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Industry and Development attempts to provide a link between practitioners and theorists working on economic and related aspects of industrialization. The focus of the journal is on applied economics, particularly in areas emphasized in the Lima Declaration and Plan of Action on Industrial Development and Co-operation.

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The Supervisory Panel of *Industry and Development* welcomes readers' opinions and comments, and will be glad to consider for possible publication articles relevant to the aims and scope of the journal (see "information for contributors", back cover).

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Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

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Totals may not add precisely because of rounding.

The following symbols have been used in tables:

> Two dots (..) indicate that data are not available or are not separately reported.
>
> A dash (--) indicates that the amount is nil or negligible.

The following abbreviations are used in this publication:

Organizations or bodies

BIS	Bank for International Settlements
DAC	Development Assistance Committee
EEC	European Economic Community
IMF	International Monetary Fund
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
UNCTAD	United Nations Conference on Trade and Development

Technical abbreviations

CAD/CAM	computer-aided design/computer-aided manufacturing
DRC	domestic resource cost
GDP	gross domestic product
GNP	gross national product
ECU	European Currency Unit
LIBOR	London Inter-Bank Offered Rate
NPV	net present value
RV	retained value
SAP	Structural Adjustment Plan

INDUSTRIAL POLICY IN DEVELOPING COUNTRIES: THE FOREIGN EXCHANGE COST OF EXPORTS

Ajit Singh*

Introduction

The slow-down in world economic activity which followed the second oil price rise of 1979 and the adoption of restrictive monetary policies in the leading developed countries has had devastating effects on the economies of the third world countries. After the first oil price increase there was, between 1973 and 1979, only a small reduction in the average annual rate of economic growth of developing countries, from 6.3 per cent to 5.2 per cent. Evidently, these countries managed on the whole to cope with this major economic shock and the consequent disorders that plagued the world economy in the subsequent years reasonably well. Indeed, developing countries performed better in this respect than the developed market economies, the long-term trend growth rate of which nearly halved between 1973 and 1979 compared with the period 1960-1973 (see World Bank [2]).

From 1979 to 1983, however, the growth rate in developing countries averaged only 2 per cent, which in view of a population growth of a roughly similar magnitude implies that there was no rise in per capita gross domestic product (GDP) at all in the third world. In fact, in 1982, for the first time since the Second World War, per capita GDP in developing countries actually fell, and the fall in 1983 was even greater. Although developing countries have recorded somewhat higher economic growth rates since then, these are both below historical levels as well as below the level required to support sustained socio-economic development.

In view of their large foreign debts, the Latin American countries have been particularly hard hit by the world economic crisis. In 1983, GDP in these countries fell by more than 2 per cent, and per capita income by nearly 6 per cent. The year 1983 was also the third consecutive year of falling GDP in Latin America. Per capita GDP in seven Latin American countries was reduced to the 1972 level or below in 1982. For the region as a whole, per capita GDP levels in 1983 were lower than in 1977, and in some countries as low as in the 1960s. Similarly, the low-income African countries have fared particularly badly during the period 1970-1983.

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*Faculty of Economics. University of Cambridge. This paper is a shortened version of Singh [1], with some editing by the UNIDO Secretariat. For an expansion of the author's views, especially on current development in the international economy and on industrial policy choices for developing countries, see Singh [1].

Reduced economic growth has, not surprisingly, been accompanied by large falls in the levels of consumption and employment, and in a number of African and Latin American countries by enormous underutilization of industrial capacity and deindustrialization. For example, in the United Republic of Tanzania, which is not untypical of low-income sub-Saharan African economies, manufacturing production fell by more than 25 per cent in both 1981 and 1982. Capacity utilization in industry in 1983 was approximately 20 per cent. Similarly in Latin America, in countries such as Mexico and Brazil, which already have large manufacturing sectors, there have been sharp falls in industrial output, employment and capacity utilization since 1981. In Mexico, for example, industrial production had been increasing at a rate of over 6 per cent per annum between 1977 and 1981. It declined by 2.5 per cent in 1982 and by about 5 per cent in 1983. Real wages fell by almost 25 per cent in 1983.

The central industrial policy issue for these Latin American and African economies is how to arrest their current industrial decline and to restore industrial development to its long-term trend rate of growth.

It is certainly arguable that in many Latin American and African countries, a large part of the economic and industrial decline over the last four years is due to the world economic crisis. The most important channels through which the slow-down in world economic activity since 1979 has affected these economies are the following:

(a) A reduction in the demand for their products, particularly commodity and mineral exports;

(b) As a consequence of (a), a fall in commodity prices and hence adverse movements in terms of trade;

(c) An increase in the real burden of interest and debt service payments, due partly to (a) and (b) and partly to an enormous increase in interest rates;

(d) A reduction in the amount of aid and other capital flows.

The three factors (a), (b) and (c) above have played havoc with the balance-of-payments situation of the non-oil-producing developing countries.* Their combined current account deficit rose to $108 billion in 1981 and to $87 billion in 1982, about twice the average annual level during the period 1977-1980. However, as the International Monetary Fund (IMF) [4] has pointed out, for the oil-importing developing countries, the entire deterioration of the combined current account balance from 1978 to 1981 can be ascribed essentially to these three adverse factors.

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*For a full discussion of the nature and the extent of changes in (a), (b) and (c), see Singh [3]

Whether the deterioration in the balance-of-payments position of a Latin American or African economy is wholly due to external factors or is the result of both internal inefficiencies and external changes, it has far-reaching consequences for all spheres of the economy. The external payments constraint can become so binding that a country has to curtail not only imports of luxuries or other consumer goods, but also the essential imports needed to maintain the existing levels of domestic production. Since neither the necessary complementary inputs such as industrial raw materials or spare parts can be imported, nor foreign technical knowledge or managerial expertise utilized, the level of industrial capacity utilization falls and industrial production declines.

Thus, the dollar value of Mexico's imports fell almost 40 per cent in 1982 and 70 per cent from the first quarter of 1982 to the first quarter of 1983. The fall in the dollar value of Brazil's imports was 12 per cent and 23 per cent in the corresponding periods, in addition to an earlier fall in 1982 [2]. Similarly, in the United Republic of Tanzania it is estimated that the level of imports at the end of 1985 was 25 per cent below its volume in 1970.

Reduced industrial production also has adverse effects on other parts of the economy. Thus, agricultural production becomes handicapped, directly as well as indirectly, by the non-availability of foreign and domestic industrial inputs (such as fertilizers, transportation equipment or other agricultural machinery for farmers). These disequilibria in agricultural and industrial production in turn generate inflation and disequilibrium in government finances.

In many developing countries, sales and excise taxes on industrial production and import duties are a major source of government revenue, so that the balance-of-payments constraint is both directly and indirectly responsible for the enormous increases in budget deficits or public sector borrowing requirements experienced by these countries. With regard to the United Republic of Tanzania, it has been estimated that if industry were operating at a normal level of capacity utilization instead of its present low level, sales and excise tax revenues would be doubled, which would not only eliminate the current fiscal deficit, but also make a sizeable contribution to the capital account (see JASPA/ILO [5]).

In considering the present and future prospects of industrial development in the Latin American and African countries and in the formulation of industrial policy, an important factor to bear in mind is that the current world economic crisis may not simply be a temporary phenomenon, but may instead herald a long-term deceleration in the expansion of world economic activity. There are a number of extremely important factors which suggest that the world economy may grow much more slowly in the future than it did in its golden age of 1950-1973 (see Kindleberger [6]). The Latin American and African countries have to contend with the probability that the rate of growth of the world economy during the next decade may not be significantly greater than it was between 1973 and 1983 (which at 2.5 per cent per annum is less than half the rate recorded from 1950 to 1973).

The crucial consequence for developing countries of the expected long-term deceleration in world economic growth is that world trade will expand much more slowly than in the period 1950-1973, when world exports of manufactures increased at a historically unprecedented rate of 10 per cent per annum. Moreover, the slower growth of world economic activity is likely to mean that the adverse movements in the terms of trade experienced by developing countries during the last decade will not be reversed. Thus, the foreign exchange constraint on industrial development in the Latin American and African countries will continue to remain as severe in the foreseeable future as it has been in the recent past.

A. Industrial crisis and industrial policy choices in Africa and Latin America

Although there is an acute industrial crisis both in Africa and in Latin America, the level and past history of industrial development in the two continents is rather different. In order to bring out more clearly the nature of the difficult industrial policy decisions facing these countries today, this study examines the specific experience of one country in Africa (the United Republic of Tanzania) and one country in Latin America (Mexico).

1. United Republic of Tanzania

As in most other sub-Saharan African economies, the overall level of industrial development in the United Republic of Tanzania is very low. Even before the onset of the present industrial crisis in the late 1970s, industry accounted for only about 10 per cent of GDP and employed less than 1 per cent of the total work force. A large part of the existing industry was established after the country's independence in the mid-1960s. This fledgling industrial development has been hard hit by the continuing foreign exchange crisis of the last six years.

Tables 1 and 2 bring out the plight of Tanzanian industry. For various reasons, the more reliable data pertain to "large-scale" manufacturing, that is, firms employing 10 or more workers. Such firms account for nearly 75 per cent of total manufacturing production, and between 1977 and 1983, their manufacturing value added in constant prices fell by nearly 50 per cent. Table 1 gives data on industrial capacity, volume of physical production and capacity utilization for selected industries in 1976, 1981 and 1984.

Two observations may be made with respect to this table. First, the level of capacity utilization in the beer and cigarettes industry has remained relatively high in the 1980s. The main reason for this is that these two industries are the main revenue earners for the Government and have, therefore, been accorded preference in the allocation of foreign exchange. Secondly, despite the low level of capacity utilization, capacity in a number of industries has continued to increase in the 1980s, thus resulting in even greater capacity underutilization. This paradoxical situation arises partly from the time-lags inherent in the completion of investment projects, and partly from the fact that by and large foreign aid is provided for creation of new capacity rather than for activation of existing capacity.

Table 1. United Republic of Tanzania: capacity utilization and production in selected industries

Product	Unit	Capacity			Production			Percentage capacity utilization		
		1976	1981	1984	1976	1981	1984	1976	1981	1984
Textiles	Metres a/	90.0	200.0	200.0	75.0	95.5	69.2	83	48	35
Cement	Tonnes b/	340.0	1 100.0	1 350.0	244.5	390.0	369.0	72	35	27
Beer	Cases a/	6.3	6.8	10.9	5.3	5.1	5.5	84	75	50
Cigarettes	Billions	4.8	5.5	5.9	3.7	3.9	3.6	77	71	61
Paints	Litres a/	5.0	5.6	10.3	3.2	1.5	1.2	63	27	12
Fertilizers	Tonnes b/	105.0	134.0	134.0	41.6	69.0	51.6	40	51	39
Shoes	Pairs a/	6.0	14.0	14.0	4.0	4.0	1.9	67	29	14
Tyres and tubes	b/	438.0	538.0	580.0	375.0	170.6	198.7	86	32	34
Leather	Square feet a/, c/	11.8	32.5	32.5	7.8	13.8	10.2	66	41	31
Hoes and ploughs	Tonnes b/	2.0	3.0	3.0	1.7	2.5	3.4	84	83	113
Corrugated iron sheets	b/	52.0	43.0	43.0	30.0	14.4	21.0	58	33	53
Blankets	a/	6.0	6.0	6.0	0.86	0.7	0.6	14	12	10
Dry cell batteries	a/	96.0	96.0	96.0	54.8	78.0	37.4	57	81	39
Iron and steel	Tonnes b/	30.0	30.0	30.0	12.2	16.5	10.0	41	55	33
Bags	a/	10.0	10.0	15.1	3.7	5.3	5.5	37	53	36
Containers	a/	63.5	196.0	190.0	76.7	80.2	56.1	121	41	30
Chibaca	Litres a/	21.7	21.7	21.7	11.6	14.2	15.0	53	65	69

Source: Ministry of Industry of the United Republic of Tanzania.

a/ Millions.
b/ Thousands.
c/ 1 square foot = 0.0929 m^2.

Table 2. United Republic of Tanzania: exports of manufactures
(Millions of dollars)

Product	1965	1970	1975	1980	1981	1982	1983	1984
Food products	8.9	8.1	11.1	16.9	17.7	7.7	13.7	2.0
Beverages and tobacco	1.4	6.3	11.9	15.5	21.1	21.4	14.5	9.7
Petroleum products, dyes and paints, processed oils and other chemicals	4.9	21.7	25.4	33.9	23.3	20.3	17.4	21.3
Textile yarn and fabrics	0.9	3.7	12.2	30.9	13.6	13.4	11.1	12.9
Sisal fabrics	0.9	3.7	11.9	28.1	10.9	12.9	8.3	9.3
Other processed minerals and materials	0.6	1.3	0.7	6.1	3.1	5.1	5.1	3.7
Machinery and transport equipment	-	-	-	2.9	3.5	3.4	2.6	2.2
Miscellaneous manufactures	0.5	0.5	0.7	17.2	4.8	3.1	3.5	4.2
Total	18.1	45.3	73.9	151.5	98.0	87.3	76.2	65.3

Source: Annual Trade Report of the United Republic of Tanzania, several issues (Dar-es-Salaam, Bureau of Statistics).

Table 2 shows that the value of manufactured exports of the United Republic of Tanzania is very small, only $65.3 million in 1984, compared with a figure of approximately $450 million for the country's total exports in that year. The table also shows that between 1980 and 1984, Tanzanian manufactured exports have fallen by more than 50 per cent in current prices.

Table 3 indicates the nature of the foreign exchange constraint faced by Tanzanian industry during the three years 1978-1980, which mark the beginning of the industrial crisis. In nominal terms, the foreign exchange allocation to industry in 1979 fell by nearly 50 per cent compared with 1978; although the situation improved in 1980, the total 1981 allocation in nominal terms was at roughly the same level as in 1979. Since then, as the overall foreign exchange crisis has deepened, the allocation to industry has progressively declined even further, leading to further reductions in industrial production.

Table 3. United Republic of Tanzania: allocations of foreign exchange to different industries in 1978, 1979 and 1980
(Millions of Tanzanian shillings)

Industry	1978	1979	1980
Textile, knitting and weaving	363.62	190.20	237.54
Sisal-based industries	11.70	17.95	33.07
Sugar	48.20	18.00	22.00
Coffee	13.80	8.40	11.83
Tea processing	5.30	3.30	9.94
Cashew processing	4.62	1.53	2.88
Manufacture of vegetable oils	64.40	21.60	57.85
Milk, ghee and cheese factories	21.50	12.80	5.60
Tanneries and hides and skin-based industries	9.76	3.28	38.68
Tobacco processing	32.80	24.60	23.50
Wattle and pyrethrum extraction	1.77	2.90	2.05
Meat and fish processing	1.20	5.30	4.38
Cement	9.60	6.80	7.50
Mining	63.80	86.00	31.80
Safety matches	10.70	7.60	19.20
Wood-based industries	3.92	4.35	13.60
Assembly of bicycles and vehicles	23.00	11.80	11.00
Watch assembly	--	0.90	1.00
Soft drink manufacture and bottling	16.79	10.10	20.46

continued

Table 3 (continued)

Industry	1978	1979	1980
Soap and detergents	135.60	69.40	173.25
Agricultural and industrial chemicals	169.80	88.30	87.9C
Mosquito coil manufacture	0.20	0.90	2.13
Leatherand rubber-based industries	173.20	87.10	147.06
Artificial leather and plastic products	68.80	37.70	73.31
Paint manufacture	19.00	7.20	25.00
Paper containers and paper products	57.90	25.30	56.80
Stationery	28.30	10.50	16.00
Printing and binding	51.30	32.30	34.50
Aluminium and metal products	249.30	138.90	199.60
Metal containers and utensils	39.30	38.00	83.00
Body-building equipment	23.00	9.90	31.70
Electric equipment assembly	226.30	38.30	62.00
Furniture	68.09	25.70	15.90
Food products	12.20	23.09	23.70
Drugs and toothpaste	28.80	20.00	20.70
Alcoholic beverages	49.30	34.30	61.70
Spares and components	56.70	31.14	71.70
Wire-based industries	39.40	17.00	21.00
Total	2 203.77	1 172.44	1 760.93

Source: Ministry of Industry of the United Republic of Tanzania.

It is interesting to observe (table 3, first column) that in the peak year of 1978, the total foreign exchange cost of Tanzanian industrial production (including raw material and technology imports, payment for management services etc.) was approximately 2,200 million Tanzanian shillings (TSh), which amounted to over $250 million at the current exchange rate between the United States dollar and the Tanzanian shilling. However, total manufactured exports in that year amounted only to approximately $100 million. Thus, before the onset of the current industrial crisis, Tanzanian industry was a net user of foreign exchange of up to $150 million per annum.

The overall performance and efficiency of Tanzanian industry can only properly be assessed in a longer-term perspective when industry is operating at a normal level of capacity utilization. There is, however, a tortuous academic debate on the long-term industrial record of the United Republic of Tanzania. The debate has revolved around the following two questions: the appropriate statistical series to be used and issues of statistical methodology; and, more importantly, the appropriate economic criteria for an assessment of industrial performance in a developing country like the United Republic of Tanzania.

Table 4 provides summary indicators of the long-term industrial performance of the United Republic of Tanzania in the pre-crisis period 1971-1978, assessed by Bienefeld [7] as follows:

> In short, the aggregate statistics present a picture of a healthy and positive long-term trend where substantial industrial growth had been achieved with an almost constant capital/labour ratio, and a falling real product wage (labour cost per worker deflated by implicit GDP deflator for manufacturing), together with a declining share of labour costs in value added. For a situation where labour absorption is itself an important objective, such a combination has much to recommend it .... At the macroeconomic level the role played by industry has been dynamic. It has helped to raise productivity in the economy as a whole, has produced substantial amounts of investible surplus, and has developed skills in Tanzanian workers and managers.

Finally, in considering industrial policy for the United Republic of Tanzania at the present juncture, the overall economic situation must be kept in mind. As has been argued in detail elsewhere (see Singh [8]), the Tanzanian economy is currently in "long-term structural disequilibrium", in the sense that the productive economy is unable to generate sufficient exports to pay for the required imports at a socially desired rate of economic growth, at a socially acceptable exchange rate, and at a normal level of current account deficit. This equilibrium is not simply a short-term liquidity or financial problem but one which requires profound changes in the structure of national production, both agricultural and industrial. More specifically, the central task before the Tanzanian authorities is to reduce the current account deficit while maintaining reasonable economic growth.

Table 4. Summary of trends in Tanzanian manufacturing a/

Item	(i) 1970-1972	(ii) 1976-1978	Ratio (ii)/(i)
Value added (millions of TSh at constant 1966 prices)	536.9	874.3	1.63
Employment	51 560	84 819	1.65
Capital (millions of TSh at constant 1966 prices	1 049.3	1 833	1.73
Capital-output ratio ((3)/(1))	1.95	2.10	1.08
Capital-labour ratio ((3)/(2))	20.35	21.61	1.06
Output per worker ((1)/(2))	10 413	10 308	0.99
Labour cost as share of value added (percentage)	41.3	34.2	0.33
Real wages (TSh per worker)	4 065.3	3 579	0.88
Actual real rate of return on capital (percentage)	21.1	21.0	0.99

Source: Tanzania Industrial Studies and Consulting Organization (TISCO).

a/ Firms employing 10 or more workers.

In the light of the above discussion, the following seem to be the most important industrial policy questions which face the Government of the United Republic of Tanzania:

(a) Should the available foreign exchange for the industrial sector be allocated to all existing industries on a pro rata basis, or concentrated on a small number of industries which can then operate at normal capacity;

(b) How much of the existing industrial sector is viable in the new international environment in the medium or long term? Which industries should be allowed to survive and to grow and how should the government choose these industries;

(c) How should the indirect foreign exchange costs of new projects covered by foreign aid be measured and how can foreign donors be encouraged to cover both direct and indirect foreign exchange costs?*

Mexico

In sharp contrast to the United Republic of Tanzania, Mexico has one of the third world's largest industrial economies, and by 1980 accounted for more than 10 per cent of total third world manufacturing output. Within the South, the absolute size of Mexico's manufacturing sector in the early 1980s was about half that of Brazil, but larger than that of India, and nearly twice as large as that of the Republic of Korea.

Table 5 provides data on the recent record of Mexican industry. Excluding oil and considering manufacturing alone, output expanded at a rate of 6.5 per cent per annum in the oil-boom years from 1977 to 1981. GDP increased at an even faster rate of over 7 per cent per annum during this period. When the balance of payment crisis came to a head in 1982, manufacturing production fell by 4 per cent, and in 1983 the fall was even greater (over 8 per cent). As table 5 shows, the production of consumer durables has been particularly hard hit by the crisis; it declined by 10 per cent in 1982 and nearly 15 per cent in 1983. Capital formation in manufacturing, which had been increasing at a rate of over 10 per cent per annum between 1977 and 1981, fell by more than 15 per cent in 1982 and by over 20 per cent in 1983.

Because of the size and sophistication of Mexico's industrial sector, the industrial policy issues which confront the country's policy-makers are rather complex. In order to obtain a proper appreciation of these complexities, it is essential to consider Mexico's recent industrial experience in a longer-term perspective. It is also necessary to examine certain important aspects of the country's industrial structure.

Table 6 summarizes the main features of the long-term structural transformation of the Mexican economy during the period 1950-1978. The following aspects deserve particular attention. First, Mexico is a high growth economy whose trend rate of growth of production over 1950-1973 has been about 6 per cent per annum. The rate of growth of productivity over the same period averaged 3.5 per cent per annum. Secondly, the economy has consequently undergone enormous structural change. By 1978, the contribution of agriculture to GDP had fallen to a mere 9.2 per cent, although agriculture still employed a third of the country's labour force.

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*Ideally, foreign donors should be encouraged to provide aid for increasing production from the already installed, and massively underutilized, industrial capacity, but they are reluctant to do so.

Table 5. Index of industrial production in Mexico
(1980=100, period averages)

Item	1975	1976	1977	1978	1979	1980	1981	1982	1983 a/
General index of industrial activity	68.60	72.10	73.89	81.92	91.10	100.00	108.95	106.95	98.24
Mining b/	54.66	57.97	62.38	71.28	61.74	100.00	115.32	127.61	123.57
Manufacturing c/	70.78	74.20	76.26	93.95	92.76	100.00	107.39	103.12	94.85
Consumer goods	73.17	76.15	79.08	85.20	93.66	100.00	106.78	104.93	98.18
Durables	68.12	71.23	71.50	81.34	91.86	100.00	109.56	97.12	81.88
Non-durables	74.38	77.36	80.91	86.15	94.09	100.00	106.02	106.87	102.24
Intermediate goods	69.75	73.89	75.60	83.75	92.45	100.00	107.16	107.65	85.63
Capital formation	65.52	65.96	66.29	78.62	89.78	100.00	112.66	95.70	72.49
Construction	68.25	71.13	68.97	78.34	88.71	100.00	111.48	109.22	93.26
Electricity	63.65	71.12	78.23	85.22	93.48	100.00	108.22	116.61	117.87
Petroleum d/	48.70	52.59	57.91	68.12	90.64	100.00	116.71	129.11	115.99

Source: Bank of Mexico.

a/ Preliminary estimates based on January-October figures.

b/ Includes extraction of crude oil and natural gas.

c/ Includes the refining of crude oil and derivatives and basic petrochemicals.

d/ Includes a subgroup in mining (SITC 0601) for the extraction of crude oil and natural gas and a subgroup in manufacturing (SITC 3301 and 3401) for refining and basic petrochemicals.

