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Soviet Metal-Fabricating and Economic Development: Practice vs. Policy.
By DAVID GRANICK. Madison: University of Wisconsin Press, 1967. Pp 367. $8.50.

Professor Granick has written a thoughtful and provocative analysis of Soviet industrialization experience during the key development years of 1928-1937. His case study also analyzes the impact of this early period upon development policies through the early 1960's. Massive investments were made in the machine tool and equipment industries during the 1930's. The investment strategy was to concentrate available resources on large-scale, specialized plants utilizing the most advanced production techniques. Granick argues that this calculated effort to take a great leap forward in the 1930's was premature and resulted in widespread underutilization of scarce resources. This was due to both technological and organizational gaps over a prolonged period. First, there were widespread and prolonged deficiencies in supplier industries upon which the large scale, specialized plants depended for critical materials and parts. Secondly, under the planning frame of the 1930's and subsequent periods plant managers were impelled toward a product mix and a degree of vertical integration which ran counter to the overall planning strategy.

On the first of Granick's arguments, Soviet planners believed that the capital equipment associated with the more advanced continuous-flow techniques, which were then being introduced in American and European metal-fabricating industries, could not substitute for acknowledged deficiencies in skills and industrial organization. These advanced techniques required standards of quality control and interplant scheduling that were far beyond existing sector capabilities. There were also widespread deficiencies in technical and managerial skills during this period. Under these circumstances, Granick argues, it would have been more advantageous to introduce intermediate scales and techniques during this earlier period and later move into the more sophisticated technologies and industrial structures. This would have allowed time for the indispensible skills and industrial capabilities to be developed and the necessary adjustments in planning practise and managerial behaviour at the plant level to take place.

As for the second argument, considerable capital wastage occurred during the earlier period due to the widespread tendancy toward excessive vertical integration at the plant level which resulted from efforts by plant managers to offset widespread supplier deficiencies and meet production quotas. Under the planning frame, cost and quality considerations were also neglected. (An analogous situation exists in the seller's market created by protection and import control systems in developing economies.) In their efforts to suboptimize, Soviet plant managers were subverting the long-term goals of growth and productivity gains that Soviet planners hoped to achieve through specialized production among interdependent plants.

As Granick himself points out, his analysis suggests (but does not prove) that Soviet strategy during this period was not an optimal one. (This is at least true on an ex-ante basis, given the structural deficiencies that prevailed during this period.) But much may be drawn from the Soviet experience that is relevent to the industrialization problems of developing economies. To begin with the Granick analysis raises basic questions on the advisability of an all-or-nothing push into industrialization with a ~~bearing~~ heavy reliance upon capital-intensive techniques. A major thrust of the Granick thesis is that the premature introduction of advanced techniques may actually retard long-term growth. His evidence and analysis questions the "inherent advantage" in borrowing advanced technology as a means for overcoming basic deficiencies in technical and managerial skills. These technologies usually rely upon a high degree of inter-plant dependence, tight production schedules, and rigid standards and specifications for materials and parts - all of which are generally lacking in newly industrializing economies.

My own case study of Manufacturing Problems in India (Pergamon, 1967) reveals some of these shortcomings and constraints affecting diesel engine production in India during the early 1960's. The Indian experience in developing steel production also indicates marked difficulty (and economic loss) with the more sophisticated products and techniques during early stages of industrialization. (The success of the Bhilai plant, which was built with Russian assistance to turn out standard grades of construction steel using convential techniques, stands in contrast to the much more sophisticated plant built at Rourkela with German assistance and designed to produce the much more complex alloy steels requiring a much more complex technology and level of managerial skills.) For infant economies, less sophisticated technologies that rely more intensively on lower levels of skills may be more appropriate. Contrary to Soviet official policy, labor-intensive techniques were widely used in assembly, materials handling, equipment maintenance, parts inspection, and in other auxiliary production activities.

The Hirschman view that "machine-paced" technology forces an upgrading of managerial capabilities in such areas as maintenance and quality control may be valid. But the question raised by Granick's interpretation of the Soviet experience is whether this does not result in inefficient capital utilization in the long run because of what Toynbee would term an "inadequate response" to an "overwhelming challenge". The Soviet experience seems to suggest that an intermediate strategy and investment role would have been more advantageous. This would imply preliminary emphasis upon labor and engineering training and the establishment of more effective administrative systems.

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notes by LJL

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VEHICLE MANUFACTURING COSTS IN SELECTED

LATIN AMERICAN COUNTRIES

by

Jack Baranson*

*Author is a staff economist of the World Bank. All opinions expressed are his own and do not necessarily reflect Bank policies or views. The article is based upon an Economic staff paper soon to be released entitled "Automotive Industries in Developing Economies". Findings are based upon extensive interviews by the author with automotive and parts manufacturers in Europe and North America and field work in Argentina.

A growing number of developing economies have made determined efforts in the past decade to establish automotive industries. At least thirty developing countries now have automotive plants. These facilities range from single assembly plants turning out a few hundred vehicles a year to industrial complexes supplying 90 percent or more of components and parts for upwards of 200,000 vehicles a year. Even among the leading producers, the comparative cost of domestic value added has been double or more the international equivalent. Cost differentials have depended upon the size of the domestic market, the proliferation of models and plants (particularly among component and parts suppliers), and the combined effects of tariff (including protectist profits) and the exchange rate.

The analysis that follows provides inter-country comparison for the same vehicle manufactured in Argentina, Brazil, and Mexico. The data is broken down in three ways: Table 1 compares domestic costs with import costs and then net of taxes to arrive at resource cost differences. Table 2 analyzes cost increments as a function of domestic content. Table 3 compares the cost elements of labor, materials, and indirect charges. In interpreting the data it should be remembered that costs relate to a particular firm, a particular economy, and a particular point in time. The following should also be noted:

A. Costs to the firm vary depending upon: a) percentage of in-plant production, b) scale of plant, and c) capacity utilization. The size of the industrial economy and the stage of development have a profound effect upon cost decisions to make or buy particular components or parts.

B. Data applies to a given number of model configurations in an industrial complex turning out other series and models. Proliferation in the product mix, without proportional increases in overall volume, would shift the curves upward.

C. Domestic price structure, taxes, tariffs, and the exchange rate vary over time. Costs of domestic procurement, which loom large in the production bill, are influenced by obtainable profits of component and materials suppliers under non-competitive conditions and by their relative efficiency. Tax (or tariff) increases or a lagging exchange rate would shift cost curves upward. Devaluation, which was not offset by subsequent increases in domestic prices and production costs, would shift the curves downward. (Import costs increase, total cost measured in international values decreases.)

D. Costs reflect a particular point on the firm's learning curve. Improvements in plant efficiency, other factors remaining unchanged, would result in a downward shift in the cost curves. The same applies to capacity utilization, which may vary over time. It has not been possible to separate cost differences attributable to diseconomies of small scale production and those due to learning, but it would be very useful and significant to do so.

Light truck manufacture runs 2.5 times US costs in Argentina, 1.7 times as much in Brazil, and 1.6 times in Mexico (Table 1, column 10). Aside from obvious body differences, there is a close similarity in the production of light trucks and passenger cars both in terms of components and parts and length of production runs. Colum 11 gives domestic resource costs per dollar of foreign exchange savings - which is sometimes referred to as the "Bruno ratio" or the shadow rate of exchange.[1/] Thus, for Argentine cars, it cost $3,922 (pesos converted at official rate at time of procurement - column 1) to produce domestic content valued at $1,782 c.i.f. international costs (column 9) - a ratio of 2.20 (column 11). This means a peso valued at 550 to the US dollar (250 times 2.20) to equate the difference in resource costs. For a comparison of relative <u>resource</u> costs, tax estimates have been netted out of ex-factory costs for the ratios shown in column 12. Since the incidence of taxes on automotive manufacture are higher in Latin America than in the United States, resource cost differences are somewhat lower than those shown in column 10.

Table 2 shows cost increases as a function of domestic content.[2/] Implicit in these cost indices are the increased costs of domestic manufacture in the numerator and the so-called deletion allowance given by the overseas supplier. These deletion allowances characteristically are well below c.i.f. prices.[3/] Dramatic increases in production costs occur at the integration of

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1/ For reference to shadow rate computations, see Michael Bruno, <u>Interdependence, Resource Use and Structural Change in Trade</u> (Jerusalem, 1963), pp. 104-113. This ratio is closely related to the concept of effective protection, which is defined as the extent by which domestic value added (measured in domestic prices) exceeds value added at world prices.

2/ Definitions of domestic content vary widely. In some countries, it is defined according to value, in others to weight. What may be included in domestic value (e.g., indirect taxes, tariff duties, and categories of factory overhead) is also open to administrative decision.

3/ The "deletion allowance" is the amount deducted from the price of a c.k.d. kit for the parts no longer imported because they are to be reproduced domestically. Low deletion allowances reflect in part the actual cost of the the residual sub-assembly. But more importantly, low deletion allowances are a device for covering fixed overheads in industrial transplants and maintaining profit targets based upon a projected earnings base.

engine and driveline components (particularly in Argentina). Sheet metal for vehicle bodies also involves substantial cost increases. Column 13 in Table 2 indicates the magnitude of investment in equipment for manufacture of component and parts at progressive phases of domestic content. They are the lowest for miscellaneous parts outside the "power train" (engine and transmission), which make up about 20 percent of vehicle value.

Assembly of 100 percent CKD sets involves only moderate cost increases (Table 2, line 1). In fact, beyond a certain scale, decentralization of assembly plants close to consumer markets is often economically advantageous. But it is rarely justifiable on economic grounds for the production runs required by even the largest firms now located in developing countries. Vehicles assembled overseas from CKD (completely knocked down) units are more costly (three to ten percent more) than completely built up units. There are 30 to 40 percent savings on shipping costs because of the smaller freight volume, but these savings are offset by added costs of rust proofing and packaging against damage in shipping. Assembly and painting generally cost slightly more overseas than allowed as a deletion factor by the manufacturer. For low-volume producers in Sweden, special handling and packaging costs more than offset slight savings in assembly costs. Firms like FIAT have specialized in CKD operations and have managed to reduce costs to a minimum.

Tires, batteries, engine fluids, and flat glass are included under mandatory parts (in Table 2, stage 2). These are generally items manufactured locally for the parts replacement market even before domestic manufacture of new vehicles is undertaken. Items such as shock absorbers and small stampings (stage 3) can be supplied with minimum additional investment in production capability and are often produced by an established supplier manufacturing a similar item for refrigerators or other consumer goods. The forging or casting and machining of engine, axle or transmission parts (stages 4 and 5) involves both substantial investment and manufacturing know-how. In the US there is a negligible difference between make-buy costs for most items. In developing countries, in-plant costs, especially at scale, tend to be much lower than supplier prices - the joint result of protectionist profits and technical inefficiency.[1/] In large scale, competitive economies with well developed supplier capabilities, specialization among parts manufacturers is both feasible and advantageous The risk and uncertainty of markets and production in developing economies inhibit investments in parts manufacturing facilities when they can be purchased locally. It is generally necessary to persuade parts manufacturers in the home country (often with long-term contract assurances) to establish a manufacturing affiliate in the developing country, particularly in such items as wheel drums, brakes, and axles (stage 7), areas in which domestic suppliers generally lack the required capital or technical capability. Sheet metal for vehicle bodies (stage 8) involves the heaviest investment commitments by manufacturers.

Brazil is considered the best sourcing area from the point of view of price and quality of purchased materials and parts. The "closed-border" rule in Mexico, under which a manufacturer is forced to purchase from a local supplier once he is licensed and established, undermines efficient procurement. In Brazil, costs are lower relative to Argentina's because: a) the domestic market is larger; b) manufacturers have been operating longer and have in many cases already written off capital costs for equipment that is still in good working order; and c) Brazilian automobile manufacturers have had a longer period to develop suppliers, improve quality, and reduce costs. Price stabilization programs in

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1/ Volvo's success in manufacturing a relatively low volume of passenger cars for the domestic and world markets is in large part attributable to corporate capabilities to design and engineer automotive parts, which are then subcontracted to domestic suppliers on very narrow margins of profit. Volvo has followed this pattern for over 40 years.

Brazil and Mexico, in contrast to Argentina, have also been an important factor in keeping suppliers' profits (and end-product costs) down. In Argentina, the tendency is toward a further proliferation of vehicle models and parts manufacturers, in contrast to Mexican efforts to "rationalize" production by limiting the number of vehicle models and attempting to standardize components and parts production.

Table 3 shows that the major element contributing to high costs in Latin America is local procurement of materials and parts, which are either protected or carry high import duties. In Argentina, material and parts run average 3.3 times US costs and they constitute about 75 percent of total costs. Administrative and selling costs (four to seven percent of total costs) are twice as high in Mexico and six times higher in Argentina. Interest charges (and exchange depreciation losses) average about $126 per vehicle in Brazil as compared to under $12 per vehicle in the United States. Special tooling and amortization are also nearly three times as much per vehicle in Brazil and Mexico (on considerable smaller production volumes) than they are in the United States.

Capital costs per unit manufactured increase considerably at lower volumes of production. A European firm reported the following investment costs for a small passenger car:

		Index Factors		
Annual Production (Units)	Investment (US$ millions)	Production	Investment	Investment per Unit
180,000	$125.0	1.00	1.00	1.00
60,000	75.0	.33	.60	1.82
3,00	25.0	.02	.20	10.00

In most cases, firms have managed to keep capital charges down on short production runs by amortizing tooling dies on vehicle bodies over a five to 10 year period. This is less of a problem on designs with longer life cycles than it is on the more rapidly changing US models. In order to minimize capital costs, Volkswagen in Brazil is continuing to manufacture the older body with smaller windows. Similarly, Volkswagen in Mexico will retain the 1963 design until 1968. For domestic markets, this is a small price to pay for the capital savings. Variations in capacity utilization make a relatively slight difference because of the small percentage that constitutes fixed costs. This is even more true of firms with a high percentage of outside procurement; their percentage of equipment and fixed costs are proportionately lower and variable material costs higher.

Policy Implications

The empirical evidence presented in this article indicates that costs premia are largely a function of the diseconomies of low volume production. Improved production efficiency lies in the direction of longer production runs of the components and parts that go into automotive vehicles. This may be achieved through rationalization of production for domestic markets and, where feasible, outward orientation to regional and world markets. For domestic markets, costs may be lowered by reducing the number of models standardizing parts and consolidating plants. In some cases (as in LAFTA), markets may be extended and production rationalized on a regional basis. But the major cost reduction opportunities lie in the direction of specialized production of vehicles and components for world markets. Even the largest European producers are forced to market abroad 30 to 50 percent of their output in order to stay competitive. The US-Canadian Automotive Agreement is indicative of what might be worked out with an integrated LAFTA. FIAT is now planning to utilize a Yugoslav manufacturing affiliate as a global supplier of one of its passenger car lines. Massey-Ferguson has worked out arrangements with its Mexican affiliate to manufacture and export specialized tractor parts to the US and Canadian market. Such arrangements permit a developing economy to specialize in the less costly range of parts production, thereby improving efficiencies in resource utilization while reducing the net foreign exchange burden through export earnings.

Table 1

INTERNAL COMPARISONS OF COSTS:

ARGENTINA, BRAZIL, MEXICO, UNITED STATES, JANUARY, 1967

	LATIN AMERICAN COSTS[1/]					U.S. COSTS				RATIOS		
	Domestic Value Added	C.i.f. Value of Imported Content[2/]	Ex-factory (2-1)	Taxes[3/]	Cost Net of Taxes	Ex-factory[4/]	Net of Taxes[5/]	C.i.f. Latin America[6/]	Foreign Exchange Savings (8-2)	Ex-factory L.A./U.S. (3÷6)	Cost of Domestic Value Added[7/] (1÷9)	Resource Costs Net of Taxes L.A./U.S. (5÷7)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ARGENTINA:												
Car	$3,922	$ 693	$4,615	$1,463	$3,152	$1,775	$1,331	$2,475	$1,782	2.60	2.20	2.37
Trucks	3,092	977	4,069	1,290	2,779	1,634	1,226	2,469	1,492	2.50	2.07	2.27
BRAZIL:												
Trucks	2,816	180	2,996	1,013	1,983	1,752	1,314	2,587	2,407	1.71	1.17	1.51
MEXICO:												
Car (small)	1,440	1,440	2,880	311	2,569	1,756	1,317	1,956	516	1.64	2.79	1.95
Car (large)	1,884	1,883	3,767	407	3,360	2,297	1,723	2,497	614	1.64	3.07	1.95
Truck	1,315	1,315	2,630	284	2,346	1,604	1,203	1,804	489	1.64	2.69	1.95

1/ Cost in local currency converted to dollars at official exchange rate at time of procurement. (In the case of Argentina, this was prior to devaluation in March 1967, or 250 pesos = US$1.00.) Figures are for annual production runs of 20,000 to 30,000 vehicles - which is 5 to 10 percent the size of production runs for comparable vehicles in the U.S.

2/ These figures include allowances for import content of domestically supplied parts (estimated at 15% for Argentina, 30 percent for Mexico, and 10 percent for Brazil.)

3/ See footnote 5, below.

4/ Cost estimate for a "reconstituted" vehicle equivalent to the overseas model.

5/ Based on estimated average of 25%. This includes all Federal, State and Local taxes, except for taxes on profits and income. A comparable concept is used in estimating tax component for the Latin American countries.

6/ Difference in "C.i.f. Latin America" (Column 8) and "U.S. ex-factory" (Column 6) costs represents ocean freight, insurance and port handling fees; it does not include import duties.

7/ This is generally referred to as the "Bruno Ratio."

Source: Calculated from data furnished by American vehicle manufacturer.

Table 2

COST INCREASES AT SUCCESSIVE STAGES OF VEHICLE PRODUCTION IN SELECTED LATIN AMERICAN COUNTRIES, 1967

Vehicle Production Stages	ARGENTINA				BRAZIL				MEXICO				
	Cost Index 1/ (US=100)	Share of Local Content %	Index of Cost Increase (1)x(2)	Cumulative Index of Cost Increases	Cost Index 1/ (US=100)	Share of Local Content %	Increase (1)x(2)	Cumulative Index of Cost Increases	Cost Index 1/ (US=100)	Share of Local Content %	Increase (1)x(2)	Cumulative Index of Cost Increases	Relative Magnitude of Investment 2/
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Local Content													
1. Assembly	115	15	17	102	140	15	21	106	106	15	16	101	4
2. Mandatory Items	280	6	17	113	150	6	9	109	180	6	11	106	1
3. Easily Sourced Parts	320	4	13	122	160	4	7	112	225	4	9	111	2
4. Some Supplier Development Required	300	10	30	142	150	10	15	117	230	10	23	124	3
5. Engine & Driveline-Assembly and Machinery													
a. -Make	190	5	10	147	130	5	7	119	190	6	11	129	6
b. -Buy	400	3	12	156	270	4	11	126	240	1	2	130	
6. Engine & Driveline-Foundry													
a. -Make					160	13	21	134	220	10	22	142	5
b. -Buy	400	14	56	198	180	3	5	136					
7. Specialized Investment for Parts Production	430	9	39	228	200	12	24	148	240	8	19	153	7
8. Sheet Metal & Other Components	200	17	34	245	180	27	49	170	250	3	8	158	8
9. Sub-total	272	83	227		172	99	169		192	63	121		
10. Import Content	161	17	27	254	160	1	2	171	115	37	43	164	
11. Total Vehicle		100	254			100	171			100	164		

1/ Compares manufacturing costs for light trucks (see Table 15, Column 8 and footnote 1.) Computation of indices explained in note below.

2/ Investments ranked from lowest (1) to highest (8).

Note: This table illustrates costs of vehicle production in selected Latin American countries as compared with production costs in the United States. Column (1) shows the index of increased costs at each production stage as compared with US costs; Column (2) indicates the percentage value of local content to the total vehicle value for each production stage. Column (3) indicates the cost increase for each production stage: Column (1) x Column (2). Column (4) gives average total costs at each successive stage of production. For example, on line 2 under Argentina, 15 percent total content is produced locally at 15 percent (Column (1)) more than U.S. ex-factory costs (from line 1), 6 percent total content is produced locally at 180 percent (Column 1) more than U.S. ex-factory costs (from line 2) and the remaining 79 percent (100-15-6) is valued at U.S. ex-factory costs. The result is 113 (line 2, Column 4), computed as follows: .15(115) + .06(280) + .79(100) = 113. The cumulative cost index for the Argentine vehicle is 254 (line 10, Column 4.) In other words, a vehicle which costs $2,000 to manufacture in the U.S., would cost $5,080 to reproduce in Argentina.

Source: Calculated from data furnished by American vehicle manufacturer.

Table 3

COMPARATIVE ANALYSIS OF COST ELEMENTS IN THE MANUFACTURE OF LIGHT TRUCKS: U.S., BRAZIL, ARGENTINA, AND MEXICO, 1967

	DOLLAR COSTS[1/]					PERCENTS					RATIOS		
	United States	Argentina	Brazil	Mexico		United States	Argentina	Brazil	Mexico		Argentina/ /U.S.	Brazil/ /U.S.	Mexico/ /U.S.
1. Direct Labor	$ 170.98	$ 56.96	$ 35.95	$ 94.68	1.	10.3	1.4	1.2	3.6	1.	0.33	0.21	0.55
2. Material - Local	770.24	2,534.99	2,022.30	1,115.12	2.	46.4	62.3	67.5	42.4	2.	3.29	2.63	1.45
- Import	--	448.28	128.82	849.49		--	12.0	4.3	32.3		--	--	--
3. Variable Manufacturing - Overhead	335.32	224.14	--	71.01	3.	20.2	6.0	--	2.7	3.	0.73	--	0.21
4. Sub-total - Variable Cost	1,276.54	3,324.37	2,187.07	2.130.30	4.	76.9	81.7	73.0	81.0	4.	2.60	1.71	1.67
5. Manufacturing - Overhead	318.72	317.38	440.41	347.16	5.	19.2	7.8	14.7	13.2	5.	1.00	1.88	1.09
6. Special Tooling Amortization	16.60	28.48	44.94	47.34	6.	1.0	0.7	1.5	1.8	6.	1.72	2.71	2.85
7. Administration and Selling	46.48	284.83	197.74	105.20	7.	2.8	7.0	6.6	4.0	7.	6.13	4.25	2.26
8. Sub-total - Fixed Cost	381.80	630.69	638.09	449.70	8.	0.1	15.5	22.8	19.0	8.	1.65	1.79	1.31
9. Interest and Other Income Expenses[3/]	1.66	113.94	125.84	--	9.	23.0	2.8	4.2	--	9.	68.64	75.81	--
10. Totals and Averages[4/]	$1,660.00[2/]	$4,069.00	$2,996.00	$2,630.00	10.	100.0	100.0	100.0	100.0	10.	2.45	1.80	1.58

1/ Dollar costs for Latin Countries converted at prevailing official exchange rate.

2/ U.S. vehicle represents an average cost ($1660) for the three slightly different models. See table 43, column 6, U.S1 f.o.b. prices for "trucks" Brazil ($1752), Mexico ($1604), and Argentina ($1634).

3/ Includes losses due to exchange depreciation.

4/ Ratios shown here differ slightly from those given in figure 43 because U.S. base vehicle not the same, see footnote 2 above.

Source: Calculated from data furnished by American Vehicle Manufacturer.

