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TECHNIQUE IN TAIWAN

The Role of Technology in Taiwan's Past and Present Development

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NANKANG, TAIPEI, TAIWAN
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'On a journey of 100 li, halfway is 90 li'

(Chinese proverb)

PREFACE

The present monograph was written while I was in Taiwan, in the capacity of a visiting professor to the National Taiwan University. Apart from the sources referred to in the text, data were collected through interviews with both policy-makers and entrepreneurs. Information offered by the latter category was confidential and those who kindly supplied it shall be nameless here. The former category comprised staff of the Central Bank of China, among them Professor Shirley W. Y. Kuo, deputy Governor; of the Executive Yuan, among them his Excellency K. T. Li and of the diverse branches of Government responsible for industrialization policy, such as Professor Jia-Ming Shyu, Managing Director of the Mechanical Industry Research Laboratory (ITRI); Ning Jo Chu, Ph.D., Deputy Director of the Science-Based Industrial Park Administration; Li-Ping Su, Director of Planning of that Organization; Siang-Lin Wang, Deputy Director General of the Medium and Small Business Administration; C. C. Wang, Deputy General Secretary of the Taiwan Association of Machinery Industry and Yun Kuo, President of the Institute for Information Industry.

I am indebted, furthermore, to Professor Ta-ho Lin, Chairman of the Department and Graduate Institute of Economics of National Taiwan University for his boundless hospitality and the remarkable economy with which he meted out my teaching load. Y. Pierre Chu, Ph.D. of the Academia Sinica, Chung-Shing Hsieh M. A. of Shih Chien College, and Professor Chi Shive of National Taiwan University checked my manuscript with the meticulousness I have come to value in my Chinese Colleagues, pointing out my mistakes with the courteous reticence I have equally learned to appreciate.

Should any errors remain, it is I who am to blame. I certainly cannot lay the blame on Lilian Chen who, as my girl Friday, rescued me from more pitfalls than I care to remember. Finally, but by no means lastly, I must acknowledge the support most generously offered by the National Science Council of Taiwan.

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摘　要

台灣之經濟成就，舉世認定，史不絕書。其在過去三十年所獲致之成長率，非惟絕少開發中國家所能企及，亦令已開發國家瞠乎其後。尤為可貴者，其成長果實並為全體國民所公平分享。本文旨在闡述此種為任何第三世界國家所想望之目標，如何透過追求一個相當正統的經濟政策來達成，以及台灣如何深思熟慮地選擇適當的技術，而使得成長的引擎在對內導向以及對外導向的各個發展階段皆能順利運轉。

台灣在初期雖然有接受相當外援，但台灣利用外援建立小型勞力密集工業，強化市場經濟。此種利用外援的精神，實較外援的數量，對經濟發展更具關鍵性。檢討起來，如說台灣在發展早期之資本化策略，業已注重日後所稱之適當技術 (appropriate technology)，並不為過。

天然資源之欠缺，迫使台灣利用廉價勞力之比較利益，在初期遂行進口替代，以滿足其自身對消費品之需求，並在本國市場接近飽和之後期，進而出口。早在此階段，由勞工吸收率 (labor absorption rate) 以及資本產出率 (capital-output ratio) 之變化，即可看出，由於對品質及複雜性之要求，已使產品更為資本密集。與本地企業家晤談時，他們一致透露，投資決策係根據替代原則而作成。當各生產因素在市場上之價格發生變化時，其相對使用量亦會隨之改變。

在台灣逐漸喪失其低工資之比較利益時，其他開發中國家由於成長緩慢，尚能維持勞力之低廉，因而在世界市場上，成為強硬之競爭對手，使得情勢幡然改觀。台灣未來之政策應使其工業作全盤之再調整，以促進現有之工廠自動化，並建立生產自動化設備之新產業。由於微處理機及機械人之使用，資本密集度在該階段將會增加。無可避免地，因此產生之剩餘勞力將必須為生產自動化設備之新產業或由其在此經濟體系內所衍生之其他產業所吸收。

微電技術 (micro-technology) 除將決定性地降低單位成本外，並可使台灣減少對其所欠缺之能源及其他資源之需求。所幸，最重要之資源，技術智能 (technological know-how)，在台灣並不太匱乏。但台灣仍須經由提高科技水準，並促使海外學人專家回流，來強化之。

全盤利用高級技術後，產出水準將大量提高。產品之多樣化將可避免市場飽和。但台灣似仍須要儘量將其貿易導向由已開發國家移轉至開發中國家，以消除依賴性，並擴大其未來之貿易領域。

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VOICES IN THE AIR

The perennial quest for the causes of the wealth of nations, singlemindedly pursued by development economists of all persuasions, tends to yield monocausal answers. Marx, for once in his role of the last of the classical economists, thought it was labour; Mao, consequently, insisted that uninhibited growth of the population could but enhance prosperity. Smith held labour's ongoing division to be the ultimate source of progress. Hence, contemporary development policy in Third World countries has urged industrial specialization, following the latest task-fracturing approach. For those in authority, as Keynes observed, are apt to "hear voices in the air" raised by "some academic scribbler of a few years back".

Latter-day analysis of the growth path followed by industrial countries during the decades when they registered annual advance of prosperity, has resulted in the dictum: "Technology is the engine of growth". But technology, of course, requires capital investment. And the tangible objects thus acquired represent the degree of understanding of the processes involved in producing wealth components. The augmented production can thus be further traced to the propensity to save, to invest, to engage in pure and applied science and, eventually, to apply the material outcome of these diverse activities, once embodied in machinery, to production. Not in obedience to voices in the air but, again, in consonance with data revealing the state of the economy to which the stimulus is to be applied.

Julius Nyerere's legendary option for the oxplough in preference to the tractor for Tanzania's primitive agriculture exemplifies a propensity for considered factor choice. Not all of Nyerere's policy options, judging from the state of Tanzania's

economy, seem to have been equally rational and non-ideological. But if the legend is true this one, at least, was.

Investment choices in developing countries have not always been made so thoughtfully. In an attempt to modernize at breakneck speed, bridging the technological and thereby economic gap that separates them from the first world, some third world leaders have indeed broken their neck and threaten to break those of their bankers. High dams, generating power for which there was no use were built and smelters for which there was no power. Surinam built a modern railroad through the bush, only to discover the bauxite suspected at the terminal station could not be mined. Nor was Ghana's sugar refinery within reach of any viable sugar plantation. These are the rather obvious mistakes made in the great haste to modernize. But the misalignment can be more subtle, yet thwart a well-intended development policy. Any sophisticated machine imported from abroad reflects the wage level of its origin; the prevailing wage rate in the less prosperous country, where it is meant to operate is likely to be lower. By the same token, the operative skill and the maintenance facilities required may not be available. Breakdowns will be frequent and parts hard to come by. Production capacity of this big indivisible apparatus may well exceed demand and costly idleness is consequ ntly unavoidable.

This is all bad news but it has been broadcast throughout the Third World with a frequency that, in development quarters, inevitably has evoked response: appropriate technology emerged as the catchword of the eighties, variously known also as: intermediate technology, half-way technology, soft technology, alternative technology or technology for emancipation. These last terms reveal the ideological hinterland of the new movement, appealing more perhaps to academic, ILO and World Bank theoreticians than to entrepreneurs confronted with investment decisions. In the latter's estimation, the appropriate technology is the one that incurs the lowest cost per unit produced and sold. From the broader viewpoint of those responsible for national development, a further criterion would enhance compatibility, viz. the absorption of available labour. But those goals need not conflict.

THE ENIGMA ANALYSED

Taiwan's development record is common knowledge, having been described in detail in a deluge of publications, using such epithets as "meteoric" and "miraculous". Now, miracles, in common parlance, cannot be explained, indeed, they need not be

as they are subsumed in the elevated realm of the supernatural. An Italian peasant seeing the Virgin Mary in a chestnut tree can be said to have witnessed a miracle. Equally, a wooden statuette depicting the same Lady, which periodically produces tears, presents the observer with a miracle. Indeed, the 'Immaculate Conception' for which the depicted Virgin is known, obstretically speaking, confronts us with a miraculous phenomenon. For a long time, in economics, such enigmatic occurrences were explained in terms of nature's inevitable periodicity, or similar metaphors, which do not appeal to the rational mind. Although it is clear that the collective economic activity or non-activity of people ultimately causes these up-and down-swings, occasionally commentators discuss our uncertain future as though the outcome were entirely in the lap of the Gods.