Table 6. Mexico: output, employment and productivity in the long term by industry or activity, 1950-1978

Item, industry or activity	Percentage average annual growth rate				Industry or activity shares and relative index		
	1950-1960	1960-1968	1968-1973	1973-1978	1950	1968	1978
						Percentage	
Output	5.52	7.12	6.21	3.96	100.00	100.00	100.00
Agriculture	4.52	3.58	1.44	2.38	17.82	12.39	9.21
Mining	1.70	2.20	4.16	2.69	1.70	1.34	1.09
Oil	9.45	8.50	5.32	11.97	1.67	2.66	3.70
Manufacturing	6.02	8.98	6.91	4.37	18.79	22.61	23.88
Construction	7.34	10.02	9.91	4.49	4.18	6.14	7.48
Electricity	12.79	13.04	9.57	7.76	0.22	0.67	0.93
Transport	5.52	6.49	6.78	6.63	2.15	2.05	2.39
Commerce	6.16	7.60	6.43	3.02	27.05	29.73	28.76
Other services	4.81	5.59	5.82	3.17	18.97	15.31	14.93
Government	4.37	8.92	8.32	5.01	6.46	6.61	7.68
Employment	2.70	2.65	2.66	..	100.00	100.00	100.00
Agriculture	1.27	0.22	0.23	..	54.85	39.39	33.06
Mining	3.24	-1.46	-1.55	..	1.05	0.80	0.59
Oil	5.63	7.20	3.18	6.93	0.37	0.70	0 76
Manufacturing	4.71	5.18	3.34	2.79	12.82	18.90	19.50
Construction	6.12	3.94	4.56	2.99	3.01	4.61	5.39
Electricity	5.08	4.38	5.48	6.47	0.28	0.40	0.47
Transport	3.92	2.97	2.87	4.88	2.63	3.04	3.10
Commerce	2.84	3.49	3.32	5.10	9.79	10.60	10.77
Other services	4.47	4.71	4.76	4.43	10.92	15.20	17.11
Government	2.80	6.50	7.00	5.46	4.27	6.37	9.15
						Relative index	
Production	2.75	4.35	3.46	..	100.00	100.00	100.00
Agriculture	3.21	3.35	1.20	..	32.30	31.46	27.55
Mining	1.76	4.07	5.50	..	256.78	160.60	191.70
Oil	3.62	1.21	2.07	4.71	445.03	379.31	374.62
Manufacturing	1.25	3.61	3.46	1.54	146.61	119.68	118.19
Construction	1.16	5.35	5.12	1.35	139.80	133.13	141.75
Electricity	7.33	8.30	3.87	1.31	79.73	166.18	171.88
Transport	1.53	3.42	3.80	1.57	81.55	67.41	72.12
Commerce	3.22	3.97	3.02	-1.98	276.23	281.81	280.15
Other services	0.33	0.88	1.01	-1.20	173.02	104.01	89.81
Government	0.55	2.27	1.23	-0.43	151.30	103.77	80.47

Source: Brailovsky [9].

Thirdly, manufacturing industry expanded at a rate of 8 per cent per annum between 1960 and 1973, and by 1978 it accounted for nearly a quarter of the total output and employed about a fifth of the country's labour force.

Comparing Mexico's industrial structure with that of Brazil and Argentina, the industrial structure of Mexico and Brazil are broadly similar, with the one major difference that Mexico has a much less developed capital goods industry than Brazil. For example, the machinery and transport equipment industry accounts for only 19 per cent of total manufacturing production in Mexico compared with 30 per cent in Brazil (and 24 per cent in Argentina).

Another indication of the relatively low level of development of Mexico's capital goods industry, compared with other developing countries at a similarly high overall level of development, is given by Dahlman and Cortes [10]. They compare the "domestic procurement ratios" - the percentage of capital goods consumption that is supplied locally - for Mexico, the Republic of Korea, Brazil and India. This comparison (using figures for the latest year available) showed that Mexico had the lowest ratio (56 per cent), followed by the Republic of Korea (61 per cent), Brazil (78 per cent), and India (87 per cent). Dahlman and Cortes also note that, unlike the Republic of Korea, Mexico also had a very low export ratio for capital goods. These ratios for the four countries were as follows: India, 4 per cent; Mexico, 7 per cent; Brazil, 18 per cent; and Korea, 25 per cent.

During the course of the industrial revolution that has taken place in third world countries in the last two decades, a number of countries have not only become exporters of manufactures and capital goods, but many of them have also themselves become significant exporters of technology. These exports are a very important, although by no means the only, indicator of the development of technological capabilities in these countries. While there are severe difficulties in obtaining comparable inter-country data in this area, Lall [11] has assembled the best available information on technology exports for a group of selected developing countries and areas. The results, presented in table 7, show that in industrial project exports the leading exporter is India, followed at a large distance by the Republic of Korea and Brazil. In non-industrial civil construction project exports, by far the most important country is the Republic of Korea, followed by India and Brazil. Mexico's performance in these respects is quite poor relative to that of India, the Republic of Korea or Brazil.

Similarly, recent UNIDO work on the comparative development of the machine tools industry in the South again show clearly that this key capital goods industry is much less developed in Mexico than in other selected developing countries (UNIDO [12]). Whereas countries like Argentina, Brazil, and India export about 10 per cent of their production, the comparable figure for Mexico is less than 1 per cent. Similarly, Mexico has the highest import penetration ratio of all the selected developing countries. These data provide further evidence of the paradox that, despite the very large absolute size of the Mexican industrial sector - the second

Table 7. Summary of technology exports by selected developing countries and areas: cumulative values a/
(Million of dollars)

Technology exports	Argentina	Brazil	Hong Kong	India	Mexico	Republic of Korea	Taiwan Province
Industrial							
Industrial project exports (contract values)	106	-285	--	2.200-2.500	..	(-802)	..
Direct investment (equity share)	49	..	1 800	95	23	67	83
Licensing, consultancy and technical Services							
1. Actual receipts	0.3	..	..	322	51	..	..
2. Contract values	22	357	..	(500)	..	472	..
Non-industrial							
Civil construction project exports (contract values)	696	4.284	--	6 024	984	43.953	..
Direct investment (equity share)	..	252	..	2[illegible]	..	256	18

Notes: Two dots (..) signify positive but not available.

Figures in parentheses are estimates.

a/ For a full discussion of the definitions and qualifications to the figures, see Lall [11].

largest among third world countries - and its very rapid rate of growth over the three decades from 1950 to 1980 its capital goods industry and technological capacity appear to be considerably less developed than that of comparable developing countries.

This weakness in Mexico's industrial structure has been directly linked with the balance of payments crisis that engulfed Mexico at the beginning of the 1980s, when its current account deficit increased from $1.6 billion in 1977, to $4.8 billion in 1979, to $6.7 billion in 1980 and to a colossal $11 billion in 1981. This occurred in spite of the nearly thirtyfold increase in oil revenues, which rose from $0.5 billion in 1976 to $14.4 billion in 1981.

There were three main reasons for the huge increase in the current account deficit over the period 1977 to 1981:

(a) A massive increase in manufactured imports which quadrupled in nominal value and tripled in terms of volume over the five years from 1976 to 1981;

(b) The relatively poor performance of non-oil exports, which was in large part due to the United States and world recession;

(c) A rapid increase in interest payments on public debt.

Of the three, (a) was an avoidable act of public policy, while (b) and (c) were less so since they depended to a large extent on United States and world economic activity and interest rates. An analysis of (b) and (c) lies outside the scope of the present paper, but (a) is of direct concern here since it was intimately connected with the imports of capital goods.

In the early 1950s, the ratio of imports to GDP in Mexico was around 15 per cent. During the phase of import-substitution industrialization in the 1960s, the economy, and particularly the manufacturing sector, performed exceptionally well, and by the early 1970s the import ratio had fallen to 10 per cent of GDP. The crude elasticity of manufactured imports with respect to growth of manufacturing production between 1960 and 1973 was appreciably less than 1.0, about 0.8. However, from 1977 to 1981, imports as a percentage of GDP increased by 5 percentage points, and the elasticity of manufactured imports with respect to manufacturing production increased to 4.0. Even with a large increase in oil exports, such an elasticity was unsustainable.

It is also interesting to note that despite - or as some would say because of - the enormous increase in imports, the rate of growth of manufacturing production from 1977 to 1981 was only about 6.5 per cent per annum. The latter figure is lower than the corresponding rate of growth of GDP, and, equally importantly, it is also less than the long-term trend rate of growth of manufacturing production over the period 1960-1973, which had been about 8 per cent per annum (see table 6).

What were the reasons for the large increase in imports between 1977 and 1981? This is a complex subject which has provoked a major debate among students of the Mexican economy (see in particular Barker and Brailovsky [13], Schatan [14] and Jiminez, Felix and Schatan [15]). One extremely important factor in the surge in imports during the boom years from 1977 to 1981 was clearly, however, the large increase in imports of capital goods. Although the liberalization of imports during these years led to a massive increase in import penetration in the consumer goods industry, 90 per cent of Mexico's imports during the economic boom consisted of capital and intermediate goods. The deterioration in the trade balance of the latter industries played a very important role in the balance-of-payments crisis of the economy. Mexico's total current account deficit in 1981 was $11 billion. Of this, the deficit in the capital and intermediate goods industries in that year was nearly $10 billion. In 1982, as a consequence of the balance-of-payments crisis and a very sharp recession in the economy, Mexico ran a trade surplus of nearly $7 billion; but the capital and intermediate goods industries were still in deficit by $5 billion.

The above analysis of the relationship between industrial structure, the balance of payments and the economic crisis in Mexico helps to identify the following significant industrial policy questions:

(a) In view of the continuing balance-of-payments crisis, can Mexico's industrial policy-makers rely in the short term on stimulating exports, or must they also greatly reduce their imports, while simultaneously pursuing vigorous import-substitution policies so as to maintain as high a level of industrial production as possible?

(b) As the Mexican economy moves out of the slump, will the country have the foreign exchange to allow it, even in the medium and longer term, to achieve the socially necessary higher rates of economic growth? Can export promotion generate the required foreign exchange, or must there be a very substantial reduction in the import elasticity of industrial production?

(c) What are the best ways of achieving the necessary development of Mexico's capital goods industry? Should the industry be exposed to more foreign competition to foster economic efficiency, should it be pushed as an export industry, or should there be further import substitution?

In principle, one could argue that an external balance at a high rate of economic growth could be maintained by greatly expanding Mexico's oil or non-oil exports rather than through import substitution. However, as Brailovsky [9] has argued, and as more recent events on the international oil market have underscored, the former would be unfeasible. And the required growth of non-oil exports would be extremely difficult to achieve in a slow-growing world economy.

As noted earlier, towards the end of the oil boom in 1981, the crude import elasticity of output in Mexico's manufacturing sector had been of the order of 4. Even if the non-oil exports were to expand to some degree, the crucial task before Mexico's policy-makers would seem to be to help reduce this figure over time to its long-term trend value of less than 1, which was achieved in the 1960s when Mexican industry grew exceptionally fast. Such reductions in import elasticity would require far-reaching changes in Mexico's industrial structure. The development and expansion of the capital goods industry must constitute an essential component of this transformation.

B. Traditional approaches to industrial policy under a foreign exchange constraint

The three most traditional approaches to the foreign exchange constraint involve:

(a) The import content of exports;

(b) The retained value (RV) of exports and production;

(c) The domestic resource cost (DRC) per unit of foreign exchange and the effective rate of protection.

In this section the definition of the underlying theoretical basis and the applicability of each of these concepts to the current industrial policy problems of countries such as Mexico and the United Republic of Tanzania will be examined. Some limitations of these measures, as conceived within their own theoretical paradigm, will also be noted.

1. Import content of exports

The most empirically tractable of the major approaches involves the import content of domestic demand, production or exports. The direct and indirect import content of total production can be calculated from the input-output tables. More information is required to measure the direct and indirect import content of exports, although in many studies it is assumed to be the same as the import content of total production of an industry.

What is useful is not the import content of an industry's production at a point of time, but changes in it over a period of time. In general, in developing countries the import content of production would be expected to decline progressively as import-substitution takes place. A recent study by the United Nations Conference on Trade and Development of a cross-section of 50 developing countries in 1970 showed that a 1 per cent increase in GDP will decrease the ratio of imports to value added by 0.276 per cent.

It is important to emphasize that a high import content of an industry does not necessarily imply that the industry in question is inappropriate for the economy. However, changes over time in import content of different industries give useful information about their relative efficiency from the point of view of the economy as a whole, particularly with respect to relieving the balance-of-payments constraint. As a comprehensive investment criterion or as a guide to changes in industrial structure, this measure is flawed for the same reason as it will be seen that the retained value concept is flawed: there is no reference to scarce economic inputs. Moreover, it ignores all foreign exchange costs associated with activities such as the purchase of foreign management services and technical know-how, as well as the servicing of borrowed foreign capital.

2. Retained value of exports and production

Various definitions of the notion of retained value have been used to examine the contribution made by exports (particularly mineral exports) to economic growth in developing countries. Following Brodsky and Sampson [16], retained value refers to that part of the country's value added in production or exports which accrues to the domestic factors of production; in other words, it is net of payments (managerial salaries, interest, profits etc.) accruing to foreign factors of production. In the context of a developing economy with a mineral exporting industry that is wholly or partly foreign owned, the following production function can be applied:

$$Q = f(L_d, L_f, K_d, K_f, M_d, M_f, R)$$

where Q is the quantity produced, L is labour services, K is capital services, M is intermediate inputs, R is the rent associated with the activity (normally accruing to the Government in the case of mineral exports), and d and f refer to domestic and foreign factors of production, respectively.

In terms of market prices of the output and factor inputs, the total factor payments, V, can be expressed in terms of the following identity:

$$V = L^*_d + L^*_f + K^*_d + K^*_f + M^*_d + M^*_f + R^*$$

where * denotes payments to a factor in value terms.

Now V is also equal to retained value (RV) + non-retained value (NRV),

where $RV = L^*_d + K^*_d + M^*_d + R^*$, and NRV is the rest of the terms in the above equation.

Thus RV measures the total returns to the domestic factors of production plus the total funds accruing to the Government for the operation of the foreign-controlled domestic industry. With respect to the foreign exchange constraint, it is more usual to use a variant of RV, here called RV', to indicate foreign exchange availability as a consequence of the operation of the industry:

$$RV' = RV + K_f$$

where K_f represents the net flow of foreign investment.

Note that $K_f = I_f^* + aK_f^*$

where I_f^* is foreign equity investment, K_f^* is the value of gross profits, a is the proportion of gross profits which is invested, and $0 < a < 1$.

Many authors have provided empirical estimates of the retained value in specific mineral exporting industries in developing countries. The main use of the concept is to show that the value of a developing country's exports, or the rate of growth of these exports, is by itself a misleading indicator of the contribution of exports to either foreign exchange availability or to economic growth. Thus the fact that developing countries achieved very high rates of growth of exports during the 1960s and 1970s does not mean that they thereby managed to relax the foreign exchange constraint. The advocates of the retained value concept imply that the rate of growth of the retained value of these exports was considerably lower.

Similarly, Brodsky and Sampson [16] suggest that the normal measures of the terms of trade understate the deterioration in the relative prices suffered by developing countries in recent years. They persuasively argue that the "retained value terms of trade", calculated as the index of the retained-value per unit of exports relative to the index of unit value of imports, should be used instead of the traditional ratio of the index of the unit value of exports to the index of the unit value of imports.

A major drawback to the concept of retained value is that it does not have a numeraire or normalization factor, so that the retained values of different industries cannot be compared. Thus, in several of the empirical studies of retained value it is used as a static measure of the contribution of a production or an exporting activity. However, changes over time are the essence of industrial development in a developing country and it would be much more useful to measure changes in retained value over a number of years.

Therefore, although the notion of retained value is clearly useful in many instances, it does not appear to be particularly helpful in relation to several of the industrial policy issues outlined earlier. For example, in the Tanzanian case where a major issue is which of the existing industries is viable in the medium and long term, the calculation of static retained value for the various production and export industries will not be an adequate guide to assessing their long-term viability. In principle, the dynamic measurement of retained value is possible, but the data problems inherent in any large-scale micro-economic exercise for almost all developing countries are generally recognized to be enormous.

However, much the more important difficulty with using the retained value as a criterion for industrial investment is the lack of any proper economic accounting of inputs. Suppose the retained values in different industrial activities are normalized by total value added in the relevant industry (that is, RV/(RV + NRV)). This would permit inter-industry comparisons of retained values, but as an investment criterion, it would not be an economically meaningful one. To illustrate, it would clearly not be sensible to prefer an industry with a high ratio of retained value to total value added if this industry uses a rather large amount of scarce inputs compared with another industry with a smaller retained-value ratio but also a lower use of scarce inputs. Therefore the retained-value concept, if adcpted for investment analysis, must be employed together with other criteria.

3. Domestic resource cost per unit of foreign exchange

The concept of DRC, which is widely used as an investment criterion in orthodox applied economic analysis, explicitly takes into account both scarce inputs and the foreign exchange constraint in the production process. Very simply, the rationale for the calculation of the DRC for different industries may be expressed as follows. The export of a commodity implies the earning of foreign exchange and the domestic production of a tradeable commodity implies the saving of foreign exchange. These foreign exchange earnings from exports are usually made possible only by spending both domestic resources and also foreign exchange, as is also the case with the domestic production of tradeable commodities. The net earning or saving of foreign exchange is the difference between gross earnings or savings, and the cost of foreign exchange. The domestic resources are the value of labour, the return on capital, and the value of non-tradeable inputs. These factors should be evaluated at their shadow price.

Domestic resources cost per unit of net foreign exchange earned or saved is thus given by the following ratio:

$$\frac{\text{(Value of labour + Interest + Domestic capital depreciation + Return on capital + Non-traded inputs)}}{\text{(Output in world prices - Imports - Domestic tradeable inputs - Imported capital depreciation)}}$$

The denominator should also be expressed in foreign currency at the shadow exchange rate. The DRC can be used as an *ex ante* device for the optimal allocation of foreign exchange resources to different industries, or *ex post* to indicate the misallocation or the waste of resources as a consequence of protection and other government-induced distortions in the economy.

The concept of DRC essentially represents a statement of the comparative costs doctrine in a static general equilibrium framework. In other words, the optimal pattern of production and trade for a country is determined from the comparison of the opportunity cost of producing any given commodity with the price at which the commodity can be imported or exported. In equilibrium no commodity is produced which could be imported at a lower cost, and exports are expanded until marginal revenue equals marginal costs. With full employment, perfect competition and the usual restrictions on production conditions, the opportunity cost of a commodity in equilibrium is equal to its market price. When such conditions are not met and there exist various market and government-policy-induced distortions (tariffs etc.), the use of suitable shadow prices for inputs and the exchange rate is therefore necessary in the calculation of DRCs.

However, even within its own framework, the exponents of DRCs recognize a number of its limitations. Thus, Bhagwati [17] notes that the demonstration of wide differentials in DRCs among different activities is not equivalent to arguing that the losses therefrom must also be correspondingly large because:

(a) The shift of resources from a higher DRC activity to a lower DRC activity may result in increasing costs;

(b) The expansion of output in the lower DRC activity may result in reducing output prices (when, for example, exports are increased to clear stocks).

Moreover, in general equilibrium analysis, three further complications in relation to the use of DRCs as indicators of resource misallocation arise. First, as resources are shifted from a number of activities to other activities in a shift to optimal equilibrium (for example, the introduction of free trade in a small country), the associated shift of prices may imply that, at the changed technology, an activity may now have a relatively lower DRC in the optimal equilibrium. Secondly, evaluation of the activity at, say, c.i.f. international prices in the suboptimal equilibrium may have to give way to its evaluation at f.o.b. prices in the optimal equilibrium. Thirdly, the relative expansion and contraction of different activities in optimal equilibrium as compared to suboptimal equilibrium can, therefore, not in general, be forecast from the mere examination of the relative DRCs in the initial suboptimal equilibrium [17].

In addition, it should be observed that even with all the strict assumptions of the orthodox international theory, the DRCs for all industries would only be equalized for an economy in equilibrium. In practice, even such an economy would experience disequilibrium and would continuously be adapting itself to changing technical know-how, factor supply changes, variations in international prices and so on. The variations in DRCs that would be observed in any one cross-section at a single point in time cannot therefore be regarded as evidence of resource misallocation.

Notwithstanding all these conceptual difficulties with the use of DRCs, and despite noting a whole series of equally serious empirical problems in their measurement, Bhagwati nevertheless goes on to assert that the DRCs "do give a reasonable clue to the wide variations in the social returns to different activities in the system". Despite strictures against the "overenthusiastic users" of DRCs, he goes on to suggest that "the process of careful qualification and skepticism should not be carried too far" [17].

C. Empirical results for domestic resource cost and other industrial performance indicators

This section presents the practical applications of the DRCs and other industrial performance indicators to Mexico, Zimbabwe and the United Republic of Tanzania.

1. Mexico

Recently, in the wake of the economic and industrial crisis in Mexico, the Ministry of Commerce has carried out a comprehensive investigation of industrial protection and performance in Mexico. This investigation follows the standard World Bank methodology and provides estimates of the DRC and certain other indicators at the four-digit level in order to guide future industrial policy. The DRCs have been calculated on the basis of market prices. The results for a selection of industries are presented in table 8.

In table 8, columns (1)-(3) indicate whether the industry in question (at the four-digit level) is dominated by small-scale enterprises (employing 1-100 employees), medium-sized enterprises (employing 101-250 employees) or large-scale enterprises (employing 251 or more employees), or a mix of enterprises of different size. Columns (4)-(6) provide similar qualitative information on the ownership of the enterprises in the industry, that is, whether the industry has predominantly foreign enterprises, public enterprises or private national enterprises. Column (7) reports estimates of the DRCs in 1984; in line with the methodology outlined earlier, the smaller the figure the higher the relative efficiency of the industry.

In column (8), on the profitability of exports, a negative sign indicates a greater relative profitability of the domestic market and a positive sign suggests greater profitability of the export market. The estimates in this column are based both on the level of effective protection accorded to the industry and on any export subsidies which the industry receives. The price-competitiveness indicator in column (9) shows whether domestic prices have increased faster than foreign prices since the base year 1978; a positive sign suggests a lower rate of growth of domestic prices relative to foreign prices and a negative sign indicates the opposite. The export coefficient in column (10) shows exports as a percentage of total sales. Column (11) gives similar information about imports; it gives imports as a percentage of total national supply of the product. In both columns (10) and (11) weighted averages for the years 1978 and 1984 are used.

Thus, the first row in table 8 shows that in the meat processing industry (1101) large, publicly owned firms accounted for the bulk of production in 1984. The value of the DRC at 1.256 is the eighth highest of the 36 given on the table, suggesting that it cost rather more than a unit of domestic resources to earn or save a unit of foreign exchange in this industry, in other words, this activity was less "efficient" than similar activities abroad. Column (8) indicates that, from the point of view of profitability, there was a large bias (96 per cent) against exports, which was

Table 8. Basic indicators of efficiency of manufacturing activities in Mexico, 1984

Industry	Type of firms			Origin of capital							
	Small (1)	Medium (2)	Large (3)	National private (4)	National public (5)	Foreign (6)	DRC (7)	Profitability of exports (8)	Price competitiveness (9)	Export coefficient (percentage) (10)	Import coefficient (percentage) (11)
1101 Meat processing			X		X		1.256	-96	-18	1.23	0.02
1201 Fruit and vegetables (dehydrated)			X	X			0.736	26	31	85.95	14.01
1301 Wheat (for flour)	X			X			0.502	84	57	0.00	0.00
1412 Tortillas	X			X			0.455	84	45	0.00	0.00
1512 Soluble coffee and tea			X			X	0.690	40	36	2.36	0.48
1602 Brown sugar	X			X			0.627	48	39	0.00	0.00
1701 Vegetable fats and oils		X		X			0.532	59	44	0.01	3.37
1801 Animal feed		X				X	0.204	78	47	0.15	6.33
1901 Chocolate	X			X			0.902	34	22	2.93	0.00
2001 Beer			X			X	0.889	24	9	6.49	0.00
2002 Rum			X	X			0.594	57	36	1.73	0.03
2201 Non-alcoholic beverages			X			X	0.459	58	58	0.08	0.01

2311 Cigarettes			X			X	0.505	58	33	0.00	0.00
2423 Cashmere (weaving and knitting			X	X			0.823	20	0	0.00	3.34
2612 Rugs, mats			X	X			0.862	6	8	1.53	3.75
2702 Jumpers (clothing)	X			X			1.010	-37	-1	0.00	0.00
2802 Shoes		X	X	X			0.800	39	7	0.01	0.00
3121 Paperbags		X		X			0.738	59	24	0.63	0.00
3201 Newspaper and journals			X	X			0.678	29	30	2.88	1.66
3401 Basic petrochemicals products		X			X		0.624	66	50	6.21	43.16
3601 Fertilizers			X		X		0.247	90	63	1.08	18.61
3711 Artificial fibre			X	X			1.597	-110	-18	4.31	7.34
3801 Medicinal products			X			X	0.480	74	41	3.94	7.80
3901 Soaps and detergents			X			X	0.795	18	22	0.03	0.60
4001 Insecticides		X	X			X	1.212	-89	0	1.18	6.31
4111 Vulcanization of tyres (rubber products)	X			X			1.687	230	-56	0.21	9.47
4201 Plastic articles	X	X	X	X			1.587	-290	-36	0.33	3.78

continued

Table 8 (continued)

Industry	Type of firms: Small (1)	Type of firms: Medium (2)	Type of firms: Large (3)	Origin of capital: National private (4)	Origin of capital: National public (5)	Origin of capital: Foreign (6)	DRC (7)	Profitability of exports (8)	Price competitiveness (9)	Export coefficient (percentage) (10)	Import coefficient (percentage) (11)
4601 Steel plates			X			X	1.115	-72	-2	0.62	1.93
4713 Metals made of zinc, tin, and lead		X		X			1.362	-130	-13	65.20	109.07
4813 Gas and water tanks made of metal			X	X			1.331	-87	-28	2.65	4.60
5112 Machinery and equipment for beverages industry	X			X			1.215	-96	-16	-1.16	177.44
5211 Industrial electrical machinery and equipment			X	X			1.088	-51	0	5.29	103.11
5401 Radios, televisions and record players			X	X			1.410	-380	-50	0.52	21.97
5301 Car batteries			X			X	1.054	-77	-16	1.44	29.36
5601 Cars			X			X	1.597	-610	-31	2.76	11.40
5901 Machinery and equipment for photography etc.		X				X	1.159	-34	18	7.74	116.24

Source: Ministry of Commerce of Mexico.