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A NEW ORIENTATION FOR

AUTOMOTIVE MANUFACTURING IN

DEVELOPING ECONOMIES

by

JACK BARANSON*

*Author is a staff economist of the World Bank. All opinions expressed are his own and do not necessarily reflect Bank policies or views. The article is based upon a recently completed study on Automotive Industries in Developing Economies. The report will eventually be issued as a World Bank Economic Staff Paper. Findings are based upon extensive interviews by the author with automotive and parts manufacturers in Europe and North America and field work in Argentina, Yugoslavia and New Zealand.

Since 1950, there has been a significant trend toward the manufacture and assembly of automotive products by the developing countries themselves to satisfy their own needs, largely because of the insistence of the developing countries to reduce import requirements. Prior to then, except for certain assembly operations, automotive products were manufactured in home country plants for export to overseas markets. More recently, the more advanced developing countries such as Mexico, Brazil, Argentina, India, Spain and Yugoslavia, have been bargaining for export capabilities built into the manufacturing operations to help pay for continuing import requirements. In taking this stand, countries like Mexico and Yugoslavia have in effect followed the lead of Canada whose trade agreement with the United States has resulted in a substantial increase in Canadian parts manufacture for the U.S. market. For international corporations, this trend has posed new technical and managerial problems in servicing overseas manufacturing affiliates. For developing economies, it has raised a much broader and deeper issue on the economics of industrial transplants designed to supply domestic markets.

In 1965, about one million cars and trucks were being assembled and manufactured to varying degrees by over 200 firms in more than 25 developing countries. Spain, Argentina, Brazil, Mexico and India, accounted for 80 percent of the near million vehicles manufactured and assembled in varying degrees by developing economies. The other remaining 120,000 vehicles were assembled and partially manufactured in 19 other countries, with some turning out as few as 1,000 vehicles a year.

Vehicle Production, 1965

(Passenger Cars, Trucks, Buses)

Spain	212,500
Argentina	196,800
Brazil	180,800
Mexico	126,700
India	69,500
Venezuela	53,500
Portugal	37,000
Malaysia	25,000
Other (16) countries	93,400
Developing countries	995,200
All other countries	24,106,700
World Total	25,101,900

Adjustment Problems of International Firms

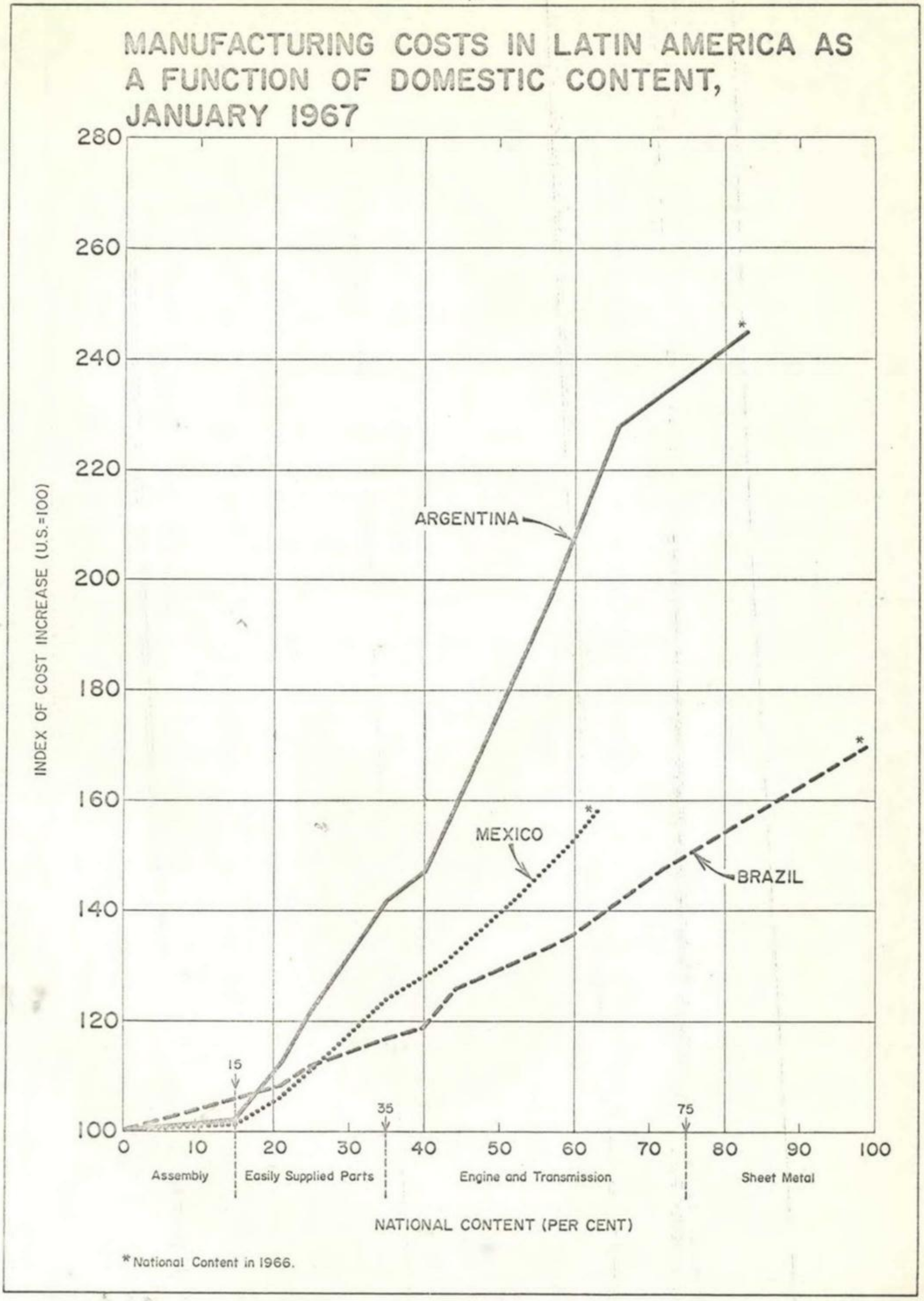
The requirement to develop overseas manufacturing capabilities has posed some basic dilemmas for international firms. One dilemma stems from the need to duplicate small-scale production facilities throughout the world at a time when competitive conditions and technology are moving firms toward corporate mergers and consolidations of production facilities. Among industrialized economies, rising wages and technological progress have forced corporate mergers and the adaptation of high-volume production techniques. This stands in contrast to operations in developing countries requiring small-scale assembly and parts plants using labor-intensive techniques. A second dilemma relates to the need to redesign products and techniques to fill specialized demands and small-scale markets. For example, Chrysler found it necessary to build 25 percent more value into Turkish trucks (axles, shock absorbers, and differentials) in order to withstand local road conditions and driver usage. But the size of local markets are generally too small to warrant the additional expenditures to adapt product designs or production techniques and to amortize special tooling costs on low-volume production runs.

In adjusting to overseas manufacturing as a necessary marketing condition, international firms have had to increase their commitments of financial and human resources, develop new capabilities for transplanting industrial systems, and adjust their attitude toward ownership and control of overseas affiliates. They have been faced with the problem of developing local suppliers, providing technical and managerial skills, and upgrading quality control systems to meet international standards. They also have had to increase investments in the face of the added risk and uncertainty of doing business in a developing country. The acuteness of difficulties and magnitude of adjustment have depended upon the stage of development of the industrial sector, the nature and degree of economic regulations in force, and the sophistication or complexity of the industrial transplant.

The major difficulties in running manufacturing plants are underdeveloped supplier capabilities, inadequate quality control, and a dearth of qualified technicians and managers. Achieving and maintaining quality standards in the production of basic materials for the manufacture of intermediate components is an especially difficult task in economies sheltered from competitive forces. Inferior quality undermine the entire fabric of production and indirectly contribute to even higher production costs than market prices indicate. Many basic materials that are considered standard stock in open economies often must be procured locally or specially ordered in small batches at considerably higher cost or at inferior quality. In high-volume production, precision and uniformity are built into automated equipment. Developing countries with limited markets are much more dependent upon the very machine labor skills in which they are deficient. They also lack the engineers and technicians to convert machine-intensive techniques to differences in factor costs and proficiencies.

Supplier industries are crucial in the development of an automotive industry. Outside plant procurement averages about 60 percent in countries like Mexico and Brazil, where supplier industries are not as well developed. The higher percentage of in-plant production intensifies the diseconomies of small-scale production. Given the foreign exchange constraints under which developing economies are attempting to industrialize, vehicle manufacturers are under relentless pressure to develop local suppliers of components and parts. The manufacturer-supplier relationship in developing economies is the exact reverse of what is typical of industrialized areas, where the manufacturer relies upon supplier know-how even to design required components and parts. In developing areas, it is the other way around; licensors have a heavy responsibility to help develop the supplier industry. Supplier industries, even in countries like Mexico and Brazil, typically lack engineering capability and foreign contacts to develop required capabilities.

Plants in developing economies are especially short of managerial and supervisory personnel to implant transmitted technology and carry on plant operations. This includes engineering, financial, and marketing people to plan, organize, and carry out a production program. There is an even more acute shortage of "conversion" personnel to adapt product designs and production techniques to local environments and deficiencies. Organization and management is especially critical in automotive manufacturing operations involving tens of thousands of parts and hundreds of suppliers. Plant engineering, quality control, production and cost control (including the preparation of



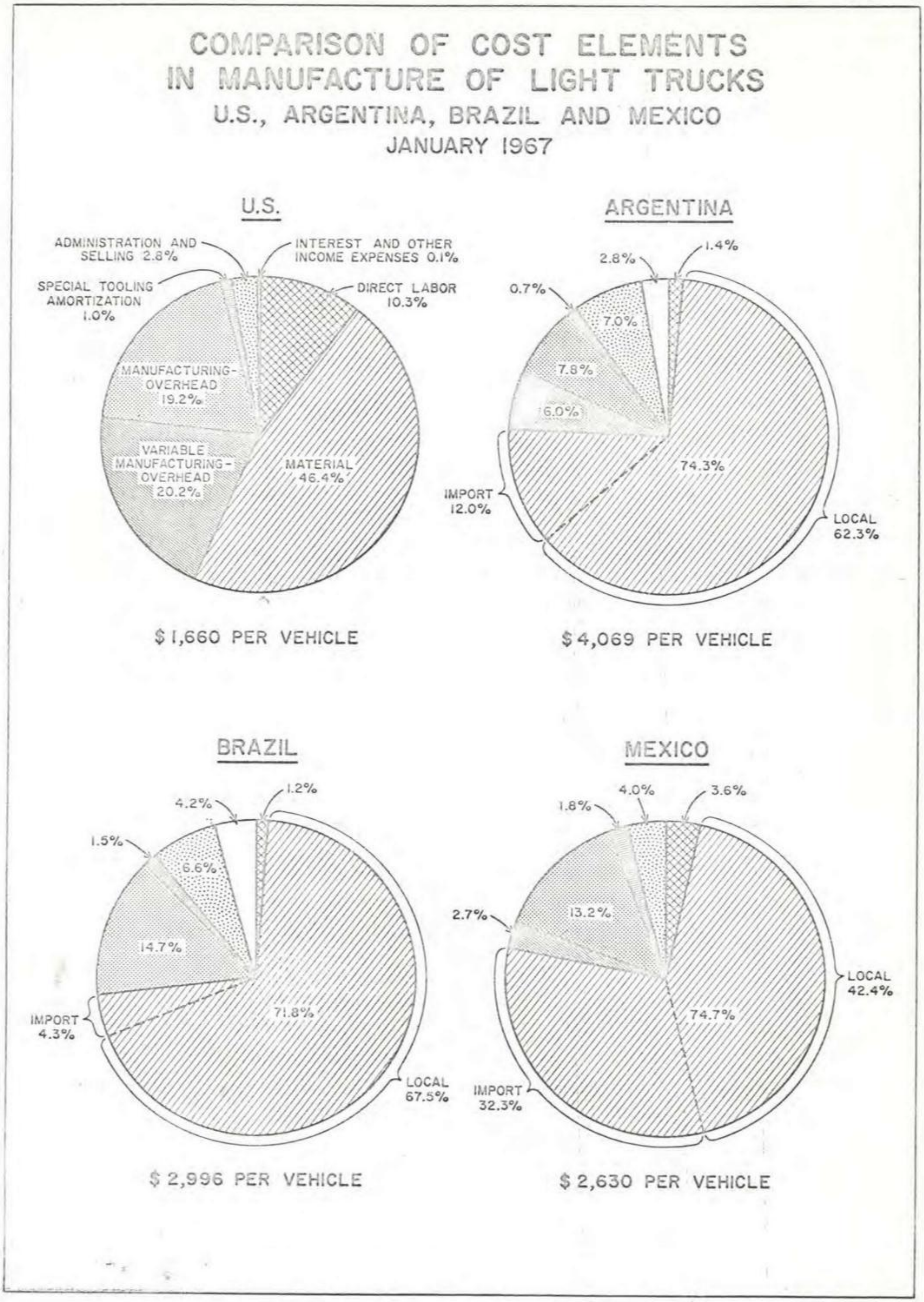
MANUFACTURING COSTS IN LATIN AMERICA AS A FUNCTION OF DOMESTIC CONTENT, JANUARY 1967
INDEX OF COST INCREASE (U.S.=100)
280
260
240
220
200
180
160
140
120
100
ARGENTINA
MEXICO
BRAZIL
*
15
35
75
0
10
20
30
40
50
60
70
80
90
100
Assembly
Easily Supplied Parts
Engine and Transmission
Sheet Metal
NATIONAL CONTENT (PER CENT)
* National Content in 1966.

production standards and machine-load studies), and inventory control are among the many specialties in which experienced personnel are difficult to find. Engineers from developing countries often lack the necessary practical experience to take over plant responsibilities and are often unwilling to soil their hands in factory operations. There is also an inadequate supply of the 20 to 30 middle-range managers, technical supervisors, and master mechanics necessary to set up initial procedures and improvise or make adjustments when things go wrong, especially during the first few years of plant run-in.

Economic Effects of Automotive Sector Expansion

Import substitution strategies which have guided the development of automotive sector in developing economies are aimed basically at reducing foreign exchange costs and improving overall efficiencies in national resource utilization. But progressive autarky under protective systems has lead to comparative costs that run two to three times international standards with a continuing or even expanded foreign exchange burden. Low-volume production for domestic markets of limited size has resulted in a widening technological gap in terms of vehicle designs and production techniques. High costs and technological retardation are in part due to the production inefficiencies and excessive profits that are inevitable under the limited competition that prevails in protected markets.

Production costs of the three leading automotive manufacturing countries in Latin America in 1965 ranged between 60 and 150 percent more than in the United States. A vehicle that costs approximately $1,660 to manufacture in Detroit averages about $4,070 in Argentina, $3,000 in Brazil, and $2,630 in Mexico. In each of these cases the production run is about 20,000 vehicles as compared to about 300,000 in Detroit. In Mexico, the relatively low cost premium is accountable by the fact that only 60 percent of the domestic content including assembly


COMPARISON OF COST ELEMENTS
IN MANUFACTURE OF LIGHT TRUCKS
U.S., ARGENTINA, BRAZIL AND MEXICO
JANUARY 1967
U.S.
ADMINISTRATION AND SELLING 2.8%
INTEREST AND OTHER INCOME EXPENSES 0.1%
SPECIAL TOOLING AMORTIZATION 1.0%
DIRECT LABOR 10.3%
MANUFACTURING-OVERHEAD 19.2%
VARIABLE MANUFACTURING-OVERHEAD 20.2%
MATERIAL 46.4%
$ 1,660 PER VEHICLE
ARGENTINA
2.8%
1.4%
0.7%
7.0%
7.8%
6.0%
74.3%
IMPORT 12.0%
LOCAL 62.3%
$ 4,069 PER VEHICLE
BRAZIL
4.2%
1.2%
1.5%
6.6%
14.7%
71.8%
IMPORT 4.3%
LOCAL 67.5%
$ 2,996 PER VEHICLE
MEXICO
1.8%
4.0%
3.6%
2.7%
13.2%
74.7%
LOCAL 42.4%
IMPORT 32.3%
$ 2,630 PER VEHICLE

is produced locally and the remaining parts are imported duty free.

Cost differences are a function of the size of the domestic market, the proliferation of vehicle models and plants, and the domestic content requirement imposed by government regulations. Tariffs and the exchange rate also have an indirect bearing on price differentials. There are also varying degrees of realized profits by parts suppliers and production inefficiencies under the protectionist regime.

The worst case on record for Latin America is that of Chile where approximately 7,800 vehicles were assembled in 1964 by 22 firms at four times what it would have cost to deliver a comparable vehicle to a Chilean port. Since only 40 percent of the vehicle is produced locally, this meant domestic value added cost about 8.5 times international costs. A rough estimate of the added resource costs to manufacture automotive products in developing economies is somewhere in the neighborhood of $1.3 billion. It cost developing countries about $2.1 billion in domestic resources to manufacture about $0.8 billion of internationally valued goods. (This cost differential would be reduced to about $1.1 billion if allowances are made for overvaluation of currencies and the somewhat higher tax incidence.) For an individual vehicle, it cost about $2,180 in national resources to manufacture about $840 worth of a $2,100 vehicle.

The major element contributing to high costs in Latin America is local procurement of materials and parts, which are either protected or carry high import duties. In Argentina, material and parts run average 3.3 times US costs and they constitute about 75 percent of total costs. Administrative and selling costs (four to seven percent of total costs) are twice as high in Mexico and six times higher in Argentina. Interest charges (and exchange depreciation losses) average about $126 per vehicle in Brazil as compared to under $12 per vehicle in the United States. Special tooling and amortization are also nearly three times as much per vehicle in [illegible] (on considerable smaller production volumes) than they are in the US.

A second problem has been that as production and consumption of automotive products have been allowed to expand, the foreign exchange burden has risen almost proportional to the rate of sector expansion, even with the offsetting effect of progressive increases in domestic content. In Argentina, consumption of automotive products was allowed to expand under the illusion that import substitution would allow rapid growth with little increase in foreign exchange costs. Under the Government decree, domestic production grew six-fold from 33,000 vehicles in 1959 to 200,000 by the end of 1965. By progressively increasing domestic content, this growth was planned with little or no increase in the foreign exchange burden. Actually, foreign exchange costs increased six-fold relative to the ten-fold increase in domestic value added.

A third major problem of adjustment relates to the "technological gap". Because of the high cost of tooling up for low-volume production, developing countries usually end up with vehicle models and production techniques that lag behind latest developments. Because of the high costs of research and development, little or no effort is made to adapt product design and production techniques to low-volume production. Nor is any effort being made to develop indigenous research and development capabilities. This pattern has important implications for future growth and development of the automotive industry; product proliferation associated with transplanted technology is not economic for domestic production, and obsolete products and techniques cannot compete in world markets.

A fourth major difficulty has been that once protection is built into a national economy, it is difficult to phase out because of vested interests. The windfall profits possible under systems of protection and import substitution encourage the mushroom growth of small-scale, inefficient plants until markets become saturated. The higher the tariff wall, the more extensive the inefficient growth, as the previously mentioned case of Chile demonstrates. As domestic markets are saturated and competition intensifies, survival becomes progressively precarious. Protection also dulls forces in the economy that could help develop more economic industries. The high cost structures induced under protection have tended to price most industrial goods from developing countries out of world markets, thereby undermining any effort to solve the basic problem of scale through volume production for larger world markets. Protectionist interests are also a major block to the development of regional markets

Restructuring Automotive Sectors Along More Economic Lines

Restructuring models must respond to three basic needs to a) improve production efficiencies (largely through longer production runs), b) reduce the foreign exchange burden, and c) reverse the trend toward a widening technological gap in vehicle design and production techniques.

Rationalization of automotive production for domestic consumption involves a) limiting the range of vehicle models and plants, b) standardizing components and parts and their interchangeability among models and makes, and c) selective adaptation of foreign design to local manufacturing capability and demand. To the extent feasible, regional arrangements to rationalize production and overcome the basic problem of scale should be pursued. Specialized manufacture for larger world markets is the principal alternative to further expansion of the high-cost range of import substitution. It may well be that the acceptance of industrial goods in world markets may give new impetus to LAFTA and similar regional arrangements. Export orientation should also help reverse the trend toward a widening technological gap which has characterized industrialization under import substitution. Product designs and production techniques for protected internal markets have lagged behind those associated with production for competitive markets.

Specific measures to improve production efficiencies through long production runs for local or regional markets may include programs aimed at the standardization and interchangeability of components and parts. In some cases, more economic scales have been achieved through the use of consolidated assembly facilities for various models and makes or through the joint utilization of a parts manufacture plant to serve a broader range of equipment manufacturers. Another approach to rationalizing production for limited markets is to redesign vehicle components or parts in order to decrease tooling costs for low-volume production. Substantial savings are possible through body designs that avoid contouring and require much less expensive equipment. Fibreglass bodies are also much more economical for low-volume production. Modular design principles based upon interchangeable body panels and the use of standardized mill forms for additional body and chassis elements also reduce production costs.

The other approach to increased production runs is specialized production for regional or world markets. There are numerous possibilities: 1) manufacture of specialized components and parts, 2) responsibility for a particular vehicle line, 3) specialization in low-volume replacement parts for obsolete models, or 4) reconditioning of engines and parts. Such arrangements are now in the process of being worked out by various North American and European firms. These arrangements are often feasible a) where production runs are small by international standards (such as in heavy trucks or specialized vehicles); b) where there is a low bulk-to-value ratio (such as in axles and transmissions) so that transport charges may be absorbed in the relatively high value of the traded parts; c) where there is a disproportionately high requirement for labor (such as in sand bus manufacture or in the manufacture of machine tools); or d) where a product or part is being phased out by the foreign partner and there is a need to maintain production of spare parts or a special type vehicle.

Developing economies will need to enlist the cooperation and assistance of international firms in restructuring their automotive sectors along the lines outlined above. Competition in world markets requires a combination of resources and capability in manufacturing, marketing, and research and engineering. Firms in newly industrializing economies generally lack the resources and skills to develop competitive products, efficient techniques, and distribution and servicing systems necessary to market products abroad. Typically, developing countries encounter an overriding difficulty in gaining product acceptance in world markets, even after they have attained technical standards and are cost competitive. This is in part a problem of psychological acceptance, in part a question of scale and resources to invest in world-wide distribution systems.

International firms on their part have a long-term interest in assisting developing economies along this line. Many firms now realize that future growth in these areas depends upon more efficient production and more favorable balance of payment effects. Competitive advantage in future markets will accrue to firms that mobilize the resources and develop the corporate capabilities to re-export from developing countries. Firms such as Massey-Ferguson in the tractor field and I.B.M. in the typewriter and electrical equipment field are already well-advanced in this direction. This trend toward a new international division of labor reflects the comparative advantage that multi-national firms have in engineering and organizational abilities to plan and carry out complex industrial operations on a global scale.

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Role of Science and Technology in Advancing Development of Newly Industrializing States

by

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World Bank

This study was prepared under a contract with the Department of State. The author is solely responsible for its contents, including the accuracy of both statements of fact and interpretative comments. Publication of the study does not imply official endorsement of its conclusions by either the Department of State or the World Bank.

