristics which Indian firms would have exhibited, were they to produce the very same bundle in terms of a two-digit industrial breakdown.[5] The data on individual

Figure 1: Heuristic Presentation



Indian firms is then adjusted correspondingly with equal changes in a firm's labor, capital, and value added; the weighted variables are subset, we reweighted the domestically-owned set so that chemicals account for 25% of total value added in domestic manufacturing. The effect of this adjustment is to compare the production characteristics of U.S.-owned firms producing a certain bundle of manufacturers with the production characteristics which Indian firms would have exhibited, were they to produce the very same bundle in terms of a two-digit industrial breakdown.[5] The data on individual Indian firms is then adjusted correspondingly with equal changes in a firm's labor, capital, and value added; the weighted variables are denoted by L^*, K_T^*, K_T^*, and VA^*.[6]

III. Results

Ordinary least-squares regressions are reported for the Cobb-Douglas production functions, estimated for a sample of 80 domestic firms, utilizing three alternative measures of capital services.

$$\text{(2)} \quad \log VA = .037 + \underset{(5.59)}{540} \log K_F + \underset{(2.45)}{.316} \log L$$

$$\bar{R}^2 = .72$$
$$n = 80$$

$$\text{(3)} \quad \log VA = .358 + \underset{(4.07)}{.460} \log K_W + \underset{(2.96)}{.425} \log L$$

$$\bar{R}^2 = .67$$
$$n = 80$$

(4) $\log VA = -.716 + .572 \log K + .302 \log L$
$\qquad\qquad\qquad\qquad (4.97) \qquad {}^{T}(2.09)$

$\bar{R}^2 = .70$
$n = 80$

Unless noted all parameter estimates are significant at the 1% level. T statistics are reported in parentheses; $\bar{R}^2$ is the adjusted coefficient of determination; n is the number of observations. Testing of returns to scale indicates that equations using working capital and total capital exhibit constant returns to scale at the 1% level. In the case of fixed capital, the equations exhibit constant returns to scale at a 5% level of significance and decreasing returns to scale at a 1% level of significance.[7]

Adjusting the data to reflect the industrial distribution of two-digit manufacturing firms in the U.S.-owned sample of establishments, we obtain equations (5-7). SSR is the sum of squared residuals.

(5) $\log VA^* = -124 + .460 \log K^* + .460 \log L^*$
$\qquad\qquad\qquad\qquad (5.11) \qquad {}^{F}(4.29)$

$\bar{R}^2 = .79$
$n = 80$
$SSR = 10.65$

(6) $\log VA^* = -.426 + .384 \log K^* + 537 \log L^*$
$\qquad\qquad\qquad\qquad (3.40) \qquad {}^{W}(4.24)$

$\bar{R}^2 = .68$
$n = 80$
$SSR = 12.43$

(7) $\log VA^* = .817 + .579 \log K^*_T + .411 \log L^*$
(4.45) (3.21)

$\bar{R}^2 = .71$
$n = 80$
$SSR = 18.47$

It is interesting to note that the average capital intensity for the adjusted Indian data is higher than for the unadjusted data, reflecting the higher capital intensity of the U.S. bundle of output. This finding is interesting from the viewpoint of comparative advantage and a composition analysis of manufacturing; it indicates that indigenous firms in the aggregate either seem to be concentrating in industries requiring less capital per worker or the indigenous technology, ex post, is less capital intensive regardless of the industrial breakdown.

The production function estimates for the U.S. sample are reported in equations (8-10).

(8) $\log VA = 1.597 + .244 \log K^*_F + .623 \log L$
(2.08) (5.30)

$\bar{R}^2 = .61$
$n = 49$
$SSR = 6.83$

(9) $\log VA = -.823 + .948 \log K_W + .223 \log L$
(6.21) (1.93)

$\bar{R}^2 = .77$
$n = 49$
$SSR = 4.11$

$$(10) \quad \log VA = 1.226 + \underset{(4.79)}{.740} \log K_T + \underset{(2.71)}{.334} \log L$$