Note: For definitions of columns, see text.

presumably at least partly a result of the fact that (see column (9)) domestic prices in this industry rose by 18 per cent more than those abroad between 1978 and 1984. Nevertheless, the figure for the export coefficient (in column (10)) indicates that 1.23 per cent of the industry's output was exported and the last column suggests that imports constituted only 0.02 per cent of the total supply.

The table provides data only for selected industries. In order to provide a full coverage of Mexico's industrial sector in a manageable form, normally only one (but in some cases more than one) four-digit industry has been included. The DRC estimates presented in table 8 are very much along the lines that would be expected, the values of DRCs being low in the light consumer goods industries (food, drink, tobacco, textiles, leather etc.) and high (that is, greater than one) in the capital goods industries (steel, chemicals, machinery, automobiles etc). The lowest DRC in 1984 (0.204) is recorded for animal feed, and the highest DRC is 1.50 in the car industry.

What implications follow from this analysis for Mexico's industrial policy? Taking into account all of Bhagwati's caveats noted earlier, the data in table 8 imply that accepting the DRC criterion to any degree leads to the conclusion that Mexico's capital goods industries should not be given resources to develop further. Rather, resources should be reallocated to sectors with low DRCs, such as the consumer goods industries. Within the analytical framework of DRCs, such a resource shift should lead to a more efficient industrial structure for the country.

For reasons which will be discussed in the next section, there are other grounds for arguing that such a policy conclusion will lead to a dynamic misallocation of resources and do irreparable damage to economic and industrial development in Mexico in the medium and the long term.

2. Zimbabwe

Zimbabwe is the most industrially developed developing country in sub-Saharan Africa. A large part of this industrialization took place under a highly protectionist economic régime following the unilateral declaration of independence by the minority white settler Government in the mid-1960s. When the country gained independence under majority rule in 1980, the Government turned to the World Bank for assistance for the rehabilitation and development of the industrial sector. In response to this request, the World Bank commissioned an important report on Zimbabwean industry, the Jansen Report [18]. This Report used the DRC framework and carried out a detailed micro-economic analysis of a large sample of Zimbabwean manufacturing firms. The sample consisted of 122 firms in 10 broad industrial groups. The sample was biased towards larger firms, and the sample firms accounted for 65 per cent of Zimbabwe's gross manufacturing output. The main results of the Jansen Report for 10 groups and 33 manufacturing products are summarized in table 9.

Table 9. Zimbabwe DRCs and other industrial performance indicators, 1981

Product	Percentage share of value added (1)	Nominal protection coefficient (2)	Effective rate of protection (3)	Domestic resource cost (4)	Capacity utilization (percentage) (5)	Gross output (thousands of Zimbabwe dollars (6)	Average wage by category (Zimbabwe dollars) (7)
<u>Foodstuffs</u>	21	0.94	0.86	0.88	88	27	2 471
Slaughter and processing of meat	7	0.93	0.73	0.69	85	30	
Grain, animal feeds	6	0.96	1.02	1.03	100	31	
Bakery products	1	1.00	1.04	0.70	61	20	
Dairy products	3	1.00	1.04	1.11	92	17	
Sugar (refined) confectionery	2	0.83	0.44	0.83	88	26	
Other food products	2	0.95	0.83	0.74	100	44	
<u>Beverages and tobacco products</u>	10	1.00	1.04	0.88	79	20	3 495
Beer, wine and spirits	6	0.89	0.88	0.66	82	24	
Soft drinks	1	1.11	1.48	1.32	75	13	
Tobacco products	3	1.09	1.19	1.13	76	24	
<u>Textiles, including cotton ginning</u>	11	1.18	1.74	1.28	81	23	2 074
Cotton ginning, textiles (including CMB) a/	9	1.17	1.79	1.30	82	28	
Cotton ginning, textiles (excluding CMB) a/, b/	4	1.29	2.54	1.72	79	18	
Knitted products	2	1.24	1.50	1.20	76	11	

<u>Clothing and footwear</u>							
Clothing	3	1.27	1.43	1.32	84	10	
Footwear	5	1.14	1.21	0.92	87	13	
<u>Wood and furniture</u>	3	1.21	1.38	1.33	65	5	1 425
Sawmilling, wooden products	2	1.19	1.35	1.35	1.33	62	4
Furniture	1	1.23	1.45	1.32	69	8	
<u>Paper, printing and publishing</u>	3	1.32	1.90	1.87	87	20	4 391
Paper products	2	1.33	2.30	2.40	92	22	
Printing and stationery	2	1.30	1.52	1.36	79	17	
<u>Chemical products</u>	20	1.08	1.29	0.94	88	38	4 196
Fertilizers, insecticides	7	0.99	0.99	1.17	0.83	96	48
Soaps, detergents, toilet preparations	5	1.05	1.10	0.81	100	50	
Pharmaceuticals	1	1.13	1.36	1.19	93	42	
Paints, industrial chemicals	2	1.24	1.57	1.17	75	24	
Rubber products	2	1.23	1.56	1.21	70	35	
Plastic products	2	1.25	1.54	0.95	78	21	
<u>Non-metallic mineral products</u>	5	1.12	1.25	0.98	85	12	2 196
Pottery		1.03	1.13	1.07	65	4	
Glass and glass products	1	1.07	1.20	0.68	94	17	
Cement and bricks	3	1.15	1.29	1.08	84	13	

continued

Table 9 (continued)

Product	Percentage share of value added (1)	Nominal protection coefficient (2)	Effective rate of protection (3)	Domestic resource cost (4)	Capacity utilization (percentage) (5)	Gross output (thousands of Zimbabwe dollars) (6)	Average wage by category (Zimbabwe dollars) (7)
Metal and metal products	18	1.20	1.77	2.41	78	22	3 329
Steel and non-ferrous metal products (including Zisco) b/	9	1.18	2.03	3.62	86	30	
Steel and non-ferrous metal products (excluding Zisco) b/	4	1.15	2.23	2.69	90	53	
Heavy metal products	2	1.33	1.71	1.41	68	13	
Light metal products	4	1.17	1.35	1.12	65	16	
Agricultural implements	1	1.16	1.22	0.91	78	14	
Household electrical equipment	1	1.44	2.77	2.29	48	10	
Industrial electrical equipment	2	1.18	1.38	1.09	87	26	
Transport equipment	1	1.23	1.49	1.27	70	14	2 924
Total manufacturing	100	1.09	1.33	1.27	83	21	

Source: Zimbabwe 1983, Jansen Report [18].

a/ CMB: Cotton Marketing Board.

b/ Zisco: Zimbabwe Iron and Steel Company.

Column (1) of table 9 indicates the percentage share of each group and activity in total value added in manufacturing, valued at international prices. The nominal protection coefficients are shown in column (2), and show a reasonably high range, but an average level of protectionism (see the last row) of only 9 per cent for all manufacturing). Column (3) shows effective rates of protection; these were on average considerably greater than nominal protection rates, the "weighted" mean effective rate of protection for the manufacturing industry as a whole being 33 per cent (see the last row of the table). Column (4) provides estimates of the DRCs (further discussed below), while column (5) shows capacity utilization. With an average of 83 per cent, capacity utilization in Zimbabwe was very high by developing country standards, let alone those of African industry. Column (6) indicates labour productivity and column (7) the average wage rates.

The Jansen Report recognizes that in the calculation of DRCs, domestic factors of production (land, labour, capital) should be calculated "at their social opportunity cost". However, for various reasons no shadow prices were used: "... for labour, it was assumed that the wages paid reflect opportunity costs -- and thus labour costs in social prices do not diverge from labour costs in private prices". This is despite the fact that Zimbabwean economy suffers from very considerable open and disguised unemployment. Similarly for capital, the Report states that the "social rate of return was assumed not to have diverged greatly from the private rate of return".

It is recognized that the proper calculation of DRCs requires the use of an equilibrium exchange rate. However, the report argues that "the Zimbabwean dollar does not appear to have been significantly overvalued in 1981", a conclusion which is disputed by many students of the Zimbabwean economy, some of whom believe that the exchange rate was overvalued by as much as 50 per cent in that year.

Nevertheless, the report finds that the average DRC value of 1.27 for Zimbabwean industry (last row, table 9) compares very favourably with those of other African countries. Thus, World Bank studies for some West African economies carried out in the mid-1970s found the average DRC to be 1.95 in Ghana, 1.83 in Cameroon and 1.34 in Côte d'Ivoire. The final chapter of the report then concludes: "The losses in efficiency that are occurring under the present set of policies have no offsetting benefits in terms of satisfying other government objectives and have been shown to be extremely costly". In line with the DRC methodology, it proceeds to recommend that foreign exchange should be allocated on the basis of DRCs: firms with relatively low DRCs should be rewarded by larger foreign exchange allocations, and those with higher DRCs should get less.

3. United Republic of Tanzania

A full-scale DRC exercise has not been carried out so far for the Tanzanian manufacturing industry. However, to deal with the balance-of-payments crisis, the Government of Tanzania prepared its own Structural Adjustment Plan (SAP) in 1982. As a part of the SAP, the Ministry of Planning undertook an investigation of the manufacturing industry, which was of a rather different kind than that required for the calculation of DRCs. Detailed quantitative and qualitative studies at a micro-economic level were prepared for each large industrial firm, paying particular attention to various constraints on their growth, including the foreign exchange constraint. To illustrate the nature of these studies with respect to the analysis of the use of foreign exchange, some examples are given below.*

The Tanzanian Electrical Goods Manufacturing Company, a parastatal firm set up with Norwegian co-operation, produces transformers and switchgear. Most of the raw materials are imported from National Industries (Norway), which also provides the management and technical consultants. The project design had postulated that domestic production of transfomers would save foreign exchange, as a percentage of import prices, as follows:

Capacity of transformer in kilovolt-amperes	Import savings as percentage of imported price
50	14.5
100	9.1
250	16.6
500	30.9
750	33.0

The above figures, however, are based only on the direct foreign exchange costs; they do not include the technical fees (3 per cent of sales) and management fees (4.46 per cent of sales). According to the SAP estimates, if these indirect foreign exchange costs are taken into account, the foreign exchange savings from local production became negative for all ratings below 500 kVA; at 500 kVA, savings are only 15.2 per cent of the import price, and at 750 kVA, they are 17.6 per cent of the foreign price. However, since most transformers manufactured by the company are of less than 500 kVA, there is a net foreign exchange loss from domestic manufacture.

Another parastatal company, Steel Co. (a subsidiary of Alum Africa Ltd.), produces cold-rolled steel sheets. Its foreign exchange costs of inputs per tonne of steel billets was estimated to be 2,696 Tanzanian shillings (TSh). The cost of directly importing steel billets was 2,299 TSh in 1982. Thus, even excluding management fees, costs of spares etc., the SAP study estimates that there was no foreign exchange gain from local production.

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*These illustrative case-studies have been culled from SAP industrial sector reports, and the permission of the Tanzanian Ministry of Development Planning to consult them is gratefully acknowledged.

In the production of steel pipes by Steel Co., the SAP study found that there was a marginal foreign exchange saving from domestic production if only direct foreign exchange costs are considered. However, of the indirect costs, the inclusion of management fees alone (which worked out at 2.7 per cent of sales price) would make the foreign exchange savings negative for all sizes of pipes.

Similarly in Galco, another parastatal subsidiary, which produces galvanized roofing sheets, the SAP study estimated the import content per tonne of sheets to be 5,583.4 TSh. The c.i.f. cost of imported sheets was 5,359 TSh per tonne, which produced a net foreign exchange dissaving of 224.4 TSh per tonne of local production. The SAP study noted that some savings may be made from importing thinner sheets, but nevertheless, if indirect foreign exchange costs (such as management fees) were taken into account, domestic production by Galco would still yield negative value added.

It is, however, important to note that in all the above examples of negative value added at international prices, production was considerably below capacity due to the foreign exchange constraint. Moreover, in the case of the Tanzania Electrical Goods Manufacturing Company, production had started only in 1980. The results could be rather different at normal levels of capacity utilization or when there was more opportunity for learning by doing.

D. Domestic resource costs as a guide to industrial policy: a critique

A novel use of the DRC concept is being made by economists at the IMF in deriving their prescriptions for economic adjustment in African countries burdened by balance-of-payments constraints. Large devaluations are often recommended for these economies as a part of the IMF conditions. However, the economic rationale for such exchange rate variations (sometimes of the order of 300 to 400 per cent) is often thin for countries that are essentially exporters of primary commodities with low income and price-elasticities of demand, and where the Marshall-Lerner conditions are often unlikely to be satisifed.*

In response to such criticisms, the IMF economists** have put forward an alternative justification for currency devaluations and derived the required level of devaluation for a country from the calculations of DRCs of different agricultural and industrial activities. In this approach, the exchange rate is viewed not as an instrument for increasing the demand for a country's tradeable goods, but to enhance the profitability of supply.

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*For a further discussion of these issues, see Singh [8] and Branson [19].

**See in particular Nashashibi [20] and IMF reports on countries such as Sudan and the United Republic of Tanzania.

Following Hussain and Thirlwall [21], the IMF method may be described as follows. The basic idea is to calculate the competitiveness of each export by relating its international value added to domestic cost. First the international value added (V) is measured as the difference between the value of (exportable) output and the value of imported inputs used in production, both measured in domestic currency:

$$V = (P_x X - P_m T)$$

where X is output, P_x is the world price of (potentially exportable) output in domestic currency, T is the quantity of imported inputs, and P_m is the price of imported inputs in domestic currency.

Secondly, a coefficient of competitiveness (C) is defined as the ratio of the international value added (converted into foreign currency) to the cost of domestic inputs used in its production:

$$C = \frac{Vr}{P_d D}$$

where D is the amount of domestic resources used in production (non-traded goods and factors of production), P_d is the price of domestic inputs and r is the exchange rate (the foreign price of domestic currency).

The supply-side approach interprets this coefficient - which is a measure of the foreign exchange obtained (or saved in the case of import substitutes) per unit of domestic resources used in the export sector, in other words, it is a measure of DRC - as an implicit exchange rate. If $C < r$, the product is considered as not profitable at the existing exchange rate, and vice versa. In this way, export and import substitute activities can be arranged on a profitable scale, and the appropriate devaluation is the one that goes down the scale far enough to ensure the profitability of traditional exports, as well as possibly encouraging marginal export activities and import substitutes. Since, from the foregoing analysis, $C < r$ implies $V/P_d D < 1$, a devaluation sufficient to increase a country's competitiveness relative to its exchange rate must raise V relative to $P_d D$ more than proportionally.

Hussain and Thirlwall [21] argue that at a conceptual level the use of DRCs in the supply-side approach to exchange rate determination is flawed for two reasons. First, the index of competitiveness (C) itself depends on the exchange rate (r) to the extent that P_x, X, P_m, T, P_d and D are all responsive to a change in r. Devaluation - that is, a fall in r - may reduce C, and indeed it may reduce C by more than the fall in r. Secondly, reducing r to make some goods more profitable may reduce $VR/P_d D$ for other goods that are already profitable at the existing exchange rate and reduce overall foreign exchange earnings per unit of domestic output. But such interdependence and supply elasticity problems, while clearly important, may also merit attention primarily in countries with rather sophisticated economic structures.

The policy recommendations following from this use of DRCs as a guide to appropriate industrial structure and industrial policy would encourage developing countries to favour industries with low DRCs or to reallocate resources from activities with high DRCs to low DRCs. Underlying these recommendations, and the entire DRC approach, is the orthodox proposition that, other things being equal, free trade leads to an optimal allocation and development of the resources of a society. The underlying paradigm is that the competitive process produces an "equilibrium" outcome which is also necessarily a desirable outcome. Modern economic theory, even in its neo-classical version, shows both these proportions to be incorrect (see Sen [22]).

At the practical policy level, the level at which the DRC estimates are used in developing countries, the basic criticism is that it is inadequate, as well as misleading, to judge the "efficiency" of a country's industry entirely by the difference between domestic costs and prices and international prices. This is for the simple - but extremely important - reason that even in orthodox terms, and in equilibrium, international prices reflect existing comparative advantage. But it is also well known that the present international division underlying this comparative advantage is a highly unequal one that favours developed countries.

Thus DRCs, as a guide to allocating foreign exchange, are flawed because they assume that international prices are equilibrium prices. Moreover, since they are static and tied to the <u>status quo</u>, they do not allow for dynamic changes in the process of international comparative advantage. They also, therefore, ignore the linkages and industrial implications of the long-term industrial strategy of a country.

An alternative approach to industrial policy that would be equally concerned with the scarcity of foreign exchange resources in developing countries and the need to use them to their maximum advantage is the neo-Keynesian-cum-structural view. Rooted in the works of Prebisch, Kaldor and others, it lays major emphasis on the dynamics of the industrialization process, on technological change, and on changing sectoral productivities and income elasticities for imports and exports. Instead of a theoretical exposition, it is more useful to provide a specific illustration of this approach by considering the case of Mexico's capital goods industry and contrasting it with the DRC analysis.

As previously noted, the relatively low level of development of the capital goods sector played a significant role in Mexico's balance-of-payments crisis of 1981-1982. How should Mexico foster the development of its capital goods industry? The DRC analysis in the last section showed that DRCs in this industry were generally greater than 1 and much higher than those in the consumer goods industries, thus suggesting a greater allocation of resource towards the latter.

Brailovsky [9], following what was called above the neo-Keynesian-cum-structural approach, has provided a rather different analysis of the Mexican industrialization process. He used the following international trade indicators for each branch of manufacturing industry:

(a) Trade balance coefficient: (X-M)/(X+M), where X is exports and M is imports;

(b) Ratio of imports to domestic demand (D): M/D;

(c) Ratio of exports to gross output (Y): X/Y;

(d) Import elasticity e_m, defined as g_m/g_y, where g_m is the rate of growth of imports and g_y is the rate of growth of gross output;

(e) Export elasticity e_x, defined as g_x/g_y, where g_x is the rate of growth of exports.

The long-term evolution of these variables for each industrial branch over the period 1960-1979 is reflected in tables 10 and 11. The years selected - 1960, 1963, 1968, 1973 and 1979 - represent peaks in economic activity. It is, however, important to distinguish the period 1960 to 1973 from the years 1973-1979. In 1975-1976, the Mexican economy experienced a severe balance of payments crisis. Consequently, the Government had to accept an IMF programme of substantial devaluation and deflation. This programme was implemented in 1976 and 1977. With the big increase in oil production and exports, the balance-of-payments position was greatly improved by the end of 1977, and Mexico embarked on its oil-led expansion. However, at the same time, the Government instituted a major change in its commercial policy and greatly liberalized its hitherto stringent régime of import controls. The net result of this turbulence in economic policy and performance was that during 1973 to 1979 there was a significant trend decline in the growth of manufacturing production.

In the light of the above, following Brailovsky, the following conclusions may be drawn from these statistics:

(a) Over the period 1960-1973 most industries tended towards balanced trade or achieved a surplus. Exceptions to this trend include the so-called traditional industries (clothing and footwear, wood and paper) and the basic metals industry. The capital goods branches, which were almost pure importers in 1960, increased their coefficient substantially. In general, the foregoing trend was interrupted during the period 1973-1979, and in many industries, including capital goods, actually reversed;

(b) Between branches, and in the same branch over time, there seems to be an inverse relation between import elasticity, e_m, and the growth of domestic output. Thus, as table 11 indicates, for total manufacturing, the import elasticity during the period of highest growth (1960-1968) was only 0.26; however, during the period of lowest growth (1973-1979) the value of this elasticity

Table 10. Mexico: Manufacturing trade indicators, 1960-1979

Industry	$(X_i-M_i)/(X_i+M_i)$				M_i/D_i				X_i/Y_i			
	1960	1968	1973	1979	1960	1968	1973	1979	1960	1968	1973	1979
Total	-0.759	-0.647	-0.524	-0.537	0.233	0.147	0.141	0.168	0.040	0.036	0.049	0.057
Clothing and footwear	0.638	0.197	0.479	0.481	0.013	0.018	0.015	0.015	0.057	0.027	0.042	0.042
Wood and paper	-0.436	-0.478	-0.661	-0.577	0.064	0.079	0.119	0.102	0.026	0.029	0.027	0.029
Rubber and leather	-0.576	-0.235	-0.157	-0.635	0.026	0.022	0.027	0.037	0.007	0.014	0.020	0.008
Chemicals	-0.701	-0.553	-0.428	-0.423	0.188	0.162	0.151	0.190	0.039	0.053	0.066	0.087
Cement and glass	-0.214	0.076	0.402	0.258	0.061	0.030	0.027	0.047	0.41	0.035	0.060	0.069
Basic metals	-0.057	-0.255	-0.431	-0.445	0.078	0.084	0.116	0.226	0.070	0.052	0.050	0.101
Capital goods	-0.967	-0.818	-0.699	-0.719	0.527	0.278	0.251	0.255	0.018	0.037	0.056	0.053
Metal products equipment	-0.676	-0.045	0.053	-0.564	0.136	0.075	0.067	0.109	0.029	0.069	0.074	0.033
Mechanical engineering equipment	-0.990	-0.946	-0.881	-0.876	0.904	0.596	0.521	0.536	0.045	0.039	0.064	0.071
Electrical engineering equipment	-0.937	-0.864	-0.928	-0.606	0.219	0.263	0.246	0.167	0.009	0.025	0.012	0.047
Transportation equipment	-0.910	-0.611	-0.585	-0.792	0.186	0.140	0.199	0.169	0.011	0.038	0.061	0.023
Automobile industry	-0.987	-0.939	-0.477	-0.475	0.262	0.176	0.172	0.175	0.002	0.007	0.068	0.070
Others	-0.900	-0.868	-0.662	-0.720	0.297	0.194	0.142	0.239	0.022	0.017	0.033	0.049

Source: Brailovsky [9].

Notes: X_i = exports of branch i; M_i = imports of branch i; Y_i = gross output of branch i; $D_i = Y_i + M_i - X_i$ = domestic demand of branch i.

All indicators are based on 1975 prices.
The years selected correspond to peaks in the economic cycle.
Production, imports and exports are classified by industry of origin.
Excluded from the total and from the industry are the food, beverage, and tobacco industries and the net exports of the in-bound industry.
The electrical engineering industry includes household electrical applicances.