Office of External Research

Department of State

January 1969

C O N T E N T S

Summary and Conclusions

Policies to advance science and technology in support of economic development should be conceived and carried out in the context of a particular country and its particular stage of development of human resources and industrial organization. This study has been concerned largely with industrial technology, since the technological development of agriculture poses a special set of problems in social and institutional development. A basic premise in this study has been that the primary goal in advancing technology is to achieve more efficient use of available resources and in other ways contribute to long-term economic growth.[1/]

Improved effectiveness in the technological sphere is dependent upon two interrelated dimensions. First, there is the need to develop concepts of how technology can be economically advantageous or appropriate. Economic policy has a strong bearing upon market structure, which in turn has a determining effect upon the design of products and production systems. Secondly, resources must be mobilized and applied and institutional arrangements developed to adapt and implant appropriate technology.

The salient themes that emerge from this paper are:

1. If adequate returns are to be realized from investments in research and technological capabilities, these activities must be directly linked to defined market or social demands and actual production environments.

1/ The role of technology in trade and development was the theme of a recent conference held by the National Bureau of Economic Research in New York October 11-12, 1968. It was generally recognized that investments in education and research influence efficiency in resource utilization and overall patterns of trade and development.

2. The implanting of indigenous capabilities to absorb foreign technology and engage in engineering of products and processes should be a fundamental goal of national policies on science and technology. Advantageous foreign licensing regulations are among the most important environmental factors that can favor technological progress.

3. Financial institutions chartered to finance projects that contribute to the country's technological progress are vital elements in national programs to advance technology.

4. Economic policies have an important bearing upon emerging technological structure and capabilities. Policies to close the technological (or managerial) gap cannot be divorced from the overall frame of economic policy.

5. As an economy moves from protected internal markets to more competitive world markets, the requirements for technology and capabilities are heightened. Dependence upon external support and partnership arrangements to acquire technology expands accordingly.

Policy on science and technology as formulated in this paper has addressed itself to the basic need in developing economies to adjust product designs and production techniques imported from modern advanced economies. This need for adjustment is proportional mainly to the technological gap between transmitting and recipient societies and the set of economic policies in force in the recipient country.

This paper has focused upon strategies and recommendations to enlarge and enhance the process of technological transfer. Included here are recommendations to improve the absorptive capabilities of recipients of technology and proposals on ways and means for donors of technology to enlarge or improve their role in the process of transfer and adaptation. Donors' assistance may take the form of investments in the training of scientists and technicians, funds to adapt engineering curricula to indigenous problems and needs, or financial support of research and development at the plant or industry level. Specific recommendations follow.

Programs and Measures by Developing Countries

National laboratories should be developed where necessary to help firms develop new product designs and production techniques - particularly small plants that cannot afford their own laboratory and development facilities. National laboratories can also operate in direct support of the agricultural sector, by finding new or more effective use of forest and farm products or wastes.

Industry and government can cooperate in organizing autonomous corporations (of the RAND or COMSAT variety) and, where appropriate, mobilize resources to finance ventures based upon frontier technology, This approach can be applied to the development of new sources of protein foods, water desalination techniques, low-cost housing, or educational television.

Governments should review industrial regulations and licensing practice to enhance and enlarge the role of multinational corporations as transmitters of technology and developers of indigenous capabilities to design products and adapt techniques. The experiences of Japan and Yugoslavia in providing guidelines for the negotiation of foreign licenses are instructive in this regard.

Further consideration should be given to the chartering of nationally based corporations that combine development of products and processes with capabilities for international marketing and manufacturing. Among these might be national corporations to develop low-cost housing, process domestic raw materials, and in other ways serve development needs.

National surveys should be carried out to identify gaps in the research capabilities or human resources needed to locate, adapt, or transmit technology from foreign sources.

A.I.D. and Other International Assistance

In general, A.I.D. assistance should concentrate on institution-building aimed at developing indigenous capabilities to absorb foreign technology and carry out programs of domestic research and development. In principle, funds should be allocated to cover the foreign-exchange component of the kinds of national programs outlined above or in support of experiments in international institutional arrangements. For example, international funds could be used for experiments with satellite communication for use in national educational television networks. Wherever feasible, funds should be channeled through national institutions that have an ongoing role in the country's technological development.

A.I.D. and others can assist in arrangements between university-industry complexes in industrialized countries and suitable counterpart institutions in developing economies. University-industry complexes can provide planning and design for school systems, housing and agro-industrial complexes and projects in the field of power and transport.

International assistance may also be appropriate to finance studies of a transnational nature. Included here are problems related to the international transfer of technology, the role of agents of change in developing economies, the technological component of commodities in world trade, and techniques in costing out alternative choices in technology and in forecasting technological change in the world economy. Such studies have been outlined in the body of the report.

International organizations can assist in bringing together foreign industrial groups with national authorities and financial institutions to upgrade technology as an ingredient of competitive production for world markets. For example, the United Nations Food and Agriculture Organization has been instrumental in the implementation of several agro-industrial projects by mobilizing international suppliers in the fields of agricultural processing and distribution.

Multinational firms are able to incorporate supply and demand characteristics of a particular developing economy into their global marketing and manufacturing systems. When they earn profits in this way, firms in developing countries derive special benefit from the economies of a scale achieved in production designed for larger world markets. Fiat's arrangements in Yugoslavia and Massey-Ferguson's contract in Mexico are indicative of what can be accomplished in this direction.

Basic Concepts and Definitions

Science and technology refers to a continuum of knowledge ranging from basic understanding to practical application. The two principal sources of technical knowledge are invention through discovery or experiment and innovation or adaptation to meet new needs or modified conditions. Research and development are activities which lead to discovery, invention, and application in a market-relevant sense. Development beyond the invention stage is generally necessary to convert a technical discovery to an economically useful product or production technique. Technical innovation must have a time and place relevance to be economically useful or commercially viable. (In India, pressure cookers and butane burners have been widely accepted by consumers, but solar cookers have not.) Beyond research and development, industrial engineering is concerned with the overall design of products and systems to meet the functional requirements of consumers at the most economic cost.

Technological innovation may be cost-reducing or time-saving, or contribute to safety or convenience. The same industrial good may be produced at different scales of production and by a variety of production techniques. Implicit in alternative techniques are varying combinations of labor management, equipment, and materials. Qualitative differences in labor skills, industrial management, and organization, and in available materials and other producer's goods, influence the relative cost and efficiency of a particular technology. The size of market demand is another major determinant of technological choice and relative production efficiency. Technological progress refers to the gains in economic output that are attributable to the more efficient use or combination of production inputs.

The limits of technological progress are set in part by the quality of human resources, social organization, the stage of industrial development, and the prevailing economic policy frame.

The supply and demand for technological innovation depend upon the commercial and economic contexts. On the demand side, an important distinction needs to be drawn between market demand and social demand. A firm's willingness to expend funds on product or process changes or innovations depends upon competitive forces to reduce costs or comply with consumer demands. In the choice of techniques, there are often substantial gaps between commercial and economic criteria due to factor price distortions. In most developing economies, unskilled labor is overpriced, capital goods are underpriced, and foreign exchange is undervalued. Firms responding to market prices tend to favor capital-intensive techniques and imported producer's goods and materials. Social demand is another matter. Among industrialized economies, there is an identified need for innovation in such fields as defense, space exploration, atomic energy, air-pollution control, and super-sonic air transport development. Among developing economies, there are analogous fields vitally affecting the public interest - water desalination, population control, cheap protein foods, and cost-competitive technologies for small-scale production.

On the supply side, a basic issue of national policy is the portion of technical knowledge or know-how that can be secured through domestic research and development and the residual that must be purchased abroad. Most developing countries are now almost entirely dependent upon foreign sources - in India 99 percent of industrial know-how is purchased under some form of collaboration agreement. In developing indigenous capabilities to design new products or adapt techniques, a major problem is to link research activity to research users. Technological structure refers to the products and techniques called forth by economic and social environments. Optimal technology refers to the most advantageous product and process design (in either an economic or a commercial context), given environmental constraints.

"Transfer space" has been usefully described as having vertical and horizontal dimensions. Vertical transfer refers to the transformation of fundamental science to product designs and production systems. Horizontal transfer refers to lateral transfer to other theoretical fields, other industrial applications, or other socio-economic environments. In the transfer process, there are elements of time and resource requirements, which are in turn conditioned by the degree of change or permutation in the transfer media and the transfer milieu. In the transfer of usable technology, the role of the technical entrepreneur is critical, coupled with a market opportunity at a particular point of time. In considering the problems of technological transfer, a basic distinction needs to be drawn between the transfer of technology embodied in products and equipment and the transfer of engineering and design capabilities to adapt and absorb technology.

Role of Technology in Development

Technological adjustment contributes to economic growth in a variety of ways. To begin with, it provides developing economies with opportunities to utilize their resource endowment more effectively, by economizing on "scarce" resources and making more intensive use of their "abundant" factors. Factor abundance and scarcity are themselves a function of the technology that can be brought to bear. In general, capital, foreign exchange, skilled labor, and management are considered "scarce" as compared to unskilled labor and certain natural resources which are relatively abundant. In the industrial development of Great Britain and the United States during the 19th century, a substantial portion of the technical innovation was in response to factor scarcities of industrial labor in the United States and of land and fuel resources in Great Britain. In the early phases of Japanese development, capital scarcity was in part overcome by using factory equipment more intensively on multiple shifts and with more labor assigned to tend and repair machines.

The need for technological adjustment stems from the fact that the products and techniques developed for the more affluent and industrially advanced countries are by no means best suited to the stage of development and factor endowments of developing economies. Underdeveloped areas find themselves in the basic dilemma of neither being able to utilize foreign technology effectively nor having the resources and capabilities necessary for conversion. Economies in the early stage of development are particularly in need of technological adjustment to the smaller scales of production for domestic markets and for the upgrading of technical capabilities to compete in world markets. The market demands of developing economies are typically a fraction of those in larger, more affluent nations and typically require plants one-tenth the optimal size by world standards. There is also a basic difference in equipment requirements. For small-scale manufacturing operations, universal-type, single-station equipment is more economic than the single-purpose, multi-station equipment typical of large-scale production.

The products themselves need to be adjusted to domestic patterns of customer usage, income levels, and other local factors affecting the cost and relative efficiency of industrial products. If the products are to be manufactured locally, further consideration must be given to adapting production techniques. Products and techniques that economize on scarcities such as foreign exchange and managerial skills are particularly applicable to the needs and deficiencies of developing economies. Technologies that can be handled efficiently at emerging levels of productive capacity and with available human and physical resources are specially advantageous at transitional stages of development.

It should be pointed out, however, that despite the need for small-scale or factor-adapted technologies, there are several factors which limit the range of adaptation. In opting for small-scale, labor-intensive techniques, it may turn out that the total capital requirements are actually greater for a given volume of output and total resource costs intolerably high. Another inhibiting factor is that opportunities to substitute labor for capital diminish rapidly as the technical standards and tolerances are intensified. Labor-intensive techniques often demand higher levels of human skills to replace machine precision and quality; precision and standardization are now built into machines with numerical controls to replace human skills. Moreover, there are substantial costs associated with converting acquired technology -- engineering and technical skills to convert transequipment and process steps. The ability of individuals and groups to adapt to industrial equipment and systems is an important factor in the efficiency and effectiveness in technological transformation and its contribution to economic progress. The effective use of "abundant" resources also depends upon the availability and utilization of concomitant, "scarce" factors. Developing economies often lack essential industrial capabilities or human resources to organize, manage, and control production. On mainland China, the failure of small-scale iron-ore blast furnaces using labor-intensive techniques is attributed to the low quality of coking coal and high transportation costs to service widely dispersed units. (Other social and psychological factors inhibiting adaptation of optimal techniques are described on p.14 ff.)

In fitting technology to environment, a country is faced with the alternative of either duplicating product designs and production systems with minor adjustments to accommodate differences in scale of production and relative factor availability, or making major adjustments in product designs and production systems to accommodate differences in the stage of development. The first choice involves investment costs in developing human resources and production environments; the second alternative entails technological conversion costs to adapt products and techniques. Limitations in the size of internal markets and related diseconomies of small-scale production force developing economies either to extend market size (through regional arrangements and export to world markets) or to adjust production techniques to less efficient scales.

Investments in new or adapted technology can serve economic development strategies in a variety of other ways. New technologies afford an opportunity to bypass historical stages in technological development. This may be especially applicable to social overhead investments in transportation, communications, and the development of energy sources. For example, new communication techniques (satellite television) may help overcome critical shortages in teachers and educational facilities. Modular design principles can help overcome the diseconomies of small-scale production in a wide range of manufacturing industries through the development of standard components and interchangeable product elements. Certain development strategies reinforce technological linkages - for example, the interaction between agricultural and rural based industrial technology. Rural-based industry is more likely to incorporate indigenous technological change or the rearrangement of factors along new types of labor-using production functions. Location of industry close to soil reduces difficulties of labor mobility and permits economic absorption of marginal labor, while reducing peak-harvest labor demands, transfer costs, and premature urbanization costs.

It should be pointed out, however, that the premature introduction of advanced techniques may actually retard long-term economic growth. This was the case in Soviet economic development during the 1930's. At that time, advanced continuous-flow manufacturing techniques were introduced into metal-fabricating industries, and the result was widespread under-utilization of scarce capital and managerial resources. These advanced techniques required a high degree of inter-plant dependence, tight production schedules, and rigid standards and specifications for materials and parts - all of which were then lacking or deficient in the Soviet economy. Intermediate technology geared to the emerging levels of technical skills and managerial organization would have been more appropriate.1/

1/ See David Granick, Soviet Metal-Fabricating and Economic Development: Practice versus Policy (University of Wisconsin Press, 1967). See also review of Granick's book by Jack Baranson in American Economic Review, September 1968.

Impact of Economic Policy on Technology

Under protectionist policies adopted in most developing countries, the tendency has been to industrialize in an extensive range of processing and manufacturing industries - everything from steel and cement to heavy electrical and heavy mechanical equipment. Inevitably, this results in spreading thin the critical, but scarce, technical and managerial skills needed to run industrial plants and handle modern technologies. Absorptive capacities are even further strained as developing economies advance from simple consumer goods such as home appliances and bicycles to much more complex products such as diesel engines, electrical transformers, railroad locomotives, and hydro-electric turbines - all of which most industrializing countries are now attempting to manufacture themselves rather than import from abroad. 1/ Policies aimed at progressive autarky foster high costs and undermine technical standards throughout the economy. Product designs and production techniques for the small-scale, protected markets lag behind latest developments, partly because of the high conversion costs for low-volume production. These technologies have a built-in obsolescence and are rarely able to compete in world markets. Another side-effect of "inward oriented" industrialization policies has been to nurture entrepreneurial and managerial groups that have little incentive to adapt and innovate in order to reduce costs or develop new products to

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1/ See World Bank Reports EC-161 and EC-162 on Manufacturing of Heavy Electrical Equipment in Developing Countries (May 29, 1968), and Automotive Industries in Developing Countries (May 31, 1968).

meet competition. Export-oriented producers are bound to be more sensitive to the needs for adapting appropriate technology and efficient methods and to develop the required technological resources.1/

Protectionist and import substitution policies also contribute to the high costs and inferior quality that often characterize procurement and production in developing countries. Industrial firms are compelled by domestic-content regulations to duplicate too broad a spectrum of manufacturing capabilities, a task that becomes progressively difficult in proportion to the sophistication of the transplant and its dependence upon special capabilities and skills. 2/ A basic difficulty in carrying out domestic-content programs has been the gap between the targets set by economic planners and what industrial managers actually have been able to achieve. Foreign industrial partners tend to be over-optimistic about overcoming manufacturing difficulties and developing local suppliers. Once the plant is established, unless it is allowed to continue to import components and parts, operational difficulties develop. Inferior quality in materials and parts and underutilization of capital equipment are among the major technical difficulties encountered. The practice of licensing new plants without significant regard for technical feasibility is basically at fault. It is not that the industrialization authorities are unaware of these technical difficulties, but rather that both parties involved in

1/ For a discussion of these and related items, see Harry G. Johnson, Economic Policies Toward Less Developed Countries (Brookings Institution, 1967); D. B. Keesing, "Outward Looking Policies and Economic Development", The Economic Journal (June 1967), 303-320; Albert O. Hirschman, "The Political Economy of Import Substituting Industrialization in Latin America", The Quarterly Journal of Economics (February 1968) 1-32; and Jack Baranson, Chapter 1 "The Role of Trade and Industrialization in National Development", Manufacturing Problems in India (Syracuse University Press, 1967), pp.1-17.

2/ See Technological Adjustment Requirements.

negotiating manufacturing licenses tend to underestimate procurement and manufacturing difficulties and the time it will take to overcome them. Government authorities set high domestic-content schedules to conserve foreign exchange, and corporations accede to them in order to get the license.

Aside from high production costs and continuing foreign exchange burdens, policies aimed at progressive autarky have fostered a seller's market which tends to undermine technical standards throughout the economy. These policies have also contributed to a widening of the technological gap between the developing and more advanced economies. Product designs and production techniques for the small-scale, protected markets lag behind latest developments because of the high conversion costs for low-volume production. These technologies have a built-in obsolescence and are rarely able to compete in world markets. The alternative is a gradual shift toward outward-oriented export industries, which have the advantage of viable market scale and the nurturing of a more effective managerial group. But these export markets also demand much higher technological standards in terms of updated product design and production techniques.

Under prevailing industrialization policies, adjustments in product design and production techniques are kept to an absolute minimum. This is because such adjustments are both costly and disruptive to industrial transplant activities. Generally speaking, changes in design are more frequent in home-country markets than in developing countries where competition is not as keen. But from the viewpoint of the developing economy, there is great potential advantage in products that are more closely adapted to local market demands and operational environments. For example, in developing countries, where crop yields per acre are low, harvesting combines require "big mouths and small stomachs"; in more advanced agricultural regions with higher crop yields, the need is for "small mouths, big stomachs."

The automotive industry is indicative of the long-term effect of progressive autarky under regimes of protection upon technological structure. As a consequence of the high capitalization costs in automotive production, developing countries usually end up with vehicle models and production techniques that lag behind latest developments. Because of the high cost of research and development, little or no effort is made to adapt product design and production techniques to the longer cycles associated with low-volume production. Nor is any significant effort being made to develop indigenous research and development capabilities. This pattern has important implications for future growth and development of the automotive industry in a developing country: product proliferation associated with transplanted technology is not economic for domestic production, and obsolete products and techniques cannot compete in world markets. A developing country needs to maintain international standards in product design and manufacturing specifications if it is to maintain its earning capability in the world economy. Export items also serve as benchmarks of quality and efficiency for industrial goods produced for the domestic market. This type of international involvement is the best assurance for the developing country maintaining a technological position which will assure continued growth in the world economy. 1/

1/ See World Bank Report EC-162 (31st May 1968), cited above, pp.59-62.

Various incentive systems, import licensing regimes, and foreign supplier credits also have important effects upon technological choices. Investment incentives in the form of income tax allowances for profits reinvested in capital equipment or accelerated amortization allowances have resulted in a higher degree of capital intensiveness than would otherwise be the case. In many instances the regime of import licensing designed to protect domestic manufactures also forces foreign procurement of larger or more costly equipment than is needed. This is often the case with heavier machine tools that are not on a restricted list as are the lighter domestically manufactured varieties. Similarly, the availability of certain foreign supplier credits induces excessive expenditure on capital goods.

Cultural Constraints in Technology

Social organization, cultural values, and behavioral patterns have a direct bearing upon a society's willingness and ability to adapt and absorb technology. Attitudes toward authority and change, achievement motivation, and the desire for material gain have an impact upon labor productivity and managerial proficiency. The propensity to innovate and take risks and a belief in scientific method are basic ingredients of the entrepreneurial function in technological transformation. Social, psychological, and institutional factors inhibit the substitution of labor for physical capital. These include labor policies and practices and managerial attitudes that reinforce the bias toward capital-intensive techniques. 1/

1/ For example, factor organization based upon kinship and personal relations rather than on ability or productivity, can undermine labor force efficiencies. Thus, textile mill owners in Northeast Brazil have found difficulties in modernizing work rules and breaking away from the traditional patron system. Workers recruited from traditional sectors in Southeast Asia seek personal relationships and individual recognition.

In India, individuals and groups accustomed to craft-oriented industry have had considerable difficulty in adjusting to the techniques and organization associated with modern, mechanized factories. In a highly mechanized Indian textile mill, efficiency of production and quality of output were lowered by the social values oriented to small cohesive groups. Workers felt lost operating isolated machines in a huge factor building. On automatic machines, they no longer had to service their looms, refill shuttles, or stop equipment to prevent damage, thus reducing "craftsmen" to "laborers." An American manufacturer of diesel engines in Northern Scotland encountered similar difficulty in adapting local labor to machine capabilities. Plant managers had difficulty in implementing a quality control system based upon machine precision rather than operator's skill. The Scottish worker simply refused to relinquish his pride in workmanship to become a mere machine-minder. This tendency of modern industrial systems to turn "machine-users" into "machine-minders" is keynoted in Thorstein Veblen's The Instinct of Workmanship and the State of the Industrial Arts (1918).

Management and its ability to plan, organize, and carry out production programs is an essential ingredient of efficient industrial systems. Much depends upon the quality of managers and the socio-economic environment in which they operate. One of the basic reasons why Professor Hirschman recommended "process-oriented, machine-paced" industries for developing societies is this managerial deficiency based upon differences in cultural attitudes and values. Managerial philosophy and underlying cultural values have a strong bearing upon the effectiveness of quality-control systems, the maintenance of technical standards, and the general ability to adapt and absorb technical knowledge. Managers and technicians raised in non-rational, non-scientific worlds do not necessarily believe in man's ability and the need to predict and control human activities. Science and technology are often viewed as a superior form of magic that can cause the desert to bloom. In certain cases managerial effectiveness is undermined by attitudes and values that are inimical to social efforts toward industrial progress. Professor Hirschman argues that both the "group-focused" and the "ego-focused" images of change can be inimical to economic progress; the former can diffuse efforts to a degree of social ineffectiveness, and the latter undermines the indispensable consensus and cooperation of other producers in an industrial society.

Functional or economic optimality in product and equipment design is also influenced by cultural preferences and modes. Industrial equipment is often designed to accommodate physiological and psychological differences among different societies and cultures.[1/] Professor Hirschman has argued

1/ For example, lighter weight welding tools and weight-lifting devices were introduced in the United States to accommodate the higher percentages of older people recruited during World War II. Pilot compartments and instrument panels of aircraft designed for American pilots had to be redesigned for the smaller stature typical of Japanese pilots. In India, workers normally tend machines while in a crouching position, whereas operational controls on machines designed in the West are at the standing for "built-in spurs" in equipment and systems to assure adequate maintenance in societies where the necessary industrial attitude and discipline are lacking. One argument for the use of less sophisticated, single-purpose machines is that they require a much lower level of skills to operate, maintain, and repair.[1/]

1/ References to Professor Hirschman's views are from The Strategy of Economic Development (Yale University Press, 1959), pp. 11-12, 139-43.

Technological Adjustment Requirements

Industrial technology consists of product design, production techniques, and managerial systems to organize and carry out production plans. Products and production techniques developed in modern industrial societies need to be adjusted to different needs and conditions encountered in developing economies. The nature and extent of transfer adjustments will depend upon the technical sophistication of the product, the prevailing trade and industrialization policies, and the technological gap between transmitting and recipient groups and sectors. The time and resources it takes to make the necessary adjustments depend upon the size of the gap, the absorptive capabilities of the recipient groups, and the level of protection of domestic production.