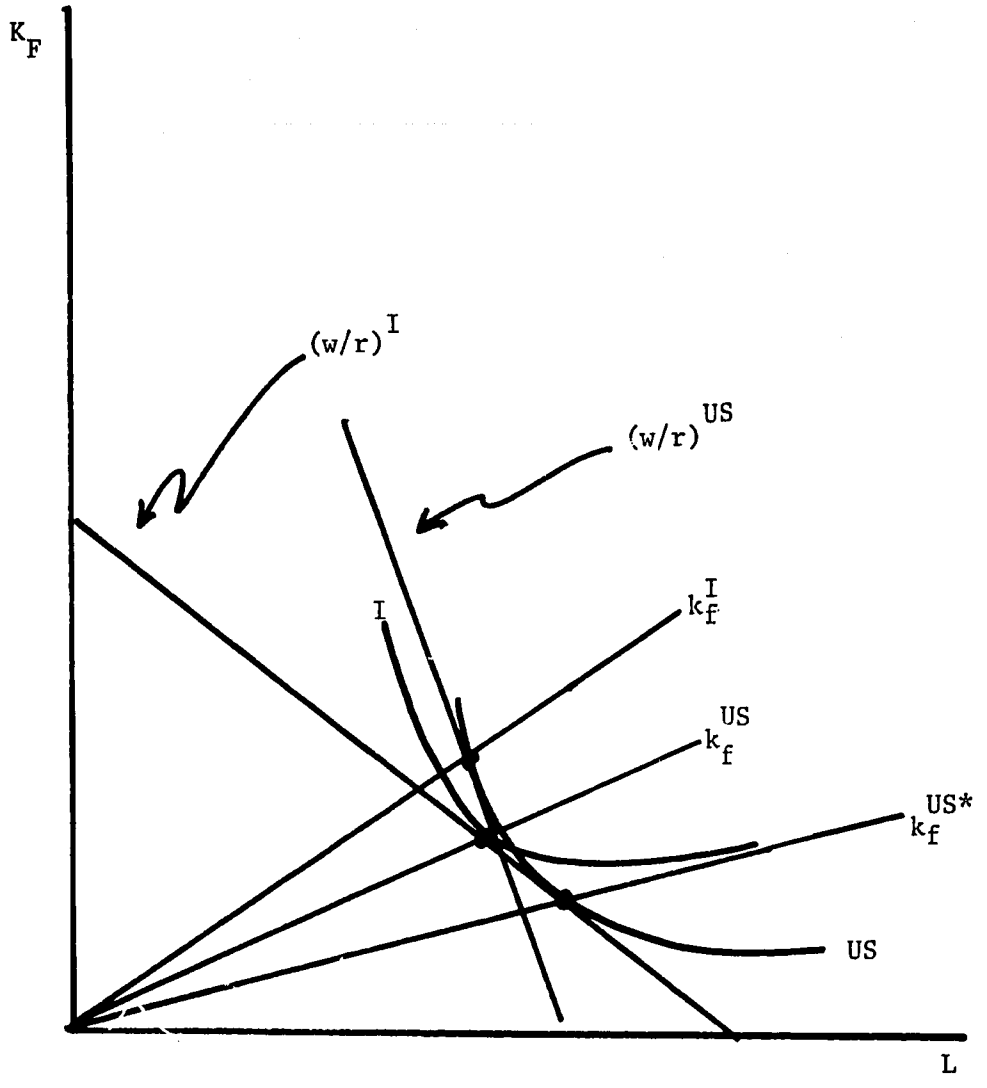
$$\bar{R}^2 = .72$$
$$n = 49$$
$$SSR = 5.04$$

The Chow test F-ratios indicate that the estimated equations for U.S. firms utilizing fixed and working capital, (8) and (9), are significantly different from equations estimated for Indian firms, (5) and (6), at a 1% level of significance. The estimated equations using total capital assets, (7) and (10), are not significantly diverse for the two samples, since differences in the productivity of working and fixed capital are being aggregated.

Since the respective samples exhibit diverse production functions in the cases of fixed and working capital, let us examine these differences more closely. Let k_f^{US} be defined as the observed averaged fixed capital-labor ratio for U.S. firms and k_f^I be defined as a similar variable for Indian-owned firms. A comparison of observed means, k_f^{US}/k_f^I yields a value of 1.296, indicating that U.S. firms employ more fixed capital per man than do Indian firms.