Table 11. Mexico: growth of output, imports and exports by industry of origin, 1960-1979
(Average annual growth rates, in percentages, and elasticities)

Industry	g_y			g_m			g_x			$e_m = g_m/g_y$			$e_x = g_x/g_y$		
	1960-1968	1968-1973	1973-1979	1960-1968	1968-1973	1973-1979	1960-1968	1968-1973	1973-1979	1960-1968	1968-1973	1973-1979	1960-1968	1968-1973	1973-1979
Total	10.1	8.7	5.9	2.6	7.4	9.4	8.5	15.9	8.7	0.26	0.85	1.59	0.84	1.83	1.47
Clothing and footwear	6.9	8.0	4.7	11.9	3.5	4.6	2.6	17.7	4.7	1.72	0.44	0.98	0.38	2.21	1.00
Wood and paper	8.0	5.8	5.9	10.9	16.1	2.7	9.5	4.0	7.5	1.36	2.78	0.46	1.19	0.69	1.27
Rubber and leather	8.1	5.6	6.9	5.3	10.2	12.7	17.4	13.8	7.5	0.72	1.82	1.84	2.15	2.46	1.09
Chemicals	10.9	11.3	4.0	8.2	9.1	8.6	15.1	16.6	8.8	0.75	0.81	2.15	1.39	1.47	2.20
Cement and glass	8.3	8.9	6.6	-1.2	5.5	15.1	6.4	21.4	9.0	-0.14	0.62	2.29	0.77	2.40	1.36
Basic metals	9.7	7.3	8.4	11.1	15.3	22.7	5.6	6.4	22.0	1.14	2.10	2.70	0.58	0.88	2.70
Capital Goods	14.9	9.2	7.2	0.3	5.3	7.6	25.4	18.7	6.2	0.02	0.63	1.06	1.70	2.03	0.86
Metal products	12.9	3.8	3.9	3.4	-1.2	16.5	25.6	5.1	-9.1	0.26	-0.32	4.23	1.98	1.34	-2.33
Mechanical engineering equipment	20.9	8.9	9.2	-1.1	1.5	13.4	18.9	20.1	11.0	-0.20	-0.17	1.46	0.90	2.25	1.20
Electrical engineering equipment	16.0	10.4	8.3	19.3	6.4	1.0	32.3	-5.0	35.7	1.21	0.62	0.12	2.02	-0.48	4.30
Transportation equipment	7.6	9.0	6.3	2.8	3.5	15.5	26.0	20.1	-9.7	0.37	0.39	2.46	3.42	2.23	-1.54
Automotive industry	18.7	13.7	8.2	11.3	8.4	11.2	35.9	81.0	8.6	0.60	0.61	1.37	1.92	5.91	1.05
Others	13.3	13.0	2.7	5.7	4.6	13.9	9.5	29.2	9.7	0.43	0.35	5.15	0.71	2.25	3.59

Source: Brailovsky [9].

Notes: g_y = average annual growth rate of gross product at 1975 prices; g_m = average annual growth rate of imports at 1975 prices; g_x = average annual growth rate of exports at 1975 prices; e_m = import elasticity in relation to gross output; e_x = export elasticity in relation to gross output.

increased to 1.59. Hence the greatest reductions in the import coefficient M_i/D_i tend to occur in the most dynamic branches, and the growth of domestic production tends to exceed that of manufacturing industry as a whole to a greater extent when overall growth is higher than when it is lower;

(c) Relative export growth, as between different branches and over time, is directly associated with the growth of output. Therefore, the most dynamic branches show higher export growth rates than do the least dynamic branches. As a case in point, the capital goods branches practically tripled their X_i/Y_i coefficient between 1960 and 1979, registering a faster relative increase than any other manufacturing activity and reaching a level higher than that of the so-called traditional industries.

Taken together, these relationships suggest a pattern of cumulative causation. Higher growth rates of domestic demand seem to be correlated with lower import coefficients and higher export coefficients. This, would seem to make it possible to relax the balance-of-payments constraint, thus permitting a greater rise in domestic demand. The interruption of this process in the period 1973-1979 was partly due to balance-of-payments problems caused by the rapid and substantial decline in the trade surplus of the primary industries, which could not be offset by the drop in the external manufacturing deficit as a proportion of total manufacturing trade or production. It was also due in part to the import-liberalization policy implemented by the Government in 1978 and 1979.

In contrast to the previous DRC analysis, which used only data for 1980, the above analysis suggests that the long period of the most rapid expansion of Mexican manufacturing industry (1960-1973) may be described as one in which the import substitution process advanced rapidly in heavy industries producing industrial inputs and capital goods rather than in the light and consumer goods industries. The development of the latter was at best not very dynamic in terms of net exports.

The policy implications of this analysis are also rather different than those previously suggested. Instead of devoting greater resources to the consumer goods industry, within its balance-of-payments constraint, Mexico should foster a balanced development of the capital goods industry on the basis of internal market growth and further import substitution. A balanced development implies that proper attention is given both to sectoral linkages as well as to the dynamic long-term industrial performance indicators of the kind discussed above.

In the application of this alternative approach to the United Republic of Tanzania, because of the early stage of industrial development in that country, the concepts of industrial linkages and learning-by-doing assume even greater importance. The exigencies of the current balance-of-payments constraint also require much greater attention to the proper balance between industrial and agricultural development. In the short to medium term, it is very important that, in the allocation of foreign exchange, those industries should be preferred that have the greatest linkages with agricultural development and that, taken together, are not net users of foreign exchange. Over a five-year time horizon, agricultural development must receive much the larger share of the country's foreign exchange resources.

Compared with the neatness of the DRC analysis, the analysis suggested above is inevitably messy and complex. Instead of a single magic measure like the DRC, it requires estimation of a number of dynamic performance indicators for firms and industries as well as an empirical study of industrial linkages (not just a mechanical application of some outdated input-output table). In the present industrial crisis in these countries and the unpropitious international economic environment, there is no escape from this more difficult analysis. The detailed SAP studies of the industrial sector by the Government of the United Republic of Tanzania, referred to in the last section, are steps in the right direction.

E. Conclusions

This study has been concerned with investigating the present acute industrial crisis in African and Latin American countries and the issues of industrial policy that today confront such economies. It examined the relationship between the world economic crisis and the foreign exchange constraint on industrial development in these countries, and concluded that this constraint was unlikely to be significantly relaxed in the foreseeable future.

In examining the relationship between industrial structure, industrial development and the balance-of-payments for one country in Africa (the United Republic of Tanzania) and one country in Latin America (Mexico), it was concluded that in the case of the United Republic of Tanzania, the central policy issue in the short run is which industries should be favoured with the limited amount of available foreign exchange for the industrial sector. In the medium to long term, the main policy problem is how to modify the existing industrial structure so as to ensure its compatibility with the foreign exchange constraint. For Mexico, which is industrially much more highly developed, it was noted that the relatively low level of development of the capital goods industry played an important role in that country's balance-of-payments crisis. Two main related policy issues were identified. First, how is the import propensity of industrial production to be permanently reduced from the extraordinarily high levels reached in the late 1970s? Secondly, what is the best way for enhancing Mexico's capital goods capability; should it be achieved by greater integration with the world markets or by greater protection?

In an analysis of the traditional approaches to industrial policy questions, the concepts of the import content of exports, retained value, and domestic resource cost per unit of foreign exchange earned or saved were discussed, and empirical estimates of DRCs and other industrial performance indicators for Mexico, Zimbabwe and the United Republic of Tanzania were presented. A more fundamental critique of DRCs, which are widely used by leading organizations engaged in the analysis of industrial policy issues in third world countries, was then developed, and it was concluded that the Latin American and African countries should also consider other performance indicators when making policy decisions as to the appropriate long-term industrial structure for their development. An alternative neo-Keynesian-cum-structural approach to industrial policy was outlined with its major emphasis on learning by doing, on the dynamics of industrial structure and on the interconnections between industries.

In conclusion, it is worth reflecting that with the Baker Plan for third world debt relief and the World Bank Programme for Sub-Saharan Africa, Latin American and African countries will be under enormous pressure from donors to use the DRC as the leading criterion for future industrial development. The IMF may even use the DRC as a basis for arriving at the appropriate level of devaluation required for medium-term adjustment in commodity producing countries. If the DRC became the main basis for industrial policy, there would be very little development of capital goods industry in selected developing countries such as Mexico, and hardly any industrial development at all in African countries. As demonstrated in the foregoing sections, the DRCs calculated for capital goods industries in a country like Mexico tend to be higher than those for consumer goods industries, and in the United Republic of Tanzania they tend to be higher in commodity exports than in industry.

In theory the proponents of DRC recognize the static nature of the concept, but in practice this fundamental limitation, as far as industrial development in a developing country is concerned, is often ignored. As a minimum, therefore, when World Bank economists present the Ministry of Industry of a developing country with DRC estimates of their industrial sector, they should be asked to provide similar DRC calculations for, say, three years, five years and seven years previously. The intellectual and policy rationale for requiring such calculations over time is obvious: to assess the relative degree of development of the dynamic economies of scale and learning by doing in different industries. Whereas cross-section estimates of DRC at a point of time lead to straightforward, but incorrect, policy conclusions, a study of the evolution of DRCs over time will lead to a richer, more appropriate, and far more complex analysis. The Ministry of Industry of the developing country should seek to supplement this analysis with an examination of changes over time in other industrial performance indicators discussed in this paper, including the trade balance coefficient, the import coefficient, the export coefficient and the rate of growth of productivity. In addition to these quantitative indicators the Ministry should also undertake qualitative studies of industrial performance along the lines carried out by the Ministry of Development Planning in the United Republic of Tanzania.

These modifications and supplements to the DRCs will greatly enhance their usefulness for industrial policy analysis, but they will still remain subject to their other serious limitations which derive from their inability to take into account the interconnections between industries. A full consideration of industrial linkages is essential for balanced industrial development. Further, as was noted in the last section, the proper balance between agricultural and industrial expansion in both the short and the medium term is particularly important in the present context of acute foreign exchange constraints in the African countries.

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COMPARATIVE ADVANTAGE, EXTERNAL FINANCE AND THE VULNERABILITY OF INDUSTRIALIZATION

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A. Comparative advantage: static and dynamic

In orthodox economic theory, the pattern of international division of labour is supposed to be guided by comparative economic advantages among countries. However, it has long been recognized that this comparative cost doctrine is too static a notion to be an adequate guide to policy. If countries always specialized on the basis of their existing comparative advantage, then Japan would perhaps still be exporting silk cloth and parasols instead of automobiles, television sets and semiconductors.

Specialization on the basis of existing comparative advantage reinforces the status quo in the pattern of international division of labour. Naturally, this appeals more to countries that benefit most from the existing pattern of international trade. It is by no means an accident that the United Kingdom in the nineteenth century as the foremost industrial power found comparative cost to be a most appealing doctrine. However, the virtues of comparative advantage were not equally appreciated then either by Germany or by the United States of America, as they were the "late-comer" countries industrializing to challenge the world-wide industrial supremacy of the United Kingdom.** The classical argument about protecting infant industries from free trade articulated this tension between the ruling industrial power and other late-comers trying to industrialize. The historical context has changed now, but that tension still persists between industrially developed countries and developing countries seeking rapid industrialization to alter the existing pattern of international division of labour.

The argument for protecting infant industries can be intellectually justified by extending the same principle of comparative advantage beyond its limited, static context. Dynamic comparative advantage, however, is a much wider principle because it is based on comparative adavantage through reduction in the cost of production over time. The accrual of dynamic comparative advantage to a country in certain branches of manufacturing can occur as a process

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**The proto-reserve-currency status of the pound sterling under the gold standard enabled the United Kingdom, through its financial supremacy, to reinforce its industrial supremacy prior to the First World War. Needless to add, this bears some analogy to the role of the United States dollar under the Bretton Woods system.

through time in a variety of ways. It can occur as a result of increasing returns to scale, with the average production cost decreasing as the scale of operation increases. This is the classic case of industries characterized by increasing returns, originally enunciated by Marshall. It has been given a sharper focus in recent years by the so-called "Kaldor-Verdoon law" (Kaldor [1]), which encompasses the notion of induced technological progress. Basing himself on the notion of cumulative causation, Kaldor argued that technical progress stimulates economic growth which, in turn, induces further technical progress. The net result is dynamic increasing returns associated with a higher rate of economic growth.* The process of cost reduction through time may also come about as a result of "learning by doing", which can be looked upon as a special case of labour-productivity raising technical progress (Arrow [5]). A somewhat different but related line of argument was originally put forward in the "big push" theory of industrialization (for example, Rosenstein-Rodan [6] and Scitovsky [7]), which concentrated more on the static aspect of how to exploit economies of scale in a developing economy. The argument emphasized the need to develop a range of interrelated industries more or less simultaneously through co-ordinated investment decisions in the form of a "big push" in order to exploit economies of scale that are external to each investment project, but internal to the economy as a whole.

From an analytical point of view therefore, the case for dynamic comparative advantage rests on increasing returns to scale, both in a static and in a dynamic sense. And, when increasing returns to scale operates, it is a well-known result of conventional economic theory that even the mythical world of perfect competition fails to allocate resources efficiently. Consequently, neither a general prescription for freer trade nor specialization in trade on the basis of current international prices can be intellectually justified even on the narrow ground of allocative efficiency, if increasing returns (indicating possibilities of dynamic comparative advantage) exist in some form or other. In this context, two analytically distinct elements in the argument for deliberate industrialization, which may often run contrary to the static view of comparative advantage, need to be distinguished. First, if dynamic comparative advantage operates, then even on grounds of allocative efficiency of (global) resources over time, most developing countries would need to embark on a path of industrialization, protecting their particular infant industries whenever necessary. Secondly, considerations of allocative efficiency apart, the current pattern of international distribution of income sustained by the existing international division of labour can be structurally altered only if developing countries acquire greater industrial and technological capabilities over time. In a political vision of rapid industrialization shared by many developing countries, these two considerations of more efficient allocation of (local) resources

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*For a discussion of various formulations relating to this topic, see also Cripps and Tarling [2] and Rowthorn [3]. The classic article elaborating the concept of dynamic increasing returns is Young [4].

over time and a moreequitable pattern of income distribution among the nations through trade are often intertwined. These considerations, in turn, also provide a compelling logic to the need for industrialization of the developing world at a rapid and sustained rate beyond mere political rhetoric arising from the North-South dialogue.

B. Pre-conditions for sustained industrialization

An economic strategy designed to exploit the dynamic increasing returns and comparative advantage would typically require substantial transformation of the economic structure of a developing country through a sustained process of industrialization. The longer-term content of the process of industrialization, namely, which type of industrial structure to aim at, is guided in turn by the specific areas or types of increasing returns that the country intends to exploit over time. The empirical evidence surrounding the "Kaldor-Verdoon law" generally suggests that the accrual of dynamic increasing returns are usually significant when the manufacturing sector has a sustained, high rate of growth. This also provides some support to the logic of industrialization which places particular emphasis on the development of the manufacturing sector.

However, as the recent experiences of several developing countries under widely different individual circumstances have demonstrated, the ability to sustain a high rate of growth of the manufacturing sector over time is a complex and difficult task, both economically and politically.* From an economic point of view, a whole configuration of economic factors has to be supportive of such an industrialization process. For analytical purposes, one can distinguish a set of these necessary (but not sufficient) conditions. First and perhaps most important is the requirement of an adequately high and rising level of effective demand, in other words, expanding markets for selling manufactured products. While much of the conventional academic discussion of import-substitution versus export-promotion strategies concentrates on questions of allocative efficiency and the associated production costs in the two strategies (which is basically an application of the static comparative cost principle), the choice for import substitution rather than export promotion has often been dictated in practice by considerations of steady access to a secure market for selling manufactured products. Indeed, the size of the country and its home or domestic market is a crucially relevant consideration here, because a larger home market where imports can be gradually substituted increases the likelihood of such a strategy being more viable over time. In this context, it seems an over-simplification to suggest that an economic ideology of "self-reliant" nationalism is the dominant influence governing the import-substitution strategy of relatively large economies such as those of China or India. In any case, the size of their potential domestic market would weigh

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*Some of the political difficulties associated with rapid industrialization have recently been analysed by Skouras [8].

heavily in favour of placing greater reliance on the internal rather than on the external market during the process of development of their manufacturing sector.

Secondly, a related and theoretically unresolved problem is that of market uncertainty. Arguments can be marshalled on both sides to show that greater reliance on the domestic or on the foreign market increases the degree of risk. For individual countries, it is largely an empirical question of whether their export market or their domestic market fluctuates more widely.* Nevertheless, two reasonable generalizations are in order. First of all, to the extent that developing countries seek to finance their industrialization process through the export of primary commodities, the terms of trade between manufacturing and primary products is known to have a very strong cyclical bias. This means that the slow-down of industrial activities in the North depresses far more strongly the price level of primary products than that of manufactured products.** Consequently, the relative price moves sharply in favour of manufacturing when industrial activity slows down in the countries of the Organisation for Economic Co-operation and Development (OECD).

Secondly, and at least in principle, greater reliance on the domestic market by a developing country permits its Government to try to manage domestic demand through a conventional set of fiscal and monetary policy instruments. The policy instruments at the disposal of the same Government seem far less certain or effective when heavy reliance is placed on the external market. These two considerations suggest that an inward-looking strategy, if otherwise viable, would probably be marked by a lower degree of market uncertainty.

Finally, there is the important question of both the source and the mechanism by which the financing of an industrialization process can be sustained over time.*** The historical evidence of the agrarian revolution preceding the Industrial Revolution,

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*Domestic and export market fluctuations may be linked through the operation of the foreign trade multiplier.

**Kalecki [9] made the important distinction between cost-determined and demand-determined prices. Manufactured commodities have usually cost-determined prices that remain insensitive to variations in the level of demand. In contrast, primary products are sensitive to changes in demand. Consequently, the prices of primary products are far more strongly influenced by cyclical fluctuations in OECD countries than the prices of manufactured goods. Thus, Okun ([10], p. 136) noted that "with the exception of 1958, United States wholesale prices of domestically produced food crops fell (absolutely) in every recession year since World War II". See Kaldor [11] for use of this distinction between demand-determined and cost-determined price in the international context.

***See Kalecki [12] for one of the most comprehensive analyses of this issue.

particularly in the case of the United Kingdom, has often been interpreted as providing evidence that an adequate level of agricultural development is a pre-condition for rapid industrialization. There is certainly an essential element of truth in this historical interpretation in so far as an agricultural surplus can play a crucial role in financing the process of industrialization. Nevertheless, the physical route to the transformation of agricultural surplus into industrial investment for increasing capacities is by no means an easy historical process. The easiest route to this transformation is through the intermediation of foreign trade, that is, the developing country concerned sells its surplus agricultural produce to buy back machinery, equipment and industrial intermediate goods needed for industrialization. However, as already pointed out, this route of transformation of domestic agricultural surplus into industrial investment through foreign trade has been exceptionally vulnerable to adverse terms of trade. In addition, it may also happen that there is an absolute limit to the size of the international market for selling agricultural produce. The operation of such quantity and price constraints may tend to make the financing of steady industrialization unsustainable over time.

For a longer-term point of view, even more problematic is the question of generating agricultural surplus in the face of rising population pressure in many developing countries. Even when institutional reform of the agrarian system is carried out, its productivity-raising effect is likely to level off over time, and a developing country trying to finance its process of industrialization through agricultural surplus is still confronted with the longer-term problem of how to raise agricultural output. This has almost a paradoxical aspect for policy formulation because, beyond a certain point, growth in agricultural productivity can only be maintained through application of higher doses of industrial inputs and mechanization of agriculture. But this in turn becomes feasible only if the country has been already industrializing at a reasonable pace.

However, the case should not be overstated on either side. On the one hand, a process of industrialization that is financed almost entirely through an agricultural surplus generated by foreign trade is almost certain to run into serious problems over time, because of its vulnerability to constraints imposed by the terms of trade and by the limited size of the international market. But on the other hand, it is equally true that a country that does not have a dynamic agricultural sector cannot usually maintain a steady and rapid pace of industrialization, except under very special circumstances.* Not only the requirement of foreign

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*Until recently, some of the oil-exporting countries may have been under these "very special circumstances". In this sense, the recent example of Mexico should serve as an important qualification. From self-sufficiency, Mexico became a net importer of food, largely under the impact of its short-lived (1978-1981) oil boom. Subsequent debt problems and falling oil prices worsened the international payments constraint, which became even more severe due to the requirement of food imports.

exchange to meet domestic demand for food and agricultural raw materials may set up a binding constraint on the financing of industrialization, but also, more importantly, the vulnerability of a developing country that is not reasonably self-sufficient in food must generally be considered to be exceptionally high, both in economic and in political terms. In short, the familiar theme of development economics that the forward and backward linkages between industry and agriculture are far too strong to be neglected in a process of industrialization continues to hold true as a general principle. The neglect of this general principle, especially because of an over-reliance on the transformation possibilities created by foreign trade or temporary access to foreign capital, can only make a process of industrialization exceptionally vulnerable to unpredictable developments on the international front.

C. International capital movements and the vulnerability of industrialization

So long as a developing country depends predominantly on its domestic savings or surplus to finance its level of industrial investment, net inflow of foreign capital plays a relatively minor role in the industrialization process. As already pointed out in the last section, the external vulnerability of the industrialization process under these circumstances depends mostly on the difficulties associated with the transformation of domestic savings into industrial investment due to such factors as adverse terms of trade or limited export markets. However, the very mechanics of vulnerability changes significantly as the relative importance of net inflow of foreign capital increases for financing the process of industrialization.

Broadly speaking, until the first oil shock of 1973, developing countries as a whole maintained relatively modest trade deficits, often through such policies as import and exchange control. Their current account deficits were largely financed through intergovernmental grants and official loans (including those from international institutions), with direct foreign private investment playing a relatively minor role. For instance, during the decade of the 1950s, total official grants to developing countries were of the order of $2 billion per annum, with both official loans and direct private investment from abroad on an even more limited scale. This pattern did change somewhat during the 1960s, especially as direct investment by United States corporations began to rise perceptibly from the late 1950s. However, a large proportion of United States corporate investment was directed to Europe, and the broad pattern of the 1950s persisted in a modified form through most of the 1960s. It was also during this period that the Eurocurrency market started its remarkable growth which, in turn, spurred the growth of international banking. The long-term market in Euro-bonds developed (though at a significantly lower rate) along with the Eurocurrency market. Such bonds were initially underwritten by United Kingdom mechant banks and United States investment banks, but the technique of financing soon became more broadly based and dominated by international loan syndicates involving commercial banks of various nationalities. These rapid institutional changes in the international capital market set the stage for its subsequent development.

On the one hand, the emergence of a significant payments surplus of the countries of the Organization of Petroleum Exporting Countries (OPEC) following the first and second oil price rise (in 1973 and 1979) and the counterbalancing deficit mostly incurred by the non-oil-exporting developing countries since 1973 brought about almost a mutation in the pattern of international capital flows. It is well-known that commercial bank lending to developing countries largely recycled petrodollars to meet the payments deficit of oil-importing developing countries. However, it is not always emphasized that commercial bank lending was concentrated on a small number of developing countries in conformity with the pattern of direct foreign private investment. For instance, developing countries with an annual per capita gross national product (GNP) exceeding $1,000 received 65 per cent of foreign investment from countries of the OECD Development Assistance Committee (DAC) from 1978 to 1980, while, during the same period, low-income developing countries with an annual per capita GNP of less than $380 received less than 5 per cent of direct private investment from DAC countries.* This pattern of concentration was even more pronounced in the case of commercial loans from private banks, with nine newly industrializing countries or areas in the above-thousand-dollar per capita income category accounting for nearly 72 per cent of total Euro-currency bank credit in 1979-1981.** Therefore, one crucial impact of the tendency towards privatization of the international capital market must be seen as quantity-rationing of almost all forms of private capital flows against the poorest developing countries, which had to depend almost entirely on the far more limited flow of official development assistance.*** Indeed, information available from banks in the reporting area of the Bank for International Settlements (BIS) suggests that some of the poorest developing countries were net depositors during the 1978-1981 period of heavy commercial lending.

While the poorest among developing countries were severely credit-rationed by the international commercial banking system, there was massive but selective expansion in international commercial loans. The net external assets of banks in the BIS reporting area increased more than six times between 1973 and 1983. Of this increase in net credit from $155 billion at the end of 1973 to $1,020 billion at the end of 1983, almost half was accounted for by credit-receiving countries lying outside the BIS reporting area [14]. However, already by the middle of 1982 and definitely by

*See United Nations Centre on Transnational Corporations [13], pp. 28-29, for details.

**These nine countries or areas are Argentina, Brazil, Greece, Mexico, Portugal, Republic of Korea, Spain, Yugoslavia and Taiwan Province.

***For example, total official development assistance to developing countries during 1979-1981 was slightly over $100 billion, as compared with medium- and long-term commercial lending of $530 billion in 1982.

early 1983 the boom in net commercial lending, mostly to a group of middle-income, newly industrializing countries or areas was over. For instance, during the year of high lending from 1978 to 1981, the average annual net transfer to developing countries was approximately $28 billion; it shrank to $6.6 billion in 1982 and was thereafter negative, with reverse flows of approximately $11 billion in 1983 and over $13 billion in 1984.*

The short-lived boom in the transfer of net resources to newly industrializing countries or areas followed by their subsequent massive external indebtedness provides concrete illustration of how an industrialization process can become exceptionally vulnerable when it depends too heavily on foreign commercial borrowing. The operation of at least three distinct mechanisms contributes to the debt-servicing problem and the crippling external finance constraints on the industrialization process. First, variation in the interest rate at which debt is contracted causes significant and arbitrary fluctuations in the debt-servicing burden, and therefore in the availability of foreign exchange for industrialization. This is highlighted by the recent experience of developing countries.