In an industrially advanced country, it is feasible to separate product design and production engineering. But this is rarely the case in developing countries, where there are significant gaps in industrial materials and processing capabilities. Too often, engineers from industrially advanced countries assume that production factors and environments will eventually adjust to equipment and techniques that have proven efficient in their home country. From an economic viewpoint, product designs and production techniques need to be adjusted to the industrial capability of the developing economy in terms of foreign-exchange requirements, quality-control demands, materials-standards range, and manufacturing-specification tolerances. For example, in designing a plastics industry for a developing economy with a small internal market, plant size, product range, and the factor mix of domestic and imported materials can be adjusted to minimize the added cost of small-scale production.

Economies may be realized by limiting the color range and variety of grades in basic plastic compounds. Products and techniques can be adjusted to an abundant raw material such as natural gas with supplementary imports of an item such as chlorine.

In a broad range of manufacturing industries, design engineers must decide whether to relax materials standards, change manufacturing specifications, or as a last resort, redesign components or parts to accommodate local materials, customer usage, or inability to handle a particular production technique. Where market development patterns are uncertain, it may be less costly in the long run to invest in plant and facilities whose output capacities can be increased incrementally as demand materializes and supply conditions allow. Similarly, processing facilities near physical resources are often economically preferable to increased investment in transport. Analogous adjustments apply to infrastructure projects. For example, flexibility in standards for power or water supply systems (sacrificing, for example some round-the-clock convenience to consumers) can result in considerable savings of resources that could be usefully employed elsewhere in the economy. Engineering solutions designed to minimize unit production costs at peak demand may waste resources in the long run.

The adaptation of manufacturing techniques to local conditions requires the very capabilities and industrial organization that developing economies lack and are anxious to develop. There is a marked difference in this respect between the absorptive and adaptive capacity of a country like Japan and that of newly industrializing societies such as India and Mexico.[1/]

1/ See Jack Baranson, Manufacturing Problems in India (Syracuse University Press, 1967) pp. 68-69.

The problems encountered by manufacturing affiliates located in developing economies in absorbing transferred technology are revealed in various studies that have recently appeared.

The major deficiencies found among local suppliers of automotive equipment were a) inadequate quality control, b) low level of technical sophistication and engineering capabilities compared to U.S. suppliers, and c) almost complete lack of research and development capabilities to adapt designs or production techniques to local materials, skills, and available equipment. Manufacturing firms that attempt to introduce products and techniques that are too advanced for the economy's industrial capabilities are especially vulnerable to phase-in difficulties. A dilemma arises from the fact that many international corporations are either unwilling or unable to make the necessary product design adjustments.

In face of import restrictions designed to increase domestic content, firms are often forced to procure materials and parts that are high cost or of inferior quality relative to continued imports. Most local procurement has to be custom-ordered in small batches, which means higher unit costs. This has been true of basic materials, and it also applies to such items as nuts and bolts, raw castings, and forgings. As a result of inadequate procurement sources, considerable managerial talent has to be devoted to cultivating domestic suppliers and rendering technical assistance. Time and resources need to be expended to convey industrial technique, develop quality control, and assist in equipment engineering. This is in marked contrast to industrially advanced countries where much of the technical know-how is with parts suppliers who advise manufacturers on product design and production techniques.

There is also the related problem of adapting systems to plan and control production. Although individual industrial tasks and manufacturing procedures are frequently efficiently performed, overall scheduling and coordination of production are often deficient. The difficulty may trace back to the basic problem of transition from craft industries to machine culture. In newly industrializing countries much time and effort are required to introduce the concept and use of process sheets, production standards, machine-load studies, materials control, and other plant-engineering and production-control procedures. When adopted, techniques are rarely applied in a systematic and comprehensive way, and the results are inevitably bottlenecks, shortages, and idle capacity, while machines or labor or materials wait on one another. Too often, managers in newly industrializing areas view rigorous production planning and control as an exaggerated fetish on the part of foreign engineers or as systems inapplicable to their environments.

Technical coordination between overseas plants and engineering-support facilities in the industrially advanced country is another thorny problem. Part of the difficulty is the sheer quantum of the transplant -- the thousands of process steps and the hundreds of materials standards and manufacturing specifications, in addition to the special adaptations that have had to be made in equipment and tooling to accommodate local supply conditions. The volume of technical interchange is particularly high during the phase-in period of manufacturing operations, which in the case of underdeveloped areas may run several years. One measure of a product's technological suitability for an underdeveloped area is the economic costs and time lag involved in transmission and adaptation. (See also Appendix F - Guidelines to Technical Adjustments in the Automotive Industry.)

National Programs to Advance Technology

National programs in support of technology should include the development of technical manpower to convert and absorb acquired technology, systems to locate and disseminate technical knowledge, the selective establishment of national laboratories in fields linked to developmental needs, and above all the reinforcement of technological absorptive capacity at the plant level. The broad tendency has been to over-emphasize the role of national and regional institutions as the major means of technological adaptation. One of the major criticisms levelled against national programs has been their tendency to engage in inappropriate projects that either are status-seeking or neglect the industrial sectors upon which the economy vitally depends. For example, Pakistan has been criticized for spending vast sums on nuclear research to the neglect of research on jute processing. National laboratories can address themselves more properly to areas of "social demand" for products and techniques. For example, applied research institutes can focus upon the immediate problems of raising productivity in such vital areas as protein foods or water desalination. (See Appendices A-D.) There may even be justification for special task forces in close touch with research centers in other parts of the world.

National laboratories have assisted industrial plants in the development of processing techniques and new products from indigenous resources. (See Appendix E.) National centers have also been helpful to small plants that lack their own laboratory facilities and need advice on the design and selection of manufacturing equipment. For example, the Indian government has sponsored a prototype production center to help select and adapt technologies for small-scale industries (the Small Industry Extension Training Institute in Hyderabad). SIETI has developed manufacturing techniques for bicycles, machine tools, and agricultural equipment, and arranged for foreign collaboration, built pilot plants, and trained essential technical personnel. 1/

There is much room for institutional innovation, depending upon the magnitude of the problems and the intractability of circumstances. Mission-oriented institutions, such as the RAND Corporation established by the US Air Force, can fill a vital need in identifying social problems and their technological interfaces. Other examples include Government laboratories (such as the US Department of Agriculture), contract research centers (such as the US Aerospace Corporation and the Institute for Defense Analyses), central industrial laboratories (such as Bell Telephone and General Electric's Research and Development Center), and multi-purpose research institutes (such as Stanford Research or the Battelle Memorial Institute). 2/

1/ Work has been done to redesign general purpose machines, portable pneumatic and electrical tools, traditional hand tools, and machine tools operated by human energy; for energy, automatic feed mechanisms in turning lathes and milling machines have been eliminated, and crank-actuated devices for reciprocating mechanisms on power shafts replaced. Suggestions also have been made to redesign interchangeable elements for machine tool elements such as power heads, motors, and ball-bearing systems, in order to reduce unit costs by increasing production runs on modular parts.

2/ See also Suggestions for Further Research, pp. 45-46.

Various international organizations have concerned themselves with the task of designing "intermediate" technology. For example, a group in London known as the Working Group of Appropriate Technology for Developing Countries has issued a directory of products manufactured by British firms that might be suitable for use and manufacture in developing economies. Principles of "value engineering" could be applied to the special sets of economic and cultural conditions found in developing economies.[1/] Value engineering is used to adjust product design without raising production costs, reducing the quality, or curtailing the product's basic function. In redesigning products for a developing economy, the aim could be to minimize scarce resource utilization, given the particular quality and functional requirements. This could be achieved in part through tax or subsidy, rather than leave product design and consumer choices entirely to market forces.

1/ See Lawrence D. Miles, Techniques of Value Analysis and Engineering (McGraw-Hill, 1961).

Coordinated efforts between industry and university laboratories have been increasingly common in industrialized countries. 1/ In Sweden, research and development companies are owned by a group of smaller firms to develop new product designs and production techniques. These research companies operate in close cooperation with universities and laboratory centers.

Cooperative efforts were begun in 1965 between the United Nations Food and Agriculture Organization and multinational corporations to help accelerate industrial expansion associated with the agricultural sector, broadly interpreted to include forestry and fisheries. Activities cover processing of raw materials from the agricultural sector and suppliers of sector inputs including seeds, fertilizers, farm machinery, processing equipment, and packaging materials. A joint committee includes FAO officials and senior executives of large international corporations. The purpose of the program is to match agricultural development opportunities with managerial and technical know-how to survey resources, develop markets, and engineer suitable product designs and production systems. Several agro-allied investments have been brought to fruition - for example, a new tomato paste industry in Turkey. The various sub-committees provide interaction among Government ministries, industrial groups, and financial institutions leading to project identification and implementation. New organizational forms and

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1/ For example, the Fluid Mechanics Laboratory at the University of Grenoble in France has developed, in cooperation with Electricité de France, a tidal energy project for the Bay of Mont-Saint-Michel. Special turbines that could pump water in both directions were designed and engineered to harness the tidal energy. Costs were shared for the construction of a rotating model to study the tidal movements. The Science Faculty, in cooperation with the Centre National de la Recherche Scientifique, also developed equipment for the frozen food industry. See Robert Trehin, "Links with Industry at the University of Grenoble," Impact of Science on Society (1965), 27-40.

analytical techniques employed in the joint efforts include demonstration manufacturing and marketing, consortia of production and service capabilities, goal-oriented systems approach to the survey of resources and development of investment projects, and corporate diversification schemes into new fields of farming and processing.

Education and training of technical manpower are important ingredients of national efforts to advance technology in support of development. A basic issue in the scientific manpower development field is whether to emphasize the development of excellence in scientific cadres or to focus attention upon technological institutions in support of economic development. There is a strong urge for quick payoff by the economic planners, but many scientists give high priority to the gradual build-up of institutions and scientific cadres from laboratory technicians to basic researchers. The latter emphasize the point that society must cultivate an understanding and appreciation of science and its role in adjusting technology to evolving social goals.

The flow of technical and scientific information from national and international sources to industrial plants is another important ingredient of technological development. Small firms are in a particularly disadvantageous position to identify and utilize technical knowledge. They must work through research cooperatives, develop risk-capital schemes, and take full advantage of special small-business legislation. Technological Digests, a monthly OECD publication containing abstracts of new industrial products, is a good example of an information-dissemination medium. Fiscal incentives to encourage research by private firms in these vital areas may prove effective. Matching grants to private firms for industrial research were recently introduced by the Australian Government (p.42).

There has been a growing trade in technological know-how among the industrially advanced countries, particularly in research-intensive industries such as chemicals and electronics. Effective interchange requires not only that technical experts from industrially advanced countries visit developing countries, but that engineers and technicians have an opportunity to work in the engineering divisions of firms in industrially advanced countries, so that they may take back with them realisitic ideas on products and techniques that can be used in home-country plants. The emphasis here should be upon developing a capability for technological innovation, rather than upon apprenticeship to learn how to do things the Western way.1/

Government policies toward foreign collaboration have a decisive bearing upon efficacy in transplanting industrial technologies. In India, foreign investment has been encouraged in order to acquire modern technology and to acquire additional foreign exchange resources through equity investment. While recognizing that foreign collaboration fills vital development needs during critical transitional periods of industrialization, most governments seek to limit foreign participation in terms of ownership, management, and the employment of foreign technicians. The propensity to discriminate against, and hostility toward, foreign enterprise has been cited as an important aspect of the economic nationalism inhibiting development.2/

1/ See reference to Fiat agreement with Yugoslav automotive manufacturer, pp. 32-33.

2/ See Harry G. Johnson, Editor, Economic Nationalism in Old and New States (Chicago University Press, 1966).

Tax incentives and other fiscal devices can be used to encourage research at the plant level and help train technologists. The widespread practice of giving tax allowances for investments in capital equipment has resulted in a higher degree of capital intensiveness than is economically desirable. Fiscal measures favoring the training and utilization of labor skills would be much more appropriate.

Relevant Experience of Japan and Other Countries

Japanese experience in adapting technology to available resources and skills and in developing the necessary conversion capabilities is in many ways a model for developing countries. Japan demonstrated a high degree of social adaptability to meet the demands of volume and standardization that characterize modern industrial systems. It was also eminently successful in developing "cottage industries" at the turn of the century as sub-suppliers to larger industrial complexes. By so doing, the Japanese were able to advance from simple to more complicated technologies on a massive scale. Japan's labor-intensive sector factories supply more modernized, capital-intensive plants.

Japan has also pioneered the adaptation of equipment to employ large numbers of relatively unskilled village labor. At the turn of the century, it imported second-hand textile machinery from England and used additional workers to mend broken threads and repairmen to keep the older equipment running. Several of the large industrial firms are outgrowths of small auxilliary shops to larger industrial groups. One such example is the Hitachi Machine Works, which started as a small repair shop for equipment used in the Hitachi Copper Mines. In the post-war period, Japan has continued to demonstrate its ability to adapt to changes in world markets.

The Japanese Government has **exercised** considerable influence over foreign investment and licensing. Government controls have aimed at maintaining Japanese industry on a technological par with world competition, and they have had much to do with Japan's successful thrust into world markets.[1/] Under controls applied by the Foreign Investment Council, the aims have been to obtain foreign licenses at reasonable cost, avoid where possible foreign ownership or prolonged dependence, and develop indigenous engineering and design capabilities. It is of interest to note that more recently, Japan has liberalized controls in order to fill important gaps in its industrial structure, recognizing that foreign firms demand more in the way of equity participation for sharing the more advanced or sophisticated technologies. These policies are reinforced by the Japan Development Bank, whose charter directs lending operations "to the promoting of technological development in order to strengthen Japan's international competitive position." Japan's industry has developed to the point where it is now itself a substantial donor of technology in world trade.

Two other countries whose experience may be relevant to the technological problems and needs of developing countries are Yugoslavia and Israel. Yugoslavia is an interesting case of a country in an intermediate stage of industrial development that has now become a transmitter of technology to countries like Egypt and Indonesia - partly as a result of barter arrangements and partly due to the fact that its product designs and production techniques are nearer to the income and scale requirements of developing countries. Yugoslavia has also been very astute in negotiating licensing agreements with foreign partners.[2/]

1/ See Terutomo Ozawa, Imitation, Innovation, and Trade: A Study of Foreign Licensing Operations in Japan (doctoral thesis, Columbia University, 1966).

2/ See reference to Fiat and Crvena Zastava, p.32-33.

Israel is a small country with a limited domestic market and poor in physical resources. Ninety-five percent of its industrial enterprises are small-scale, employing less than fifty workers. It has a widespread need to develop products from local resources and adapt techniques to small-scale production requirements. It is also constantly searching for industrial opportunities to utilize a comparatively high level of manpower skills. In the product development field, for example, Australian eucalyptus trees were imported to drain marshlands. Subsequent research disclosed that the tree had acquired additional properties in its new environment, and eucalyptus pulp is now used to manufacture insulation material and cardboard. Newsprint in Israel is produced from another variety of eucalyptus, thereby doing away with both wood-pulp and paper imports. A good quality pulp is also derived from corn stalks, and previously discarded cotton stalks are used to manufacture fiberboard and other building materials. A high quality paper has also been developed from fibers of a plant that thrives on the saline soils found in the Wadi Araba. Chemical by-products include a new drug from the agave fiber plant, and plastic glues and tannin are derived from eucalyptus bark.

(On the need to explore further the experience of other countries in acquiring and adapting foreign technology, see Suggestions for Further Research, pp.43-44.)

Potential Role of Foreign Enterprise

Foreign enterprises can assist developing economies in the vital tasks of adjusting imported technology and developing long-term research and engineering capabilities. As part of international marketing and manufacturing complexes, firms in developing economies can be assigned manageable manufacturing roles at emerging levels of technological capabilities. Foreign firms engaged in multinational marketing and manufacturing are in a unique position to incorporate design parameters drawn from developing economies into other world market requirements. For example, the Cummins Engine Company designed and built a light-weight diesel engine with fuel economy features and low costs on initial outlay to fit the stop-and-go delivery truck market in the United States, the small truck market in Latin America, and a new line of passenger cars in Great Britain. 1/ This type of research and design support is especially critical in technologically dynamic industries. Opportunities to serve world markets have the dual advantage of earning foreign exchange and narrowing the technological gap, because these activities must compete in world markets.

Recent arrangements negotiated between Fiat of Italy and a Yugoslav automotive manufacturer (Crvena Zastava) are indicative of the opportunities in this field. 2/ Under the agreement, the Yugoslav plant will expand vehicle production from 40,000 to 130,000 units a year by 1972. This expansion in volume permits the Yugoslav plant to make the critical volume jump from

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1/ Baranson, Manufacturing Problems in India, p.121.

2/ World Bank Report EC-162, (cited in footnote 1, page 9), p.48.

production limited to the domestic market to more efficient higher volumes for regional and world markets. It also improved substantially the economic efficiency in terms of resource utilization and balance-of-payment effects. Under such an arrangement, Yugoslavia will earn sufficient foreign exchange to pay for an expanded foreign content on other models assembled locally, which enables it to eliminate domestic procurement on items that are high cost or outside the range of their technological capabilities.

The arrangement with Fiat also provides for the development of Yugoslav engineering and design capabilities through the stationing of personnel in Italy. This can eventually lead to joint engineering and design of new product families for partial manufacture or assembly in Yugoslavia and sale in both domestic and world markets. Such arrangements for co-production, co-marketing, and cooperative research and engineering help overcome the basic diseconomies of scale that beset a small-scale market economy such as Yugoslavia's. Otherwise it would require a substantial production base to support an independent automotive design and engineering capability that can keep up with intensive international competition.

A similar contract was signed in the tractor manufacturing field between Massey-Ferguson and a Mexican manufacturing affiliate. The agreement provided for the manufacture in Mexico of tractor parts for export and interchange with other Massey-Ferguson plants to cover the import requirements of more costly or technically complex parts. Mexican axles, machined parts, and tractor accessory implements will be exported for foreign exchange earnings. It is significant to note that Massey-Ferguson assumed technical responsibility for developing parts manufacture to meet international standards. Recent guidelines issued in Canada for foreign enterprise emphasize responsibilities for developing indigenous research and design capability, in order to take full advantage of domestic and foreign market opportunities.[1/]

The willingness on the part of foreign enterprise to advance technology under licensing arrangements depends upon the amount of research undertaken by the firm, which in turn is a function of competitiveness and technological progress in the industry at home and abroad. Much depends upon the ability of the firm to earn royalties and dividends from exported technology and at the same time maintain a technological lead on licensees and competitors. American firms have been more disposed to export technology than European firms, due to a more dynamic product cycle and the associated profit patterns. In the past decade, the ability to maintain shares in overseas markets has increasingly depended upon a willingness to implant manufacturing capabilities. More recently, host governments have pressed foreign enterprise to develop export of manufactures, which are even more demanding in terms of technological capabilities.

Developing countries should seek out international firms that are willing to adapt to their specialized need for technological adjustment. Massey-Ferguson, mentioned above, reorganized its corporate structure to handle the "nursery stage" of overseas plant operations; over ten percent of its annual earnings is now derived from plant operations in developing countries (as compared to 2 or 3 percent by most large international firms

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1/ Canadian Government, Privy Council Office, Foreign Ownership and the Structure of Canadian Industry (Ottawa, January 1968), pp.360, 412.

engaged in this field). Fiat of Italy has also spent much time and resources in developing its knocked-down vehicle operations for servicing overseas assembly and partial-manufacture facilities.

The willingness to adjust earning patterns and accommodate the specialized needs of manufacturing affiliates in developing countries depends also in part upon the firm's overall growth and diversification strategy. Sustained growth and success in the home markets is often a deterrent to venturing into difficult foreign areas. Overseas manufacturing as a marketing condition requires expanded commitments of financial and managerial resources. Small firms are rarely in a position to assign or recruit personnel required to effect successful transplants, and certain larger firms are unwilling to adjust corporate philosophy and practice to this new type of world enterprise. Differences in corporate attitudes towards profits and risks affect the international firm's role as a developer, adapter, and transmitter of technical knowledge for underdeveloped areas. Many international corporations lack the willingness or ability to maintain flexibility in product design and to accommodate to differences in overseas market and manufacturing environments. Understandably, the more complex the technological transplant and the more adverse the production environment, the heavier is the corporate burden in adapting the transplant. Some corporations are simply unwilling to "downgrade" their trade-mark to more nearly fit the technical capabilities encountered in the underdeveloped areas. Managerial differences over international standards and quality control systems are another point of contention. In all of these areas, the marketing and manufacturing strategies of multi-national firms need to be reconciled with the economic interests and developmental strategies of the host countries.

A.I.D. Support of Science and Technology Programs

Substantial sums are now spent on technical assistance to upgrade the quality of human resources so as to make more effective use of physical capital and related resources. Social investments to adapt technologies are justifiable on the same grounds. In industrially advanced countries, public expenditures on research and development to advance the state of the art in atomic energy, space communications, and supersonic air transports are all examples of social costs incurred to increase the net social return in the absence of sufficient private incentives. Arguments justifying national expenditures also apply to international assistance funds to advance technical knowledge for the special case of developing economies. Foreign aid money spent for technological research increases returns and contributes to development, just as do funds spent directly on physical capital transfers or indirectly on human resource development.

A.I.D. support of science and technology in developing economies should aim primarily at developing indigenous capabilities to absorb foreign technology and carry out domestic research and development activities. Thus, recommendations contained in this section focus on institution-building, which would involve minimal outlays of foreign aid funds. The proposals that follow should be envisaged as national programs, assisted where necessary by foreign aid funds which could be provided either by A.I.D. or by international aid authorities. A.I.D. can help formulate a program frame and, in principle, could finance the foreign exchange component involved in national efforts.

This general problem of utilizing foreign aid funds to advance technology in developing economies should be explored with international firms doing business in developing economies. From this realistic context of industrial operations, outside inter-governmental and foundation support may be earmarked. As in the case of Japan and Yugoslavia, national policies should provide the basic frame for encouraging the transfer and indigenous development of appropriate technology. From these national policies and programs, additional budgetary requirements suitable for international financing may be identified.

1. Financial Institutions in Support of Science-Based Industries. Investment institutions sensitive to the need for technological progress can contribute significantly to economic growth. In the United States, certain financial institutions specialize in projects based upon technological innovation (the American Research and Development Corporation of Boston, for example). Previous reference also has been made to the activities of the Japan Development Bank in financing projects that advance the competitive position of Japanese industry in world trade. Banking institutions in Mexico have shown an emerging concern over the technological implications of their financing of industrial investments. Foreign aid funds can be allocated to development banks chartered to finance technologically innovative projects of the kind described in this report. The basic purpose of development finance corporations of this type would be to carry research and engineering through to a commercially viable stage.

Development banks chartered to finance technologically innovative projects could sponsor and finance Litton-type development corporations to survey the resource base, identify commercial ventures emanating from technological innovation, and sponsor or carry out the necessary product and process development. There is also a specialized need for corporate ventures to develop low-cost housing, the processing of local commdities and raw materials for world markets, or other specialized manufacturing and marketing activities based upon product and technique development. The Rockefeller Brothers International Basic Economic Corporation, which specializes in low-cost housing design and construction, is a case in point. Nestlé of Switzerland and Lever Brothers of England are two other examples of large multi-national corporations that combine product and process development with international marketing and manufacturing. Both of these firms became major exporters of processed agricultural commodities. They adjusted product mix and production design in response to changes in world supply and demand - the types of industrial versatility and flexibility that are much needed in developing economies. Developing economies dependent upon commodity exports are in particular need of national corporations of the type described to help diversify the economy and reduce the dependence upon unprocessed raw materials for exchange earnings.[1/] Industrial corporations with indigenous research and engineering capabilities are in a unique position to serve the economy's needs.