In the event that Taiwan's remarkable development is to be attributed to supernatural forces, it will indeed escape rational analysis. Other countries, not thus blissed, in that event will not be able to follow the example. It would indeed be generic in a surprisingly strict sense of the word. However in these enlightened days it seems worth a try.

In an exceptionally memorable year like 1976, growth of Taiwan's economy reached a record within a period of record achievements, 13.7% having been registered. Average annual growth from 1952 to 1981 was an impressive 9.3%. Per capita GNP, in 1982 stood at U.S.$2720 -placing Taiwan among the wealthiest in the developing world. Even the 1973 oil crisis did not seriously thwart progress: although 1974 and 1975 registered a mere 1.1% and 4.8% respectively, recovery was fast and in 1976-1978, although the oil bill increased by 6% yearly, the average growth still reached 12.3%, compared with 4% for the industrial economies.[1] Table I shows the rates for these 29 years, as well as indexed GDP series, in which the recent world slump is also reflected.

Theoretical consensus ascribes increased skewness of income distribution to the initial stages of development. Indeed S. Ho found that phenomenon in Taiwan in the pre-war era, when real wages in the then most important sector, namely agriculture, grew more slowly than productivity. Kuznets' computations allow a similar conclusion for that period.[2] It is clear, though, that ever since take-off the fruits of growth have been spread in an examplary even manner throughout the population. The Gini coefficient which in 1953 was estimated at 0.55, after take-off in 1964, when growth rose significantly beyond the 10% mark, had dropped to 0.360 and

Table I: Selected Economic Indicators, 1952–1981

Period	Gross Domestic Products*		
	Index 1952 = 100	Index 1976 = 100	Growth rate (%)
1952	100.0	12.8	12.0
1953	109.3	14.0	9.3
1954	119.8	15.4	9.6
1955	129.5	16.6	8.1
1956	136.6	17.5	5.5
1957	146.7	18.8	7.4
1958	156.2	20.0	6.5
1959	168.3	21.6	7.7
1960	179.1	23.0	6.4
1961	191.4	24.5	6.9
1962	206.5	26.5	7.9
1963	225.9	29.0	9.4
1964	253.4	32.5	12.3
1965	281.7	36.1	11.1
1966	306.9	39.4	9.0
1967	339.6	43.5	10.5
1968	370.6	47.5	9.2
1969	403.6	51.7	8.9
1970	449.3	57.6	11.3
1971	506.7	65.0	12.8
1972	573.8	73.6	13.2
1973	647.6	83.0	12.9
1974	654.9	84.0	1.1
1975	686.3	88.0	4.8
1976	780.0	100.0	13.7
1977	856.3	109.8	9.8
1978	971.1	124.5	13.4
1979	1,046.5	134.2	7.8
1980	1,117.7	143.3	6.8
1981	1,179.3	151.2	5.5

Source: Taiwan Statistical Data Book (1982).

continued to fall to 0.303 in 1980. Income share of the poorest 20% of families, which was 3% in 1953, rose to 7.7% in 1964 and 8.8% in 1980. Alternatively, income share of the richest 30% of families decreased from 61.4% in 1953 to 41.1% in 1964 and 36.8% in 1980.[3]

These shifts are reflected in consumption. In 1961 the number of telephones per 1000 inhabitants was 9.2, in 1971: 32.7 and in 1983: 310.6. Television came to Taiwan in a significant way by 1970, when there were 68 sets per 1000 inhabitants. In 1981 the number had risen to 1030.[4]

Daily per capita caloric food intake rose from 2078 calories in 1952 to 2845 in 1979, protein intake from 49 grams to 79 grams. Life expectancy rose from 58.6 years in 1952 to 70.7 in 1979. The Physical Quality of Life Index which the Overseas Development Council in Washington computed for 150 countries and which is based on index ratings for life expectancy, infant mortality and literacy, places Taiwan 32nd, an honourable rank for a recently poor country. M. P. Todaro engaged in a similar exercise for 15 selected Asian, African and Latin American developing countries, using six indicators to compare economic performance: per capita income levels, distribution ratio of bottom 40% to top 20% of population, literacy rates, population growth rates and infant mortality rates. Taiwan ranks 1st in three of the six indicators, 2nd in two and 3rd in one.[5]

All in all, it seems reasonable to conclude that the growth targets, as defined on the inauguration of consecutive United Nations Development Decades, have been realized if not transcended in Taiwan. Also, the trickling-down mechanism whereby the fruits of growth gravitate towards the nether income brackets, has operated satisfactorily. Hopes for these achievements had all but evaporated among Development Agencies, whose latest approach bear witness to the conviction that straightforward modernization strategies of the sixties are doomed to fail. In 1976 the International Labour Office indeed proposed to abandon efforts along those lines, as it was believed to have become clear that rapid growth, if at all attainable, would not "automatically reduce poverty and inequality". Hence, a new policy was advocated whereby the modest goal of the fulfilment of "basic needs" was adopted. Basic needs defined as "minimum requirements for private consumption, adequate food, shelter and clothing", also "sanitation, public transport and health and educational facilities" have been met long since in Taiwan through the pursuit of a fairly orthodox policy, in which a considered choice of technology kept the growth engine going in

each of the successive phases.[6]

DEPENDENT YET DEVELOPING

Taiwan's enviable growth record naturally evokes the question whether her example admits of imitation by other less developed countries. One reply occasionally given is to deprecate the example per se, by questioning its validity. This is done by casting doubt on the statistics, a line taken by H. Gates in *Modern China* in 1979 and repeated, under the pseudonym S. Wynn. in the *Monthly Review* in 1982.[7] "All income survey data are somewhat suspect as to accuracy", sums up the argument. Exponents of the centre-periphery school are especially driven to these and similar queries, as Taiwan presents a prime case of exploitation and victimization by Powers Without, and thus ought hardly to exist upon the earth, let alone to live rather well. For such a country to, as it were, reincarnate as a comfortably placed economy by some of the dearest left wing criteria, is anathema. The island was, for all practical purposes, subjected to classic colonial treatment by diverse European conquerors, by Japan and after Restoration, as a minor province, by China.

It is estimated that Japan extracted 10% of Taiwan's GNP in the years after 1911, as against, for instance, Britain 1.5% from India in the same period. The first Chinese Governor to arrive after 1945, Ch'en Yi, was a Fukien warlord not known for generosity, efficiency or even honesty. And the Taiwanese rose against his rule in the best tradition of the colonial scenario.[8]

To compound the case for exploitation, Taiwan in subsequent years relied heavily on foreign investment; she welcomed multinationals and was active in creating capitalist enclaves in the shape of export processing zones. She has one of the world's highest foreign-trade ratios, gearing her economy mainly to the U.S. and Japan. To this day, her administration is dominated by an elite that cannot be said to have emerged from the rank and file. As the growth statistics cited earlier can hardly all be deemed mere fabrication, the country's recent economic history does not seem to support the case for the dependency theory.

Within the modalities of interdependence it is probably nearer the truth to attribute Taiwan's good fortunes to geopolitical accident. The position is summed up in General D. McArthurs often cited comparison of the Island to "an unsinkable aircraft carrier". The Dutch early settlers, at any rate, used the place in such a, be it pre-air power, capacity when, capitalizing on its strategic location, they occupied

the Tainan area in 1624. Trade was carried on from there with both Japan and China, which were otherwise impenetrable. The Japanese, having reduced Taiwan to an agricultural appendage since 1895, realized its unsinkableness in the thirties, when airpower was becoming a stark reality, and hastened to build its infrastructure. [9] In 1949 the Chinese Nationalist Government and Army headed by General Chiang Kai-Shek arrived, determined to avail themselves of Taiwan's bastion properties to make a Last Stand.