By 1983 their debt service payment exceeded capital inflow from all official and unofficial sources, forcing them all of a sudden to rely in effect solely on a fraction of their export earning. Total debt service payment by all developing countries was $99.1 billion and interest payment $46.8 billion in 1983 alone, while the major Latin American borrowers (Argentina, Brazil, Chile, Mexico, Peru and Venezuela) paid $49.2 billion in debt service (or 49.7 per cent of the total) and $24.2 billion in interest alone (or 51.7 per cent of the total). Again, by 1983 each 1 per cent increase in the basic interest rates (London Inter-Bank Offered Rate (LIBOR) and United States prime rate) implied about $4 billion in additional interest payment by developing countries. Particularly vulnerable to higher interest rates were the heavy borrowers, not only because of the high level of their outstanding debt, but also because they tended to borrow a disproportionately large amount in floating-interest (for instance, variable LIBOR plus spread) arrangements. Thus, only four major borrowers, namely, Argentina, Brazil, Mexico and the Republic of Korea accounted for 85 per cent of total variable interest debt, which stood at $150 billion in the first quarter of 1983. Such flexible interest arrangements on debt shift the entire burden of risk associated with interest variation to the borrowing countries. In turn, this has made them exceptionally sensitive to the monetary policies of developed countries, especially of the United States, in conducting their industrial development policies.

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*Figures based on OECD, United Nations Conference on Trade and Development and Morgan Guaranty sources and on The Economist, 18 February 1984.

A second route to vulnerability of the heavily indebted countries has been the exchange rate variation, especially the appreciation of the United States dollar in terms of other major currencies. For instance, during the boom years of commercial lending from 1979 to 1982, developing countries without oil borrowed the equivalent of $137 billion from commercial banks and almost the entire amount was denominated in United States dollars. According to one estimate made by the Federal Reserve Bank of New York, if developing countries had borrowed in a trade-weighted mix of currencies instead, the saving would have been of the order of $16 billion in repayment obligations. Of the total, $11.5 billion would have been accounted for by limiting the effects of the appreciating dollar and the remaining saving of $4.5 billion would have come from lower interest payment on mixed currency borrowing.* Although the present system of predominantly dollar-denominated debt provides some unique advantages to the United States, it must be recognized that the recent appreciating phase of the dollar (from 1980 to March 1985) has increased the debt servicing burden of developing countries by at least $4 billion per annum on average, in addition to creating a negative "real balance effect" on the borrowing countries as net debtors. Its repercussions on the industrialization process have been to further tighten the external payments constraint, making it more vulnerable to exchange variations. It should also be noted that a group of newly industrializing countries and areas of East Asia together with Japan gained perceptibly in terms of price competitiveness vis-à-vis traditional American industries due to the appreciation of the dollar. But the advantage of higher levels of export to the United States accrued only to a handful of developing countries where the process of industrialization has already attained a relatively advanced stage.

The third and final aspect of vulnerability is often imbedded in the very economic structure of a developing country, which may become temporarily obscure due to relatively easy access to foreign capital. Such structural vulnerability has received wide attention in international debate only in its most obvious form, namely, the vulnerability of foreign exchange earning caused by fluctuations in the terms of trade for primary-commodity exporting countries. However, the recent experience of a severe "foreign exchange crunch" in several relatively more industrialized Latin American countries and the various adjustment or stabilization programmes required for their renegotiation of debt** have brought to surface a somewhat different issue of structural vulnerability. It relates in particular to the industrial structure rather than to the overall, general

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*See also The Economist, 11 February 1984, p. 100. Had the borrowers also refinanced their maturing dollar debt with an appropriate currency mix, an additional $14 billion could have been saved.

**It may be recalled here that the number of cases of renegotiated debt jumped from only 12 in 1982 to 29 in 1983, while the amount renegotiated increased from $4.7 billion to $68.8 billion between 1982 and and 1983.

economic structure of some of these relatively more industrialized developing countries. Their industrial structure may be very "thin" in the sense that the final product of some crucial industries may not at all be vertically integrated to the rest of the domestic industrial structure. This entails serious gaps in terms of backward and forward linkages in inter-industrial flows. As a result, these final products can only be produced through critical and heavy reliance on imported raw materials. Macro-economically, such imported raw materials, which are needed to utilize already installed domestic industrial capacity, can be viewed as the total level of maintenance imports. A simple but telling statistical index in this context would be the ratio of maintenance imports to total export earnings on the average and at the margin for these developing countries.* Any sharp reduction in the availability of foreign exchange, whether through a terms-of-trade effect or rising interest rate or shrinking export market due to recession abroad, could trigger off serious supply-side problems in developing countries, since the failure to obtain adequate maintenance imports would lead to sharp reductions in domestic capacity utilization. Such reductions in domestic capacity utilization could depress private investment and the overall level of effective demand through the traditional Keynesian multiplier mechanism to precipitate acute demand-side problems in a chain reaction.

Such vulnerability of the industrial structure also has a more subtle political aspect. Large "gaps" in the domestic inter-industrial structure, as well as the underdeveloped state of the capital goods sector, typically imply that during periods of high growth mostly financed by easily available foreign capital, disproportionately large amounts are spent on imported capital goods and intermediate goods. The consequent trade deficit leads to a reduction in the level of realized profits in domestic industries, as effective demand tends to leak out in the form of higher imports.** Under these circumstances, even a period of high growth

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*If maintenance import is Z and export earning is E, then the ratio of the marginal to average ratio, that is,

$$\frac{\Delta Z}{\Delta E} \div \frac{Z}{E},$$

defines the relevant elasticity as a measure of the degree of vulnerability through the maintenance import requirement.

**This is the basis of Kalecki's well-known analysis of "determinants of profits" in Kalecki [9]. According to his formula:

realized gross profits = capitalists' consumption + gross investment - level of trade deficit

The formula holds for an open economy with a balanced government budget and negligible savings out of wage income.

financed largely by higher inflow of foreign capital may not lead to adequate domestic profits and the consolidation of a class of domestic industrialists capable of carrying through a process of sustained industrialization over time. Such an underdeveloped capitalist economy then becomes vulnerable not only in terms of its maintenance-import-dependent industrial structure, but also in politico-sociological terms of not having a powerful enough class of independent domestic industrialists capable of sustaining the industrialization process. Under these circumstances, there develops a sad but predictable response. Any serious difficulty relating to external finance does not merely interrupt the industrialization process but also leads to large capital flights. This in turn further tightens the grip of the external financial constraint on industrial growth to set up a vicious circle of underutilization of industrial capacity, capital flight and stagnation of industrial investment. The industrialization process in several developing countries, especially in Latin America, has become acutely vulnerable in the sense of being continuously threatened by the operation of such a vicious circle.

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IMPROVING EXISTING INDIGENOUS TECHNOLOGIES AS A STRATEGY FOR THE APPROPRIATE TECHNOLOGY CONCEPT IN GHANA

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Introduction

Over the past 25 years the appropriate technology concept, defined by Morawetz [1] as the set of techniques that makes the optimum use of available resources in a given environment, has gained national and international attention as an alternative framework for development. The rationale for this new framework for development stems from the observation, formally articulated for the first time by Schumacher [2], that the wholesale and uncontrolled transfer of technology from developed to developing countries, implicit in conventional development programmes, creates more problems than it solves. Rather there is the need for a new kind of technology that will alleviate such problems as underemployment, unemployment and rural-urban migration at a lower economic and social cost. Three main strategies to create this new technology have been suggested: improving existing indigenous technologies, adapting advanced technologies and developing new technologies through research and development (Schumacher [2] and [3], Brace Research Institute & Canadian Hunger [4], Evans [5]).

In January 1972 Ghana revealed its intention to adopt the appropriate technology concept as a framework for development when the Technology Consultancy Centre was established at the University of Science and Technology, Kumasi. Several national and international conferences have since been held in the country and several developments have taken place. In particular, the Technology Consultancy Centre has gained world-wide acclaim as one of the most successful appropriate technology organizations, and its initial activities in steel bolt production, its advice to small-scale soap manufacturing and bee-keeping industrialists and its recent moves to help the workers in the Kumasi Suame Magazine develop an indigenous capital goods production sector should be commended (Ntim and Powell [6], Powell [7], [8] and [9]). Yet most of the traditional technologies have not been affected in any substantial way. In particular, the hope that the appropriate technology concept will among other things help improve Ghana's existing indigenous technologies, sometimes also referred to as traditional or village technologies or handicrafts, has not been realized despite the fact that the majority of Ghanaians are still directly or indirectly dependent on these technologies for food, shelter, health, some clothing and a whole range of miscellaneous items of household and cultural value.

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The reasons for this situation are not very difficult to find. Generally speaking, existing indigenous technologies are regarded as obsolete or static technologies which have no room for further improvement. They are therefore considered uneconomical, and attempts to improve them have been variously branded as "a waste of time," "reinventing the wheel," or "turning the clock back" (Cukor [10], Eckaus [11], Robinson [12], Emmanuel [13], Fransman [14]). Thus the two other strategies of the appropriate technology concept, namely adaptation of advanced technologies and development of new technologies through research and development, have been much more favoured. Even when existing indigenous technologies are considered, their frequent misinterpretation as traditional or off-the-shelf technologies in developed countries (see Singer [15], Rush [16]) has made the strategy of improving them appear to be a neo-colonialist tool designed to perpetuate the already existing technology gap, thus making such technologies unpopular. Moreover, existing indigenous technologies are often considered to be important only for rural areas, producing goods for those areas and providing jobs for women and the elderly who dwell there.

In Ghana, these reasons are exacerbated by the fact that there has been no attempt to incorporate the appropriate technology idea into a national technology policy, beyond the establishment of the Technology Consultancy Centre, much less deciding on the strategy to adopt. For political reasons, government policies and plans for rural development and, in particular, rural industrialization which could have been favourable to existing indigenous technologies have never been well and fully implemented. Moreover, with the exception of Browne's [17] study of Apeadu clay pottery, there are no detailed studies on existing indigenous technologies in the country, even though the general area of small-scale industries under which such technologies may be categorized have been studied by Steel [18], Hakam [19], Aryee [20] and Yankson [21] and [22]. The result is that a lot of the existing notions about those technologies have not been empirically examined within the Ghanaian context.

Admittedly, it is wrong to think that every traditional technology can be improved. Some may no longer be relevant in terms of their products and the current needs of the country. As Browne [17] has shown in the case of the Apeadu clay pottery, it might even be better to leave some of these technologies in their current state until they disappear through the industrialization process. It is the view of this paper, however, that existing indigenous technologies possess some regional development roles and potentials within a diversity of characteristics, and that decisions as to whether or not to improve them must be based on thorough studies of the general and particular roles and potentials of each of them.

To provide more information on the nature of existing indigenous technologies along the lines suggestod by Browne [17], and to contribute towards a greater understanding of their general and particular roles and potentials in regional development, this paper presents a detailed study of three of Ghana's rural-based manufacturing activities, one involving pottery and two involving textiles, which employ four traditional technologies. In particular, it investigates the following four questions: what is the nature and origin of these technologies; what role do these technologies play in the regional development process of Ghana; what development potentials do these technologies have, and what policy implications do answers to these questions have for Ghana?

The original study on which this paper is based was carried out in 1979 and 1980 (Ofori-Amoah [23]). The three manufacturing activites studied were the aluminium pottery of Jamra, in the Central Region of Ghana, the Kente textiles of Wonoo, in the Ashanti Region of Ghana, and the Adinkra textiles of Ntonso, also in the Ashanti Region. A sample of 20 potters, 15 weavers and 20 printers and dyers were interviewed for personal data and information on the origin and characteristics of the technologies employed in the activities, input sources, market outlets, income and expenditure and future prospects of the activities. Prospective school-leavers in the three villages were also interviewed concerning future prospects on those activities. This paper is in four sections. Section A describes the origins and nature of the technologies of three manufacturing activities. Section B examines the role of the activities in Ghana's regional development. Section C explores the development potential of the activities and section D deals with the policy implications.

A. Origins and nature of the technologies

1. The technology of the Jamra aluminium pottery

The Jamra pottery industry specializes in the production of aluminium pots and a whole range of other aluminium household wares, such as bowls, laddles and spoons. It is not very clear as to exactly where and when the technology originated, but as far as the study area is concerned, the technology was introduced into the village in the early 1960s.

The technology involves a simple set of techniques by which aluminium pots, moulded from sand, are cast from smelted aluminium scraps. An old iron pot split into two equal halves is used as a pattern. The two halves of the pot are tied together and filled with plaster sand, which has been sprinkled with water and shovelled up and is neither too wet nor too dry. A small hole of about 62 cm deep is made at the top of the filled pattern and the pattern is then inverted over a hole on the casting floor. The inverted pattern is then enclosed by two halves of an open-ended rectangular box and the box is tied. A curved tin plate is fixed to the top of the pattern and a rubber tube is fixed to the plate. The box is filled with sand and neatly shaped. The rubber tube is then removed leaving a hole at the top through which the casting is done. The box is untied and the two halves are gently pulled out from the moulded pot. The two halves of the pattern, which are still stuck in the box, are removed by gently hitting at the edges. The pattern leaves its outward features imprinted in the box. The moulded pot is further smoothened with a round door holder and a flattened spoon, gently powdered with some white material and enclosed again with the moulding box. The box is tied and all outlets and openings are sealed with swish. At this stage the pot is ready for casting.

The scraps, which constitute the main raw material, are smelted in an improvised blast furnace set on a hearth and heated by firewood. To generate the maximum heat required for smelting, about 9,000 °C, the fire is fanned by a spraying machine which is connected to the hearth by a long iron tube. The scraps begin to melt after 30 minutes, and if the right amount of heat is maintained, it takes about 3-4 hours to smelt 220 kilograms of scraps. The melting aluminium is constantly purified by scraping the dirt from the scraps as they rise to the surface. The smelted aluminium is ready for casting when it attains a reddish colour. The hot liquid is then scooped out from the furnace with a long scooping bowl and quickly poured into the hole at the top of the mould till it overflows at the top. The liquid runs down the mould in all directions and solidifies within 10 seconds, after which the box is untied and removed leaving the pot standing. The pot is emptied of the sand, trimmed with a hammer, chisel and hacksaw, and then polished with a silver polish or paint and packed for marketing. Three main groups of sizes are manufactured: small (sizes 1-3), medium (sizes 4-12) and large (sizes 15-40).

2. The technology of the Wonoo Kente textiles

The Wonoo Kente textiles industry produces Kente, a heavy-textured and very colourful traditional cloth woven out of yarns of different colours. Unlike the pottery example, there are several accounts as to how the weaving technology evolved. The commonest account is that the technology originated when two farmers from Bonwire, a village in Ashanti, were struck by how a spider wove its web and one day decided to weave a cloth in the same way. When they succeeded they submitted the cloth, fashioned after silk, to the chief of the village who in turn forwarded it to Osei Tutu, an Ashanti King in the early eighteenth century. The king appreciated the cloth so much so that he encouraged more to be woven and the technology spread out to other places.

The first stage in the weaving process is the preparation of yarns. The yarns are wound off into spools by the use of a simple winding machine. The spools are then fixed on a bobbin carrier and the warp threads are laid by trailing the thread over two posts at intervals of about 40 metres. The different coloured threads are then tied at the intersections of different colours and the trailed threads are removed from the posts and wound on a stick. The warp is then beamed into the loom and weighted at a coiled end with a heavy stone to secure it. The weaver, who sits in front of the loom, then passes a shuttle horizontally between the warps as he moves the warp up and down by operating pedals with his toes. The shuttle leaves a thread across the warp which is pressed firmly with a comb. As weaving proceeds, the weaver winds the cloth round the cloth beam of the loo and the warp is dragged towards the loom while at the same time being kept taut by the heavy stone. In this way, long narrow bands of cloth about 8-9 centimetres wide are woven. These are then cut into appropriate lengths and sewn together to form one big piece of cloth. Two main types of Kente cloth are woven: adwin ntoma, or the designed pattern type, and the ahwepan, or the undesigned type, but the basic operations are the same.

3. The technologies of the Ntonso Adinkra textiles

The Ntonso textiles industry specializes in textile dyeing and printing. The dyeing division produces the dark Kuntunkuni cloth, while the printing division produces the Adinkra cloth, a printed textile fabric produced by stamping designs with dye on the surface of a Kuntunkuni cloth or plain fabrics of different colours.

Like the Kente textiles there are several accounts of how these technologies originated. The most plausible claims that the technologies originated from the people of Gyaman, who lived in the present-day Brong-Ahafo region of the country. As a result of the Ashanti invasion of the land of the Gyamans during the eighteenth century the Gyamans were forced to teach the craftsmen of Osei Bonsu, the Ashanti King, who after learning the technologies returned to make the cloth at the King's court. The cloth was named Adinkra after the Gyaman chief Kwadwo Adinkra-Kakai, who was killed during the invasion. On an official visit to the Ashanti King's palace, the chief of Ntonso learned the technology and introduced it to his village.

The dyeing technology begins with preparation of a dyestuff which is obtained from the roots of the Kuntunkuni tree. The roots are cut into pieces and pounded to remove the barks, which are then boiled for 24 hours and left to stand for three days to cool. Both old and new cloths are dyed. In both cases, the cloth is steeped in the dyestuff, taken out, left to dry and steeped again until the colour turns black. Depending upon the colour of the cloth and the weather this might take from 2 to 4 weeks. In order to fix the colour, the cloth is then buried in a muddy pool for some hours. After this the cloth is rinsed and then steeped in the dyestuff two or three times to complete the process. The cloth is then sun-dried and made ready for either printing into Adinkra cloth or marketing.

The first step in the printing process is the preparation of the printing liquid, which is also prepared from the badee tree. The outer skin of the tree is scrapped off and the woody tissues, which contain the dyestuff, are broken into pieces and soaked for 24 hours. The pieces are then pounded till they become soft and pulpy. The pulpy badee is then boiled for 3-4 hours in the same water in which it was soaked, after which the water becomes a dark-brown colour solution called badee nsuo or badee solution. The solution is cooled, drained off into another container and reboiled for seven hours with iron slags to obtain the proper viscosity, when it becomes sticky and blackish-brown in colour. The stage is then set for printing.

The cloth to be printed is stretched out and nailed to a printing-board. The printer, who squats beside the board, dips a comb into the badee nsuo and moves the comb over the surface of the cloth by free-hand and unidirectionally, moving downwards and then across. The printer then picks up a stamp with the design he or she wants to print, dips it into the badee nsuo and stamps inside the rectangular boxes made by the comb movements. The cloth is then dried and made ready for the market.

Even though the origins of these technologies are shrouded in legend, the fact that these have originated within the Ghanaian society is indicative of the existence of indigenous technological capability. What development roles, then, do these technologies play in Ghana?

B. The role of existing indigenous technologies in regional development

Every manufacturing activity results in the creation of goods, employment and income. The immediate question that arises is how the three activities described in this study perform in these three functions?

1. Production of goods

Table 1 gives the average daily, weekly, monthly and annual output per worker of the pottery at the time of study. The annual output figures reflect 6 months of full-time work only since for most of the potters the remaining 6 months of the year were taken up largely by delays and minor occupations such as farming. The average weekly output for the undesigned Kente cloth was one piece of 12 yards and the annual output was 30 pieces of cloth, while for the designed type it was one piece for monthly output and 10 pieces for annual output. The dyeing division of the Adinkra textiles industry averaged 25 pieces for monthly output and 300 pieces yearly, and it was 50 pieces weekly, 200 pieces monthly and 24,000 pieces annually for the printing.

Table 1. Average physical output of the Jamra pottery

Pot size a/	Average output per worker			
	Daily	Weekly	Monthly	Annual
1	15	75	300	1 800
3	14	56	224	1 344
5	12	48	192	1 152
8	10	40	160	960
20	4	16	64	584
40	1	4	16	96

Note: Data based on field survey of the Jamra pottery.

a/ Selected sizes only. See Ofori-Amoah [23] for the full range of sized produced.

These products have country-wide demand. The quality and durability of the aluminium pot far exceed those of the clay pot as a household ware and particularly as a cooking utensil. In the same way, Kuntunkuni and Adinkra clothes are the most widely used mourning costume in Southern Ghana, while the Kente is a ceremonial cloth for most people, and especially chiefs, other important national figures and the well-to-do. The main markets for the pots are the cities of Accra and Kumasi, other large urban areas, Cape Coast, and the other regional capitals as well as large marketing centres such as Mankessim. Here the pots are sold in bulk to middlemen who may, in turn, retail them in several other places. As for the two textiles, most of the products are purchased by middlemen, who go to the village. Some are also made to individual orders. The products generated by these existing indigenous technologies therefore are not only for rural areas, as it is often thought, but indeed for the whole nation.

2. Generation of employment and income

The three activities constituted the main source of employment for the persons sampled in their respective locations. Weaving constituted the leading occupation for the 15 people interviewed at Wonoo, with farming as their minor occupation. Of the 20 people interviewed at Ntonso, nine (45 per cent) had dyeing as their leading occupation, seven (35 per cent) had printing as their leading occupation, and farming constituted the minor occupation for 17 of them. At Jamra, eight (40 per cent) out of the 20 respondents in the industry were farmers, seven (35 per cent) were unemployed, three (15 per cent) were labourers, while the remaining two were a driver and a carpenter before they entered the industry. At the time of the survey, they all had pottery as their major occupation and farming as their minor occupation, just as Browne [17] found at Apeadu.

The average net income per worker for the pottery and the Ntonso Adinkra textiles on the assumption of an all-year production are given in tables 2 and 3, and it can be seen that some of the earnings were relatively high. Though it was not possible to compare these income earnings with previous or equivalent jobs, respondents in all three activities indicated that their incomes were higher than their previous or alternative jobs in the area. The income-generating capacity of the Kente textiles, however, was relatively weak. The net income for the weaving of the designed cloth was 1,742 cedis and that for the undesigned cloth was 2,136 cedis (Ofori-Amoah [23]).

Since the purchase of raw materials and the sale of finished products have led to the rise of middlemen, jobs have been created for the urban areas as well. In fact, these technologies provide important links with the outside world for the rural areas. That is, they have important regional development functions by way of the jobs and incomes they generate and the raw material and market links they generate between rural and urban areas.

Table 2. Average net yearly income per worker of the Jamra pottery at 1979 prices (In cedis) a/

Item	Pot size					
	Small		Medium		Large	
	1	3	5	8	20	40
Income per worker	9 682	25 153	34 263	26 403	65 079	20 025

Note: Data based on field survey of the Jamra pottery.

a/ ₵1 = $0.363.

Table 3. Average net income of the Ntonso Adinkra textiles industry at 1979 prices (In cedis) a/

Item	Dyeing	Printing
Old (dyed) cloth	7 133	34 139
New cloth	11 608	356 612

Note: Data based on field survey of the Ntonso Adinkra textiles industry.

a/ ₵1 = $0.363.

However, the fact that existing indigenous technologies are able to perform the basic functions of producing goods and creating jobs and income does not necessarily mean that their development potential is good. Since any policy decision to invest in them involves foregoing other alternatives, and since the country cannot afford to misinvest its limited resources, it is important to investigate the development potential of these technologies more closely.

C. Development potential of existing indigenous technologies

1. Economic viability of existing indigenous technologies

The obvious question to start with in considering the development potential of existing indigenous technologies is whether such technologies are economically viable. Cost-benefit analysis was used to investigate this question, though not in the conventional sense of evaluating the technologies as alternatives among a given range of technologies (Mishan [24], but rather as a simple way to show whether or not the technologies have some profitability potential. The primary question was therefore considered in two parts: whether or not the three manufacturing activities had been profitable in previous years; and whether or not they were going to be profitable in future. Cost-benefit analysis was used to investigate both parts of the question (Mishan [24]).