1/ See also Suggestions for Further Research, No. 3, p. 47.

2. Industrial Licensing Capability. A realistic and enlightened industrial licensing authority is an essential ingredient of national policy to advance technology. A recent study of technological licensing in Mexico 1/ points out that national policy must be realistic in terms of commercial arrangements that yield an adequate return to technology donors and based upon a reasonable partnership in technical management. Enterprises operating in sheltered markets behind high tariff walls are less concerned about incurring high costs for acquired technology, which they can then pass on to the consumer. Smaller firms, with meager financial resources and limited access to foreign sources of technology, are in a more vulnerable position. Domestic engineering firms acting as intermediaries merely add to the high total bill for acquired technology.

A.I.D. can assist developing economies in establishing a licensing authority with adequate facilities to investigate world sources and assist domestic enterprises (particularly medium and small firms) in negotiating the acquisition of foreign technology. The Nacional Financiera of Mexico, a development bank, has assisted Mexican firms in finding suitable foreign partners and in channeling industrial activity into product lines and production techniques that utilize local raw materials and in other ways contribute to developmental goals. The Department of Industrial Research of the Banco de Mexico has carried out research on technological obsolescence and related technical manpower deficiencies. These types of activities are well worth funding.

1/ United Nations, "Annex III: Case Study of Mexico", Arrangements for the Transfer of Operative Technology to Developing Countries (E/4452/Add.3), 6 March 1968.

3. National Surveys In project proposals submitted by the Japanese for international financing, the technological component is built in from the outset. Thus, in the rapid transit system between Tokyo and Osaka, the latest in transport technology was incorporated in the original cost and feasibility study submitted to the World Bank. The same is true of proposals for new port facilities which include the latest features of operational technology in the field of containerization. This is not the case in proposals submitted even by developing countries on the leading edge of industrialization. This is because the science and technology dimension, thoroughly integrated in the Japanese economy, is woefully deficient in developing economies.

One step toward filling vital gaps in technological capabilities at national levels would be to conduct national surveys similar to those carried out by the National Science Foundation for the U.S. economy. Such surveys should cover expenditures on science and technology in the public and private sectors and inventory scientific and technical manpower. Inventories of financial expenditures and technical manpower resources should also contain an analytical description of existing research facilities and their functional roles in the economy. These might be usefully supplemented by an appraisal of major institutional gaps to absorb and adapt foreign technology or engage in indigenous research as reported by industrial firms. Gap analysis might also be extended to technical manpower requirements in science-based or export industries.

4. National Research Institutes. There are long-standing international technical assistance programs in support of national laboratories through such intermediaries as the Battelle Memorial Institute, the Armour Research Foundation, and the Stanford Research Institute. The United Nations Special Fund has also given direct support to national and regional technological research institutes. Many such institutions now lack funds to act as general advisors to the government on science and technology programs in support of economic development. The Mexican Institute of Technological Research (IMIT) is a case in point. Such institutes also lack funds to act as clearing houses for available technology in the world market. Funds are also lacking in specific fields vital to national development, such as cheap food proteins from local sources, water desalination, low-cost housing, and educational television (See Appendices A-D).

5. University-Industry Ties. Important linkages have been established in industrially advanced countries between university-based research and industrial facilities. In the United States, important centers include the Cambridge-Harvard-M.I.T. and Stanford complexes, and industrial research and extension centers at Princeton, Illinois Institute of Technology, University of North Carolina, and University of Colorado. Previous reference has been made to the research support programs of the University of Grenoble to the local industrial community (p. 25). Counterpart assistance involving universities in developed countries to implant similar arrangements in developing countries can contribute to national development of technological capabilities.

6. Research Grants to Industry. The Australian Government passed a law in 1967 providing direct grants to manufacturing firms (matched funds up to $50,000) for research and development on new products or techniques leading to an expansion of exports or significant reduction in production costs. Similar results are achieved in industrialized countries through special tax exemptions for R & D expenditures by private firms. These grants may be administered through specialized development banks suggested above. Foreign aid funds could be earmarked for research partnerships between domestic and foreign enterprises in related institutions. Such aid might take the form of underwriting of research, which if successful would be reimbursed from the earnings of commercially viable ventures.

7. Other Research Projects. A.I.D. may wish to sponsor or finance further studies on reinforcing technological capabilities in developing economies. See Suggestions for Further Research.

Suggestions for Further Research

1. Transfer of Industrial Technology.

Developing economies have a vital interest in expanding the quantity and quality of transferred technology. The issue is largely one of reconciling the motivation and interests of developing economies with the cost and efficiency considerations of appropriate technology. Commercial manufacturing and marketing arrangements need to be reconciled with the goals of economic growth and technological development.

Research which explored a cross-section of developing countries and sectors should produce some useful guidelines for effectiveness in technological transfers. Studies should deal with the impact of economic policies, legal constraints, and political attitudes on transmitted technology and the development of indigenous design and engineering capabilities. Country case studies should also examine the techniques of technology transfer and evaluate their relative effectiveness. Issues of technological dependence and built-in technological obsolescense also should be examined. The quality of transferred technology has a long-term effect upon industrial productivity and cost-competitiveness in the world economy. In seeking policy guidelines, distinctions need to be drawn between the problems of access to technology, effectiveness in transfer, and issues of equitable payment. 1/

The project should include an analysis of the interests and motivations of technology donors. The experiences of countries like Japan, Taiwan,

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1/ A research approach to some of these problems has been explored in a preliminary way by the United Nations Industrial Development Organization. Case studies have been completed on Mexico, Brazil, and Israel. See reference on page 39, footnote 1.

and Yugoslavia in regulating or influencing the acquisition of foreign technology should then be examined for relevant insights and guidelines. Among the more important aspects to be examined is the bargaining framework between technology donors and recipients. Corporate philosophies and practices need to be examined in relation to the capabilities and constraints that prevail in the transfer environment. The study should provide donor firms guidelines on how to contribute more effectively to the technological (and economic) progress of a developing country.

An important ancillary issue concerns the special problems of small-to-medium size firms as recipients of technology. It may well be that small-to-medium scale enterprises in industrialized countries are more suitable donors of manufacturing and processing systems. But smaller companies have limited resources and encounter other special problems in becoming effective transmitters of technology. Most European vehicle manufacturers, small by U.S. standards, find great difficulty in servicing the industrial transfer requirements of developing economies.1/ Policies and measures to expand the transfer role of smaller firms should be explored.

1/ See World Bank Report EC-162 (cited in footnote 1, page 9), p.14.

2. Role of Technological Change Agents

Further research on the required institutions and instrumentalities needed to introduce technological change in fields of vital importance to developing economies is urgently needed. Such knowledge would begin with social problems and practical implementation environments and work back to the required science and technology. The purpose would be to identify institutional forms to state social problems, identify technological elements, and structure a task force approach to problem resolution. This is a central theme in Margaret Mead's Continuities in Cultural Evolution, the need for institutional innovation in engineering cultural change. In a similar vein, Michael Michaelis refers to the institutional barriers to applying existing technical knowledge in such fields as housing and transport. In a recent paper Michaelis describes the new institutional relationships that evolved in connection with a school construction program in California.[1] The collaborative effort resulted in new facilities design more suited to new curriculum and educational requirements. Alvin Weinberg also stressed the need for devising technological instrumentalities and related institutions for dealing with vital social problems.[2]

1/ "Environment for Innovation," Proceedings of a Conference on Technology Transfer and Innovation, sponsored by the National Planning Association and National Science Foundation, May 15-17, 1966 (Washington, D.C. : N.P.A., 1966).

2/ "Social Problems and National Socio-Technical Institutes," Applied Science and Technological Progress, A Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences, June 1967 (Washington, D.C.: U.S.Government Printing Office, 1967).

Establishing the relevance of science and technology activities to developmental needs is a basic problem. What is technologically feasible and economically desirable is not always commercially viable or socially implementable. If technology is to be made socially relevant, problems must be stated in mission-oriented and operationally-practicable contexts. In market-oriented research and development, technological relevance and applicability are implicit in the commercial considerations. But in other areas of vital social need, technological relevance and applicability are much more difficult to define and establish. Included here are such fields as educational television and food and population problems. There is also a widespread need for practical institutional arrangements linking product and process innovation to changes in market structure.[1/] (See research proposal that follows.)

1/ An example of institutional innovation in this area is the Pyrethrum Board of Kenya, which carried out a highly successful combined program of technological and marketing research to establish pyrethrum as a commercial crop in world markets. Product and process research was undertaken to develop pyrethrum flowers as an insecticide which is now widely used throughout the world. Pyrethrum became a cash crop to help offset the risk and uncertainty of coffee and tea cultivation in the Kenya Highlands. (See Jack Baranson, "Economic and Social Considerations in Adapting Technologies", Technology and Culture, Winter 1963, 28.)

3. Improving the Competitive Position of Primary Products.

A fundamental problem faced by many primary commodity producers is price competition from synthetic materials. One approach to the problem is research designed to improve natural materials vis-a-vis synthetics, or to reduce relative production costs. Natural rubber and natural fibers such as wool, cotton, and jute are all in competition with synthetics. Research on synthetics in industrialized countries far exceeds research expenditures on natural materials by developing countries.

Developing economies can individually or collectively undertake research to defend the competitive position and national income earnings of natural commodities. Recommendations along this line were made by the United Nations Conference on Trade and Development; it proposed a special research fund to undertake broad research and development in natural products. In the field of natural rubber, research expenditures might be to find new uses for natural rubber or to develop new varieties of rubber trees, to increase acreage yields and thereby reduce production costs.

4. Conversion Costs versus Cost of Using Off-the-Shelf Technology.

This is an important issue for developing economies, given limitations in national resources in general and in technological manpower and facilities in particular. But the stock of knowledge in this area is very limited. In beginning to deal with this problem, it will be necessary to develop first an economic cost-benefit analysis technique which integrates the research cost variables with economic costs of alternative technologies. This is particularly important in industrial activities involving considerable capital outlays.

5. Technological Forecasting.

Considerable work has been done in recent years in the field of technological forecasting.[1/] These studies have largely been concerned with conditions and needs in industrially advanced societies. But the same analytical techniques could be applied to the specialized problems and particular stages of development in newly industrializing areas. Technological forecasting should assist developing countries in dealing with broad social problems of urbanization and population growth; investments in transport, power, and communications systems; mass education; and capital investment and technical research policies to minimize the problem of technological obsolescence.

1/ See, for example, Erich Jantsch, Technological Forecasting in Perspective (O.E.C.D., 1967); James R. Bright, Editor, Technological Forecasting for Industry and Government: Methods and Applications (Prentice-Hall, 1968); and Herman Kahn and Anthony T. Wiener, Toward the Year 2000: A Framework for Speculation (Macmillan Company, 1967).

APPENDIX A [1/]

New Sources of Protein Foods

There is a world-wide need among low-income economies for cheap protein foods derived from local resources. Even where calorific intake is sufficient, staple foods such as rice or cassava lack the protein and vitamins essential for health and growth. New forms of protein should be foods that are acceptable to local tastes and affinities and can be easily processed and stored. Manufacturers of dehydrated soups, breakfast preparations, milk substitutes, and the like are quite familiar with these arts of creating new food forms and adapting them to local tastes.

Food technologists have developed a number of high protein and multi-purpose foods. The Central Food Technological Research Institute in Mysore, India, has developed a multi-purpose food to enrich "atta" flour from which chappaties are made. The food additive can also be mixed with other commonly used cereals and flours. A mixture of peanut, sesame, and bengalgram were used to manufacture the food supplement. In Central America, a similar local product is known as "Incaparina," which is made from a mixture of corn meal, sorghum, cottonseed flour and yeast. A stabilized tortilla flour has also been developed by the Institute Mexicano de Investigaciones Tecnológicas.

Fish meal products are among the more promising sources of food from the sea. They provide a high quality source of protein that is relatively cheap. Dehydrated and defatted fish meal yields a preservable product of reasonable biological uniformity. The most economic way to produce fish meal is by grinding up whole fish, but until recently this form of fish meal was not considered fit for human consumption by U.S.

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governmental authorities. Recent approval of this product as an edible protein should add considerably to world supplies of cheap protein. Fish flour can be produced in a variety of tastes and forms - for example, as a protein-rich coating on rice grains. Research is still needed to adapt this stable, low-cost protein to an acceptable form.

Aside from vegetable and fish flours, some other sources of protein which seem promising are: 1) yeasts - for example, torulopsis, a microbiological culture feeding on sugar cane; 2) algae - for example, chorella, which derives protein from the sun's radiant energy by a process of photosynthesis; and 3) wolffia - a tiny flowering plant yielding starches and protein which can be grown on still waters in tropical countries spontaneously and abundantly. Ongoing experiments in Japan include efforts to convert these edible microbes and plant buds into such foods as chlorella-peas and chlorella-spaghetti. Other Japanese efforts include research on soybean and fish products such as a toasted soybean flour, soybean milk curds in frozen and dehydrated form, and various processed fish foods. In the Philippines, research is now underway at the Biological Research Center of the National Institute of Science and Technology to derive edible proteins from nitrogen-fixing algae and torulopsis yeast, protein and food flavour from mushrooms, citric acid from blackstrap molasses, and poultry feed from beer liquor wastes.

The ocean affords an abundance of potentially exploitable resources, which could alleviate the already excessive demands upon subsistence agriculture. To provide these yields, new techniques are needed to cultivate protein-intensive species and perhaps even fertilize productive oceanic areas (nitrates and phosphates from sewage in the Thames estuary greatly increase the fish catch in the surrounding North Sea). New knowledge is needed of the chemistry of ocean organisms and of techniques for processing and preservation for human consumption. Expanding the protein yield of ocean resources would contribute significantly to food-deficient economies.

Farming brackish waters and harvesting sea plankton - tiny protein-containing organisms that abound in the sea - are two other promising food sources. Japanese scientists have studied the nutritive value of organic compositions found in the sea, particularly algae and seaweed. Aside from human consumption, seaweeds can be used as a potash fertilizer or as a livestock feed. Technological problems are posed by the variations in chemical composition and the necessity of locating processing plants near dependable sources of supply.

APPENDIX B

Water Desalination Processes

In large areas of the Middle East and certain areas of North Africa and Latin America water deficiencies or brackish waters have rendered soils unproductive, but the cost of desalinated water is still beyond the means of low-income economies. The price of desalinated water depends upon capital equipment and energy costs. Other factors influencing the choice of process include volume requirements and economic uses, local climate, and impurities in the salt water base. Water purity required in agriculture or industry or by human beings also influences the expense of processing salt water.

Known processes may be divided into two classes: 1) distillation or freezing, in which a small amount of fresh water is removed from salt water; and 2) membrane systems of electrodialytic processes, in which all salt is removed by replacing the salt particles with hydrogen or other unobjectionable elements. Although widely used, distillation methods are costly because of energy consumption and equipment corrosion. Membrane fouling and electricity costs are critical elements in economic processing by the electrodialysis method; solar energy as a source of evaporation may be combined with the membrane process, thus obviating the need for electrical energy.

Scientists from all over the world have come up with imaginative ideas to combine salt water conversion with the generation of power; a most promising combination involves steam turbine power and distillation processes. In Japan, research on desalination processes has included an interest in marketing both mineral by-products and the conversion equipment itself. Eventually, mineral by-products of desalination (magnesium, for example) may pay for undistributed fresh water supplies. Basic research on the properties of water and steam, on crystal formation, and on heat transfer may lead to as yet unforeseen technological breakthroughs. This is the type of research that lends itself to a regional or even world-wide approach. One such joint effort is now under way in the Organization for Economic Cooperation and Development. Desalination research in the United States still overshadows the rest of the world's efforts. It should be pointed out, however, that desalination costs for agricultural purposes still run much higher than the value of resulting crops would warrant in most parts of the world. A scientific breakthrough in substantially lowering the deliverable costs of fresh water would constitute a major contribution to the economic development of certain regions.

APPENDIX C

Low-Cost Housing

Low-cost construction techniques and materials research are the two major technological links in providing housing and industrial buildings for low-income economies. Research institutes in the developing areas working in cooperation with product and technique development abroad can lead to significant breakthroughsin the low-cost building construction field. In the developing areas themselves, experimental programs to test new techniques and new materials could be carried out as part of regular construction projects. For example, the tropics demand building materials that can withstand vermin, heat, and humidity. In Latin America, the International Basic Economy Corporation has developed construction techniques in pre-cast structural concrete and pressure-sprayed concrete walls and roofs for low-cost housing in Puerto Rico and in Argentina and other Latin American countries. House designs have been adapted to climatological conditions and cultural patterns, and production techniques have sought to utilize local materials and available skills.

APPENDIX D 1/

Educational Television

The challenge in elementary education among the developing areas is to reach vast numbers despite the dearth of qualified teachers and other limited resources. Broadcast media can serve as an instrument of economic growth for educating large numbers, introducing new agricultural and industrial techniques, changing tradition-bound values, and raising levels of manpower skills. Technical equipment and program content will have to be system engineered to assure effective results. There is a special logistic attached to each of the developing areas, depending upon population distributions, patterns of individual or group listening, and the vastly different eyes and ears of the many cultural groups. In using broadcast media for educational purposes, behavioral scientists will have to adapt program content to the selective perception and the learning propensities of different audiences. Low-cost receivers and inexpensive power units that are rugged and require limited maintenance are characteristic of equipment needs.

It is also necessary to adapt broadcast and receiving equipment to the low national income and rudimentary environments normally encountered in developing countries. Ling Electronics of Texas has designed television broadcast systems that are low cost and modular in design, which means components can be added to increase capacity, and faulty elements can be

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1/ Material adapted from documented material in Jack Baranson, "Implementing Technology Programs for Underdeveloped Countries", Oregon Business Review (June 1962), 4. See also Selected Bibliography, items 54,56, and 64.

readily identified and replaced by relatively unskilled personnel. Such features permit incremental investments in broadcasting facilities as communication needs develop and expand. Sending and receiving apparatus has been designed to withstand the rigors of climate and other adversities of physical environments.

Various efforts have gone into adapting course material for mass learning systems. Indicative of what can be done is a series of pictorial film-strips that were developed for elementary science education. One prototype film-strip on sixth-grade biology pictorially presents useful knowledge based on plants and animals familiar to village life and is designed to be taught by teachers themselves untrained in biology. The materials are verbally simplified and designed to convey a clear understanding of fundamental processes. Film-strip courses guide teachers and pupils through observations and simple experiments that can be performed with available equipment. A series of such courses in basic subjects could eventually reach dispersed populations through village television receivers. Teacher training and advanced classroom preparations could also be arranged through radio or television contact.

Certain broadcasting techniques developed in France and Australia are also of interest to developing areas. Experiments in France with rural community discussion groups over television networks suggest the possibility of televised extension services to improve educational curricula or demonstrate farming techniques, sanitation practices, and house and road construction methods. Australia has pioneered the use of radio media to provide remote or isolated regions with medical services and elementary school education. Compact two-way radios, which are easily operated and repaired and contain a pedal-operated source of electric power, have been developed for the communication system. The Australian School of the Air is now able to educate children up to the high school evel with new approaches and learning techniques. This radio communication system is also used for conferences and meetings among otherwise isolated settlements. In 1959, an Australian mission was sent to train the Filipinos in these school broadcasting techniques.

Satellite communication has opened a new era of international television broadcasting. It is now technically feasible to link centers of learning and technical information to audiences in remote areas of the world. The Euravision network, operative among fourteen Western European nations, demonstrates the operational feasibility of direct international television broadcasting.

Technological advances in satellite and receiver design now provides realistic opportunities for national educational broadcasting systems via satellite in countries like India. It has been technically feasible for some time now to serve small regions with distribution satellites that beam signals to individual receiving sets equipped with low-cost antennas. Manufacturing costs on direct receivers have also been appreciably reduced.

Such systems can supply a complete range of educational broadcasting linking centers of learning throughout the world to local classrooms and seminar groups. Audiovisual aids, library materials, and computer capabilities can also be made available to local research and training centers. The principal gap now is no longer in the technology, but rather in massive development of program content.

APPENDIX E [1]

Activities of National Research Centers in Developing Countries

The Applied Research Institute in Burma has worked on rice starches, rice bran oil, and paper from shredded bamboo. In Central America, the Institute Centroamericano de Investigacion y Technologia Industrial has developed new techniques for the preservation of tropical foodstuffs, the processing of turpentine and essential oils, and a high-protein flour ("Incapurina") to replace the less nutritional corn meal commonly used in tortillas. In Ceylon, the Institute of Scientific and Industrial Research has worked on new or improved techniques for the desiccation of coconut, for the processing of citronella snd cinnamon oils, and for the manufacture of cheap shoes and rugs from banana stalk fiber. At the East African Industrial Research Organization in Nairobi, Kenya, research laboratories are engaged in projects on the processing of coffee, jasmine, and tannin and on developing building and construction materials from local resources.

The National Institute of Science and Technology of the Philippines has developed in cooperation with the Armour Research Foundation new techniques to utilize the entire coconut, which is a major source of national income in the Philippines. In most tropical countries, coconuts are processed under primitive techniques to yield copra, which is a raw material used in the manufacture of detergents. Typically, 65 percent of the coconut is disregarded and the remaining coconut meat is sun-dried, followed by indirect tray drying in small, inefficient direct-fired ovens. New processing techniques utilize nearly 100 percent of the coconut, yielding a quality-grade edible food product along with several commercial by-products. These include a fiber of uniform quality made from selected husks that can

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[1] [illegible] 7, 12, and 89

either be used as a fuel, as a deactivating charcoal, or in metallurgy. A third by-product from the coconut liquid is a distillate used to treat lumber and as a base for other crude chemicals. Non-condensible gas, a fourth by-product, is used largely as a fuel. Further experiments are underway to extract a fine grade oil, with the residual cake used for baking. Protein extracts as food supplements are another possibility.

APPENDIX F [1]

Guidelines to Technical Adjustments in the Automotive Industry

There is some room for rationalizing production in a small-scale industry through the consolidation of production facilities, the standardization of components and parts, reduction in the number of manufacturers, and limitations on the proliferation of models and makes. High tariff walls provide the commercial environment for small-scale, high-cost industries. But as domestic markets are saturated and internal competition intensifies, economic costs rise and commercial survival is threatened. Intensified competition takes the form of an increased number of models and styles and more frequent changes, which inevitably lowers production efficiency throughout the economy by further reducing the length of production runs on components and parts.

Automotive sectors of developing economies can benefit greatly from partnerships with international firms to engineer, manufacture, and market automotive products in the world economy. In attempting to trade in world markets, developing countries find they lack the capital and human resources to develop competitive products, efficient techniques, and distribution and servicing systems necessary to market products abroad. Partnership with international firms, in which the developing country is assigned a manufacturing role, is one way to enter world markets. The alternative is to develop indigenous capabilities and acquire the necessary capital for research and development, production engineering, and overseas distribution and servicing networks. World market specialization possi-

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1/ Material adapted from World Bank Report EC-162 (cited in footnote 1, page 9), pp. 19-24, 50-62.

bilities for developing countries might include: 1) manufacture of specialized components and parts, 2) responsibility for a particular vehicle line, 3) specialization in low-volume replacement parts for obsolete models, and 4) reconditioning of engines and parts.