In the 1950's the U.S. began to support that ultimate position vigorously, extending both military and economic aid. During the Korean war, Taiwan became all the more part and parcel of the super powers' logistics and although she has had her share of the ravages of battle, to some extent she has also profited by international tension and shifts of power, which lately, through worldwide diplomatic recognition of Red China, have once more turned to her disadvantage. However, if the island indeed is part of mainland China, as both the Chinese and the Taiwanese Governments maintain, she is indubitably the most affluent part!

Some observers have been tempted to attribute Taiwan's economic success predominantly to the financial assistance she received from the U.S. when she held strategic value.

TRADE NOT AID

Thus H. Kahn talks of the role played by "unusually large amounts of aid and military spending". P. Streeten, likewise, denies Taiwan any model value for other L. D. C.'s. Here is "a special case. She enjoyed massive aid". [10] Neither observer bothers to adstruct his statement quantatively. It is true that in the initial phase, Taiwan was the recipient of ample aid. Between 1948 and 1951 the U.S. made available U.S.$100 million, or about U.S.$10.- per head and per year. By the end of 1964, commitments ceased, although disbursements continued until 1967. The per capita average by then had decreased to U.S.$6.- and several other LDC's, among them South Vietnam, Korea, Zaire, Turkey, Yugoslavia and Egypt, Cyprus, Israel, Jordan as well as the French former colonies were receiving more economic aid per head. [11] Taiwan's case, however, is rather special because when economic aid was discontinued, her economy graduated to sustained growth at a level of about 10% for the next few years and, indeed, she started to dispense foreign assistance herself to some 25 countries in Asia, Africa and Latin America. The notion that U.S. foreign aid was

the great lever, began to circulate in the literature when N. H. Jacoby, having done a study of the subject at the instigation of the U.S. Agency for International Development, concluded that GNP growth until 1983, without aid would have rated a mere 3.5%.[12] This would mean, since the population anually increased by 3.1%, that per capita growth would have amounted only to 0.4%, implying that Taiwan's performance would have been worse than that of other South and Southeast Asian countries. Yet she was already further advanced during the late Japanese colonial period and by war's end was, in fact, industrially superior to any other Chinese province. A diametrically opposed stand is adopted by those economists who consider all aid to be counterproductive, since it only bolsters the position of the already entrenched bourgeosie and leads to oppression, apathy and waste. Indeed, K. Griffin produces a series of figures, showing a negative correlation between growth of national income and aid, although consumption is positively correlated. (Table II) [13]

I. M. D. Little, likewise, concludes that "heavy aid coincided roughly with periods of slow growth".[14] These findings may at least partially be explained by the considerable element of "basic needs" fulfilment in the initial aid stage, when surplus food was made available as well as raw materials, both comprising 86% of the total aid value. After 1958, commitments to infrastructure began to prevail and in the late aid period, after 1961, emphasis shifted to the furtherance of private enterprise. [15]

In retrospect, the ideological persuasion responsible for that particular shift may well have been a major factor determining Taiwan's subsequent development course. The U.S. Agency for International Development, (A. I. D.) imbued with the creed of unfettered entrepreneurship, already in the 1950's intimated disapproval of the Nationalist predilection for public enterprise and sought vigorously to foster private investment.

The American advisors responsible for the disbursement of funds resolutely pursued a policy to build small-scale, labour-intensive industries, whilst dissuading the Government from going for large-scale and capital-intensive undertakings.

To that end, they availed themselves of a considered strategy of non-lending, withholding funds from such projects as a nuclear reactor, an integrated steel mill and an international airline.

A pivotal role in implementing this policy was entrusted to J. G. White Engineering Corporation of New York, which had set up office in Taipei and was instrumental in the establishment of many flourishing enterprises, among them glass, fiber

Table II: Aid, Consumption and Growth in Taiwan 1951–1968

Year	Growth of National Income (% per annum)	U.S. Aid as % of National Income	Consumption as % of GNP
1951-1955	5.49	8.22	92
1956-1960	6.09	7.40	90
1961-1965	9.88	4.07	82
1966-1968	11.87	0.00	75

Source: K. Griffin: An assessment of Development in Taiwan; World Development Vol. 1, No. 6, June 1973.

and the plastics industry.[16]

A. I. D.'s intervention went surprisingly far. To support the textile industry, for instance, funds were made available for the purchase of American cotton, which was then distributed to the local spinners, along with appropriations for the payment of wages.

Subsequently, A. I. D. purchased the yarn, which the Taiwan Cotton Textile Guild was authorized to sell to the weavers at a set price. Hence, the raw materials acquisition, the finance of the production process and the sale of the final products were all the responsibility of the foreign aid institution.

The thoroughness with which the White engineering consultants handled their assignment leads one to suspect that they, too, were primarily responsible for the choice of technology which was applied in the production processes they initiated and which would have gladdened the heart of any latter-day proponent of the appropriate technology school. Data on the labour force in the early postwar years are not too reliable, but it seems reasonable to assume a higher level of unemployment than that registered in later years, when it was for instance 3.34% in 1965, declining, as the pace of industrialization quickened, to 1.28% in 1979.[17]

Certainly labour was reported to be both abundant and cheap in the early years, so there was every reason to induce industry to liberally tap that resource in an era when cost-cutting automation technology was still in the realm of science-fiction.

The textile industry cited above provides a case in point. The early industrial advance of Britain, Japan and several other countries is known to have been fed by that particular sector. It played that role here, too. Some equipment had been brought to Taiwan by mainland entrepreneurs, who had dismantled their plants upon the approach of the Communist Army.

Handlooms traditionally were in operation in Taiwanese cottages. At a wage level of 10-20% of that then prevailing in the U.S., even the simplest techniques available would yield a surplus. Such indeed were the techniques that were made to serve. At a much later stage, the electronics industry, for which Taiwan since has acquired a fearful reputation, provides another example.

It was cheap labour for manual assembly operations (that had become too costly in the U.S.) that induced General Instruments to venture into Taiwan. When local firms followed suit, it was again a limited scale operation, small workshops manufacturing and assembling components, using simple techniques but ample labour.

Many in those days believed that things would stay that way. Conventional wisdom held that countries like Taiwan were lucky to be able to exploit their single comparative advantage of a low wage level, producing the goods for which the prosperous countries' workforce had grown too expensive. Production processes requiring technological know-how and skilled labour would remain the province of the industrial West. There is a measure of Western conceit in such beliefs, which are remarkably persistent. Even Japan, which by 1968 ranked third among nations by the criteria of GNP, is denounced for using essentially imitative technology. Western Nations invent and innovate; the Japanese "merely apply". China in the 14th century is thought to have exhausted her innovative resources, so that only by turning to the West could she be rescued from economic stagnation. At least in that version China is supposed ever to have possessed some sort of inventive capabilities. Many commentators do not even grant her that. In the words of J. Needham, Chronicler of Chinese Science and Technology: "The majority of her achievements in this field she is widely supposed *not* to have had".[18] In a series of volumes of which the first appeared in 1954, Needham traces a myriad of "ingenious devices", from the mechanical clockwork via the collar harnass, to gunpowder and textiles, navigation and steering techniques which were developed in ancient China predating by ages similar inventions in the West. In many cases, these techniques in fact were copied in Europe with a timelag which, in the case of cast iron, lasted 10-12 centuries, in the case of the canal lock gates 7-17 centuries and in the case of porcelain 11-13 centuries.