For the first part of the question, economic profits of each activity over previous years were verified by subtracting estimated costs from estimated revenue. Due to the difficulty in getting data over a longer period, the four-year period from 1976 to 1979 was chosen. Three main types of costs were computed for each activity, namely fixed, variable and opportunity costs. Fixed costs included workshop construction costs and equipment and replacement costs. Variable costs included costs of raw materials, energy, hired labour and transportation. Opportunity costs were calculated as the wage or salary the producer would have earned by using his or her services elsewhere and the interest that would have accrued if the investible funds had been deposited at the bank. Depositing investible funds at the bank was chosen because it was the only alternative which could lend itself to exact and easy calculation (see Ofori-Amoah [23] for details). All three activities proved to be economically profitable during the period 1976-1979. The printing of new clothes was the most profitable, followed by the pottery, while the weaving of the designed Kente cloth was the least profitable (see tables 4, 5 and 6).

Table 4. Gross revenue, total economic cost and economic profit of the Jamra aluminium pottery, 1976-1979 (In cedis)

		Pot size					
		Small		Medium		Large	
Year	Item	1	3	5	8	20	40
1976	Gross revenue	22 500	28 224	34 560	40 320	51 840	25 920
	Total economic costs	17 068	15 882	2 084	27 290	26 013	19 209
	Economic profit	5 432	12 342	14 079	13 030	25 827	6 711
1977	Gross revenue	32 400	38 976	48 384	64 320	72 460	36 480
	Total economic costs	23 242	22 977	27 544	37 003	34 667	25 769

continued

Table 4 (continued)

		Pot size					
		Small		Medium		Large	
Year	Item	1	3	5	8	20	40
1977 (cont.)	Economic profit	9 158	15 999	20 840	27 312	38 293	10 711
1978	Gross revenue	36 000	49 728	62 208	70 080	94 080	47 040
	Total economic costs	30 213	27 367	34 582	48 083	44 774	32 983
	Economic profit	5 787	22 361	26 726	21 997	49 306	14 057
1979	Gross revenue	45 000	60 480	74 880	81 600	115 200	57 600
	Total economic costs	35 318	32 486	40 617	55 197	50 121	37 575
	Economic profit	9 682	27 995	34 263	26 403	65 079	10 025

Note: Data based on field survey of the Jamra pottery.

Table 5. Gross revenue, total economic costs and economic profit of the Wonoo Kente textiles, 1976-1979 (In cedis)

	Designed cloth			Undesigned cloth		
Year	Gross revenue	Total economic costs	Economic profit	Gross revenue	Total economic costs	Economic profit
1976	5 500	7 502	-2 002	4 500	5 652	-1 152
1977	6 000	8 462	-2 462	5 400	6 273	-873
1978	6 550	8 314	-1 814	7 500	7 171	329
1979	7 000	8 742	1 742	9 000	6 864	2 136

Note: Data based on field survey of the Wonoo Kente textiles industry.

Table 6. Gross revenue, total economic costs and economic profit of the Ntonso Adinkra textiles (In cedis)

Year	Item	Dyeing: New cloth	Dyeing: Old (dyed) cloth	Printing: New cloth	Printing: Old (dyed) cloth
1976	Gross revenue	24 000	6 000	240 000	12 000
	Total economic costs	15 837	2 886	111 476	8 069
	Economic profit	8 163	3 114	128 524	3 931
1977	Gross revenue	30 000	7 500	288 000	19 200
	Total economic costs	20 228	3 300	145 168	9 951
	Economic profit	9 772	4 200	142 832	9 249
1978	Gross revenue	36 000	9 000	360 000	24 000
	Total economic costs	25 236	4 064	256 661	11 915
	Economic profit	10 764	4 936	103 339	12 085
1979	Gross revenue	45 000	12 000	600 000	48 000
	Total economic costs	33 392	4 867	243 388	13 861
	Economic profit	11 608	7 133	356 612	34 139

Note: Data based on field survey of the Ntonso Adinkra textiles industry.

To investigate the second part of the question, namely, whether or not the activities were likely to be profitable in future, the net present value (NPV) method of investment appraisal was adapted. The NPV method rests on the assumption that the value of money today is more than that of tomorrow, so that the net cash flow of a project over its lifetime should be discounted to its presen value. The method therefore involves estimation of costs (fixed and variable costs) and gross revenue of a project over its lifetime. The costs are then subtracted from the revenue to obtain the net cash flows, which are then multiplied by a discount factor to obtain the present value of the project for each year in the project lifetime. These values are added up and the initial capital outlay or investment is subtracted to obtain the NPV. If the NPV is negative, the project is not viable. If it is positive, the project is viable.

In order to use this method, it was assumed that the three activities were three separate investment projects. A ten-year period, from 1980 to 1989, was considered to be reasonably long for the impact of the projects to be fully felt and was thus chosen as the project lifetime. The costs and revenue were estimated from the data obtained for the previous four years. The net cash flows were then discounted to their 1979 present value, using a discount factor calculated on the basis of the then interest rate of 18.5 per cent. The initial capital outlay was calculated as consisting of construction cost and the variable cost needed to start each activity. The construction cost was the cost of the plant and equipment. To calculate the variable cost, a recovery period (that is, the period during which the initial variable cost could be recouped) was calculated using the time after which the first products of each activity could be marketed as the criterion. This turned out to be one week for the pottery, the weaving of the undesigned Kente cloth and the printing of new clothes, and one month for the weaving of the designed Kente cloth, the dyeing and the printing of dyed clothes (see Ofori-Amoah [23] for more details).

The results of the NPVs thus calculated showed that the aluminium pottery and the Adinkra textiles were both economically viable (see tables 7 and 8). With the Kente textiles, the weaving of the designed pattern was not viable (see table 9). The case of the designed Kente cloth is a good example of a product which is becoming obsolete. This is because the cloth is becoming so expensive that most people can no longer afford to buy it. The demand by the general public has therefore declined, and the cloth seems to be going out of fashion. These findings show that not all existing indigenous technologies are uneconomic as it is generally believed.

However, economic viability alone is of little practical value if the cost of the technologies far exceeds the capability of local resources, and if their regional development impact in terms of employment, income and rural-urban linkages is minimal and restricted. As indicated by the World Bank [25] study, an acute shortage of foreign exchange, leading to severe reductions in the supply of

Table 7. Net present value of the Jamra aluminium pottery in 1989 at 1979 prices (In cedis) a/

Item	Pot size: Small 1	Small 3	Medium 5	Medium 8	Large 20	Large 40
Total present value	127 900	274 963	449 022	300 808	600 141	228 832
Initial capital outlay	-1 885	-1 818	-2 082	-2 555	-2 391	-1 984
Net present value	126 015	273 145	446 940	298 253	597 750	226 848

Note: Data based on field survey of the Jamra pottery.

a/ ¢1 = $0.363.

Table 8. Net present value of the Ntonso Adinkra textiles industry in 1989 at 1979 prices (In cedis) a/

Item	Dyeing: New cloth	Dyeing: Old (dyed) cloth	Printing: New cloth	Printing: Old (dyed) cloth
Total present value	131 692	71 143	3 036 106	370 084
Initial capital outlay	-2 453	-447	-4 301	-1 180
Net present value	129 239	70 696	3 031 805	368 905

Note: Data based on field survey of the Ntonso Adinkra textiles industry.

a/ ¢1 = $0.363.

Table 9. Net present value of the Wonoo Kente textiles industry in 1989 at 1979 prices
(In cedis) a/

Item	Designed cloth	Undesigned cloth
Total present value	-2 050	43 150
Initial capital outlay	-696	-606
Net present value	-2 746	42 544

Note: Data based on field survey of the Wonoo Kente textiles industry.

a/ ¢1 = $0.363.

raw materials, new equipment and spare parts, has caused Ghana's industrial sector to lose momentum since 1977. Manufacturing output has precipitously dropped, with factory capacity utilization falling from 53 per cent in 1975 to 25 per cent in 1980. The next important question to ask in considering the development potential of these technologies is therefore the following: to what extent are the characteristics and requirements of these technologies relevant in terms of Ghana's present difficulties in supporting its large-scale industrial plants?

2. Relevance of the characteristics and requirements of existing indigenous technology

The main characteristics and requirements of existing indigenous technology were examined for plant and equipment, raw material and sources, labour, and start-up capital.

(a) Plant and equipment

Four main types of workshop were identified in the case of the pottery. These were open sheds, enclosed bamboo sheds, unoccupied swish buildings and cement-and-bamboo-built sheds. Most of the workers carried out their operations in the enclosed bamboo sheds. In the case of the Kente textiles industry, eight of the 15 people interviewed (53 per cent) used open spaces in homes, four (27 per cent) used open huts and three (20 per cent) used open spaces under tree shade. With the Adinkra textiles, two out of the nine engaged in dyeing worked in open spaces in their homes, while the remaining seven worked in open spaces in the streets. In the printing division, seven out of the 11 people (67 per cent) worked in open sheds roofed with thatch, while the remaining four (33 per cent) operated in open sheds roofed with corrugated aluminium sheets.

With regard to equipment, 50 per cent of that used in the pottery was locally made, while the remaining 50 per cent consisted of ready-made items, usually purchased from the urban centres. All the equipment used in the Kente industry and most of that used in the Adinkra industry was also locally made.

(b) Raw material sources

Any scrap which has some aluminium component such as broken aluminium cooking utensils and certain parts of old vehicles qualifies as a raw material for the pottery. These can therefore be obtained locally. However, at the time of the study, the local supplies were completely depleted and the manufacturers had to rely on middlemen in the urban areas, some of whom could obtain scraps directly from large aluminium plants in the city. The yarns which constitute the main raw material of the Kente industry are mostly imported and the weavers have to purchase them from the city shops. The main raw materials for the Adinkra industry are calico, badee and kuntunkuni. The first is usually obtained from the large wholesale and retail shops in the urban areas or from the old clothes of customers. The last two are obtained from trees which grow in the northern region of the country.

Apart from a small quantity of petrol required in the pottery, firewood is the main source of energy for the pottery and the printing, the two activities that require energy in their production process, and all the firewood is obtained locally. Thus, even though not all the raw materials are obtained locally, these technologies do generate important non-local linkages for urban and other rural areas. In addition, by using scraps, the pottery in particular helps to reduce the amount of wastage in the economic system. Besides, most of the equipment, even if improved, might not be as expensive as that of the large-scale capital-intensive urban plants that depend heavily on foreign exchange.

(c) Labour characteristics

Browne [17] found that all those engaged in the Apeadu clay pottery were women, most of them between 35 and 64 years of age. The age structure in the three activities under study spanned 16 to 50 years, with most of the workers between the ages of 16 and 35: 16 out of 20 (80 per cent) in the pottery, 12 out of 15 (80 per cent) in the Kente textiles industry and nine out of 11 (81 per cent) in the printing shop. The only activity which had a higher age structure close to Browne's [17] finding was the dyeing division. All the nine people engaged in it were between 30 and 50 years of age (see table 10).

The sex structure of the workers in the industries was also different from that generally believed. Both men and women were engaged in the industries, though they did not perform the same productive processes. In the pottery, the weaving and the printing divisions only males were directly engaged in actual production. Women worked mainly as suppliers of firewood and raw materials and as retailers for the products. In the dyeing division, the

Table 10. Age structure in the different activities

Age group	Pottery: Number of workers	Pottery: Percentage of total	Weaving: Number of workers	Weaving: Percentage of total	Dying: Number of workers	Dying: Percentage of total	Printing: Number of workers	Printing: Percentage of total
16-20	2	10	4	27	0		0	
21-25	7	35	4	27	0		2	18
26-30	4	20	1	7	1	11	6	55
31-35	3	15	3	20	2	22	1	9
36-40	1	5	2	12	3	33	2	18
41-45	1	15	1	7	2	22	0	
46-50	2	10	0		1	11	0	
Total	20		15		9		11	

<u>Note</u>: Data based on field survey of the three activities.

opposite was the case. Of the nine dyers, six were women. Existing indigenous technologies therefore do not provide job opportunities only for old women in the rural areas as it is usually believed, but also for men, both old and young. This means that such technologies could have the potential of reducing rural out-migration of young people, which is one of the regional development problems facing Ghana.

With regard to education, existing indigenous technologies do not require any stringent and long formal training. Both literate and illiterate workers were found in all the industries. Eleven out of 20 potters (55 per cent, six of the 15 weavers (40 per cent), one of the nine dyers (11 per cent) and nine of the 11 printers (82 per cent) were literate. Again, contrary to Browne's [17] finding, all of those who had been to school had at least completed middle-level schooling and could read and write.

Apart from the Adinkra industry, in which almost all the workers learned the technology by helping their parents do it, all the other workers had to undergo specific training in order to acquire the technology, and the duration of training was found to depend on the abilities of individuals. In the pottery, this ranged from 3 months to 2 years, with the majority (nine out of 20) taking 6 months. In the case of the Kente industry, it was 18 months to 2 years for the designed type and 6 months for the undesigned. The duration for the dyeing and printing technologies was estimated as 1 to 6 months and 3 to 6 months respectively.

(d) Start-up capital

The start-up capital had also been minimal during the 10 years prior to the study. For the potters it ranged from ₵50 to ₵800, with the majority starting with between ₵200 and ₵300. For the weavers it was between ₵50 and ₵250 and for the printers and dyers between ₵50 and ₵200 (Ofori-Amoah [23]). From the initial capital outlays given in tables 7, 8 and 9, it was clear that these were going to increase, although the amount could still be considered as minimal.

The cost-benefit analysis has already shown that apart from the weaving of the designed Kente cloth, all the other activities have good economic prospects. In addition, the characteristics and the role of these activities also indicate considerable regional development potential. The next and final question is as follows: are there any obstacles facing these three activities, and if so what implications do they have for the development potential outlined above?

3. Obstacles facing the activities

The obstacles facing the three activities are social, economic and technical. The most important social obstacle is the attitude of the public towards those engaged in the activities. First, there is a preference for white-collar jobs which makes people consider school-leavers working in the industry as "drop-outs". This kills the interest that some prospective school-leavers may have in the industry. Second, the deteriorating conditions of rural areas and the fact that the industries are found in villages tend to push people away to the cities, even though they may end up either unemployed or learning trades like driving, tailoring and welding which comparatively do not pay as well as the industries they have left behind. There is also a feeling that the industries are for older people, and this is particularly true for the dyeing division of the Adinkra industry, where all the workers surveyed were over 30 years of age. Thus, even though school children who were old enough did work in the industries part-time during the school year and full-time during holidays, when asked whether they would continue to work in the industries after school, only five (17 per cent) of the 30 school children of Jamra, four (16 per cent) of 24 in Wonoo and five (7 per cent) of 71 in Ntonso said they would (Ofori-Amoah [23]). This finding is similar to that made at Apeadu by Browne [17].

Among the economic obstacles are raw material and capital shortages and market saturation. Raw material shortages affected all the three activities, though in different ways. In the pottery, it reduced an all-year-round activity to an average length of six months. At Wonoo, it accounted for the unprofitability of the weaving of the designed Kente cloth. At Ntonso, it accounted for the differences in revenue between dyeing of old and new clothes and also between printing of old and new clothes. Part of the problem is due to the increasing number of people in the activities. However, in the case of the textiles a greater part of the problem was a result of the shortage of foreign exchange on which the importation of yarns and the production of calico depend. In the case of pottery the raw material problem was due to the lack of linkage between the village-based pottery and the urban-based capital-intensive pottery plants. Thus even though huge quantities of scrap lay unused at the large-scale aluminium plants in Tema, it was not easy for the village-based potteries to get regular supplies of raw materials.

In spite of the small size of the initial capital outlay, start-up capital was becoming a problem because of the rising cost of equipment and the lack of good sources of funds. Most of the people interviewed - 60 per cent of the potters, 60 per cent of the weavers and 50 per cent of the dyers and printers - financed themselves either by initially working as farm labourers or staying beyond their apprenticeship period. The rest received parental help (see table 11). With the increasing price of items, it was becoming more difficult to depend on these means of generating start-up capital.

A third economic obstacle, particularly for the pottery, is the possibility of eventual saturation of the market. The reason is that, unlike traditional earthenware, these pots have such great durability that consumers will seldom want new pots, unless they lose them through such rare incidents as overburning or theft. The result is that in the last few years, demand within the locality has virtually ceased, since consumers have all the pots they need. As already indicated, new markets have been found, but the fear is that the process might repeat itself.

Table 11. Sources of finance for workers in the three activities

Source	Number of workers and percentage a/ of total: Pottery	Weaving	Dyeing and Printing	Total
Parents	3 (15)	4 (27)	5 (25)	12 (22)
Other relatives	2 (10)	2 (13)	3 (15)	7 (13)
Self-generated	12 (60)	9 (60)	10 (50)	31 (55)
Local loan	3 (15)	0	2 (10)	5 (10)
Total	20	15	20	55

Note: Data based on field survey of the three activities.

a/ In parenthesis.

The main technical obstacle concerns equipment. Some of the equipment have very sort life spans even though they tend to be the most expensive. An example was the blast furnace for the pottery, which had a maximum life span of four months. The production technologies are also physically taxing and wear workers out easily and quickly. This has generated the thought that the activities lead to premature aging.

The major obstacles facing the activities have been outlined above. To what extent do they constitute a hindrance to the development potential of existing indigenous technologies.

It is clear that some of these obstacles, for example, the case of the weaving of the designed Kente cloth, are very serious and involve the very issue of whether to encourage such a technology or not. However, most of the obstacles are not unsurmountable. Indeed most of them exist because the activities employing the technologies have been long neglected by government policy, and the fact that these technologies still exist is even additional evidence of the potential and also of the dynamism of the people who employ them. For example, it was observed that some initiatives had already been taken by those in the industries to solve or adapt to some of the obstacles discussed above. The dyers were found to be concentrating mostly on dyeing old clothes since it is not possible to obtain calico all the time. Similarly, the potters were diversifying their products. At the time of the survey, large quantities of aluminium mashing bowls and ladles (formerly produced from clay and wood respectively) were being produced. Indeed some of the potters were specializing in these instead of pots. In the same way, more weavers were changing from designed to undesigned weaving. However, much more can and should be done.

For example, a broader loom to enable weavers to produce a wider strip of Kente cloth and thereby increase the speed of weaving had been invented in the Department of Rural Arts and Industry at the University of Science and Technology, Kumasi, before this study was undertaken, though the loom was not being used by any of the weavers at Wonoo at the time of the study. In the same way, it is possible to develop a better and a more durable blast-furnace system for the potters, as well as a mechanical device that will help them polish the pots instead of using a hammer, chisel and a hacksaw. In the case of the dyeing, it is possible to develop a better way of colour-fixing. This could be done either by studying the particular chemical component of the mud which fixes the colour and extracting it, or developing an alternative so that it could be added to the dyestuff to fix the colour at the same time dyeing is being done. There is also the possibility for developing a quicker way of printing by using larger stamps and doing the printing on raised boards so as to ease the problems associated with squatting during printing. There is the possibility also for a method that will print and dry at the same time so as to remove the hold-ups caused by depending on the weather for drying. The economic obstacles of raw material shortages can be lessened by establishment of formal links with the urban-based plants for raw materials. Provision of government credit in the form of seed funds for new entrants into the industry can also lessen the problem of limited start-up capital. Basic informal instruction in better management techniques and guidance in production line organization and techniques, especially to the potters, the printers and the dyers, can reduce the hardship of the production process. Similarly, more development and diversification of existing products of the activities and creation of new products, coupled with a more serious exploration of the external market possibilities of these products, can also help reduce the market obstacle facing the activities. The attitudinal problems will gradually disappear once some of these suggestions are taken up and greater public attention is given to the activities and those engaged in them.

D. Policy implications

Improving existing indigenous technologies is a worthy course for Ghana for several reasons. First, even though they are mostly located in the rural areas, such technologies do not provide jobs and higher-level income and goods for the rural areas alone, but also for the urban areas. In particular, their products are of national importance and a majority of Ghana's 12.3 million people depend, directly or indirectly, on them for a whole range of needs. Secondly, even though there are some obstacles facing the industries described in this paper, the development potential of existing indigenous technologies, in terms of their viability, is good. Not all of them are uneconomic as it is generally thought. Besides, their low-cost characteristics seem to be very relevant within the context of Ghana's development resources. Finally, the existence of such technologies is clear evidence of the indigenous technological capability within Ghanaian society. The recent adaptations by people engaged in these activities and the possibilities for change are indicative of the fact that existing indigenous technologies are not as static as they are usually considered to be, though they may be slow to change. Rather, there is room for improvement which can help to foster innovation and the technological ingenuity of the rural population, thereby providing a solid foundation for rural-based regional economic development. It is even possible for an indigenous scientific and technological community to emerge out of this.

Ghana needs a national technology policy to guide it in the choice of technologies and the strategies governing the implementation of those decisions for the benefit of the people. In particular, such a policy should consider incorporating traditional technologies into a broader framework of appropriate technology for national development so as to transform promising existing indigenous technologies from dormant to dynamic means of development, and to find alternatives for those whose improvement would be a waste of time and money. This calls for an inventory and detailed study of all traditional technologies that are currently used in the traditional sector, assessment of their present and future development potential, identification of the main social, economic, and technical obstacles to the development of the technologies, identification of ways by which these obstacles could be solved, and selection and actual implementation of the development option. In short, existing indigenous technologies should become a focus of social, scientific and engineering research, with the Government providing the necessary leadership.

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THE IMPACT OF EXPERT SYSTEMS

Eoin Gahan*

A. Expert systems: an introduction

An expert system is a computer programme and database that behaves rather like a human expert: it answers questions about new problems based on its experience of previous problems. Expert systems is the more common name, but knowledge-based systems is a term also used.

This may appear fanciful, but in fact this definition is a reasonable summary of what expert systems do. They are not confined to the world of academic research: expert systems are produced commercially and used to make commercial decisions. They are used in medicine, manufacturing, law and many other fields. Their use is spreading, and the potential number of applications is very large.

An expert system can be divided into three parts: the "shell", the knowledge base and the user interface. The shell is the reasoning power of the system, the process by which it applies rules drawn from experience to the problem in question. This reasoning process is theoretically of general applicability: thus shells are often sold separately, or with only a small sample database. The user interface is the way in which questions can be posed and the data added to. Sometimes the expert system will also explain the process by which it arrived at a conclusion. This means it will indicate the sequence of rules which it has applied in order to answer the question posed. Such a feature can be particularly important not only in constructing the system but in showing the user that a systematic and reliable chain of reasoning is applied.

In practice, however, the type of the reasoning and sophistication required will vary from one problem area to another. The problem may be one of identification (What is the chemical compound?) or of decision-making (What is the cheapest way to fly Vienna-New York-Caracas-Vienna?). It should be noted that both problems require a search of database, but the second requires a further search of possible solutions in response to the supplied criterion of cheapness.

One can envisage the system, in the first example, asking questions that chemists have found useful in narrowing down the area of search for the identity of the unknown compound (for example: What is its melting point? Is it water soluble? What is its specific gravity?) The contribution of the human experts has thus been not only in providing the general answers but also in posing the general questions.

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The second example illustrates the same point more subtly. The complex regulations on airline fares could be expressed as a series of rules, which would then form the database to be analysed by the system. The expert system may be directed to search not just for routes that involve one change of plane between Vienna and New York, but also two or more changes. These may or may not include searches in the opposite direction, for example, Vienna-Istanbul-Rome-New York, depending on exchange rates and local restrictions on particular types of ticket. Too detailed a search may, even with a fast computer, take too long. Thus (preferably variable) criteria of search and of reasonableness of the solution have to be incorporated in a way which would be unnecessary in the first example.

Further difficulties arise when probability enters. Some kinds of knowledge can be embodied quite well in the form of rules. If the problem is of identification, and if scientific knowledge is advanced enough, then the rule can be put in a form such as, "If A and B and C and D are all true then the answer is Z". However it may be that scientific knowledge is not advanced enough to do more than assign probabilities, for example, "If A and B are true then the answer is Z with 70 per cent certainty". Such systems arise especially in important areas such as medicine, where diagnosis may depend on the application of a number of different rules all involving probabilities. The choice of which medical tests to apply to the patient and in which order to apply them can be vital when time is short.

It should be stressed that the above examples are intended only to be illustrative and to introduce the subject of expert systems in a non-rigorous manner. Their actual construction in terms of providing answers to real world problems is a difficult task. Nevertheless, it is one which is now being taken up with enthusiasm in many developed countries.

Expert systems are a branch of artificial intelligence. The origins of artificial intelligence as a science antedate the invention of computers and can be traced back at least to the work of A. N. Turing and others [1]. The idea of machine intelligence is one that has found practical application in many other fields, such as pattern recognition, speech input and output, machine translation and the like.