As a consequence of the high capitalization costs in automotive production, developing countries usually end up with vehicle models and production techniques that lag behind latest developments. Because of the high cost of research and development, little or no effort is made to adapt product design and production techniques to the longer cycles associated with low-volume production. Nor is any significant effort being made to develop indigenous research and development capabilities. This pattern has important implications for future growth and development of the automotive industry in a developing country: product proliferation associated with transplanted technology is not economic for domestic production, and obsolete products and techniques cannot compete in world markets. A developing country needs to maintain international standards in product design and manufacturing specifications if it is to maintain its earning capability in the world economy. Export items also serve as benchmarks of quality and efficiency for industrial goods produced for the domestic market. This type of international involvement is the best assurance for the developing country maintaining a technological position, which will assure continued growth in the world economy.

There are several examples of slight moderations in general-purpose vehicles that would improve their functional value in developing areas. Certain features from farm tractors and overland vehicles could advantageously be incorporated into light, multi-purpose passenger and utility vehicles for use in the hinter-land areas of developing countries. Changes and improvements are needed to accommodate adverse conditions of roads and climate and the dearth of maintenance facilities. Among the features that would enhance utility are: higher ground clearances to avoid ruts in the road; added protection for the tas tank; heavy duty air cleaner for drier, dustier climates; gasoline filter on intake spout; oil pan shape to maintain lubrication level at steeper incline (as on farm tractor); larger radiator with greater heat-dissipating capacity for hot climates; additional insulation for electrical system against dampness and water; roll-down great wire mesh against insects at window openings; and lock on hood and gas tank against pilferage.

For products to be manufactured in the developing country, there is a further need to adapt product design and manufacturing techniques to the smaller market volumes and more limited production capabilities typically encountered in developing economies. Some of the adjustment difficulties discussed earlier in this chapter may be overcome by basic changes in vehicle design and in the related manufacturing techniques. A number of automotive manufacturers have designed truck bodies in order to decrease tooling costs for low-volume production. Substantial savings are possible through body designs that avoid contouring and obviate the need for expensive tooling and equipment. Modular design principles based upon interchangeable body panels and the use of standardized mill forms for additional body and chassis elements also reduce production costs.

Several firms have attempted to adjust product design to local requirements. A European firm has designed a completely new car for manufacture and sale in Brazil, which is adapted to the rougher roads and poorer servicing facilities that characterize hinterland areas. Chrysler found it necessary to build 25 percent more value into Turkish trucks (axles, shocks, and differentials) in order to withstand local road conditions and driver usage. In Argentina, "collectivo" bus bodies are fitted locally to the truck chassis manufactured by Mercedes, since low-volume demand would have made commercial production uneconomic. A British firm manufacturing automotive electrical equipment designed a high frequency horn for trucks sold in the Indian market to cope with local traffic conditions.

In certain cases it may be advantageous to redesign components to fit locally available materials. Great difficulty was found in Argentina in duplicating the molded plastics and polyurethene upholstery found in French Renaults. Instead, other type metal stampings and fiber padding were used in the Argentina product. Efforts have also been made to redesign body panels to improve "nesting" characteristics for more economical shipping for overseas assembly operations.

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THE RELEVANCE OF AUTOMATED TECHNIQUES TO INDUSTRIALIZATION IN DEVELOPING ECONOMIES

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The ultimate logic of automation lies in its efficiency in the mass production of materials, components and end-products. Modern manufacture and assembly require the putting together of myriad bits and pieces that are interconnected, standardized, and time-phased. These modern mass-production systems depend upon science and technology to produce new materials, new products, and new production techniques. Mass production also depends upon the conditioning and standardizing of consumer tastes to assure high volume production runs. Automation has emerged from three centuries of industrial evolution which have provided the metallurgies, the mechanical equipment, and the power sources. This is because efficiencies depend upon exacting materials standards and manufacturing specifications and upon tightly scheduled flows of materials and goods within and among plants and processing facilities.[1/]

Automation, strictly speaking, is one step beyond mechanization, which is the displacent of human energy and skill with machine power and sensitivity. Elevators and sewing machines are two examples of mechanization. Automation involves electrical or mechanical devices linked to equipment that carry out pre-determined tasks - a thermostat is a simple example of a device that controls heating or cooling according to a programmed range of air temperatures. More complex automated equipment may roll steel to prescribed thicknesses or shape metal to tape-recorded diminsions. The modern ribbonmaking machine for light bulbs is a dramatic example of a self-feeding, self-operating, self-ejecting piece of automated equipment. Automation may be extended from an individual machine to an entire plant, as in cement or in oil refining; or segments of fabricating industries, such as body stamping and welding of sub-assemblies (as in appliance and vehicle manufacturers), may be partially or completely automated. For example, the

Volkswagon body plant in Wolfsburg, Germany, is an example of a highly automated sub-assembly plant. Stamped body elements are fed into pre-set jig mountings and then simultaneously and automatically electrically welded. An entire car body is completed within an hour at some 25 stations on three rotating and interconnected carousels. At certain volume thresholds, automated equipment and interlaced operations are capable of turning out an expanding range of product variations. Consider, for example, the combinations in body styles, engines, accessories, and trim offered in American cars.

Modern industrial systems differ from traditional artisan industries in several important ways. In mass-production systems, every step and phase is conceived and perfected to minimize unit costs and standarize output. In an artisan craft, there is great heterogeneity in product design and individual pieces, and little thought is given to time-phasing and cost control. This basic difference often leads to difficulties in adapting artisan skills to factory labor. This was the case with an American diesel engine manufacturer who experienced considerable difficulties with its plant in Northern Scotland. Labor was recruited from among local craftsmen who were simply unwilling to yield individual skills developed over long years to the precision and standardization built into "mindless machines."[2]

There are also essential differences in specialization within and among production units. These differences are apparent if we compare the modern biscuit factory to a small bakery shop. The biscuit factory is an integrated complex of mechanical equipment and automatic controls, and working in conjunction with this factory are materials suppliers, equipment manufacturers, testing laboratories, and distribution systems. The village bakery is a one-man show - from the grinding of grain to baking the loaf, and may include the baker's fashsioning his own production utensils.

The exigencies of modern mass production systems are pervasive: Jacques Ellul in his Technological Society (Knopf, 1964) has pointed out that people in urban industrialized societies eat the kind of bread that can be efficiently mass produced and distributed, and not necessarily what they prefer.

The appropriateness of automated techniques in a developing country will depend upon several interrelated criteria and constraints. The major considerations from the viewpoint of national economic policy is resource costs versus employment effects - particularly scarce resources (such as capital, foreign exchange, skilled labor, and management), versus abundant, unskilled labor.[3/] Reliability, quality and uniformity of product, and safety features comprise another set of considerations. Volume requirements and time constitute a third set of determining factors. As for the constraints, there are first the manpower requirements associated with designing, operating, and maintaining automated equipment. The stage of industrial development, including suppliers of materials and parts, constitutes a second set of contraints. A third set of factors which may inhibit the use of automated techniques relate to market structure and include size, degree of competition, and the business cycle (which may affect utilization rates of installed equipment.) The implications and ramifications of some of the foregoing considerations and constraints are analyzed briefly in what follows.

The justification for utilizing an automated piece of equipment may be either high volume or very low labor costs relative to capital charges. Labor costs, it should be pointed out, are the combined result of wages and productivity. Thus, paradoxically, automation may be more justifiable in India than in Taiwan, since in India although wages are low, so is productivity. Automated techniques can reduce unit costs at high volumes and yield high precision in standardized production. Automation generally connotes "capital intensiveness", but this can be misleading. Because of high output volume associated with automated equipment, the capital cost per unit of output is low relative to low-volume, labor-intensive tools and equipment. But in most situations, high-volume, automated equipment is often ruled out for LDC production because of limited demand. Also, there is not the compelling need for cost efficiencies and rigorous quality standards in a protected "seller's market." In such markets, the strong tendency is towards oligopolistic competition, which results in an over proliferation of models and makes relative to market size, fragmentation of production facilities, and a further diminishing of production runs in components and parts. (See Automotive Industry below). Another factor undermining the use of automated equipment is that under the boom-and-bust conditions prevailing in most LDC's, investment in expensive,high-volume equipment can be economically wasteful. Large changes in effective demand are characteristic of many developing economies, particularly capital goods industries. Effective demand changes erratically in response to sharp variations in the general level of economic activity including government spending.

Developing countries are generally forced into an excessive use of automated equipment, relative to their capital resource endowments. An inherent attribute of automation is that the machine is manifestly more efficient than man in performing a wide range of industrial tasks. When machine-intensive techniques with precision and uniformity built into the equipment are converted to labor-intensive production methods, heavier demands are placed upon machine operators to read blueprints, set up tools, and in other ways substitute human skill for machine accuracy.

This is why segments of more advanced industrial societies such as Japan are in a much more favorable position to adapt labor-intensive techniques where wage levels or capital shortages justify these choices. After a century of industrial development, Japan now has ample supplies of experienced technical and engineering skills needed in adapting production to labor-intensive equipment and techniques. (This ability of the Japanese to substitute human skills for machine capabilities or deficiencies in raw materials was already evident at the turn of the century. Second-hand textile machinery was imported by Japan from England cheaper short staple cotton was used in combination with additional workers to mend broken threads, and repairmen were hired to keep older equipment going.) Japan also now has an intricate network of small-scale shops and plants that are well integrated as suppliers into larger industrial complexes. These small shops are able to meet material standards and manufacturing specifications and to deliver goods on tight production schedules.[4/]

Quality and precision requirements in modern production systems place absolute limits on the technical feasibility of substituting human skills for machine capabilities. Sophisticated equipment requiring limited operator's skill, generally requires more sophisticated backstopping, coordination, and maintenence skills. Simpler equipment, on the other hand, places a heavier burden upon supervisory and operator's skills to adjust tolerances, pace the feeding of materials, and control the quality and reliability of finished parts. A critical part of the fine-tuning of industrialization is selecting levels of automation compatible with idustrial manpower and organizational capability. National deficiencies in technical and managerial skills may prompt factory managers to chose equipment that has precision and control built into the machine.[5/]

David Granick, in his study of Soviet metal fabricating industries, points out that the advanced "continuous-flow" techniques introduced by Soviet planners in the early 1930's were well beyond the organizational and technical skills then available in Soviet society, and that this resulted in widespread underutilization of over-capitalized industries. In order to be effective, automated equipment depends upon industry-wide standards of quality control and efficiencies in inter-plant scheduling, which the Soviet economy did not begin to approach until thirty years after the advanced techniques were first introduced.[6/]

<u>Diesel Engine Manufacture in India</u>[7/]

Diesel engine manufacture requires a relatively high degree of mechanization even at low volumes. But developing countries inevitably experience widespread difficulties in absorbing modern industrial techniques and establishing the standards and rhythm inherent in automation. These difficulties are due mainly to manpower and organizational deficiencies in planning and carrying out industrial projects and programs. The case study presented in this section analyzes many of the difficulties inherent in a broad range of metal fabricating and other manufacturing industries.

An agreement was signed in 1962 between the Kirloskar Company of India and the Cummins Engine Company of the United States to construct a $7 million plant in Poona, India, to manufacture diesel engines in the 200 - 300-horsepower range for the Indian market. The plant, which began operations in 1965, had to be scaled down to about 2 percent of U.S. output (2,5000 engines per year in India, as compared to over 180,000 in the U.S.) The diesel engine chosen to be manufactured in India was a high performance, 220-horsepower engine applicable to a wide range of uses in the transport and power fields. The Cummins engine was designed to run 400,000 miles at low operating costs with minimum down-time for maintenance. A diesel engine costs about three times its equivalent horsepower in a combustion engine. This sophisticated, high-performance diesel contains about 750 parts, ranging from cylinder blocks to fuel injection pins. A part such as capscrew bolt requires about 5 processing steps; a part of middle range complexity such as a crosshead valve requires 20 steps; and a more complex part such as an engine block takes up to 75 processing steps including castings, machining and finishing. This adds up to a total of about 15,000 separate processing steps and production techniques. In the United States, about 40 percent of these 750 parts are fabricated in whole or in part in the Cummin's plant, and the remaining 60 percent in over 200 supplier plants. In the manufacture of this Cummin's engine, there are over 400 standards for materials (over 100 different varieties of iron and steel alone) over 200 process standards, and nearly 100 special process methods - all spelled out in over 3,000 pages of specifications and standards.

The correspondence between Cummins and its Japanese licensee, Komatsu, which was manufacturing the same type diesel engine as in India, is indicative of production intricacies. Written inquiries over a short period include questions on how to agitate blasting compound, deburr parts surfaces, sharpen milling cutters to get correct parts finish, apply and cool special "stellite" weld onto a crosshead part, and regrind gears after heat treatment. Highly detailed instructions were then issued by the Cummins plant on how to wash and deburr parts to improve qualtiy, minimize excessive milling on cylinder blocks and other heavy parts, hold tolerances on the depth of drill bores, use air jets to keep tools free of metal chips during cutting cycles, reduce burning up of bits on drilling operations, improve grinding wheels to cut down "burning" of parts surfaces, use a new type of polishing cloth to remove grinding marks, adapt an indexing mechanism on a boring machine, avoid distortion of gear teeth after heat treatment, and reduce wear on cutting tools used to machine parts after metal-hardening.

At the U.S. plant in Columbus, Indiana, equipment was designed and selected for high-volume, capital-intensive production. Most of the machine tools were single-purpose, multi-station, and multi-spindled. This meant one machine might drill sixty holes in each of five cylinder blocks at one pass. Narrow tolerances on diesel engine parts required the highest precision in tooling. Automatic control devices generally replaced operators skills, thereby building quality control into the machine and reducing the need for inspection of machined parts. The more expensive, quality machine tools are only warranted in high volume production. Some mulit-purpose, single-operation equipment was used for low-volume parts at the U.S. Cummins plant, but even there machine tools were tape-controlled for economy and precision.

It should be noted that implicit in this tooling was a complimentarity in managerial capabilities designed to meet production efficiency and quality standards. In designing production techniques and selecting equipment and tooling for the Poona operations, the main consideration was the much lower volume requirement in parts production. Thus, most of the labor-intensiveness came from scaling down plant operations to the much more limited size of the Indian market. There was also the desire to minimize capital expenditures (particularly foreign exchange costs) and to maximize employment.

Equipment at the Poona plant ranged from the simplest bench lathes, which were handmade in the Kirloskar machine shop, to the latest milling and boring machines imported from abroad. For example, the Poona plant had the latest heating treatment equipment from Germany, complete with an air-conditioned control tower set over the heat-treatment room. It also had the most modern, dust-free assembly areas. Both the tool room and the quality control lab were also exceptionally well equipped, with a good portion of the equipment more sophisticated than that used at the Columbus installation. Most of the fixtures and jigs for the U.S. plant were purchased from specialized suppliers in the United States. But in India, because of the dearth of tooling suppliers, virtually all fixtures and jigs were custom-made by the Poona plant's own tool shop. The Poona plant also relied more heavily upon its tool shop for machine maintenance and repairs, including the sharpening of cutting tools. Machine tool parts had to be made to last longer or were duplicated in the tool shop when replacements could not be purchased domestically. As a result, for a plant with one twentieth the output, the Poona plant required a tool shop with about twice the facilities and three times the labor of the Columbus plant.

In adjusting to the lower volume of parts requirements, universal type, single-station equipment was selected wherever possible, in contrast to single-purpose, multi-station tooling for volume production in the United States. A few examples will serve to illustrate the type of adjustments made. In the manufacture of a "crosshead valve," several pieces of equipment were substituted for the more expensive and specialized "Kingsbury" used in the Columbus operation. The crosshead valve is a small T-shaped part, measuring about 2 inches by 3 inches, that controls air intake and exhaust on each of the cylinder valves. It is a moving part that takes much wear and requires very close tolerances. It has a hollow cylinder stem and a flat head with reamed fittings under either end. The part requires about twenty-two steps to temper the metal, drill pockets, thread the fittings, and weld a special alloy onto heavy-wear surfaces. In Columbus, "the Kingsbury" performed all machining operations and processed ninety parts an hour. There were other less dramatic cases of substitution. For example, on fuel injector assemblies, a less expensive threading machine was used in India in place of the special grinding equipment used at Columbus.

The following are further examples of adjustments made in production techniques and equipment selection:

- In the finishing of fuel system plungers that fit into cone-shaped cups, hand-lapping (grinding and polishing) at the Poona plant replaced machine grinders normally used at the Columbus plant.
- At Poona hand-welding of tooth gears onto ring base replaced automatic hobbing and milling from die castings at the Columbus plant.
- Crankshafts at Columbus were milled from forgings that require expensive die castings, which were uneconomical for low-volume production. In India, elements are milled and welded from steel bars.
- Oil pans were manufactured in the U.S. from sheet steel molded on a heavy-duty forging press, using permanent-mold die-casting techniques. For low-volume production in India, sand molds were used to avoid the high capital investment in permanent dies.

The sand-mold technique was cheaper and industrially simpler but yielded a somewhat inferior product, as sand-molding techniques involve pouring cast iron; the resulting Indian product is thicker and heavier - thereby adding undesirable bulk and weight to the engine.

- A sand-casting technique replaced castings from permanent mold dies on flywheel housings.
- Iron castings replaced aluminum piston cylinders turned out at the Columbus plant. (Aluminum does not lend itself to sand-casting techniques, but again, iron added undesirable weight to the engine.)
- Manual labor in the Poona plant replaced various automatic devices used at the Columbus plant to convey materials, inspect components and parts and assemble engines.
- In clearing the plant site and in building construction, labor-intensive techniques were used extensively.

Many of the techniques described above for the Poona plant were adapted from methods used twenty to thirty years ago at Columbus, when production volume was much lower, labor was cheaper, and techniques were in an earlier stage of development. For example, precision-fitting parts were hand polished, and sand-casting techniques were used. A major difficulty in adapting these labor-intensive techniques was that machine precision had to be replaced by industrial skills that are lacking in India. In Japan, the problem of scaling down production and adapting techniques was exceedingly more manageable than in India. Komatsu, the Japanese licensee, producing the same "220" engine at Indian volume, was able to scale down production to simpler tooling and more labor-intensive techniques amohg parts suppliers than was the case in India. Many small factories and machine shops in Japan use second-hand or inexpensive machine tools. In the small-scale sector, processes are broken down to a larger number of individual operations, and machine precision is often replaced by machine operator's skills. Larger firms such as Komatsu extend technical assistance to their small-scale suppliers to improve quality standards and productivity.[8/]

Komatsu arranged for parts procurement on the above mentioned "crosshead valves" from the Tsuzuki Manufacturing Company, a small parts manufactures. A high degree of technical skill was required to convert techniques and produce the new technical drawings and manufacturing specifications. The special annealing process was broken down from automated techniques to hand-welding with detailed drawings and specifications to meet standards. The "Kingsbury" used in the United States was replaced in Japan by individual hand-machining operations. Hole tapping was done by a single operator, who sighted the stem and pocket centers, with apprentice machinists doing the final precision drilling. Tsuzuki suppliers used cheap lathes and depended upon human quality control. More refinishing had to be done in Japan on locally furnished forgings, which were of inferior quality.

Technical drawings were prepared which gave detailed instructions concerning process steps, equipment requirements, millimeter dimensions, and decimal tolerances. Specifications and tolerances include beveling angles on the inside bore of the stem, eccentricity tolerances, treatment temperatures, cutting tools, and machine speeds. Special instructions were given on avoiding cracking in grinding, keeping cutting tools free of metal powder and chips, and avoiding pin holes in stellite welding.

The process sheet on annealing the stellite to the crosshead surface gave details an welding temperatures, distance and angle of flame to welding surface, and bubble and color tests to assure correct welding temperatures. All this for a part that cost less than fifty cents!

But India is not Japan. To begin with, Japan had an abundance of the experienced engineering and technical skills neccessary to convert techniques to local equipment and materials. A second factor was the much higher level of machine labor skills and factory discipline developed in Japan over the past century. As indicated previously, when advanced techniques with precision and uniformity built into the equipment are converted to labor-intensive production methods, heavier demands are placed upon machine operators to read blueprints, set up tools, and in other ways substitute human skill for machine accuracy. A third element found in Japan but lacking in India was an industrial sector organization that permitted the effective use of small-scale shops as adjuncts to modern industrial complexes. To function effectively, these small shops had to be able to convert techniques to meet manufacturing specifications and, where necessary, adapt materials to meet standards. They also had to be able to coordinate their activities effectively and schedule production within the larger industrial complex. India simply did not have the experienced and industrially disciplined small-scale industrial sector found in Japan. Thus, the adaptation of "middle-range" machine techniques, which would be more advantageous to India's scale requirements and other factor endowments, were not feasible because of deficiencies in technical manpower and industrial organization to convert technology and utilize less "intelligent" machines with higher labor skills. Paradoxically, the more industrially-advanced society is better able to use industrially-backward techniques!

Local procurement in the Indian economy was a major problem. To begin with the Indian economy did not provide the range of materials available in an industrialized country, to say nothing of quality and standards. Moreover, in the seller's market nurtured under a system of protection and severe import restrictions, many of the procured materials and parts were, at best, a near-fit or substandard in quality. Rejection rates on procured materials and parts ran anywhere from 10 to 50 percent, as compared to 1 or 2 percent in the United States. For example, engine-head bolts were made from the wrong steel and improperly heat-treated. As a result, the bolts snapped under tightening tension. (In the U.S., the part is made of a special carbonized steel and is through-heated for hardening.) There were also difficulties in procuring satisfactory castings for exhaust manifolds, thermostat housings, and water pump connections; samples procured had a high porosity content, which resulted in leaking parts. Radiators and fans meeting Cummins specifications were two other items difficult to procure locally. Other rejection items included: filter cloths that failed strength tests; rubber liners and sealing rings with surface defects and/non-pliability at low temperatures and insufficient resistance to oil; compression rings that were too brittle or insufficiently hard; steel bearing strips that didn't bond properly; bearing caps with objectionable graphite flaking; cylinder liners that failed hardness and tensile strength tests; and copper gaskets that were too hard.

Automated systems depend upon tight production controls, which took several years to introduce into the Poona plant at anywhere near satisfactory performance levels. To begin with, production controls require an exhaustive list in detail of the parts to be manufactured. From these lists, process sheets detailing machine loads and tooling requirements (machines, equipment, fixtures, and gauges) are normally prepared in the United States. It is then necessary to coordinate and time-phase all departments in support of manufacturing operations: purchasing - to procure the necessary parts and materials; quality control - to approve purchased raw materiasl and simifinished parts; production control - to schedule the flow of materials and parts; and manufacturing engineering - to prepare the list of required machines and tooling. When these procedures are not followed in a systematic and comprehensive fashion, the inevitable results are shortages and bottlenecks and much idle equipment - all of which defeats the basic purpose of continuous-flow techniques in the modern industrial factory.

The systematic ordering of equipment was equally important. Lead times to procure equipment and fixtures had either been underestimated or ignored. Since no check had been kept on the status of procurement, several pieces of essential equipment were not received on time. Either domestic delivery had been held up, or import licenses had not been cleared. Other equipment to machine essential parts had not been orderd; a milling machine for engine blocks, a hobbing machine and gear grinder for gears, and an induction hardening-machine for rocker levers and cross-head valves. As a result, there was an eighteen-month delay in the machining of engine blocks and parts. (Part of the difficulty was also the low grade of sample castings for blocks and most other major parts.) Heat-treatment equipment for hardening critical parts was far in excess of needs and, in any event, could not be used until a special authorization for additional electricity was granted by New Delhi. Other shortages included drilling equipment and inspection fixtures and gauges.