Indeed, Needham and his collaborators now face the question why it was that China, for so many centuries, was more successful than Europe in gaining scientific knowledge and applying it for human benefit. Japan's reputation for imitation is solidly entrenched in conventional wisdom and perhaps more deserved, although S. Shōzan (1811-1864) who propagated the slogan "Eastern Morals and Western Arts" was assassinated because he tried to introduce Dutch science and technology in the early stage of modernization or Westernization of Japan.[19] However, using the example of cannon casting techniques, T. Nakaoka has demonstrated in recent years the application of 'rangaku' (Dutch learning) acquired from officers and merchants at Nagasaki settlement, as well as directions from a book entitled "Het Gietwezen in 's Rijks Ijzer-geschut gieterij te Luik" in the late Edo period, resulted in sophistication of the process very much sooner than could have been achieved without these examples. The Japanese engineers seemed to be making a "leap to

Western technology". [20] Still, the firebricks used for the construction of the furnace were made in Arita, which to this day is famous for its traditional ceramics. Skilled local millwrights provided waterpower and indigenous arithmetic was used in engineering calculations. And of course domestic iron-manufacturing technology was drawn upon, the point being that the imitative process involved elements of adaptation to the point of constituting an innovation in its own right. Indeed, it is the failure of such adaptation which, in development literature, is often cited when abandoned investments and derelict projects in Third World countries are being discussed. Similarly, Taiwan's reputation for successful "piracy" of industrial products for which the Government is lately taking local manufacturers to task, points to a learning ability which, when the time comes, may carry the economy into further, autonomous development.

LEARNING THROUGH SUBSTITUTING

It should be remembered anyway, that initial industrialization in Taiwan took the form of import-substitution, meaning that such manufactured goods as had so far been purchased abroad, were produced locally. In order to attain a comparable level of technical perfection to the foreign product, similar, if not identical, methods have to be followed so that, by the same token, the foreign production process is copied as well. This policy was whole-heartedly pursued until the late 1950's when saturation of the, of necessity limited, internal market became apparent, while the lack of resource endowment further rendered the strategy ineffective. Still, in those early beginnings of industrialization, goods were made locally which hadn't been before, the initial upward movement along the learning curve of applied technology being ascended. Perseverance with import-subsitution would have implied early graduation to technologically more advanced products, such as capital goods, raw materials processing and durable commodities.

However, in the mid-1950's a gradual shift was recorded in the direction of export subsitution, whereby the same, largely labour-intensive nondurable consumer items that used to be sold on the local market were now being offered abroad.

The success of the policy indicates that the technology applied had matured to the extent that quality demands made on the international markets for those goods could by now be met, although it is true that the highly competitive prices quoted may have led prospective buyers to show some leniency in this respect.

M. Scott, in fact, estimates that compared to the U.S., price levels for Taiwan-produced manufactures even in the late 1960's were 16% lower for textile, 23% lower for apparel and 38% lower for electronics, the explanation being that the proportion of wages in total costs was only half or one third as high in Taiwan.[21]

Taiwan turned to an outward-directed strategy in an era when general pessimism concerning world trade inspired UNCTAD to advise against the policy; indeed Latin-American countries that later championed the strategy, such as Argentina, Brasil, Colombia and Mexico did not embark on export drives until the mid 1960's.

This caused some economic historians to believe that Taiwan "resisted the temptations of a regime of import-substitution industrialization", when in fact infant-industry was nursed in the early postwar years, only to gradually gear production to foreign markets at the next stage.[22] But import-substitution, with all the attendant subsidies, duties and multiple exchange rates did hold sway in the early years of industrial development; nor was the policy abandoned as a result of sudden insight. Untoward developments were progressively realized and the ensuing discussion gradually turned in favour of an export effort. The Japanese example, as so often in Taiwan, may well have been decisive here.

With hindsight, it can be said to have been a happy course to steer. In 1978, B. Balassa calculated the hypothetical loss that would have been sustained by a number of Third World countries that were pursuing a policy of rapid industrialization, had they not resolved to direct their productive efforts to outside markets.

Under that hypothesis, their export growth rate would very likely have equalled the rate achieved by the average LDC, which was calculated from the export performance of ten representative countries. Taiwan, in that event, would have shown a GNP of 25% less than that effectively realized and her per capita income would have been 33% smaller. Four years later, Balassa indulged in further estimation of country economic performance, comparing the effects of the 1973 oil price shock on outward- versus inward- directed LDC economies. The former category experienced an average gain of 14% and the latter an average loss of 8% in their export market shares in the 1974-1978 period. Taiwan in those years gained an export average of 10%. In both categories of countries, GNP growth rates suffered temporarily, but rates fell less in outward-directed than in inward-oriented economies. This author calculates Taiwan's growth rate in 1973-1979 to have amounted to 7.6% as compared to 7.9% for the average attained by the combined outward-oriented countries and 4.8% for

the combined inward-oriented countries.[23]

Since 1960, when Taiwan's trade volume of GNP amounted to 30%, outward-orientation accelerated the ratio to 61.7% in 1970 and 98% in 1982. All the while the proportion of industrial products in total export value increased; until in 1982 it attained 91.5%. In the first six months of 1983, the Board of Foreign Trade reported a further increase to 96.2%.[24]

CAPITAL VERSUS LABOUR

It is clear that this continual shift towards manufactured products is the outcome of a process of rapid industrialization, whereby, moreover, expansion was attained through the increased use of capital equipment as opposed to labour, as is evidenced by the fact that the number of workers in that sector increased by only 11.9%, whereas total employment from 1971-1981 increased by 40.8%.[25]

D. Y. C. Hsu, examing developments between 1965 and 1979, found that manufacturing output during that period increased at an annual average of 12.5%, while employment in that sector increased by 9.5% only.[26] The rate of labour absorption of output in manufacturing thus is 0.76, which by contemporary standards of industrialization is quite high. Still, a movement toward greater capital-intensity is revealed here. The 1971 Industrial and Commercial Census of Taiwan found capital intensity in the manufacturing sector to have increased considerably since the previous census of 1961. The 1981 census results unfortunately are not yet available.

Yet another indicator of the factor shift in favour of capital is found in the captial-output ratio. Table III provides the 1952-1980 series of that indicator. The relatively high values in the first few years may reflect errors of capital estimation. After 1945, machinery had been taken from Taiwan to the mainland to fortify industry as part of the war effort. But after 1949 equipment was moved in the opposite direction when mainland factory owners decided to make a last stand on Taiwan also. It cannot now be established what the precise value of those capital goods was.

. Also, new machinery arrived during the early 1950's as part of the American aid program and, again, the value cannot now accurately be retrieved. It stands to reason also that production capacity was not fully utilized in the newly (re-) built plants, which again is a factor contributing to a high capital-output ratio. The table does show that investment increased sharply after 1971, while the capital-output ratio rises to a higher level. A likely explanation is that investment now was increas-

Table III: Capital Output Ratio and Capital Labour Ratio Series 1952-1980 (In constant prices of 1976, Non-Agricultural Sector)

Year	Y(Output) (NT$ Million)	K(Capital) (NT$ Million)	L(Labour) (Thousand)	K/Y	K/L (Dollar/Per Labour)
1952	34,996	131,504	1,375	3.8	95,639
1953	37,006	134,456	1,395	3.6	96,384
1954	44,545	137,850	1,443	3.1	95,530
1955	47,435	140,505	1,471	3.0	95,517
1956	51,195	143,740	1,465	2.8	98,116
1957	55,055	147,013	1,563	2.7	94,058
1958	58,992	151,088	1,631	2.6	92,635
1959	63,956	156,068	1,695	2.4	92,076
1960	66,105	162,318	1,749	2.5	92,806
1961	71,771	168,826	1,804	2.4	93,584
1962	80,177	175,432	1,860	2.2	94,318
1963	89,550	183,526	1,949	2.0	94,164
1964	98,757	191,643	2,027	1.9	94,545
1965	111,346	202,711	2,069	1.8	97,975
1966	123,140	218,012	2,105	1.8	103,569
1967	139,437	238,520	2,299	1.7	103,749
1968	155,188	264,029	2,549	1.7	103,581
1969	175,548	293,340	2,707	1.7	108,364
1970	196,413	326,266	2,895	1.7	112,700
1971	227,792	366,692	3,073	1.6	119,327
1972	260,530	412,400	3,316	1.6	124,367
1973	294,363	462,633	3,703	1.6	124,935
1974	296,539	524,945	3,789	1.8	138,544
1975	309,143	605,221	3,869	2.0	156,428
1976	357,413	681,133	4,014	1.9	169,689
1977	395,704	757,095	4,337	1.9	174,567
1978	454,823	842,254	4,675	1.9	180,162
1979	494,685	942,655	5,044	1.9	186,886
1980	533,464	1,066,621	5,270	2.0	202,395

Source: Computed on the basis of data made available by the Central Bank of Taiwan.

ingly capital-intensive, induced by the sharp rise in the wage level, caused by shortages of labour of coveted skills and associated furthermore with the inflationary pressures caused by the Vietnam war. All the entrepreneurs interviewed for the present study spoke in plaintive tones about rising wages and, indeed, manufacturing money wages in, for instance, 1973-1974 rose by a rather alarming 30-40%.[27]

This movement, incidentally, was continuous, as can be seen from table IV, which was computed from consecutive issues of *Industry of Free China* and shows that real wages rose substantially also. It is not surprising, therefore, that entrepreneurs, when asked about their motivations for past and future investments, invariably expressed an intention to go for the latest, least labour-intensive machinery available, quality control and energy-conservation being mentioned as further considerations.