B. Operational expert systems

Whatever the attractiveness of the concept, the main interest in expert systems has to be directed towards the practicability of their construction and use. Therefore, the example of existing implementations is one that has to be closely studied. The best known of the earlier applications have been in medicine. The MYCIN system developed in California has been used extensively for the diagnosis of bacterial illnesses. A later system, INTERNIST-1 has been shown to be as successful in diagnosis as the average clinician [2]. Medicine continues as an important area of research. Organic chemistry has seen a successful system for the identification of compounds from spectographic data, and, even more interestingly, a scheme to suggest new synthesis paths for organic compounds. It has already suggested routes that are commercially viable and which had not previously been invented.

Natural resources have provided a further rewarding field for expert systems, perhaps because the problems are usually very clearly defined. The prospector, whether in mining or offshore drilling, wants to know whether to drill at a particular location. The point of an expert system is that it can embody all recorded previous experience as to the likelihood of a successful find, given the particular conditions and the preliminary indications deriving from sample surveys of the area. In the mining field, a well-known expert system called PROSPECTOR helped in finding a promising extension to an existing molybdenum deposit in the United States of America [3].

Again in the mining field, an expert system called MUDMAN is being marketed that embodies the accumulated expertise in so-called "mud engineering", the skills needed to apply drilling mud (a lubricant). The system is supplied by the mud company as a source of support to users of the product which can substitute for the limited number of experienced engineers in this area [4].

Other applications, catering for more complicated questions in, however, more restricted subject areas, include insurance, investment appraisal, inventory control, training, computer operations, process and production control, fault diagnosis etc.* The assembly of computers, the selection of them and the processing of housing applications by local authorities are some other examples [5]. The choice of the best components for combinations to meet customer requirements is an application for which a valve manufacturer is now using an expert system [6].

Operational expert systems in the manufacturing sector cover the problems of process planning, production scheduling, machine problem diagnosis, as well as the areas mentioned above of order specification, completion and configuration [7]. In this last area the best-known example is Digital Equipment Corporation's internal system called XCON. This has allowed the company's sales force rapidly to select the combination of equipment needed to meet the requirements of a particular customer, and it is estimated that it now saves the company more than £15 million a year [8].

The provision of advice on complex but well-defined subjects is an area where early growth is obviously possible, since expert systems of this kind are the easiest to establish. One example of such an implementation is a superannuation (pension) adviser. A government department in the United Kingdom of Great Britain and Northern Ireland has implemented a system, using the ICL Adviser software of International Computers Limited, which guides staff through the often complex regulations. The purpose is to allow

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*Reported in brochure by Online International Ltd. for the KBS 86 International Conference and Exhibition.

those who have enquiries about their entitlements and the options available to them to make enquiries directly through the computer.*

Law is another application of the advisory type of expert system. Again the domain (the area of knowledge) can be both limited and well-defined. Employment legislation in the United Kingdom is summarized in an expert system now being marketed. The system uses a total of around 1,100 rules to assist managers in understanding the basic structure of the law in this area. It allows the manager to assess whether the employee will have a claim for unfair dismissal, and it estimates the likely costs if a claim were to be successful. The same company, Expertech, also markets an expert system to clarify the regulations on sick pay, in order to determine employee entitlements in accordance with government regulations.**

A rather different type of expert system is one which can be described as a real-time expert system. Here the purpose is to support an experienced professional in his decision-making where this decision-making is being complicated by the speed and variety of the information he or she is receiving. An expert system can monitor the information being received and decide on the basis of predefined rules whether it is changing significantly. One obvious application under significant research and development focus at the moment is in defence systems, where decisions have to be taken in the face of streams of information from all sides. However, civil applications of this kind are also developing rapidly. Decision-making with respect to certain industrial processes can be crucially dependent on timing to avoid loss or damage, as noted above, and when the flow of information is faster than the human expert can cope with, then expert systems of this type have a role to play. But the area of banking, especially in foreign exchange dealings, is another field where artificial intelligence applications are growing. The ability of systems to analyse and interpret changing trends and the relationships between them, and to apply and change the decision-making criteria used by the human expert, are of increasing importance in a financial world now operating globally for 24 hours each day [9].

Computer manufacturers, as might be expected, have applied expert systems techniques in their own work, especially for fault-finding and diagnostics. Companies reporting such activity include IBM,*** Texas Instruments, Digital Equipment Corporation, Siemens, Nixdorf, Fujitsu and Tandem [10].

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*Described in International Computers Limited information material on ICL Adviser software.

**Described in Expertech information material on Employment Legislation and Statutory Sick Pay Systems.

***Reported in an IBM catalogue for the KBS 86 International Conference and Exhibition.

C. Software trends

Research in the academic sphere has now been under way since the end of the Second World War, with a major development in 1954 with the invention of LISP, a computer programming language by John McCarthy of the Massachussetts Institute of Technology. LISP is a list-processing language, at least that is the characteristic from which its name derives. It has several other characteristics however, which also make it particularly suitable for artificial intelligence applications. Lists are collections of elements linked together in a structured way. LISP allows lists to have branches, and these to have sub-branches and so on, and the end of a list can refer back to another part, or to the beginning of the list. Now it turns out that this way of storing data can be very efficient (if a bit confusing initially) for storing knowledge (rather than data in the traditional sense). Knowledge can be thought of as a structure of facts: it is facts in a certain order and with certain relationships between them. LISP allows data to be stored in this way. Moreover, as a language, it allows these sorts of lists to be easily examined and changed. It has therefore become the major language for artificial intelligence and expert systems work in the United States.

Among its drawbacks are that it is not particularly concise nor particularly comprehensible (its syntax, for instance, involves an extraordinary number of parentheses). Other languages have arisen, of which the most successful has been Prolog. This was devised in France by Alain Colmerauer in 1975 [11]. It is in a sense more problem-oriented than LISP, and is particularly good at manipulating logical statements and relationships. It has become the major language in Europe for artificial intelligence applications, especially in the United Kingdom, France and Hungary. What may encourage its widespread use is the launch by the Borland International Company of a Prolog compiler for the IBM personal computer at a cost of $US 100, which means a significant increase in its accessibility. Other languages have also been developed for use in artificial intelligence applications. They include Smalltalk-80 and OPS5. Expert systems can be written in the traditional programming languages, such as BASIC or FORTRAN, or in newer ones such as C, even if this is not as easy to do.

However, it is likely that the main way in which the use of expert systems will spread is not through the sale of LISP or PROLOG compilers or interpreters but through the availability of "shells", that is, already written software packages which contain the reasoning processes and need only a knowledge base in a suitable form, in order to be applicable to any subject area. The creation of the knowledge base, however, seems to be the most difficult part of the construction of expert systems.

D. The influence of hardware trends

The frequently remarked fall in the price and size of microelectronics components, together with a continued increase in performance, has meant that computer power of some kind is within general reach. But it has also meant that greatly expanded computing power is available to those who previously had very limited facilities. Thus there has been a qualitative change also in the uses to which computers are being put, and there is a large body of opinion that contends that artificial intelligence applications, especially expert systems, are the principal ways in which the expansion will take place. An indication can be found in the growing availability of easy-to-use software, especially, but by no means only, in the microcomputer field. This has come about at least partly because the space is there: expanded memory means that the programme can store all the elements of a dialogue with the user and lead him or her through the steps necessary to carry out the desired process. The user no longer has to put up with a cryptic message giv. ; an error number when something goes wrong.

A second hardware trend is in the area of mass storage. The main memory of the computer is where the programme actually runs, but it will be read into the main memory (in general) only when it is desired to run it. For the rest of the time it will stay on hard disk, diskette or tape storage. All these are magnetic media. The last of these is very cheap but very slow, the first is fast but expensive and the third is in between, and all thus depend on storing information in the form of electrical charges on the surface of the disk or tape. All are likely to be replaced very shortly by optical disk (laser disk) storage. Here the information is etched onto the surface by a laser and read by another. The information cannot be lost through magnetic interference and has a "life expectancy" of about seven years [12]. Already available are CD-ROMS. The size of an audio compact disc, they can store around 600 megabytes each (the equivalent of 1,000 to 15,000 floppy disks) [13]. They cannot be written to by the normal user: they have to be pressed in a factory, analogously to records. They are thus best suited to large standardized databases of which copies can then be cheaply distributed, such as encyclopaedias. However, discs that can be written to once are now becoming available, and a 12-inch disc of this kind can store between 1 and 4 gigabytes (1,000 to 4,000 megabytes). The availability of optical discs that can be erased and written on many times is still a couple of years away.

The design of hardware specifically for expert systems applications is another development. This occurs principally through the design of so-called artificial intelligence workstations. The term workstation is widely used and little defined: it occurs most often in the description "engineering workstation" and "office workstation". It usually means a computer with networking capabilities constructed or adapted for a single-user specific field of work. An office workstation might have telephone and document facilities while an engineering workstation would have graphics design facilities (sometimes the term workstation is applied to a computer terminal with limited stor ge facilities).

An artificial intelligence workstation usually seems to have built-in languages (such as LISP, PROLOG or Smalltalk-80, a high-resolution screen, as well as a fast processor and lots of memory (RAM and hard disk) and networking facilities (usually Ethernet and often other possibilities also). The design of the microcomputer is often adapted to words of the particular language used, and in some cases the processor itself may be a hardware implementation of the language (always LISP, so far). The high-resolution screen is intended not for graphics as such. Development of artificial intelligence applications usually involves looking at text (although one system marketed by Texas Instruments for process control provides facilities for working with diagrams of the factory process in question).*

The screen having such high resolution (the typical range is 1,024 x 800 pixels, going as high as 1,280 x 1,024) can display more text at any one time, usually with the facility for "windows", by which several separate programs or program sections, sets of data, and dialogues and results can all be seen simultaneously. The developer of the expert system will usually also find other powerful tools, such as special software for designing, building and testing expert systems. Costs vary from £7,000 to £65,000 [14].

A second hardware development is in the construction of specialized processor chips which embody expert system shells or constructs (rather than just artificial intelligence languages). Work of this kind is being carried out at AT & T Bell Laboratories, where a chip implementing a "fuzzy logic" expert system is claimed to be 10,000 times faster than conventional systems [15]. The benefits of having the system in hardware rather than software are clearly considerable in terms of speed. However the design of expert systems can hardly be said to be far enough advanced for chips to become widespread soon.

In general, the consequences of hardware developments are that enormous cheap storage as well as faster processors are opening up the field of expert systems for possibly very rapid growth. The knowledge base can be large and, being on-line, can be quickly accessed. Moreover, the expert system can be reasonably portable: a computer system with a few optical disks may encapsulate a whole lifetime or several lifetimes of individual experience of particular problems.

However, this will not come overnight. With past progress in software and present progress in hardware, the preconditions are now in place. A system can analyse the rules supplied and answer questions on that basis, but the information must still be entered: the present difficulty is to find efficient ways to transfer expertise from the expert to the system. This can be done in several ways. Two of the obvious ones are time-consuming: the expert can be asked a series of questions and the answers recorded. If the questions asked are exhaustive enough a full database can be built up in this way of what the response should be to a particular combination of circumstances or preconditions. The second approach is to have the expert sum up his or her knowledge in a series of rules that encapsulate it. Without careful guidance, however, the

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*Described in Texas Instruments information material, Personal Consultant Software Series.

expert might tend to supply only "mainstream" knowledge, and the nuances, intuitive judgements and unstructured experience characteristic of the human expert might be lost to the system being constructed. If a "knowledge engineer" interrogates the expert to extract the rules, he or she can be better off not knowing the subject in question; otherwise vital information can be overlooked as being too obvious.

E. The actors

The forces shaping future development of these systems include:

(a) Computer manufactures;

(b) Software manufacturers;

(c) Systems companies;

(d) Non-computing companies;

(e) Specialist information companies;

(f) Government agencies.

All the major computer manufacturers now have a presence in the artificial expert systems field. As noted, they often use these techniques in their own work, either in planning, configuring or diagnostics. Involvement in national programmes of research is another way in which some have entered the field. The products offered include software environments, expert system shells and artificial intelligence workstations. The big mainframe manufacturers have been slower to make an impact in the market than other computer or software manufacturers, often because they cater for an evolutionary market (the traditional data-processing users) and cannot move too far ahead of them. Smaller companies can be more agile. However, they may lack the resources needed to bring expert systems developments to marketable levels. It is the large companies such as IBM that have this kind of research and development capability, and that can persuade potential users of the maturity of expert systems as a workable tool. As against this it should be noted that, increasingly, it is the end-users in a company who are determining computer policy.

Software companies typically write and sell a computer programme package which contains the expert system shell, a query system, some database management capacity (to hold the knowledge base) and perhaps some component that allows for the easier construction of the knowledge base. The typical software company plans to sell a number of its systems, this resulting in a more or less generalized system which is not tied to one particular application. If it is a microcomputer-based system the potential market may even be numbered in many thousands. In this case marketing will have a crucial role to play.

Still in the field of microcomputers, the race to establish standards in expert systems has not yet begun, but it is more important in this consumer-oriented and suggestible sector than elsewhere. A standard, at least for microcomputer-based expert systems, will be established not by an international committee but by the competitive forces of a market which has not yet been studied in any detail. Since the most difficult problem now in the construction of expert systems is the extraction of the knowledge from the human expert, the winner in the software race may be the company that produces either an easy-to-use dialogue package for construction of the knowledge base, or a standard-format knowledge database handling package.

A standard is important for several reasons. Firstly, and obviously, it will mean success for the company which establishes it. Secondly, it will release the larger market that has been waiting for a standard to be established. Thirdly, it will encourage the production of a number of third-party products. These may be extra software or software-hardware packages that are supposed to make the original standard product easier to use, or they may be sets of knowledge in different areas. All will be advertized as being "x-compatible" or as products that "meet the x standard", thus further promoting the sale of x, the standard.

Looking at present software on the market, it can be divided into that available for mainframes, for minicomputers and for microcomputers (even if these distinctions, and especially that between the last two, are becoming blurred). One source of information [16], [17] indicates that from a total of 17 packages in the United States thought to be suitable for manufacturing applications, only one was for mainframes, four for microcomputers, and the remainder, 12, for minicomputers. Of all the systems, only two were given as intended for specific applications (electronics and medicine), with the remainder being of general application, at least by implication. By contract, a survey [18] in the United Kingdom shows that expert systems (as distinct from languages intended for artificial intelligence applications) are more generally available. Of a total of nine systems, three were for mainframes, three for microcomputers, one for minicomputers and two for both microcomputers and minicomputers.

The third major group of actors is that of the systems companies, which rather than marketing a finished product will construct a computer system (perhaps supplying the hardware as well as writing the software). Such custom-built systems are likely to be more successful for the immediate future in the field of expert systems than in other fields. This is because expert systems contrast markedly with accountancy or inventory control, being a good deal less fully defined as a discipline. The average business can choose from many available software packages to carry out the payroll: at least one of the packages may have the flexibility to cope with the requirements of the particular business. But this is less likely to be the case with expert systems, not so much because of the uniqueness of the reasoning needed as of the specificity of knowledge formulation. Requirements for the near future as new applications spread are not likely to be standardized. Nevertheless, some of the systems houses are likely to become centres of accumulated experience in a way that the software manufacturers will not. The large number of firms will militate against standards developing, but the presence of many small firms may give continuing impetus to creativity and technical progress.

The fourth group of actors is that of the non-computing companies, who are in neither the software nor the hardware of the knowledge business. These are companies, whether in industry or services, that are anxious to apply expert systems to their own operations. It has been pointed out that many companies now entering the field are being extremely discreet about their activity, and that the reason is that they feel the new techniques will give them a competitive edge against other companies. This means that technical development achieved in expert systems within these companies are not going to be rapidly diffused. On the other hand, the fact of an increasingly strong vote of confidence in expert systems (or at least in the future of them) means that a cumulative effect is likely. A possibly more open development will be the supplying of expert systems with the purchase of capital goods. Covering correct use, maintenance and diagnostics and repair, expert systems could replace not only traditional technical manuals but also much of the human expertise at present provided as support services.

Specialist information companies form the fifth group of actors. They include, in particular, both general and specialist publishers, news and information companies, market intelligence and abstracting companies, database companies and the like. Many have already moved into the software and data communications fields: some have considerable experience in the field of data input and data storage. They are in some cases in a good position to exploit expert systems in making their databases more analytically oriented: the setting up of new inquiry systems which would allow for "intelligent" searches of a database, of abstracts or of an encyclopaedia. The skills of these companies can also come into play in the incorporation of knowledge in new areas into expert systems.

The final group of actors is that of national Governments. The impact of Japan's fifth generation computer project has been widespread. At first, the effects were most noticeable in the hardware field, with collaborative research between and among European and United States manufacturers being entered into. The push for co-operation was in response to what was seen as a Japanese challenge. The challenge was seen in the increasing penetration of United States and European markets by Japanese products, a process which has continued and which causes friction between Japan and its trading partners. But the fifth generation project raised anxieties about tho long-term effects of the competitiveness of Europe and the United States in many if not most fields of manufacturing, not just in the fields of micro-electronics and computers. The project could be seen as an attempt to raise modern technology to a qualitatively different level, especially because of the stated areas of application, which included the areas of inference and knowledge-base sub-systems [19] (Prolog was adopted as a language for artificial intelligence applications in the project).

The Japanese example was therefore followed, if initially more slowly, in both the United States and in Europe. Notable examples of United States intiatives has been the Strategic Computing Programme of the Defence Advanced Research Projects Agency, the Microelectronics and Computer Technology Corporation and the Semiconductor Research Corporation, all of which are supporting research in expert systems. The latter two are in fact industry co-operatives, formed by large, well-established United States firms anxious to pool research or to support joint research on the new computer technologies ([2], [4]).

In the European Economic Community (EEC), the ESPRIT Programme was launched to fund co-operative, pre-competitive research in informatics technologies. Six main areas were focussed on: advanced micro-electronics, software technologies, advanced information processing (including artificial intelligence and knowledge-based systems), office systems, computer-integrated manufacturing and infrastructure [20]. A total of 1.5 billion European Currency Units (ECU) (of which the Commission of the EEC provides half) is used to fund the research. Research in knowledge-based systems (but not expert systems per se) is supported by ESPRIT in France, Germany, Federal Republic of, Ireland, Italy, Netherlands and United Kingdom. As well as this, several individual EEC countries have their own national programmes in this field of information technology, such as France, Germany, Federal Republic of, and United Kingdom.

The EUREKA programme is a joint research and development effort which involves 18 European countries. It includes not only the EEC countries but also Austria, Finland, Norway, Sweden, Switzerland and Turkey. The programme includes technological advances in all areas, not just in informatics. Nevertheless, of the projects so far announced, four are in the area of expert systems (with another two in closely related areas). They include the following projects [21]:

(a) Mentor: an expert system for dealing with major plant failures and security control. Participating countries: France and Norway, with interest expressed by the Federal Republic of Germany and Italy. Project cost and duration: 30 million ECU, four years;

(b) Prolog Tools: development of software tools aimed at expert systems. Participating countries: Belgium, Germany, Federal Republic of, and Switzerland, with interest expressed by the Commission of the European Communities. Project cost and duration: 2 million ECU, three years;

(c) Crop Management Expert System: development of a range of expert systems software and ancillary hardware for use in crop management. Participating countries: Netherlands and United Kingdom. Project cost and duration: 0.6 million ECU, three years;

(d) BD II: database for distributed expert systems or low-level computers. Participating countries: France and Spain, with interest expressed by Denmark. Project cost and duration: 20 million ECU, five years;

(e) Paradi: automative production management system using artificial intelligence developments. Participating countries: Belgium, France, Netherlands and Switzerland, with interest expressed by the Federal Republic of Germany, Italy and the Commission of the European Communities. Project cost and duration: 30 million ECU, six years;

(f) Galeno 2000: automatic non-invasive medical diagnostic equipment based on new sensors and artificial intelligence. Participating countries: Denmark and Spain, with interest expressed by France, Netherlands and Switzerland. Project cost and duration: 60 million ECU, three years.

The latest plans for the countries of the Council for Mutual Economic Assistance include a five-year programme co-ordinated by the International Committee for Computer Engineering at the Academy of Sciences of the Union of Soviet Socialist Republics [22]. This programme is directed towards fifth-generation techniques and will have activities in the following areas: very large-scale integration; parallel and multiprocessor architecture; operating systems to support logic programming; problem-solving; and expert systems.

F. Future prospects

Estimates are available from various sources of the possible market size for expert systems, or for artificial intelligence products in general. The estimates vary widely and without full definitions of the concepts used are only useful as broad indicators. Even the estimates for the present size of the market are very diverse.

One estimate is of a $1,600 million market by the end of the decade, including hardware, software and services, with the 1985 value being given as $342 million. The shares of the different components in the total would change to some extent, with software rising from 40 per cent to nearly a half by 1989. Hardwere sales would also increase their share from nearly a quarter to 30 per cent by 1989 [23]. This would imply that services would decline from around 35 per cent to just over 20 per cent by 1989.

Another estimate gives a market value of $220 million in 1985, with a projected $780 million in 1988, then steeper growth to $2,400 million in 1991 and an even sharper growth to $8,535 million in 1993 [24]. The present situation is seen from a different point of view by another estimate giving the 1986 market as $1,000 million for artificial intelligence as a whole. The hardware share is given as 49 per cent, with artificial vision systems 25 per cent, expert systems 13 per cent, national language programs 6 per cent, voice recognition 4 per cent and artificial intelligence languages 3 per cent [25].

These contrasting figures point as much to definitional difficulties as to different assumptions. The distinction between services and software is in fact a difficult one to draw. It is true that a LISP interpreter or an expert system shell can be bought by mail order for a few hundred dollars, and the purchaser may well wish to experiment on his or her own. But the person or company serious about expert system development will usually want support and training, even in an informal way. Some vendors themselves feel that in selling expert systems software they will also need to provide a lot of support, because of the early stages at which the discipline is at present. Hence, expert system software (and hardware) sales will have to include a greater degree of implied service than software and hardware for other purposes. Such considerations also suggest that services sales per se will be important also.

Market estimates are only part of the story, since the figures refer to what is traded. But expert systems development is under way within companies and institutions, this activity being subsumed in their overall figures. Very often, this is done deliberately: the point was made earlier that the activity is being kept secret by companies in order to maintain their competitive edge. However, some would suggest that the secretiveness can also cover embarrassment at a lack of success. Nevertheless, it has been estimated that over half of the "Fortune 500"* companies in the United States have research projects in artificial intelligence [26].

Not all observers of expert systems are convinced. Some doubt that expert systems can really replace human expertise. Even if they could, would they be accepted? And can they have a commercial impact? One survey describes the XCON system referred to above as the only expert system to have "a genuine commercial impact" out of 43 systems surveyed in the United Kingdom and the United States [27].

The exaggerated promotion of the expert systems idea, usually in connection with the marketing of some product, has been remarked upon as a danger, since it will arouse excessive expectations. The resulting disappointment when the system is found not as easy to construct or as useful in operation may have the effect of discouraging future efforts. The enthusiasts for expert systems may be more the technical staff of a company than the operational or commercial staff, yet it is only when the latter are convinced of the benefits that success is arrived at. A promising approach may therefore be to build in expert system techniques into traditional computer applications (such as is being done with computer-aided design and computer-aided manufacturing (CAD/CAM)).

Certainly exaggerated claims for products can be made, and unreasonable expectations aroused. The greatest pitfall is to underestimate the work involved in the construction of a system. The difficulty is not only in the methodology, and in the transfer of knowledge: it is also the selection of a problem amenable to treatment in this way. It has been suggested that expert systems work best when the domain is clearly delimited, in other words, when the "boundaries" of the subject area are well-defined.

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*The 500 biggest companies as listed by Fortune magazine.

Nevertheless, any recognizable indicators point to continued growth in expert systems. The number of hardware and software products is increasing rapidly, both from small new companies and traditional computer manufacturers. The level of activity in expert systems within non-computing companies, while not as easy to measure, is certainly growing quickly. The increasing emphasis in public policy programmes is a third indication. Fourthly, the technology exists: at least for more straightforward rule-based systems, the logical and software issues have been under examination for over 30 years. Fifthly, the hardware is available and inexpensive: researchers do not have to compete with others for access to scarce computer resources. Finally, there is the more general consideration that technological change is itself creating the market: as knowledge expands, diversifies and specializes, the need for expert systems, to master and diffuse this knowledge, will continue to grow.

G. Implications for developing countries

It is already widely recognized that the influence of informatics technologies will be such as to transform the structure of industrial production, as well as of society generally, in the years to come. However, the likely effects of expert systems developments, especially for developing countries, have not been studied in detail, although some analyses have been made. What follows is a brief overview of some of the issues.