Erratic fluctuations in effective demand is another major contribution to plant inefficiencies in developing economies. It is not unusual for countries like India to undergo major recessions every two or three years. In the Kirloskar-Cummins case, original demand projections for 2500 engines per year by 1967 failed to materialize in an economy frought with uncertainties. Potential customers from among original equipment manufactures had been carefully surveyed, but by the time the plant was in full operation actual orders amounted to only 500 for a plant equipped to produce 2500 on a two-shift basis.

In the two critical areas of production controls and quality standards, the Indian management's philosophy was one of "doing its best" under adverse conditions. Bottlenecks and inadequacies were dealt with as they appeared, rather than by laying down and then adhering to carefully conceived production plans. Indian managers viewed the insistance by their American partners on rigorous planning and strict accounting procedures as either unreasonable or inapplicable to the Indian situation. Ultimately, the Indian management was quite satisfied to utilize expensive and sophisticated equipment to turn out simple parts for a cheap line of small diesel engines. Such views are simply incompatable with industrial systems to produce standardized, quality products using automated techniques. Indian philosophy and practise was a far cry from industrial performance by the Japanese licensee, where control systems were religiously established and rigorously implimented. The Japanese, as previously mentioned, engaged in an intensive interchange with the Columbus management over specifications, details on process sheets, and adjustments to slight variations in local materials or tools. There was virtually no such interchange between Poona and Columbus.

Automotive Industries[9]

At least thirty developing countries are now engaged in the assembly and at least partial manufacture of commercial and passenger vehicles. Automotive production covers a broad spectrum of industrial activity ranging thru the manufacture of engine and transmission parts; body construction; fabrication of diversified hang-on parts, such as tires and batteries, and accessaries, such as radios and air-conditioners; and final assembly of finished vehicles. A small British car averages 2500 major elements consisting of 20,000 parts if every nut and bolt is counted. What has been said previously about diesel engine manufacture (the heterogeneity of materials, rigid materials specifications and manufacturing standards, and the high engineering and managerial skills required to ensure the necessary quality and reliability) applies to the fuller range of automotive production. High-volume, automated techniques are used to manufacture all but a limited range of specialized vehicles and parts in plants producing for large domestic or world markets. Automated transfer lines (including rearrangeable standard machine elements) reduce operating and handling cost, increase the rate of utilization of expensive equipment, and reduce costs for machine tools, factory space, rejected parts, and machine maintenance. As mentioned in the previous section on diesel engine manufacture in India, there is a dilemma in the choice of industrial techniques--between highly integrated and mechanized equipment requiring sophisticated engineering and managerial control and less mechanized or automated equipment requiring the higher machine skills and technical personnel to convert and adapt techniques.

Volume requirements normally associated with the American market require a minimum of about 240,000 for a single basic series in a passenger car or related light truck. This scale requirement is well above the 20 to 30,000 that is the maximum for single series even in the largest of developing countries. On medium size trucks (3-8 tons), minimal volume drops to from 20,000 to 40,000 and to 5,000 or less on more specialized heavy trucks and buses. Even the smaller truck manufacturerers in Europe (20-30,000 a year) have to offer 200 or more combinations of engine, transmission, chassis, and load-carrying frame to compete in the market. Economies of scale are more pronounced in metal stamping and in the forging or machining of parts, where mechanized or automated equipment can be used, than in assembly or finishing operations requiring a minimum of automatic equipment.

Maintaining quality standards in the production of the thousands of materials and parts that converge into a single assembled vehicle is particularly difficult under regimes of protection and import restriction. In the absence of competitive forces, there is no pressing need for quality control, adherence to rigid specifications, and the maintenance of tightly controlled production schedules - all of which are indispensable to the efficient use of automated systems. Adverse effects are particularly hard felt when automotive industries in developing economies attempt to move out into competitive world markets where high quality standards and production efficiencies are mandatory. Once inefficient systems and practises are implanted, they are difficult to phase out or convert to more efficient operations.

The long-term effects of protectionism on economies of limited market size are evident in a country like New Zealand. In New Zealand, protectionist policies instituted over thirty years ago were designed to create employment. New Zealand must now face up to some difficult economic adjustments, in order to maintain growth and a rising standard of living. The country finds itself in a somewhat ironic situation with labor shortages in low skills and surpluses in highly skilled and educated labor. There is, in fact immigration from the Fiji and Cook Islands to provide unskilled labor for the highly-protected, small-scale automotive and textile industries, and out migration of the skilled and educated who cannot find gainful employment in New Zealand. In order to make more effective use of its labor skills, the economy will have to move into higher-skilled, science-based industries. These new industries, of necessity, must be outward oriented to external markets, because of the limited size of the domestic market.[10/] There are analogous manpower implications in the shifts by developing economies into science-based or automated industries. Inevitably, automated techniques require more sophisticated managerial systems and eventually industrial research and engineering capability to adjust product designs and production techniques to local conditions.

In industrialized countries with access to mass markets, automated techniques have been adopted in an even-widening range in the manufacture of automotive products. The demands for precision and standardization in this industry have also spurred the adoptation of automated techniques. But even among the largest of developing countries, the total annual demand for all types of automotive vehicles was still low in terms of minimal scale requirements for a single series as outline above. Production in Spain of passenger cars, trucks, and buses reached nearly 400,000 in 1968. Other leading countries included Brazil (280,000), Argentina (180,000), and Mexico (140,000). It is true that Sweden only manufactured 220,000 passenger cars in 1968, but production is limited to two basic models. Swedish firms also have an exceptionally efficient international procurement system. But the developing countries manufacture a much more diversified range of vehicles (about ten firms and over fifty models and makes in Argentina alone), and equally important, all the countries mentioned manufacture themselves near-100 percent of vehicle content. Oligopolistic competition under protective regimes has contributed to the proliferation of models and makes.

The fragmentation of production which has characterized automotive industries in developing countries inhibits the efficient use of automated techniques. But the demands for precision and standardization require automated equipment far beyond what scale considerations alone would allow. This has resulted in widespread overcapitalization. For example, in the Latin American Free Trade Area, as a result of national development along the lines outlined above, the region had in 1967 ten times the plant and equipment required to manufacture the total 650,000 vehicles in demand. The region, incidentally, then had more than sixty firms producing at least 200 different models and makes.11/

There are certain segments of automotive production which lend themselves to labor-intensive techniques. These include body fabrication of buses and large truck chassis, interior trim on passenger cars, electrical wiring, and most assembly operations. But in order to use automated techniques to any reasonable degree of efficiency, national industries will have to be rationalized to permit the larger production runs associated with automation. Rationalization would involve the drastic reduction in the number of models and makes that are now generally produced in developing countries. In certain instances, programs to standardize major componentry such as engines and transmission may prove feasible. But such programs after the industry is established are much more difficult to realize than if plans are made at an early stage of sector development. Stabilization of design cycles over extended periods as was done by Volkswagen, Volvo, Citroen, and most other European car producers, is another means for attaining sufficiently large production runs. Modular design of body panels and the use of standard steel shapes for body and chassis elements is another means for achieving volume. Several years ago, United States Steel designed a series of vehicles (passenger car, farm tractor, and small utility truck) based upon 20 to 30 interchangeable body elements. In certain cases, shifts to other materials and techniques may permit a moderate degree of automation. This has been the case in the use of fiber-glass car bodies, which can be produced efficiently in much smaller series than metal bodies.

Developing countries cannot hope to compete in the very high volume series, but there are many specialized areas where they might be able to produce for world markets using moderately automated techniques. Possibilities include: (a) the manufacture of specializaed components and parts, (b) responsibility for a particular vehicle line, (c) specialization in low-volume replacement parts for obsolete models, or (d) the reconditioning of engines and parts. Opportunities are especially promising in low wage areas where productivity is high, such as in Taiwan and Korea. International firms are in a particularly favorable position to assist their manufacturing affiliates in developing countries to specialize for world markets. Multinational firms have the technical assistance resources and, more important, the access to world markets, both of which firms in developing countries need if they are to export.

Several agreements have actually been signed in some of the areas outlined above. One is for parts export from in Mexico by Massey-Ferguson. Another involves Fiat, who is now going ahead on plans to transfer an entire passenger car series to its affiliate in Yugoslavia. Several governments (for example Columbia and Mexico) have revised their automotive decrees in order to encourage foreign partners of automotive manufacturers to produce or procure parts for export. Under these new decrees, exports can be developed in lieu of duplicating a much broader range of components to meet local-content requirements. It should be pointed out that overvalued exchange rates and indiscriminate import substitution price domestic supplier industries out of world markets. This means significant export efforts require some basic policy changes in protectionism.[12/]

There are also widespread shortages of managerial and supervisory personnel to implant production systems and related controls. Typically, an automotive plant requires 20 to 30 middle-range managers, technical supervisors, and master mechanics to initiate procedures and controls and to make the inevitable adjustments to the deficiencies and inadequacies encountered in local environments. This is especially important if these LDC firms are to produce for world markets where quality standards and cost efficiencies are much more demanding than production for protected "seller's markets." The section on diesel engine manufacture in India indicated critical areas, such as production engineering and quality control, where LDC's are especially deficient.

Concluding Observations

Developing countries face some basic dilemmas in automation decisions. On the one hand, varying degrees of automation are necessary to efficiently handle a widening range of standardized, volume production. On the other hand, developing countries experience considerable difficulty in maintaining the volume and standards throughout the production process, which are necessary ingredients if automation is to pay off economically.

In the Cummins case, capital costs in India ran three to five times international standards. These difficulities stem basically from managerial deficiences and the stage of industrial development. As the Cummins diesel engine case demonstrates, adaptation of labor-intensive fabrication is not necessarily a feasible alternative since developing countries lack the labor skills to replace machine skills and technical skills to adjust technology.

Automated techniques may be just as justifiable in manufacturing biscuits as in fabricating engine parts. The conventional wisdom on the choice of production techniques associates labor-intensiveness with simple consumer-goods. But under competitive conditions, where standardization and volume are important factor's, varying degrees of automation may be justified. One such case is the Minoo factory in Iran, which, in addition to manufacturing a broad range of biscuits and confectionery, also produces pharmaceuticals and cosmetics. These latter activities were an outgrowth of the fairly sophisticated laboratory control and packaging facilities built in connection with the candy and biscuit operation. The Minoo plant has one of the largest continuous baking ovens in the world. The candy making equipment is also highly automated - including mixing, extruding, and candy wrapping. The plant does make judicious use of manual labor for final packaging and sorting. Substantial laboratory facilities were built to develop suitable tastes and textures for the national and regional market and to quality control production. About 5 percent of the plant output is now exported to Persian Gulf countries and to Afghanistan in competition with European producers - despite the relatively high cost of protected raw sugar.

Achieving the proper balance between automation and labor-intensive techniques is a universal problem for developing countries. Aside from the long-term employment and income growth effect, which are not dealt with in this paper, there are the more immediate considerations of feasibility and quality of alternative production techniques, with which this paper has been more narrowly concerned. Moderate adjustments in product designs and production techniques would be of considerable advantage in arriving at a proper fit between acquired technology and emerging stages of industrial capability. The fact is that despite considerable differences in production environments (and consumer needs) changes are rarely made in product design or basic production techniques (other than scaling down plants.) Developing countries would benefit greatly from discrete development of indigenous research and engineering capability at the industrial plant levels to help bridge this technological gap.[13/]

Foreign enterprises are in a particularly strong position to assist developing economies in adjusting imported technology and developing long-term research and engineering capabilities. In some cases, they can help redesign product groups that are more in line with technological absorptive capabilities. This may mean adjustments in the degree of automation or in the product itself to accomodate high volume equipment. But most important, the multinational firm's access to world markets provide the best opportunities for using automated techniques in volume production.[14/] Fiat operations in Yugoslavia and Massey-Ferguson in Mexico are cases in point.

This paper has touched upon some of the more important side affects of protectionist policies upon technological structure - an aspect often ignored or neglected in development literature. Import substitution policies, particularly when carried out indiscriminately or to an excessive degree, tend to fragment production and undermine efforts toward industrial specialization and volume production. Protectionism and the drive toward autarky also create a seller's market, which is inimical to cost consciousness and quality standards. Automated techniques are especially appropriate to volume production in environments where high degrees of precision and standards are achievable. Once again, this is as true of biscuits as it is of engine components.

The technology transfer process could also be considerably improved in the management field. Frequent reference has been made in this paper to the dependence of automated systems on scheduling and control. Implanting effective plant management among LDC affiliates has been a major problem for international firms. Automotive manufacturerers estimate it takes 20 to 30 critical technical supervisors and managers on assignments ranging from three months to five years to get a plant operating in a country like Brazil. Much can be done to techniques and concepts in the transfer of industrial management systems. Volkswagen, for example, has put considerable effort into packaging management guides which set forth procedures in considerable detail on everything from quality control to service department organization. By so doing, they hope to accomplish two aims - to decrease the need for management skills at the receiving end and to reduce the number of critical personnel engaged in transferring production systems.[15/]

Under proper marketing and managerial organization, middle-range industrial skills may be used effectively in fairly sophisticated activities involving moderate degrees of automation. A dramatic example of this is in the aircraft maintenance and overhaul facilities which was developed in Costa Rica as an auxilliary to the national airline. The group was known as SALA and employed about 400 people. SALA was certified by the (U.S.) Federal Aviation Authority to perform standard six-month overhaul on certain classes of aircraft equipment including passenger services.

Overhaul services included complete engine and navigational system breakdown. SALA had overhaul contracts with aircarriers such as KLM and Pan American. Unfortunately, their contract with Pan American was revoked due to objections raised by the American labor unions in the early 1960's.

Finally, much can be achieved in the way of intelligent choices and adaptations of production design through the use of some of the newer analytical techniques in industrial management. "Work-restructuring" analysis, for example, is designed to improve productivity of man-machine relationships through the reorganization of tasks and control patterns.16/ Assembly-line operations have been restructured into product-oriented work groups and individual tasks enlarged or enriched to reduce the monotony of mass production and thereby improve productivity. Such groups may combine tool set-up and minor maintenance, assembly or processing, and inspection - in lieu of routinized short-cycled repetitive tasks. These techniques are now used extensively by modern industrial organizations and can be adapted to the particular cultural contexts and levels of skills in a developing country. Work-restructuring techniques ultimately can be carried back to the technical-design phase of product and production engineering. In some cases, minor adjustments in product design may also permit work-structuring which is more in line with the skills and motivational patterns of a particular society.

Footnotes

1/ For a penetrating analysis of the anatomy of automation, see Robert A. Brady, Organization, Automation and Society (University of California Press, 1963.)

2/ The difficulties encountered by craftsmen in becoming "machine-minders" is poignantly described in Thorstein Veblen, The Instinct of Workmanship and the State of Industrial Art (1918). See also Gabriel Ardant, "Automation in Developing Countries," International Labor Review, Vol. XC, No. 5 (November 1964), 460.

3/ For a survey of the literature on capital-intensive versus labor-intensive growth strategies, see Jack Baranson, Technology for Underdeveloped Areas (Pergamon, 1967), pp. 9-22. For an overview of decisions on automation, see Ardant, op. cit., pp. 432-71.

4/ See Gustav Ranis, "Factor Proportions in Japanese Economic Development," American Economic Review, XLVII (September 1957), 594-607; and United Nations, Centre for Industrial Development, "The Dual Nature of Industrial Development in Japan," Industrialization and Productivity, Bulletin No. 8 (1965), 41-52.

5/ See Albert O. Hirschman, The Strategy of Economic Development (Yale University Press, 1959), Professor Hirschman argues for "machine-paced, process-oriented, capital-intensive" techniques (pp. 150-153.)

6/ David Granick, Soviet Metal Fabricating and Economic Development: Practise Versus Policy (University of Wisconsin Press, 1967.) See also review of Granick's book by Jack Baranson, American Economic Review, Vol. LVIII, No. 4 (September 1968), 1028-29.

7/ This section is taken from my book on Manufacturing Problems in India - The Cummins Diesel Engine Experience (Syracuse University Press, 1967). Tables 2, 8, and 11 (pp. 37, 61, and 73) are especially relevant to aspects discussed in this paper on differences in tooling and reliability problems.

8/ See also Toyoroku Ando, "Interrelations Between Large and Small Industrial Enterprises in Japan," Industrialization and Productivity, United Nations Bulletin No. 2 (March, 1959), 26-36. Smaller scale factories and machine shops were able to compete with the larger, more modernized industrial plants by economizing on capital costs and paying lower wage rates.

9/ See Jack Baranson, Automotive Industries in Developing Countries, World Bank Staff Occaisional Papers No. 8 (Johns Hopkins Press, 1969.)

10/ See New Zealand Government, The World Bank Report on the New Zealand Economy 1968 (Wellington,1968), pp. 31-43.

11/ See Jack Baranson, "Integrated Automobiles for Latin America?" Finance and Development, Vol. 5, No. 4 (December 1968), 25-29.

12/ See Harry G. Johnson, Economic Policies Toward Less Developed Countries (Frederick A. Praeger, 1964). Professor Johnson recommends "maximum inducement to the less developed countries to modify their policies of currency overvaluation and import substitution to which they are addicted and to concentrate their efforts instead on economic development through trade with the rest of the world" (p.245).

13/ See Jack Baranson, "Role of Science and Technology in Advancing Development of Newly Industrialization States," Socio-Economic Planning Sciences, Vol. 3, No. 4 (January-February 1970), 351-383.

14/ See James Brian Quinn, "Scientific and Technical Strategy at the National Enterprise Level," paper presented to UNESCO Meeting on the Role of Science and Technology in Economic Development, Paris, 11-18 December 1968. See also Baranson, "Role of Science and Technology," 363-365.

15/ See Werner P. Schmidt, The International Transfer of Management Skills - Volkswagen's Needs, Experiences and Plans, paper presented to AIESEC (Association Internationale d'Étudiants de Sciences Economiques et Commerciales), Torino, Italy, 19 November 1969.

16/ See N.V. Philips' Gloeilampenfabrieken, "Work-Structuring - A Summary of Experiments at Philips 1963 to 1968", Eindhoven, 1969. See also William J. Paul et al, "Job Enrichment Pays Off," Harvard Business Review (March-April 1969), 61-78.

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BRIDGING THE TECHNOLOGICAL GAPS BETWEEN RICH AND POOR COUNTRIES

by

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BRIDGING THE TECHNICAL GAPS BETWEEN RICH AND POOR COUNTRIES

by Jack Baranson*

Implicit in the technological gap between rich and poor countries is something more than acquisition of technical knowledge and the training of technical manpower. Implanted capabilities to manufacture industrial products and intermediate goods entail sustained relationships over extended periods of time between technology donors and recipient firms. It should be noted that problems and issues associated with the transfer of technology among industrialized countries are of a different order than transfers between industrially-advanced and newly industrializing countries, stemming from the much wider disparities in respective levels of technical knowledge and industrial capabilities.[1/] A further distinction also needs to be drawn between an ability to utilize acquired technology and research and engineering capabilities to develop indigenous technology or to adjust acquired technology to local needs and conditions.

This paper focuses upon the problem and issues arising from enterprise-to-enterprise transfer of industrial technology. International relationships between Japanese automotive vehicle and parts manufacturers in Japan and their manufacturing afiliates in Taiwan are taken as a case in

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* Author is a staff economist of the World Bank. This paper is an outgrowth of a research project on enterprise-to-enterprise relationships between international firms and their manufacturing affiliates in developing countries, undertaken by the World Bank in Cooperation with UNITAR (United Nations Institute for Training and Research) under the direction of Walter Chudson. Material presented on Taiwan and Japan is based in part upon visits to those countries in March-April 1970. Opinions expressed are the author's alone and therefore should not be taken as necessarily representing the views of UNITAR or the World Bank.

1/ See recent Report of the Panel on International Transfer of Technology to the U.S. Department of Commerce Technical Advisory Board on Factors Affecting the International Transfer of Technology Among Developed Countries (U.S. Government Printing Office, 1970).

point. The factors which contribute to the technological gap between Taiwan and Japan are typical of other LDC cases and include a) differences in respective stages of industrial development and manpower resources, b) the sets of economic policies in force in each country, and c) market strategies of Japanese firms, which in turn are strongly influenced by economic policies in both countries. The intricacy of the technology transferred, the absorptive capabilities of recipient firms, and the transfer capabilities and motivation of donor firms, are determining elements in the cost feasibility of transfer.[2/]

These considerations of the so-called "technological gap" are part of the larger developmental questions related to factor endowments and long-term comparative advantage. In the short term, acquired technology is combined with available skills and other factor endowments; but over time, factor productivities and technology itself can be upgraded through investments in education, in research, and in institution building. Industrial activities in the comparative-advantage range is, in part, a question of which segments of production can be carried out with available and manageable technology - given available levels of skills and industrial organization. In its electronics industry, Taiwan was able to limit production

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2/ A study of the transfer of jet aircraft manufacturing techniques from the U.S. to Japan shows that the ability to absorb technology depends upon the intricacy of the particular component and the manufacturing experience of the parts manufacturer. The degree of self-sufficiency reached was based upon a realistic appraisal of time and resources needed to bridge the gap for each of the hundreds of materials and parts that went into the jet aircraft and its engine. See George Hall and Robert Johnson, "Transfer of U.S. Aerospace Technology to Japan," paper presented at Conference on Technology and Competition in International Trade, sponsored by Universities - National Bureau Committee for Economic Research, New York, October 11-12, 1968.

to value added based upon its comparative advantage in highly productive, low-wage labor, which is employed in plants scaled to international markets, and combined with imported skill and technology - some of which is embodied in equipment and parts. Over time, production activities can be shifted into activities of emerging comparative advantage based upon emerging factor productivities and the enlarged capabilities of enterprises to utilize technology and trade internationally. The question of whether these structural changes are best achieved through price mechanisms or through purposeful price distortions (tarifs, exchange manipulations, or public investments in research), I leave to the trade and development theorists.[3/]

Reducing Technological Gaps to Manageable Proportions

Developing countries now produce a rather impressive array of industrial goods ranging from simple consumer items to sophisticated engineering products, and from the processing of basic materials to the final stages of fabrication. Technological transfer and absorption has been both extensive and rapid in the past two decades among a dozen or more of the newly industrializing states. But this does not necessarily mean that the industrialization has been efficient from an economic standpoint. Foreign

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3/ For an analysis of the relevant theory, see Harry G. Johnson, Comparative Cost and Commercial Policy Theory for a Developing World Economy, Wicksell Lectures 1968 (Stockholm: Almqvist and Wicksell, 1968.) On the use of the tariff and other price-distortionary devices as a growth strategy in the Taiwan case, see Ken C.Y. Lin, "Industrial Development and Changes in the Structure of Foreign Trade: The Experience of the Republic of China in Taiwan, 1946-66," International Monetary Fund Staff Papers, Vol. XV, No.2 (July 1968), 290-321.

exchange constraints and the need to expand industrial employment have moved the LDC's (less developed countries) into an everwidening spectrum of industries producing at small scale for domestic markets of limited size. Such industrialization has not only been costly by international standards, it often has moved the LDC's into extensive areas of processing and fabrication that is beyond their technological capabilities.[4/]

Protectionist policies have also introduced an inevitable lag in product designs and production techniques. For example, automotive vehicle models must be stabilized over much longer periods among LDC's in order to amortize expensive tooling and dies for low-volume production. The techniques themselves are, from the outset, outmoded by international standards of high-volume production. Under the seller's market created by systems of protection, quality control and materials standards, which constitute a vital part of technological transfer, are difficult to establish and maintain. Furthermore, high cost supplier industries tend to price manufactured goods out of world markets, where volume production might be possible. In regional markets, national protectionist interests have proven to be an insurmountable obstacle.[5/]

In short, over-ambitious industrialization programs have <u>created</u> technological gaps, which are then difficult to bridge in terms of time and

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4/ See author's <u>Manufacturing Problems in India: The Cummins Diesel Experience in India</u> (Syracuse University Press, 1967).