The traditionally massive savings ratio in Taiwan, quite apart from foreign investment, renders a high investment level feasible so that even at a less impressive capital-output ratio, enviable growth rates can be attained. Thus, a savings ratio of 30% in the past has often been achieved and assuming all those savings are productively invested, an incremental capital-output ratio of 2.2, such as is estimated for 1982, yields a growth rate of over 13%!

Sheer arithmetic, however, seldom adumbrates economic reality. Should investment take the form of capital-widening, involutionary effects will ensue and the outcome is rather less happy. Indeed, the deterioration of the capital-output ratio in conjunction with the rise in investments in 1971, implies that capital productivity did not commensurably increase, for which a lapse in technological progress may well be responsible. This is precisely S. W. Y. Kuo's conclusion, whose deft manipulation with the Solow and Cobb-Douglas production-functions shows a marked decrease of the contributions of technical progress in the manufacturing sector in 1961-1980 compared to 1952-1961.[28]

One explanation is that the leading sectors within industry, electrical machinery, transportation equipment and textiles, suffered from the world recession; all exported less than previously. Since output growth and technical progress normally are positively correlated, the deceleration of the former tends to negatively affect the latter. However, to keep a proper perspective it is necessary here to distinguish between private and public investment.

The major development projects undertaken by the Government in the 1970's, among them a steel mill, petrochemical installations, a nuclear power plant and a

Table IV: Inflation and Real Wages 1971–1981

Year	Cost of Living Index*	Real Wage
1971	100	100
1972	105	103
1973	119	97
1974	164	106
1975	173	111
1976	177	126
1977	190	136
1978	201	151
1979	221	165
1980	262	166
1981	305	171

*Based on urban prices.

The index was computed on the basis of statistics, derived from consecutive issues of Industry of Free China, Taipei, Taiwan, R.O.C.

shipyard, greatly contributed to the increase in capital growth, without adding to output, as gestation of such investments tends to take some years.

Furthermore, it so happens that a major leading industry, electronics, is still predominantly labour-intensive.

It is the second-largest export-oriented industry in Taiwan and in 1978 surpassed Japan's export volume of colour TV's to the U.S.. In 1961, the then Council on International Cooperation and Development retained the Stanford Research Institute to study potential industries in Taiwan. One of the branches recommended was electronics. Soon exportation of transistorized wireless sets began, as well as the assembly of black and white TV sets using Japanese made components and locally furnished cabinets. In 1964 seven U.S. electronics companies started operations, followed by seventeen more in 1965.

Essentially, these were farmed-out production sequences relying on cheap indigenous labour, that could profitably be shifted to Taiwan. Shipments of electronic goods subsequently grew by 70% in 1966 and by 237% in 1967. Total increase from 1966 to 1971 was over 920%. [29] Though foreign firms were attracted by special incentives and accordingly settled mostly in the newly established Export Processing Zone in Kaoshiung, Taiwanese companies began to branch into the new sector also, initially through linkage, by upstream delivery of components, but later as electronics manufacturing operations in their own right. One of them blossemed into a veritable, Taiwan-based multinational, running subsidiaries in the U.S., Singapore, Japan, Hong Kong and lately England. There an ailing Decca plant was revitalized, daily production of television being boosted from 190 to 620 by cutting tea breaks, shortening holidays and generally imposing discipline. [30] As anyone familiar with the Britain industrial scene will readily admit, this must count as a first-rate management accomplishment.

RAGS TO RICHES IN PVC

As the textile sector began to face market saturation and competition, the government removed spinning and weaving from the list of preferential industries. Meanwhile, the artificial fiber industry was being established, to which existing textile machinery capacity could easily be accomodated. With the assistance of the Agency for International Development, and investment from both public and private sources, the China Man-made Fiber Corporation was established in 1957, diversifying in subsequent years into polyesters, nylon, rayon and acrylic fibers. Soon the industry

became a leading sector; in 1980 it achieved fourth place in the world, in artificial fiber production.[31] Most of these factories were started by entrepreneurs who had originally been involved in cotton manufacture, but Taiwan's leading producer of synthetic fibers was founded as a plastics manufacturer. Again, J. G. White consultants were instrumental in establishing the industry, having produced a prospectus encouraging such a venture.[32]

In 1957, PVC resin production was begun and in 1964 rayon was processed from local wood chips. Three years later acrylic was produced, with the help from a Japanese Chemical Company. A naphta cracker was built and the firm since has integrated both forward and backward. Exports of final goods is largely channelled through local firms making shoes, upholstery, travel goods etc. The operation is highly capital-intensive; the labour cost advantage thus being negligible. Hence competition on the U.S. market was never feasible with intermediate material. Meanwhile, a plant was built in Texas for which the installations were mostly produced in the Taiwan company's own workshops. Originally, complicated machinery was imported from Germany or Japan, but maintenance and running experience bred familiarity and eventually it was decided to build the machines on the premises, avoiding transportation cost of this huge equipment.

All gears used in the diverse divisions of the plastics company are also custom-made. Gears tend to wear out quickly in these applications and it was decided a cost advantage could be realized by ordering the required implements from Germany and sending some workers there to acquire the necessary skills. Capacity greatly exceeds requirements for the moment; 80% of production is sold outside.

It seems worthwhile to dwell briefly on some of these highly successful operations to provide some background to the statistical data and to illustrate the rather remarkable entrepreneurial talents which seem to abound in the island.

It was noted earlier on that interviews with local entrepreneurs consistently revealed investment decisions which closely followed a path derived from Marshall's principle of substitution. As market prices for the factors of production shifted, the relative quantity of their application was altered accordingly. In recent Taiwanese economic history this meant that capital stock increased and labour became scarcer; less and less of the latter factor was being used and more and more of the former. Labour productivity in industry is of course largely dependent on complementary equipment and this indicator in the last 30 years rose steadily at an annual average

of 5.8%.[33]

PRAGMATIC GOVERNMENT

A recently published Reader on Technology and Economic Development concludes that: "Economic forces themselves are the best 'conductor' of technology for development." [34]

Taiwan enjoys a reputation for being a haven of private enterprise, where the unfettered interplay of market forces determines the growth path. This is certainly more true here than in the majority of developing countries elsewhere, but it is not the whole truth. It is fair to say that the Government of Taiwan has played an active role in the historical developments described here. Whether or not one judges the Government of any country to intervene too much in the economy, not enough or just in the right degree is not an empirical matter only; the phenomenon is as much, if not more, in the eye of the beholder.

When M. Friedman paid a visit to Taipei, he ascribed Hong Kong's superior prosperity to the absence of any form of Government interference. Similarly, H. Kahn concludes that the Taiwanese Government would do well to exercise less control. Now, strict control over the economy is to be expected from socialist Governments, admittedly not always with happy results, but the present Government of Taiwan can hardly be reproached for leftist persuasion. It is true, however, that imperial China was ruled by an extensive bureaucratic apparatus and that the Kuomintang regime subsequently established in Taipei is not devoid of such leanings. A cynic might observe that the country is lucky the key posts are held by engineers, rather than social scientists, so that pragmatic considerations are perhaps more likely to prevail.