When we adjust the capital-intensity of the U.S.-owned firms to reflect the tangency of the U.S. firms' isoquant and the Indian firms' wage-interest constraint, we can recalculate k_f^{US}/k_f^I equal to .391. This can be interpreted as follows: the technology of U.S. firms is inherently less capital intensive than that of the Indian firms in terms of fixed plant and equipment. In Figure 2, therefore, when facing

Figure 2: Actual Configuration



a similar set of factor prices, the U.S. isoquant tangency occurs at an average fixed capital to labor ratio below that of Indian isoquant. When the constraint of equal relative factor prices is relaxed, however, and observed capital-intensities are examined, U.S. firms tend to exhibit more capital-intensive operations. These findings are consistent with the view that U.S. firms face higher wage-interest ratios and therefore, are encouraged to select a capital-labor mix biased towards capital use.[8] U.S. firms may face higher wage-interest relations as they: (1) may receive direct or indirect interest subsidies from LDC governments which stimulate the use of capital; (2) have greater access to internal capital from multinational parent companies at lower real interest rates; and (3) face perhaps stiffer union pressure than domestic firms, which raises relative wages.

In terms of working capital--inventories, cash, and input stocks--a similarly defined ratio k_w^{US}/k_w^{I} of .758 can be calculated. Thus, the average observed working capital to labor ratio for U.S. firms is <u>less</u> than the similar measure for Indian firms, perhaps due to management differences or a higher opportunity cost of capital for U.S. firms. The U.S. sample's output elasticity of working capital is significantly above that for the Indian firms; so that although the average holdings or working capital are low, its productivity is high.

IV. Summary

We estimate Cobb-Douglas production functions for U.S.-owned and Indian-owned manufacturing affiliates.[9] We discover that U.S.

firms in our sample of manufacturing affiliates employ a less capital-intensive technology but a higher fixed capital intensity than Indian firms. Abstracting from possible differences in the age of capital between samples, the inference is that the technology imported by or developed for Indian firms would be more capital-using to produce the same bundle of output produced by the U.S.-owned firms. We also find that U.S. firms in India face a higher wage-interest ratio than domestic firms and thus adjust the ex ante technology, so that on average they utilize more fixed capital per man ex post than counterpart Indian firms.

FOOTNOTES

1/ See for example Cohen, Hymer, Leff, Mason, Pack, Pickett, Reuber, Strassman, Wells, and Winston.

2/ See Courtney and Leipziger

3/ See Winston.

4/ k^{US*} is derived as follows:

(1)
$$\frac{a}{b} = \frac{\frac{\partial V}{\partial K}\left(\frac{K}{V}\right)}{\frac{\partial V}{\partial L}\left(\frac{L}{V}\right)}$$

definition of relative output elasticities, where $\partial V/\partial K$ and $\partial V/\partial L$ are the respective marginal products of capital and labor.

(2)
$$\frac{\frac{\partial V}{\partial K}}{\frac{\partial V}{\partial L}} = \frac{r}{w}$$

optimality in production requires the relative marginal products to equal the relative factor prices (e.g. isoquant, factor-price tangency).

(3)
$$\frac{K}{L} = \frac{a}{b}\left(\frac{w}{r}\right)$$

(4)
$$k^{US} = \frac{a^{US}}{b^{US}}\left(\frac{w}{r}\right)^{US}$$

(5) $$k^I = \frac{a^I}{b^I} \left(\frac{w}{r} \right)^I$$

(6) let $(w/r)^{US} = (w/r)^I$

(7) $$k^{US*} = k^I \left(\frac{a^{US}}{b^{US}} \frac{b^I}{a^I} \right)$$

5/ The very same results obtain if the U.S. sample is reweighted to match the Indian industrial breakdown.

6/ This scaling procedure is less accurate, the more the Cobb-Douglas diverges from constant returns to scale.

7/ To test whether or not constant returns to scale do obtain, we take the logarithmic form of (1) and obtain (8) by simple manipulation.

(8) $$\text{In } VA/L = \ln A + a \ln K/L + (a+b-1) \ln L + e$$

If the coefficient of ln L is not significantly different from zero, then constant returns to scale do prevail - namely, a + b = 1.

Equations 13-15 test for constant returns to scale for 80 domestically - owned manufacturing firms:

(9) $$\ln VA/L = -.037 + \underset{(5.59)}{.540} \ln K_F/L - \underset{(-2.01)}{.144} \ln L$$

(10) $$\ln VA/L = -.716 + \underset{(4.97)}{.572} \ln K_W/L - \underset{(-1.72)}{.125} \ln L$$

(11) $$\ln VA/L + 1358 + \underset{(4.07)}{.460} \ln K_T/L - \underset{(4.50)}{.114} \ln L$$

8/ The calculated $(w/r)^I$, where w is yearly wage per worker and r is net return to capital, is .43, while $(w/r)^{US}$ is .78.