5/ See author's "Integrated Automobiles for Latin America?" <u>Finance and Development</u>, Vol.5, No.4 (December 1968), 25-29.

resources. In such cases, the problem is primarily one of narrowing the gaps downto manageable proportions, before bridging the gaps between donors and recipients. Some of the gaps could be narrowed appreciably if LDC's could take on technological tasks in manageable segments - that is to say, comensurate with their technical skills and the stage of development of their supplier industries. But this implies an international division of labor not only in finished products but in sub-assemblies and industrial materials. It also entails marketing and trading arrangements that are often difficult to attain in the world economy.

One basic dilemma confronting LDC's is that whereas automated techniques are not suited to the limited size of their domestic markets and employment needs, the use of labor-intensive techniques encounters difficulties in attaining required precision in production and in training the necessary supervisory and operator's skills. There is also the problem of technical skills to convert technology to low-volume production requirements. The burden of technological development is thus shifted from capital and foreign exchange scarcities to manpower and organizational deficiencies. Thus, paradoxically, the more advanced industrial techniques associated with high volume production are often more readily absorbed in newly industrialized economies than are the so-called labor-intensive or capital-saving techniques.[6]

6/ See author's The Relevance of Automated Techniques to Industrialization in Developing Economies, paper presented at Conference on Manpower Problems Associated with Automation and Advanced Technology in Developing Countries, sponsored by the International Labor Organization, Geneva, July 1-3, 1970.

Another basic dilemma concerns the LDC's long-term technological growth and development. Economists from developing countries have used terms such as "technological dependence" and "technological imperialism" to describe relationships between developing and advanced economies.[7/] The dilemma is whether to invest in absorptive and adaptive capabilities and sacrifice, if necessary, production efficiencies; or whether to emphasize the acquisition of "narrow-gap" technologies which maximize productive output in the short run and minimize learning effects - that is to say, the upgrading of technical and organizational skills. A related set of issues concerns licensing, with a minimum of foreign involvement, versus investment, which entails ownership and technical control by foreign enterprise.[8/]

Taiwan's Automotive Industry and Japan's Role in its Development

Taiwan's automotive industry has followed a path which is now familiar in a dozen or more developing countries.[9/] It is a small industry even by LDC standards (only 11,000 vehicles annually), but already there is an excessive proliferation of models and plants. Three plants,

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7/ See, for example, Celso Furtado, Development and Underdevelopment (Berkeley: University of California Press, 1964), pp. 60-62; and Victor L. Urquidi, "Latin American Development, Foreign Capital, and the Transmittal of Technology," El Trimestre Economico, XXIX (January-March, 1962), 19-29.

8/ See author's "Technology Transfer thru the International Firm," American Economic Review, Papers and Proceedings, Vol. LX, No.2 (May 1970), 435-40.

9/ See author's "Automotive Industries in Developing Economies, World Bank Staff Occasional Paper No.8 (Johns Hopkins Press, 1969).

with installed capacities for 50,000 vehicles,already produce at least 8 basic models of light cars, in addition to several local firms that also assemble about 3,000 trucks a year. There has been a parallel over-development of the motorcycle industry, with 19 firms producing 115,000 units a year as compared to about 2,500,000 in Japan. Diseconomies of small-scale production are exacerbated by high domestic-content requirements - 60 percent in light motor vehicles and 70 percent for motorcycles. Supplying this local content are hundreds of small manufacturers of components and parts.

Minimum economies of scale by international standards are between 40,000 - 60,000 for assembly, 80,000 - 120,000 for manufacturing engines and transmissions, and 160,000 - 240,000 for body stamping. Motor vehicle production volumes for a single series now run from 1,000 - 5,000 units annually in Taiwan. It is a considerable industrial achievement that production costs do not run higher than they do (the resource cost of the 60 percent value added domestically is between two to three times the cost of the c.i.f. equivalent.) This development has taken place under a regime of protection and progressive import substitution over the past ten years. Domestic content requirements, in effect, give absolute protection to local parts manufacturers.

Procurement of quality parts at reasonable costs has been a major problem in Taiwan. Small-scale production for the limited local market has been further fragmented through competition among many producers in the protected market, which has lead inevitably to a duplication of each other's product lines and production facilities - and further deterioration in the efficiency and quality of production. This duplication of production facilities has been especially evident among foundries and in die-making, with pitiful efforts to cast moldings and make stamping dies at miniscule scale. Door frames produced under similar primitive conditions by small-scale, local supplier have to be straightened out piece by piece by the vehicle manufacturer. Efforts to establish consolidated facilities for castings, forgings, and die-making, have proven futile thus far. Among these small-scale suppliers, there is widespread under-utilization of equipment (for example, in many shops, presses are used only a few days a month, and as much as a third of time is spent in changing dies.)

The described fragmentation deeply influences the nature and quality of acquired technology and compounds the problem of transferring and implanting production systems. Typically, it requires up to a dozen foreign technicians over a period which may extend from several months to several years to transfer technical knowledge in manufacturing techniques, equipment utilization, quality and production controls, and to develop the necessary supervisory and operator skills. The magnitude of the technological transfer problem is suggested by the reality that a single automotive engine manufactured in the United States depends upon as many as 200 plants to supply 60 percent of the engine's content and as many as 15,000 separate machining and processing techniques to complete the remaining 40 percent value added by the engine manufacturer.10/

Taiwan's vehicle and parts industry has been developed largely in technical cooperation with Japanese firms. The motor car and motorcycle industries are wholly-owned by Chinese, but there are about two dozen joint

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10/ See author's Manufacturing Problems (footnote 4, supra), p.19.

ventures with Japanese firms and a limited number of American and European firms engaged in manufacturing automotive parts. Up until recently, the local affiliate of Nissan held a monopoly in passenger-car manufacture, but now three other firms - affiliated to Honda, Toyota, and Toyo Kogyo - have entered or are entering the market as vehicle manufacturers. Parts produced in Taiwan were not only high cost but of poor quality, and it is only since the new entries into the market that the quality of production has shown signs of improvement. For example, a team of Japanese officials are meticulously supervising the installation of casting facilities for the new plant being built to manufacture Toyota cars.

In order to improve further the technical efficiency of the Taiwan vehicle and parts industry, it first will be necessary to a) curb the further proliferation in models and makes, b) reduce local content to a reasonable level of cost efficiency, and c) develop specialized vehicle or parts production for world markets.[11/] Japanese partners (like other international firms in the automotive field) are in a unique position commercially and geographically to help develop parts production for world markets.

Taiwan's highly successful export industry in electronics is indicative of the direction in which the auto parts industry might move.

11/ Several international firms have already concluded agreements with other developing countries which provide for export earnings from specialized manufacture of components and vehicle for world markets. For example, Massey-Ferguson concluded an agreement in Mexico two years ago, which provided for export of tractor components to help pay for the 30 percent import requirement on production for the local market. Fiat concluded an agreement with Crvena Zastava in Yugoslavia to manufacture one of the smaller cars in Fiat's line for export, thereby moving into production volumes that could compete on the world market. See policy recommendations in author's Automotive Industries (footnote 9, *supra*), pp. 66-80.

Electronic plants turn out components and sub-assemblies for radios, TV sets, and other related equipment, including transistors and other sophisticated micro-electronic devices. Production for export is made possible by a judicious mix of foreign and domestic factor inputs. In the case of miniaturized devices, pin-head-size transistors are cut from silicon wafers using laser guns and microscopes for the fine welding. The 1,000 to 2,000 people employed locally in typical plants are supplimented by a dozen foreign technicians who are critical to the effective implantation of technology. Domestic materials and parts have been incorporated, in the Taiwan case only as local supplier capabilities have developed. It is true that these plants producing exclusively for export are wholly owned and controlled by foreign firms - but this pattern could change as indigenous capability to market internationally develops.

Several export ventures are now underway in the automotive field.[12/] One Japanese firm now has a plant in Taiwan to manufacture its car radio antennas for their export market in Europe and North America, since production costs in their Taiwan plant are nearly 20 percent below those in Japan. The savings are in labor costs, which account for nearly 25 percent of total costs. Taiwan wages are one-third of Japan's, but productivity is near Japanese standards. This is because the scale of production is nearly the same in both plants, production techniques are virtually identical in both countries, and labor productivity in Taiwan's comparable to Japan's.

12/ There are about a dozen joint ventures in Taiwan with Japanese partners producing piston rings, engine metals, forging parts, engine bearings, engine belts, springs, brake liners, water pumps, horns, switches, and wiring harnesses. Other ventures planned include rubber parts, meters, air filters, key locks, die casting parts, lamps, mirrors, engine valves, radiators, drive shafts, and clutches.

The Taiwan plant is also able to capitalize on low wages to produce its own copper tubing for the antenna rods.

There are many other opportunities for export expansion in automotive parts, provided the production series is of sufficient volume and the plants are well managed and integrated into world markets. There is a particular interest in products or product elements that are low-volume items in Japan, since these items tie up equipment in Japanese plants and require disproportionately higher amounts of labor. Japanese manufacturers have expressed interest in such items as distributor coils, starters and generators, lamps and horns, pistons and pumps, and shock absorbers and motorcycle suspension systems. One Japanese motorcycle manufacturer is considering the transfer of its lower volume series to Taiwan, leaving higher-volume production with more frequent design changes to Japanese plants. Foundry work and electrical components (with 40 percent or more labor content) are two obvious areas for potential expansion in Taiwan. Other possibilities include items in relatively low-volume series or those that have a relatively high value-to-bulk ratio (to absorb freight and duty charges). Another step in the right direction is the formation of a new company in Taiwan by the Nissan Group, Taiwan Automotive Parts, which will manufacture both for the domestic and export markets. Production will include car locks and instruments, air and oil filters, and piston rings. These particular products were chosen with a view toward common tooling in a joint facility and in order to achieve volume production of common elements or sub-assemblies.

Japanese firms are strongly influenced in their external relations with Taiwan by administrative guidelines issued by the Japanese Government.

Recent policies seem to favor industrial expansion and technical developments in Taiwan as a competitive base for indirect exports to third markets - particularly to the United States and Europe, but not for production that will compete in the home market.[13/] A leading wire harness manufacturer in Japan has been approved by MITI (Ministry of International Trade and Industry) to manufacture its products in Taiwan for export to Japan - but this was a rare case. Before permission was granted, agreement had to be reached with the four other wire harness producers in Japan as to the type of products that would be permitted into the Japanese market, and provisions made for the absorption of displaced Japanese workers. It took two years to work out this agreement, and several other similar proposals have been turned down by MITI thus far.

But the fact is that the Japanese Government has recognized that in order to continue its economic growth, Japan must export, and to export it must continue to improve its economic efficiency. For nearly two decades labor efficiency has continued to rise,[14/] but for the first time this past year wages increased ahead of productivity gains. Measures adopted thus far by the Japanese Government consist mainly of incentives to invest in

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13/ In many areas, Japanese firms maintain a dual pricing system which keeps home prices well above export prices. For example, the ex-factory price on a color TV set is $160 for the export market, as compared to $530 in the home market. See "Japan's TV Trade Told to Up Prices," Journal of Commerce (July 28, 1970).

14/ See Kiyoshi Kojima, "Japan's Trade Policy", Economic Record, Vol. 41, No.93 (March 1965), 54-77. Kojima notes that between 1953-1960, when exports expanded by a factor of 324 (1953=100), relative labor costs declined to 89. That is to say, labor productivity increased by a factor of 182, as compared to 148 for money wages, (op. cit, p.72).

labor-saving equipment and encouragement of corporate mergers to improve production efficiencies. But a third possibility for maintaining competitive costs in the face of rising wages in Japan is to relocate industrial activities with high wage costs to low-wage countries such as Taiwan or Korea. The familiarity of Japanese business firms with the Taiwan and Korean markets make these countries doubly attractive as export sites. The dilemma has been to move Japanese labor into more productive activities without creating unemployment and idle capacity in Japan. It is for this reason that the Japanese Government has been reluctant to sanction plant expansions in Taiwan that would compete in the Japanese home market. Restructuring the international division of labor between Japan and Taiwan would contribute to the increased efficiencies of the Japanese automotive industry in a minor way, but it is of major importance to technical progress in Taiwan's economy.

Technical expansion into more efficient, high-volume production in the comparative advantage range requires closer technical and marketing arrangements between firms in Taiwan and their Japanese partners. Japanese firms, like most international firms throughout the world, are not willing to commit the scarce production and marketing personnel unless they are allowed equity participation, which is the only assurance of an adequate rate of return.[15/] Export ventures in the electronics field in Taiwan have proven highly successful from a production viewpoint in a relatively short time mainly because sufficient personnel was assigned to assure high efficiencies in production and marketing. In the previously mentioned car radio

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15/ See reference in footnote 8, supra.

antenna plant, 16 Japanese engineers and technicians worked over a two year period to assure the success of the operation. Such ventures also owe a major portion of their success to the judicious choice of product lines and the structuring of value added in Taiwan in combination with value added in Japan - embodied skill and technology from Japan used in combination with the low-wage, high-productivity labor in Taiwan.

Technical development in support of more efficient industries also requires a reversal of protectionist policies on the part of the industrialization authorities in Taiwan. Businessmen in Taiwan, as in most developing countries, would prefer the quiet life of manufacturing in protected markets for themselves with limited entry for others. A reversal of the present trend toward proliferation of models and increased local content in vehicles produced for the local market is also needed, expanding instead into specialized production for world markets and limiting import substitution to the cost-efficient range.

Policies and Measures to Narrow and Bridge Technological Gaps

As indicated in the introduction, the first step toward bridging technological gaps is narrowing them down to "bridgeable" sizes. This narrowing down may be achieved through 1) adjustments in LDC industrialization policies, 2) adjustments in the trade policies of industrially advanced countries, 3) the development of indigenous research and engineering capabilities, and 4) measures designed to solicit very specialized kinds of cooperation of foreign enterprise. Policies and measures in each of these areas are outlined and summarized in this section.

1. LDC development policies

Indiscriminate import substitution creates everwidening technological gaps in manpower and know-how. An industrialization policy which is more selective in terms of scarcities in technical and managerial skills is the first step toward reducing technological gaps to manageable proportions. Understandibly, LDC governments are concerned over foreign exchange flows and overall efficiencies in resource utilization, but to the degree possible, decisions concering the factor mix in production between foreign and domestic inputs, and in the product mix itself, should be left to the firm. This is so enterprises will have the maximum latitude to manufacture and procure materials and parts in areas where the technological gaps are "bridgeable". In this regard, there is also a widespread tendency on the part of industrialization authorities to create employment through small-scale enterprise and labor-intensive techniques. This places an excessive burden upon the technological transfer process, where machine skills must then be replaced with human skills, and scarce technical and managerial resources are required to adapt acquired technology.[16/]

2. Trade policies of industrially-advanced countries

If LDC's are to avoid the high-cost range of small-scale or technologically-difficult areas of production, they must be allowed to specialize in those products and intermediate industrial goods that are in their range of emerging industrial competance. Industrially-advanced countries should specialize in value added based upon high technology, high levels of technical and managerial skills, and heavy capital investment; and devel-

16/ See reference in footnote 6, supra.

oping countries should take over an increasing share of industrial activities with high labor content in the middle-level skills.[17/] Ideally, production should be broken down to specializations and complimentaries based upon the respective capabilities of the trading partners - Taiwan's electronic industry provides a case in point. The modern world of communication and transport and the emergence of multinational marketing and manufacturing groups, has made such specialization and interchange possible. But the further development of an international division of labor along these lines is now hampered by discriminatory tariffs imposed by industrially advanced countries which are progressively restrictive toward processed goods. The same applies to escalated freight rates. Indiscriminate and excessive import substitution can only be avoided, if more economic paths to earn income and provide employment are opened up through world trade.[18/]

3. Development of indigenous research and engineering

A distinction needs to be drawn between capabilities to convert acquired technology and absorptive capacity for unaltered technology. Involved

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17/ See Hal B. Lary, Import of Manufactures from Less Developed Countries (National Bureau of Economic Research, 1968.) Lary ranks industrial products in world trade accoring to labor productivity - which is a composite including skill, technology, and capital. I believe a further breakdown into segments of products would reveal that the comparative advantage of low-wage labor is anywhere it can be used in combination with skills, technology and equipment or materials which embodied deficient factors. For guidelines to industrialization in the comparative advantage range in the automotive industry, see author's Automotive Industries (footnote 9, supra), pp. 70-76.

18/ These arguments are further developed in author's article to be published in Finance and Development, "Clearing the Way for Exports." On reorienting New Zealand's industrial economy to high levels of skills and know-how, see author's chapter in The World Bank Report on the New Zealand Economy (Wellington, N.Z.: Government Printer, 1968), pp.34-35.

in the later are measures to upgrade technical and managerial skills at the plant level. The former involves long-term programs to develop research and engineering capabilities at the firm level and among cadres in economic planning and financial institutions engaged in industrial planning and related investment decisions. These engineering capabilities are needed both for marginal adjustments in technology and for long-range planning to utilize lower-range skills in larger numbers.[19/]

Improving the quality and efficiency of the smaller-scale supplier industries is another basic task in bridging technological gaps. Smaller firms, as a rule, have very limited access to foreign technical assistance or opportunities for the "sustained relationship" that is needed to implant technology. In the case of Taiwan's automotive parts industry a development corporation aimed at upgrading local supplier capabilities might prove a suitable means for channeling technical and financial resources from Japan and elsewhere. Vehicle manufacturers in Taiwan and their foreign affiliates would have a vested interest in improving parts supply, and they might provide equity for such institutions. A development corporation has been organized in Taiwan (Chunghwa Electronics Development Company) with precisely this purpose in mind. It should be possible to involve the technical and financial resources of vehicle manufacturers, since it serves the interests of these foreign corporations to develop supplier capabilities in markets where they themselves have a manufacturing role. Industrial and

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19/ For more detailed suggestions on the development of indigenous research and engineering capabilities, see author's, "Role of Science and Technology in Advancing Development of Newly Industrialized States," Socio-Economic Planning Sciences, Vol. 3, No.4 (January-February 1970), pp. 351-383.

financial interests in Japan also probably would be receptive to such a proposal, which would reinforce the drive toward advancing productivity in the Japanese economy by helping to shift segments of Japanese industry with rising labor costs to areas with lower labor costs.

National programs may be undertaken to broaden knowledge on trade in industrial technology between industrially-advanced and newly industrializing countries. Information on sources of technology, on prices charged, and on qualitative differences among technology donors, could enhance the bargaining power of LDC enterprises. It would be unreasonable to generate exhaustive details covering the vast spectrum of industrial alternatives, but it may prove feasible to develop some general guidelines and centralized services that can channel requests from local firms to knowledgeable sources of information.[20/]

4. LDC policies toward foreign enterprise

The technological development of LDC's is critically dependent upon foreign enterprise to provide and implant technical knowledge and managerial systems. The quality and operational effectiveness of implanted technologies in terms of high contributions to economic growth, depend upon the choice of partners and the arrangements negotiated. Competitive production particulary depends upon technical proficiency, which for a wide

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20/ See, for example, recent work by Constantine V. Vaitsos, Transfer of Industrial Technology to Developing Countries Through Private Enterprises, paper prepared for Colombian National Planning Department, 9 February 1970. For an analysis of the returns earned by foreign corporations on the technology package, see also C.V. Vaitsos, Transfer of Resources and Preservation of Monopoly Rents, paper prepared for Harvard University Development Advisory Service, 28 April 1970.

range of industries can only be acquired through a sustained relationship with an experienced industrial partner. This is necessary in order to absorb the myriad of processing specifications, material standards, tooling guidelines, and control procedures that are associated with the manufacture and assembly of industrial products. Particularly advantageous are agreements which include a) marginal adjustments in product designs and production techniques to accomodate factor availibilities, b) the development of local supplier industries, and c) help develop indigenous research and engineering personnel who can participate in worldwide marketing and production systems.[21/]

As an example of the role international corporations can play in narrowing technological gaps, Volkswagen has put considerable efforts into its transfer techniques of production and related management systems. The firm has developed management and procedural guides covering every aspect of vehicle manufacture and assembly in overseas plants - from quality control to machine tool utilization - with a view toward decreasing the need for management skills at the receiving end and reducing the number of VW personnel engaged in transferring production systems.[22/]

21/ For an analysis of the adjustments made by an American diesel engine manufacturer in India, see reference to author's Manufacturing Problems in India, footnote 4, supra, at pp. 63-66, 70-73. See also author's Industrial Technologies for Developing Economies (Praeger, 1969), pp. 45-53; James B. Quinn, "Technology Transfer by Multinational Companies," Harvard Business Review (November-December, 1969), 147-161; and Hans Heymann, Jr. (Rand Corporation), Promoting the "D" in R&D: Dubious Models and Relevant Strategies, paper presented at the Research and Development Planning Management Seminar organized by the Turkish Scientific and Technical Research Council (TUBITAK) and sponsored by the OECD Technical Assistance Program, Istanbul, Turkey (May 4-8, 1970).

22/ See Werner P. Schmidt, The International Transfer of Management Skills - Volkswagen's Needs, Experiences and Plans, paper presented to AIESEC (Association Internationale des Etudiants en Sciences Economiques et Commerciales), Torino, Italy (19 November 1960).

LDC governments must come to realize that foreign firms will not part with critical transfer resources (largely manpower and the technical knowledge embodied in them) to achieve the tasks outlined above, unless they can earn an adequate return. Involved here are issues of licensing vs. direct investment policies on the part of technology donors and the related issue of ownership and control in foreign ventures. LDC's must develop a reasonable balance in their attitudes and policies toward foreign enterprise which takes into account, on the one hand, the price that must be paid in terms of resource costs and deference to foreign ownership and control.[23/]

Concluding Remarks

In the final analysis, narrowing and bridging technological gaps is part of the general problem of advancing productivity in emerging areas of comparative advantage. A principal source of comparative advantage for the LDC's in early phases of industrialization is low wage labor - provided it is employed to give the LDC a comparative advantage in labor costs. The

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23/ See reference in footnote 8, supra. See also Detlev F. Vagts "The Multinational Enterprise: A Challenge for Transnational Law," Harvard Law Review, Vol. 83, No.4 (February 1970), 739-92.

economic benefits derived from improvements in the technological transfer modes depend largely upon market orientations and production opportunities that permit the LDC to operate in its area of "emerging comparative advantage" - which in the long term means developing its own technical and managerial skills. But in the critical interim stages of development, opportunities for efficient production may be broadened through trade in intermediate goods and certain end-products in which the LDC's factor supply of middle-range skills is combined with foreign technology and high skills through trade both in factors and end-products.