Taiwan's contemporary history shows that the Government from the start pursued active economic policies designed to channel the economy in a way that, at each juncture, seemed called for, without any apparent pre-conceived conviction, apart from the desirability of achieving rapid growth. An economist of the Friedman variety might think that the Taiwanese business community is loath to be led in this or that direction, but it so happens that particular community differs from, for instance, U.S. business inasmuch as it is more prepared to look to the Government for guidance. This is not to say the American businessmen reject all Government intervention; whenever serious losses are incurred, failures threaten or local markets are being

flooded by imports, even the fiercest champions of the free market cause, tend to hastily form a lobby in Washington to curb those very market forces.

The difference is that the Taiwanese, who have been accustomed for many years to rule by what they, on the main, perceive as a well-intentioned Government, are perhaps more prone to accept economic edicts even when times are not so bad.

This may be a cultural phenomenon which the Taiwanese share with the Japanese and even Friedman presumably will find it hard to maintain that Japan would have surpassed the U.S. in economic achievement at an earlier stage if only the Japanese government would have refrained from pursuing economic policy.

A. H. Amsden, under her own name as well as under pseudonym, likens Taiwan's government conduct to 'etatisme' but seems reluctant to accept that such a vital decision as the one that turned the economy to export succeeded because it was, at the time, the proper policy to adopt. The export boom, in her estimation, was due to "an extra-ordinarily favorable international situation". The obvious question is, why not all LDC's profited by such good fortune and why Taiwan's exports in later years held out remarkably well in the face of an extra-ordinarily *un*favourable international situation. S. Ho, who probably is better versed in the Taiwanese economic scene than most other observers, holds that the government's control of the economy, whilst strict in the early years, has gradually relaxed to the point where intervention is confined to the creation of financial conditions under which capitalism is allowed to flourish.[35]

Anyway, as is the case of any other small country with insignificant impact on world affairs, Taiwan's economic policy is not so much a force unto itself as a reflection of changing exogenous conditions. The present, crucial resolve to reconstruct the export industry, going all-out for automation, is again a reflection of a change in the economic environment.

In the major export markets the country faces fierce competition in products she used to offer and, moreover, she is rapidly losing the comparative advantage associated with a wage level which is lower than that in competing Asian countries.

The range of export products in which Taiwan has been particularly successful comprises textiles, garments, plastics, shoes, toys, sports goods, luggage and electrical appliances. Imports consist largely of capital goods, engineering products and raw materials. Comparison of those ranges of goods warrants the conclusion that exported goods are more labour-intensive than imported goods, which is borne out by table

V showing their relative capital-intensity. Furthermore, table VI shows that the terms of trade, regardless of the oil prices, are deteriorating for Taiwan.

These developments demonstrate that Taiwan has once more reached a turning-point on her growth path; the obvious answer is indicated: to the extent that the same range of goods is offered, their production cost needs to be lowered. Also, it would be wise to extend the export range to include more sophisticated goods.

The Government has already formulated a fitting policy, amounting to deliberate wholesale industrial readjustment. The problems assailing Taiwan's economy were summed up by K. T. Li, (co-)architect of many a prior economic strategy, as follows:

"Industrial development in the Republic of China is now facing a very serious challenge. It is confronted on the one hand with the low cost, labour-intensive production of the developing countries, and on the other with competition from high-quality, low-priced and high value-added products from advanced countries where automated production technology has been developed and is at work". [36]

These developments, in fact, had been recognized 10 years before when the Government retained Arthur D. Little Consultants, who identified industries in the electronics sector for future investment, stressing computer peripherals, micro-computers, terminals, integrated circuits, electronic calculators and numerical control systems. These findings were incorporated in the next (indicative) Economic Plan. One of the major projects was the Hsinchu Science-based Industrial Park, South of Taipei, where the State invested U.S.$1 billion to build facilities for research into, and production of, advanced electronics and precision instruments. Also, starting in 1978, the Government called yearly Science and Technological Conferences with local and foreign experts, where potential strategies were discussed. In the spring of 1983 the Steering Committee for Production Automation under the Executive Yuan, on the occasion of one of these conferences, suggested an 8 year Development Plan for production automation, comprising a Task Force for factory automation, essentially a team representing various engineering fields, whose expertise was to be made available with the aim of automating the production process.

The Industrial Development Bureau of the Ministry of Economic Affairs was to provide low interest loans for these investments, to be recouped in 5 years. The revolving fund thus formed, would serve the financial needs of consecutive industries.

Eventually, all production processes in the textile, machine, food-processing and plastics industries are to be automated. Furthermore, an automation industry

Table V: Capital Density of Manufacturing Industry

Unit: N.T.$1,000/per labour (at constant price of 1976)

Industry \ Year	1966	1971	1976	1977	1978	1979
Industries of greater export than import	103.84	125.35	175.85	190.81	181.07	195.95
Industries of greater import than export	148.25	167.56	265.56	319.55	368.58	394.88
Average	119.10	139.76	207.70	337.77	254.34	269.30

Source: Monthly Statistics of Exports and Imports, the Republic of China.
Taiwan Statistical Data Book (1981).

Table VI: Index of Export and Import Unit Prices and Net Terms of Trade

Year	Index of Export Unit Price	Index of Import Unit Price	Net Terms of Trade	Index of Oil Price	Net Terms of Trade without Oil Price
1961	49.6	43.5	114.1	–	–
1966	53.63	47.39	113.17	–	–
1967	55.19	47.73	115.63	–	–
1968	55.42	47.47	116.75	18.83	107.44
1969	57.77	47.49	121.65	17.18	113.61
1970	59.68	48.41	123.28	16.22	115.28
1971	61.43	51.43	119.44	20.43	113.49
1972	66.77	57.65	115.82	18.05	97.23
1973	79.29	71.00	111.68	21.39	104.74
1974	103.77	104.29	99.50	61.33	91.52
1975	97.67	99.95	97.72	97.55	97.44
1976	100.00	100.00	100.00	100.00	100.00
1977	106.37	108.00	98.49	108.43	98.55
1978	112.94	121.25	93.15	109.17	91.41
1979	131.04	145.27	90.20	147.01	90.39
1980	145.72	178.03	81.85	268.38	89.09
1981	154.63	196.68	78.62	305.35	86.06

Source: Monthly Statistics of Exports and Imports, the Republic of China, 1961-1981.

is to be established. The entire plan calls for private investment of NT$292.2 billion and public investment of NT$4.25 billion over the next 8 years.

THE CHIPS ARE DOWN

The need for such a thorough overhaul of Taiwan's industrial structure basically derives from a series of electronic innovations which began with the replacement of the valve by the transistor-a semiconductor device that can store, switch or amplify electronic signals-and the subsequent integration of those devices on a "chip" made of silicon, a material after which a Californian valley, erstwhile chiefly known for its vineyards, was named. Through integration of an increasing number of transistors, one piece of silicon proceeded from 10 devices in 1969 to 46.000 in 1978. The Japanese quickly perceived the potentiality of the new technology and having started their own Science-Based Industrial Park already in the early 1970's went on to crowd more and more components on a single chip, calling a number in excess of 262.144 "very-large-scale-integration" or VLSI, thereby extending handling capacity manifold.

Such circuits can be made to perform logic and arithmetic functions and are then called microprocessors. Integration with input and output devices and (random access) memory, yields a micro-computer. Special features and increased storage capacity produce a minicomputer. And so on. Automated control of production processes used to rely on numerically coded tapes, which instruct machines to perform repetitive functions.

The steering function can now be performed by the computer. Robotics, whose name derives from the Czech word for work, are machines featuring similes of arms and hands, which can be commanded by microprocessors to perform certain tasks such as transporting, welding and assembly of components. Recently robots are being equipped with sensing capabilities and a degree of "intelligence". The performance of these apparatus for the production process has been likened to the invention of the wheel, the steam engine and the advent of electricity.