Within the software industry, there may be a tendency for the relative position of developing countries to deteriorate in the short term. This is because existing applications software approaches, in which developed countries have a very dominant position, can be upgraded through the incorporation of expert systems features. Thus, database or CAD/CAM systems can be made easier to use, and these are already areas in which developed country producers have significant strengths. The market opportunities for developing countries in newer areas directly related to expert systems appear at first sight to be limited. This is for several reasons. Compilers and interpreters for artificial intelligence languages already constitute a very competitive field. Expert system shells are perhaps easier to produce but for this very reason competition will also be considerable. Prices can be expected to fall.

As for expert systems themselves, it should be recalled that their basic purpose is to transfer and diffuse expertise. To the extent that human experts are in short supply in developing countries, the construction of expert systems is more difficult. The successful production and marketing of expert systems will therefore have to concentrate on areas in which developing countries have particular advantages.

This means that some aspects would be particularly suitable for co-operative activity among developing countries. Expert systems could be developed which convey the accumulated successful expertise of one country in a particular subject area. Health systems, agriculture, industrial process control and education are some of the many possible areas where, through expert systems, experience can be shared and the accumulated skills in these fields disseminated over other countries.

There are however possibilities also, in the longer term, for methodological advances in expert systems, especially in the promising areas of knowledge-base construction and handling. The interface with the human expert, in order to formalize the (often apparently intuitive) expertise into a series of applicable rules, is a most important area where much remains to be done. This field of research is relatively open and may offer attractive opportunities to developing countries.

Outside the software field, the impact of expert systems can be expected to be extensive. Two contrasting effects can be suggested. Firstly, the incorporation of expert systems will follow that of micro-electronics into most aspects of economic activity. Just as capital and consumer goods contain an increasing amount of micro-electronics control capability, it can be expected that expert systems software and knowledge bases will make equipment more and more flexible and adaptive. The first effect will therefore probably be that industry, and economic activity generally, in developed countries will make further productivity gains, increasing its responsiveness to changing conditions and reducing the labour content of its products, especially reducing high-cost skilled labour inputs. These considerations point to a short-term gain for developed countries, because it will be they that produce the new expert systems technologies and that will have first access to them. The significant in-house development of expert systems by non-computing companies, as well as the interest being shown by Governments, reinforces the conclusion that it is mainly in developed countries that the first benefits of expert systems will be found.

However, the characteristics of expert systems, as a computer-based technology, are such that developing countries may well be able to recover any ground lost before too long. This is because the technology is relatively portable and inexpensive, meaning that its diffusion into developing countries may be relatively rapid. Furthermore, since expert systems are essentially ways of transmitting skills, they can contribute directly to filling a crucial need of developing countries' industry. The skills shortage may be significantly reduced if capital goods are supplied with, or else embody, expert systems, which advise in the use of the equipment and which diagnose faults in its operation. Competition between suppliers may encourage such a tendency.

In general, developing countries will have to take account of trends in this area, as they have done in other branches of informatics (Singapore already has a goverment-supported programme in artificial intelligence) [27]. The impact of micro-electronics, telecommunications and other hardware fields will include wider developments in software, and expert systems have several characteristics which make them extremely important for developing countries' industrialization.

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BOOKS

INDUSTRY AND DEVELOPMENT: GLOBAL REPORT 1987

UNIDO publication, Sales No. E.87.II.B.2. 336 p.
Price: $42.00

The third issue in the Global Report series published by UNIDO reviews the world industrial economy during the 1985-1986 period and considers the industrial outlook for 1987 and 1988. Following the introductory chapter presenting a global overview, chapter II gives short-term regional projections for four developed regions (North America, Japan, Western Europe and Eastern Europe and the Union of Soviet Socialist Republics) and six developing regions (Latin America, Tropical Africa, North Africa and Western Asia, the Indian Subcontinent, South-East Asia and China). Chapter III looks back to the 1980-1985 period and analyses the impact of external shocks on the industrialization of developing countries. Chapter IV provides the outlook for 28 branches of manufacturing industry, with sections on short-term industry forecasts, the present situation, UNIDO technical co-operation activities and long-term prospects. The concluding chapter sums up the major findings.

In general terms, Global Report 1987 concludes that the world industrial economy continues to be in the doldrums, although the forecasts reflect the more positive side of the conceivable alternatives and the author's "confidence, despite recurrent doubts, in the speed at which modern industrial society has responded and adjusted to the shocks of the past decades". But the report also warns that the economic situation could further worsen in some parts of the world unless determined efforts are made to adapt to the changing fundamentals of international economic relations.

The fairly detailed assessment of regions and industries led to a number of conclusions, notably the following:

(a) The internationalization of production and finance has accelerated, but the volatility of financial markets has forced major economies to adopt defensive policies less conducive to industrial growth;

(b) Virtually all regions in both North and South have implemented a variety of policy measures to open up their economies in an attempt to bring in complementary factors such as capital funds, new technology and managerial skills, and thereby to restructure their industry for upgrading and growth;

(c) The prevalent method adopted to meet current needs consists in joint ventures, decentralization of decision-making, privatization of State-owned enterprises, institutional reforms aimed at more competition and incentive systems based on efficiency and performance;

(d) The supply-side industrial adjustment measures as noted abcve should be coupled with international co-operation and co-ordination of reflationary policy measures (demand-side management) if the world industrial economy is to emerge from the slow-growth syndrome fairly soon.

BANKS AND SPECIALISED FINANCIAL INTERMEDIARIES IN DEVELOPMENT

by P. Wellons, D. Germidis and B. Glavanis
Paris, OECD, 1986. 150 p.
Price: $20.00

This stimulating book is the outcome of a joint research project between the Development Centre of the Organisation for Economic Co-operation and Development (OECD), the International Finance Corporation (IFC) and UNIDO. It is a study of specialized financial institutions, especially institutions which may act as alternative sources of finance to commercial banks. These include: venture capital institutions; venture banking (the provision of equity capital by commercial banks, especially foreign ones); indirect venture banking, through taking a shareholding in an intermediary which in turn provides equity capital; contractual savings institutions, particularly insurance companies and pension funds; investment trusts; investment banks (the United States type, which are really securities dealers and brokers); and leasing companies. The authors argue that all these institutions have a role to play in widening and developing financial markets in developing countries, but their precise role in an individual country will depend upon the existing financial system in that country. The conclusions are aimed primarily at policy-makers in Governments of developing countries.

The book is a distillation of an extensive research programme, including 11 studies of individual developing countries, three of lower-income OECD countries, three cross-country studies of specific aspects and a survey of investment banks and other intermediaries in OECD countries, bolstered by the provision of considerable data from the IFC concerning the activities of specialized financial institutions in developing countries. The study, therefore, is well-informed and its conclusions command respect.

Different sets of policy recommendations are directed at "home countries" (that is, the home Governments of international financial institutions), and host (that is, developing country) Governments, at both the national level and the financial sector level. The first, and much the smaller set of recommendations, is aimed at amending regulations in order to encourage the greater involvement of developed country financial institutions in developing countries (other than lending commercial banks, which are already involved up to their necks). The host Governments are first urged to liberalize their financial sectors, particularly by reducing financial repression and lessening pre-emptive borrowing by Government. Secondly, the authors call for a level playing field among specialized financial institutions, and between them and commercial banks. Thirdly, they advocate foreign portfolio investment inflows, particularly by easing and clarifying the regulations. The overall framework for the recommendations, therefore, is the "new orthodoxy", which means permitting financial markets to operate freely, and on equal terms with one another.

In certain respects, it is possible to argue that several of the instruments recommended are really turning the clock back to the nineteenth century, when they were commonplace. (International portfolio equity financing was then widespread; the first British investment trust was the Foreign and Colonial, established in 1868 to investment in bonds and equities of what were then, and sometimes still are, developing countries.) The authors remind us to what extent the variety of domestic and international financing has since been curtailed by Governments of both capital-exporting and capital-importing countries.

The only serious criticism of the book (and of the underlying research project) is that it has possibly tried to be too ambitious. It attempts to address three distinct but overlapping problems. First, it represents an attempt to reduce the stranglehold which traditional commercial banking has over the financial sector. Secondly, it addresses the problem of excessive debt-to-equity ratios (partly a consequence of the first). Thirdly, it considers the problems arising from the use of foreign debt rather than foreign equity or domestic sources of finance. The consequence is that the book at times lacks a clearly defined focus. That apart, the authors are to be congratulated on a concisely written book containing a wealth of interesting detail alongside a broad international perspective. They have made a significant contribution towards bringing what are now fringe financial institutions and instruments in the developing world more to the centre of the stage. It is required reading for anyone involved in development finance. It is a pity that OECD publications do not usually have an index, as this book would have been improved by having one.

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FINANCE FOR THE DEVELOPING COUNTRIES

by Richard L. Kitchen
Chichester, John Wiley and Sons, 1986. 365 p.
Price: £29.50

Richard Kitchen has made valuable contributions to the work of UNIDO, including papers on financial statistics and on financial co-operation among developing countries in preparation for the Third General Conference of UNIDO held in New Delhi in 1980. His new book fills a gap in its treatment of finance for development in that it is up to date and brings together between two covers a variety of topics otherwise treated by authors in separate publications. Thus there are chapters on such important matters as informal and formal financial institutions in the third world, the mobilization of domestic finance by Governments as well as an extended treatment of the role of foreign capital in developing countries. After consideration of debt, adjustment and the International Monetary Fund, the book closes with an outline of recent proposals to improve the quantity and quality of development finance, including the proposals made by the Brandt Commission in 1980 and 1983 and the proposals made by the Executive Director of UNIDO to the Third General Conference at New Delhi in 1980.

In the introduction the point is made that given the fungibility of finance, the financing of development at both the macro-economic and the micro-economic levels cannot be readily separated since micro- or project-level finance generally tends to be subservient to macro-financial considerations. That is to say government monetary and fiscal policies generally determine the terms and availability of finance for projects or for that matter for investment in a particular industry. Moreover, as Kitchen emphasizes, where external financing is being considered, however good a project looks, it may have difficulty in attracting foreign finance if a country's financial position is not perceived, by external financing sources, to be sound. In addition, the view that "good" projects enable finance to be found readily suffers from two other weaknesses: it ignores constraints on lending institutions such as banks' capital-asset ratios, and the fact that the quality of a project depends upon the terms of financing, notably on the interest rate and the maturity; financing terms themselves influence project feasibility.

In discussing private sector flows to developing countries we are reminded of a historical background which is usually missing from discussion and comment in the financial and professional press. In the first wave of financial flows from more developed to less developed countries between 1820 and 1840, which took the form of private bonds issued by countries through their agents in London, most of these bonds came into default. Indeed, in most cases the defaults continued for many years, although periodically new bonds would be issued to meet the interest on old bonds. Successive waves of financial flows were to occur in later periods, in each case taking the form of bond issues; after each wave the recurrent phenomenon of default was to occur. We are taken through the details of the costs of borrowing during the first wave, with the remark that the difference between the nominal price of a bond issue and the discount at which the bonds were actually sold meant that considerably less capital was obtained by developing country borrowers than anticipated. Moreover, even after taking into account this decrease because of discounting, even lesser amounts might actually be received by countries since it was sometimes the practice of agents to retain some of the proceeds to make interest payments in the first year or two. Discounting together with such practices commonly resulted in the true interest rate on such bonds being well over 10 per cent per annum compared with the yields of CONSOLS being between 3.6 and 4 per cent at that time. In this situation there was disillusion on the side of both borrowers and lenders. Even with good management of funds it was hardly surprising that borrowing countries were unable to repay loans at real interest rates double or triple the normal real rate; and lenders naturally became disillusioned with default.

For the most part the book does not attempt to be prescriptive, although the author makes his own preferences clear, in the direction of the development of money and capital markets with limited controls, the use of government revenue and company equity capital rather than debt, especially foreign debt. Moreover, his preference for the growth of the private sector rather than government dominance of the economy is clearly stated, although these inclinations might be waived when faced with the specific social, economic and political conditions prevailing in a given country.

It should be added, however, that the author is generally sympathetic to proposals for reform of the international financial system. He recognizes the inevitable - that external indebtedness of many developing countries will, under existing circumstances, remain in perpetuity, as a form of national debt. His inclinations are that there are few grounds for either the banks (unwise lenders) or the debtor countries (unwise borrowers) to be subsidized, either by the taxpayers of industrialized countries or by a transfer of aid from the least developed countries to middle-income debtor countries. In preference he sees a conversion of loans into bonds of long maturity supported by an interest rate stabilization scheme as being workable and fairly widely acceptable.

V. A. Richardson

CURRENT ISSUES IN INTERNATIONAL TRADE: THEORY AND POLICY

Edited by David Greenaway
Basingstoke, Macmillan, 1985. 242 p.
Price: £8.95 (paperback)

Following a succinct, clear introduction by Max Corden, the book is divided into 10 independent chapters, each surveying a particular aspect of international trade economics which has been a recent "hot issue". It is not entirely theory-oriented; the chapters by Tharakan on commodity composition of trade and Milner on costs of protection focus on empirical measurement. The word "policy" in the title is somewhat misleading, in that apart from the chapters by Hamilton on voluntary export restraints and Fry on the political economy of protection, the focus is on normative theory rather than practical policy issues. The book may not be particularly suitable (despite the suggestion in the editor's preface) for most undergraduate trade courses (at least not in United States universities), because although the articles are not written at a high level of mathematical difficulty, they do explore the frontiers of trade theory, so that to benefit fully from the very considerable knowledge they contain the reader should have a sound understanding of standard pure trade theory.

Apart from chapters already mentioned, chapters by Kierzkowski and by Greenaway examine models incorporating differentiated goods, Neary analyses adjustment to exogenous shocks in an open economy, Steedman and Metcalfe bring capital goods into pure theory. Also, although perhaps not "burning issues", there are chapters on foreign investment and technology transfer (Balasubramanyam) and economic integration (El-Agraa).

Naturally, to cover all issues of topical relevance would be near impossible. The editor might have included, for example, a chapter on computable general equilibrium models (used recently in trade and cost-of-protection analysis), or perhaps one on the impact and cost-benefits of the trade liberalization policies which so many developing countries are now adopting. Nevertheless, editorial selection seems good.

In sum, this is a book well worth recommending for advanced-level international trade courses. And it will also provide trade economists with much information on the topics with which it is concerned (it provides a wealth of references, including an author and subject index).

John Cody

SOMMAIRE

Politiques industrielles dans les pays en développement : le coût en devises des exportations

Ajit Singh

Le document examine comment pourraient être modifiées les structures industrielles actuelles des pays en développement afin de les adapter, tant à court et moyen terme qu'à long terme, aux contraintes en matière de devises dans une conjoncture mondiale en constante évolution. Plus précisément, la question ici considérée concerne le processus de sélection des secteurs industriels les plus propices à la réalisation, de recettes d'exportation, permettant de résorber le déficit extérieur. L'introduction fait un exposé général de la situation économique internationale et des grandes caractéristiques des contraintes extérieures auxquelles risque d'être soumis dans un avenir prévisible le développement industriel de l'Amérique latine et de l'Afrique. La section A considère ensuite de façon plus approfondie la relation qui existe entre le développement industriel et les contraintes en matière de devises, en prenant pour exemple un pays d'Amérique latine (le Mexique) et un pays d'Afrique (la République-Unie de Tanzanie) afin de mieux définir les problèmes de politique industrielle qui s'y posent aujourd'hui. La section B poursuit en présentant dans leurs grandes lignes des notions telles que "l'élément importation des exportations", "la valeur retenue", "le taux effectif de protection" et "le coût des ressources locales" qui ont été proposées pour faciliter le choix de projets pour lesquels les devises constituent une contrainte. Une évaluation du coût des ressources locales, du taux effectif de protection et de certains autres indicateurs du rendement industriel sont ensuite présentés dans la section C en ce qui concerne le Mexique, le Zimbabwe et la République-Unie de Tanzanie. La notion du coût des ressources locales intéressant particulièrement certains bailleurs de fonds internationaux, la section D est consacrée à une analyse critique de cette approche et notamment de sa validité pour étayer les décisions ayant trait aux aspects dynamiques du développement industriel. La section E est réservée à un résumé des principales conclusions.

Avantage comparatif, financement extérieur et vulnérabilité de l'industrialisation

Amit Bhaduri

L'exposé est consacré à un examen des incidences respectives des avantages comparatifs statique et dynamique sur le développement

industriel. Sont ensuite identifiées les conditions préalables à satisfaire pour assurer une industrialisation soutenue. Le document considère alors le rôle du financement étranger, eu égard notamment aux importants mouvements de capitaux en direction de nombreux pays en développement auxquels on a assisté à la fin des années 70 et qui ont conduit à la crise actuelle de l'endettement. Le document se termine par une analyse des réactions en chaîne qui se sont alors produites, aboutissant à la création d'un "cercle vicieux".

Amélioration des techniques indigènes actuelles pour favoriser l'application de la stratégie du recours aux techniques appropriées au Ghana

Benjamin Ofori-Amoah

Le Ghana ayant, en dépit de leur importance, négligé dans une large mesure les techniques traditionnelles, le document examine trois activités manufacturières à caractère rural - à savoir, la fabrication de récipients en aluminium et le tissage de Kente et d'Adinkra - faisant appel à quatre types de techniques traditionnelles pour démontrer que l'amélioration de ces techniques pourrait favoriser, au Ghana, une application profitable de la stratégie du recours aux techniques appropriées. La section A fait un exposé des origines et de la nature des techniques employées dans les trois cas considérés, la section B examine le rôle de ces activités dans le développement régional du Ghana, la section C en envisage les possibilités d'extension, enfin la section D en examine les implications en matière de politique générale. Une analyse coûts-avantages montre qu'outre le tissage de tissus de Kente à motifs, ces activités offrent d'intéressantes perspectives économiques et l'article se termine par une énumération des obstacles sociaux, économiques et techniques à surmonter.

Incidences des systèmes experts

Ecin Gahan

L'objet de ce document est de faire un rapide exposé de l'incidence des systèmes experts, volet important de l'informatique actuellement en plein essor. Subdivision de l'intelligence artificielle, les systèmes experts sont des logiciels dont le but est de réunir tout le savoir humain correspondant à un domaine déterminé afin de le mettre à la disposition de l'utilisateur cherchant à résoudre un problème relevant de ce même domaine. Ces systèmes qui sont actuellement l'objet d'efforts de recherche et de développement toujours plus approfondis de la part des pouvoirs publics et d'entreprises privées, essentiellement dans les pays développés, sont jugés comme devant offrir d'énormes possibilités dans la plupart des activités économiques. Après un bref exposé de ce en quoi consiste un système expert (section A), la section B fait un inventaire des systèmes experts actuellement disponibles, qui permet de se faire une idée de leur vaste champ d'application, la section C examine l'état d'avancement des travaux dans ce domaine et la section D considère comment les progrès réalisés dans la conception des ordinateurs pourraient étendre encore les applications des systèmes en question. La section E étudie les grands groupes dont l'influence peut se faire sentir sur le développement de systèmes experts, notamment les fabricants d'ordinateurs et les concepteurs de logiciels et de systèmes. Le rôle que jouent les pouvoirs publics dans les pays développés pour promouvoir les efforts de recherche et de développement dans ce domaine est également examiné. La section F considère brièvement les possibilités de développement futur et la section G conclut en énumérant certaines des incidences de cette évolution sur les politiques des pays en développement.

EXTRACTO

Las políticas industriales en los países en desarrollo: el costo en divisas de las exportaciones

Ajit Singh

En el trabajo se analiza cómo pueden modificarse las estructuras industriales existentes en los países en desarrollo con el objeto de tornarlas compatibles con la limitación de divisas que, tanto a corto, como a mediano y largo plazo, imponen las actuales condiciones de la economía mundial. El problema que se examina con mayor detalle es el proceso de selección de los sectores industriales con más capacidad potencial de generar los ingresos de exportación que han de contribuir a solucionar la crisis de divisas. En la introducción se describen el contexto económico internacional y, en líneas generales, las limitaciones externas a las que estará probablemente sujeto, en un futuro previsible, el desarrollo industrial en América Latina y Africa. A continuación, en la sección A se analiza más pormenorizadamente la situación de un país latinoamericano (México) y de un país africano (República Unida de Tanzanía) en lo que atañe a la relación existente entre el desarrollo industrial y las limitaciones en materia de divisas, a fin de definir con mayor precisión las cuestiones de política industrial que esos países deben abordar en la actualidad. En la sección B se reseñan conceptos tales como "componente de importación de las exportaciones", "valor acumulado", "tasa de protección efectiva" y "costo de los recursos internos", conceptos que se han formulado para orientar la elección de proyectos industriales en una situación de escasez de divisas. En la sección C se presentan cálculos relativos al costo de los recursos internos, la tasa de protección efectiva y otros indicadores industriales en México, Zimbabwe y la República Unida de Tanzanía. Dado que las organizaciones internacionales de crédito se inclinan particularmente por la adopción del concepto de costo de los recursos internos, en la seccion D se expone un análisis crítico de tal enfoque y, en especial, de su validez como base para la toma de decisiones relacionadas con los aspectos dinámicos del desarrollo industrial. En la sección E se sintetizan las principales conclusiones del trabajo.

Ventajas comparativas, financiación exterior y vulnerabilidad de la industrialización

Amit Bhaduri

En este artículo se analizan las consecuencias para el desarrollo industrial de las diferencias que existen entre las ventajas comparativas estáticas y las dinámicas. Se definen los requisitos indispensables para una industrialización sostenida. Se examina el papel que desempeña la financiación exterior, en especial el de las grandes corrientes de capital que se canalizaron hacia los países en desarrollo a finales del decenio de 1970 y que condujeron a la actual crisis de la deuda externa. Se analiza asimismo la cadena de reacciones que se produjo entonces, creando un "círculo vicioso".

La mejora de las tecnologías nacionales existentes como estrategia para aplicar el concepto de tecnología apropiada en Ghana

Benjamin Ofori-Amoah

Las tecnologías tradicionales, pese a su importancia, fueron desatendidas durante largo tiempo en Ghana. El autor examina tres actividades manufactureras basadas en el campo -la producción de vasijas de aluminio, de textiles de Kente y de textiles de Adinkra- en las que se utilizan cuatro tecnologías tradicionales; la finalidad es mostrar que el mejoramiento de esas tecnologías puede constituir una estrategia útil para aplicar en Ghana el concepto de tecnología apropiada. En la sección A se describen los orígenes y la naturaleza de las tecnologías aplicadas en las tres actividades. En la sección B se analiza el papel que esas actividades desempeñan en el desarrollo regional de Ghana. En la sección C se explora su potencial de desarrollo y la sección D versa sobre sus repercusiones en lo relativo a la adopción de políticas. De un análisis de la relación costo-beneficio se desprende que, aparte de los tejidos con motivos decorativos de Kente, tales actividades ofrecen buenas perspectivas económicas. Se explican los obstáculos de orden social, económico y técnico con que tropiezan esas actividades.

El impacto de los sistemas expertos

Eoin Gahan

La finalidad de este trabajo es proporcionar un panorama sucinto del impacto de los sistemas expertos, un aspecto importante de la informática que evoluciona rápidamente en la actualidad. Los sistemas expertos, una rama de la inteligencia artificial, son soportes lógicos en los que se procura almacenar toda la experiencia acumulada por el ser humano en un campo particular del conocimiento, a fin de transferirla a un usuario que busca resolver algún problema en ese campo. Los gobiernos y las compañías privadas, en especial de los países desarrollados, destinan crecientes esfuerzos a la investigación y el desarrollo de esos sistemas, pues se estima que ofrecen considerables posibilidades para la mayoría de las actividades económicas. El artículo se inicia con una breve descripción de qué es un sistema experto; la sección B contiene una recapitulación de los sistemas expertos existentes a fin de dar una idea de la magnitud de sus aplicaciones posibles. En la sección C se analizan los adelantos en esta esfera y la sección D versa sobre la influencia que la evolución del equipo informático puede tener en la ampliación de las aplicaciones de los sistemas expertos. En la sección E se da cuenta de los principales grupos que influyen en el desarrollo de los sistemas expertos, incluidas las firmas productoras de equipo informático, y de soportes lógicos y sistemas. Se examina asimismo el apoyo que los gobiernos de los países desarrollados prestan a las actividades de investigación y desarrollo en este campo. La sección F trata sucintamente de su posible evolución futura y, por último, en la sección G se explican algunas repercusiones de esos adelantos en las políticas de los países en desarrollo.

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