9/ Sankar finds that Cobb-Douglas functions cannot be rejected in any Indian manufacturing industry except one in his 1950's sample; however, he does find increasing returns to scale in some industries.

REFERENCES

1. G. Chow, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," Econometrica, July 1960, Vol. 28, 591-605.

2. B. Cohen, "The Role of the Multinational Firm in the Exports of Manufactures from Developing Countries," Discussion Paper No. 177, Yale Economic Growth Center, May 1973.

3. W. Courtney and D. Leipziger, "Multinational Corporations in LDCs: The Choice of Technology," Oxford Bulletin of Economics and Statistics (forthcoming).

4. S. Hymer, "The International Operations of National Firms: A Study of Direct Investment," unpublished doctoral dissertation (Cambridge, Mass.), 1960.

5. N. Leff, The Brazilian Capital Goods Industry, 1929-1969, Cambridge, Mass., 1968.

6. R. Mason, "The Transfer of Technology and Factor Proportions Problem: The Philippines and Mexico," UNITAR Research Report No. 10, New York.

7. H. Pack, "Employment in Kenyan Manufacturing - Some Microeconomic Evidence," mimeographed paper, April 1972.

8. J. Pickett, D. Forsyth, and N. McBain, "The Choice of Technology, Economic Efficiency, and Employment in Developing Countries," Overseas Development Administration, February 1973.

9. G. Reuber, "Private Foreign Investment in Development," mimeographed paper, January 1973.

10. U. Sankar, "Elasticities of Substitution and Returns to Scale in Indian Manufacturing Industries," International Economic Review, October 1970, Vol. II, 399-411.

11. W. Strassman, Technological Change and Economic Development: The Manufacturing Experience of Mexico and Puerto Rico, Ithaca, 1968.

12. L. Wells, "Economic Man and Engineering Man: Choice of Technology in a Low-Wage Country," mimeographed paper, November 1972.

13. Winston, G., "Factor Substitution, Ex Ante and Ex Post," Journal of Development Economics, Vo. 1, No. 1 (1974), pp. 145-163.

14. United Nations Industrial Development Organization, Profiles of Manufacturing Establishments, New York, 1967.

15. U.S. Department of Commerce, Bureau of Economic Analysis, Special Survey of U.S. Multinational Companies, Washington, 1972.

A.I.D. DISCUSSION PAPERS*

Date of Paper	Discussion Paper No.	Title and Author
7/69	20	Aid, Performance, Self-Help, and Need by Alan M. Strout and Paul G. Clark
8/69	21	The Economics of Land Reform in Latin America and the Role of Aid Agencies by Dale W. Adams
10/71	22	Investment Composition and Employment in Turkey by James McCabe and Constantine Michalopoulos
11/71	23	Relative Prices, Capital Goods Imports and the Foreign Exchange Constraint: A Case Study of Argentina by Constantine Michalopoulos
11/71	24	The Nature and Impact of the International Market for Sugar by Keith Jay
12/72	25	Fiscal Incidence in Empirical Studies of Income Distribution in Poor Countries by Jacob Meerman
2/73	26	Payments Arrangements for Less Developed Countries: The Role of Foreign Assistance by Constantine Michalopoulos
6/73	27	Determinants of Use of Special Drawing Rights by Developing Nations by Danny M. Leipziger
11/73	28	Growth of Exports and Income in the Developing World: A Neoclassical View by Constantine Michalopoulos and Keith Jay
10/74	29	Multinational Corporations in LDCs: The Choice of Technology by William H. Courtney and Danny M. Leipziger
7/75	30	Evaluating Fertilizer Subsidies in Developing Countries by Dana G. Dalrymple

*A.I.D. Discussion Papers 1-19 are no longer in print.

ate of Paper	Discussion Paper No.	Title and Author
10/75	31	Food Aid: Disincentive Effects and Their Policy Implications by Paul J. Isenman and Hans W. Singer
10/75	32	Export Earnings Fluctuations and Economic Development: An Analysis of Compensatory Financing Schemes by Thomas Morrison and Lorenzo Perez
5/76	33	Production Characteristics in Foreign Enclave and Domestic Manufacturing: The Case of India by Danny M. Leipziger

DN-AAA-091
ARC # IN-338.0954-L531
1318/76