Like these prior revolutionary innovations, the chips actually have arrived and work among us. Reports about them tend to sound like science fiction, but these technical accomplishments are real. Tsukuba Science Park near Tokyo, Intel, South of San Francisco and Hsinchu, South of Taipei are instrumental in realizing the new potentialities and their effects will soon be experienced throughout the world.

"The modern era of electronics", states the U.S. National Academy of Sciences,

"has ushered in a second industrial revolution".[37] Or is it just an evolution?

The argument for the latter contention perceives the advent of microelectronics as qualitatively nor quantatively different from all the earlier technological developments, although some of them have caused the mutation which, retrospectively, is called the Industrial Revolution. The Swiss watchmakers, who lost their market to the Japanese and Hong Kong watch industry, are not likely to adopt the view that their fate is part of a linear movement, considering that their number between 1970 and 1980 dwindled from 89.500 to 46.998 and those that remain are hardly making any more movements. They, too had to stoop to quartz.[38]

For that is the one effect that distinguishes the present innovation from all preceding ones: the extent to which labour is made redundant. The savings achieved by automation derive primarily from cuts in the labour force, and there is evidence that these can be severe. "The cheapest labour is no labour", Friedrichs and Schaff drily observe and, indeed, a model for a totally automated plant has been designed in Sweden as well as in Japan.

In the, as yet less far-reaching application of robots, it was found in Germany that one robot on average replaced four workers. Where unions are strong, overmanning may be indulged, as became apparent when 125 typesetters of the Washington Post went on strike and 25 managers, operating the computerized system, took over their jobs. These experiences relate to the recent past when automation was only just affecting industry in the advanced countries, investment moreover being impeded by recession.

When the upturn comes and investment accordingly is resumed, the full impact of the new technology will be borne by the sectors whose aging machinery is replaced.

REDUNDANCY COMPENSATION

When the next boom arrives it will become evident whether the so-called compensation mechanism can be relied on, to absorb workers whose labour is no longer required in the automated plants. This mechanism is supposed to operate as follows: an increased level of investment in labour-saving machinery in one firm will bring new business to another, the supplier, or to a third firm, for whom the end-product of recently mechanical production will mean cheaper raw material; or to the engineering industry, where new orders come in as a result of automation investment. Thus, labour that has become superfluous where technological advance strikes, may

be in demand elsewhere in the industrial complex. And since different techniques develop asynchronically and occur in different branches of industry at different times, it is even conceivable that shortages of manpower will occur. The problem is, that the labour factor is not as homogeneous, nor as mobile, as the compensation theory conveniently assumes; the labour market in fact is composed of many segment markets, as many as there are occupations. And in these segments shortages and surpluses at times occur. But it is not only doubtful, it is improbable that, for instance, welders who were made redundant after the installation of a welding robot, can contribute to the construction of other welding robots. And even if workers could be retrained smoothly, and their mobility would be sufficient, the underlying assumption of the theory is that the labour-replacing machinery is built within the country and that equal amounts of labour will be absorbed by that particular sector, as are becoming superfluous elsewhere in industry. This condition for the time being is fulfilled only in countries which are the cradle of automation. However, yet another compensation is provided via the generation of income: if the goods produced by the automatic machines are low-priced, the real income of consumers rises. They can now spend part of their income on other goods. If the production of these goods requires more labour, then compensation will occur. This line of argument, too, is redolent of the flowing curves of the graphs which decorate the economics text-books: dutifully falling prices, exemplary perfect competition and collective demand curves gratifyingly shifting to the right, do not give the impression of an accurate description of the economic reality of developing countries.

Finally it is hoped that the production of goods which heretofore were beyond technological capability or whose manufacture was of a high-cost "one-off" type, may bring solace to redundant workers. Indeed, electronic calculators, quartz watches, video recorders, digital audio machines and TV games fall in this category and the question is to what extent their manufacture will create employment opportunity. The few empirical studies so far undertaken, suggest that the negative labour effect of the onslaught of electronics is likely to be much higher. This effect is caused by the reduction of components, which is a feature of the new products range. The quartz watch, for instance, consists of a mere five components, and its assembly consequently can be done with very much less labour than is required for the mechanical watch, which requires up to 1000 assembly operations. The production of an electro-mechanical teleprinter takes over 75 hours as opposed to 17.7 hours

needed to put together an electronic one. One microprocessor can replace 936 mechanical parts in such an apparatus. In consequence, an electronic calculator requires less than 1 hour to produce, as against its mechanical predecessor 9 hours. [39]

The cost argument, on the other hand, would seem more valid. Precisely because of the reduction of the number of parts, and the ease of assembly, in turn resulting in further automation of the assembly operation, the final consumer-product can be made much more cheaply, which anyway is the prime object of the entire automation drive. The most spectacular reductions have occurred in the basic module, namely the chip proper.

In 1960 a single transistor cost about US$10.—. At this writing, a transistor embedded in an integrated circuit costs a fraction of 1 cent. Consequently, while the power of computers between 1975 and 1980 increased almost 10.000 times, the price of each unit of performance has decreased 100.000 times. An ITT report on the subject states: "A typical semi-conductor company with a turn-over of US$200 million per year must expect an annual price decrease factor of approximately US$30 million, necessitating corresponding manufacturing cost reductions of US$40 million". [40] This has lead to the strange business practice of quoting prices below current costs, in anticipation of future reductions resulting from improved technology and expanded volume. Under the circumstances it is not surprising that there should be many failures of small and medium-sized companies in this field. Indeed some of the larger companies seem be banking on such eventualities, foregoing immediate profits on new products in the expectation of greater revenue once, through undercutting, the competition has been largely eliminated.

CREATIVE DESTRUCTION

This leads to another peculiarity of micro-electronics production, namely the very short life cycle of the product. Obsolescence comes early, as one new product after another is hurled onto the market. Incessant innovation is required to hang on to the market share. If ever, Schumpeter's "perennial gale of creative destruction" can be said to be blowing here full force. Companies in market economy countries have no option but to adopt micro-technology, create and upgrade products and processes, lest they be eliminated in short order. In the Netherlands, voices have been raised, to try and moderate the dire effects to the country which is already plagued by mass unemployment, by levying penal taxes on investments in automated ma-

chinery, or else by withholding subsidies which at one time were designed to encourage investment with employment-creation in mind.

It seems clear that, while such a policy might bring temporary relief, a country's competitiveness in the world market and hence its chances of survival would be maintained only if other nations were to adopt the same policy. Historically, however, the Luddite spirit has never prevailed, which is perhaps a good thing, seeing that it is precisely technology which has propelled the advanced countries to their present plateau of prosperity.

Also, micro-technology brings advantages besides low cost. It reduces energy demand as well as the requirements of other scarce resources. In view of the conservation needs which have received so much attention in recent years, such thrift is very welcome. It is a boon especially to countries that have no natural resources to begin with. Finally, modest size of economic entities is better served. Although the larger companies retain an edge, small and medium-sized business has a better chance of survival through the use of micro-electronics. This is because the versatility of micro-processors allows small batch manufacture, whilst retaining the cost-effectiveness of mass production. It seems likely, therefore, that some sort of division of labour will eventually emerge among companies of various sizes along the lines of mass, versus custom, production. This poses the problem of the international division of labour, which, at least to some extent, has been determined by the relative advantage enjoyed by certain specializations. These advantages may derive from natural resources, energy or labour availability, all of these in the final analysis being affected by technological know-how. Textile manufacture is a historical case in point: the 19th century mules of Lancashire reverting the division of labour back from India to England. Conversely, wages in Singapore in the 1980's are rising so rapidly that they may soon be expected to surpass the U.K. levels. It will then be to the advantage of the former colony to make its labour-intensive purchases in England!

Vacillation of relative cost conditions continues and it looks as though a new international division of labour is in the offing, when neither skill nor quantity of labour is any more a decisive factor. The countries primarily affected, naturally, will be the ones most involved in international trade, and primarily the ones that used to offer manufactured goods, on the strength of their low indigenous wage levels.

Essentially they are confronted with the familiar historical shifts: as technology

in certain sectors matured, capital cost tended to diminish and the labour component began increasingly to determine total unit cost.

The industries thus affected began to migrate "south". Textile became once more the province of the labour-rich countries and some radical champions of the LDC's interest in the 1960's advocated the wholesale removal of the European textile sector for the benefit of the Third World. That was precisely what was subsequently happening to this and other sectors, or at least to the sections thereof which, at that stage, could only be producing in a labour-intensive manner. The electronics industry too, though hardly "primitive", was seen to farm out chips testing and soldering operations on a grand scale. But as these operations, through automation and integration, are being rendered either labour-extensive or altogether superfluous, the need to perform them elsewhere recedes.

Automation in the textile industry, similarly and even more spectacularly, reduces labour demand. Cutting is done by self-programming robotic arms, designing is computerized, micro-processors control sewing, stitching and knitting and rapidly adjustable ink injectors produce colours. Any advantage enjoyed by low wage-level countries is thus being eroded.

The saving grace, for the moment, is provided by the recession, which is impeding investment in these new machines so long as uncertain market conditions prevail. Very rapid obsolescence, associated with the initial advance of new technology, may further contribute to conservatism: should further cost cuts render new machinery obsolete even before investment is recouped, a highly progressive policy assumes self-defeating dimensions.

Also, the weighted average annual cost per worker in high wage countries is estimated at US$12.000.- So, ironically, it is only in the successful, newly industrializing LDC's that the margin may be getting sufficiently small to warrant repatriation of labour-intensive operations.

BOON OR BLIGHT, THAT IS THE QUESTION

The alternative is, of course, investment by the new industrial countries in those selfsame labour-saving devices. The latter policy is advocated by those who view micro-electronics as a boon for the Third World. The great purveyors of this idea are Ayensu and Trachtman, who promise "an economic quantum jump" from village-based rural communities directly to the computer-based information society of the

21st century, through the adoption of "the true appropriate technologies". [41]

Vaguely alluding to the ideas vaunted by the late Marshall McLuhan, muddle-headed in their own right, the advent of the "global village" is forecast which, enjoying the advantage of a late start, will leave "primitive 20th century technology", this sorry product of linear thought, behind, leapfrogging ahead in non-linear fashion.

The design and manufacture of microprocessers is announced as the first Third World Cottage Industry. Japan's success is attributed to "an intuitive sense of the way things work", incomprehensible to "the industrial nations" (among them, presumably, the U.S., where linear thinking started the micro-electronic revolution.) During a conference at the United Nations University in Tokyo where Ayensu and Trachtman presented their paper, a further point was noted on which Third World Countries enjoyed an advantage, namely that they had no trained personnel, and consequently had no need to retrain it either! [42]

Such boons to LDC's it would seem, might easily turn into a blight, should management of the micro-electronic revolution be entrusted to social philosophers of the Marshall McLoony genre. The days when illiterate tinkerers hit upon fecund concepts and struck it rich, are over: modern industry is science-based. Computers, lasers, holograms and polymers derive from basic scientific research. Application of these findings then requires further research and development, necessitating the availability of highly trained personnel.

Japan, though still buying some of her technology from the U.S., Germany and Britain, now employs one out of every eight research workers in the world, in an attempt to take the lead. Available statistics for 1977 show she had 2.4 research workers per 1000 of the population, against 2.6 in the U.S.. The figure for Taiwan is 1.09 and for Korea 0.4.

Japan in 1982 spent 2.4% of GNP on research and development, America 2.3%, Britain 2.2%, France 1.8%, Taiwan 0.6%. [43] As the industry advances, yet further progress seems to require exponential R. and D. expenditure. On the development of Very High Speed Integrated Circuits only, Japan spent U.S.$625 million. Research costs of mechanical office machines amounted to 1-2% of sales price, the latest electronic equipment necessitated 6-10% of sales price. Development cost of a U.S. manufacturer's telecommunications switching system cost U.S.$40.- million in the era of mechanical technology, and U.S.$500 million 15 years later. [44]

THE TAIWAN CASE

However, rather than rambling on in the abstract, it would seem instructive to elucidate the various aspects of LDC, and particularly NILDC automation, taking the example of Taiwan. It was noted before that the country's very success in elevating her economy inevitably carried the penalty of jeopardizing her competitive position. This is actually saying the same thing twice: after all, economic development entails rising incomes.

So far so good. But other, less successful LDC's such as mainland China or India, by the same token, retaining the (dubious) advantage of a low wage-level, are bent on capturing export markets for traditional products: textiles, garments and shoes.

In addition, the countries in the region that also joined the ranks of the NILDC's: Hong Kong, Korea and Singapore, have already turned to micro-electronics to step up production at lowered cost, of both traditional and technically sophisticated export products. Considering, moreover, Taiwan's poor natural resources endowment, it would seem she has no option but to capitalize on the one comparative advantage open to more advanced countries, namely technological innovation. She could be said to share that position with the stagnating European economies such as the British, whose Advisory Council For Applied Research and Development argues that, unless the country embraces semi-conductor technology, she will soon "join the ranks of the under-developed countries".[45]

Taiwan's position may be even more precarious because she has no access to any natural gas or oil supplies, indeed, energy is a heavy burden on her import bill. Micro-electronics both where replacing earlier electro-mechanical devices and in their application to the production process, are important energy savers. Regrettably, the form of energy that is being saved above all is human labour. This may not seem an immediately pressing problem in Taiwan for two reasons: until recently, and in some sectors of the skilled labour market even now, the country has become accustomed to shortage of labour, rather than redundancy.

Also, unemployment is not at once translated into the heavy, deficit-provoking financial burden that the European Welfare States have to cope with. Kinship ties remain a strong cohesive force; Taiwanese unemployed workers intially fall back on their families and subsequently take to the streets, swelling the number of peddlers

and sidewalk restaurants, thus eking out a living for themselves.

Still, an uncontrolled rise of unemployment is socially destructive, as the industrial countries are now finding, and the labour-substituting potential of micro-electronics is formidable. It is essential, therefore, that eventually Taiwan proceed a step beyond the application of micro-electronics to industry, as is now being planned, and incorporate the design and manufacture of the micro-processors, robotics and associated equipment as well. Interviews with leaders of the diverse Government Agencies responsible for the intended restructuring operation, indicated reliance on the compensation mechanism described earlier.

Quantification of the labour shift between sectors is not available; indeed any such assessment, at this point, of the ensuing employment-redistribution would seem a hazardous undertaking. Yet, in view of Taiwan's impeccable record of full employment and equitable income distribution, it is to be expected that the Government will not neglect this aspect of the operation it is about to implement. Taiwan's past record of adjustment to altered economic circumstances inspires confidence in the country's resilience to overcome the difficulties of tailoring the production system sensibly to both exogenous and endogenous conditions. One indication of level-headedness transpired during high-level consultations, when it was stressed that the "real meaning of automation is to improve productivity and to reduce cost". "Automation fervor" was rejected as an unrealistic fad.[46]

Concretely, one of the most important recent policy decisions so far, has been to build the Hsinchu Science-Based Industrial Park. To the extent that this constitutes a designated zone where industrial investments under special tax arrangements are being encouraged, the park may be looked upon as an extension of the earlier, highly successful export processing zones which Taiwan was the first country to introduce.

Curiously, with some stretch of the imagination, the concept of confining foreign economic activity to sequestered areas can be traced to an old Chinese tradition of allowing alien traders to establish themselves in "factories", like those of Canton in the 1830's.

Anyway, the world's first contemporary zone of that description came into being in Kaohsiung in the early 1960's. It offered exemption from customs duties, substantial tax concessions and of course, low-cost labour. It was soon oversubscribed and in 1970 two further export processing zones, at Nantze and Taichung, were established. By 1980, 70.000 workers were employed in the three zones, foreign

investment amounting to US$300 million and boosting the foreign trade balance from US$7.8 million in 1969 to US$594.6 million in 1979.[47]

As the Government already aimed eventually to graduate from these predominantly simple, labour-intensive operations to sophisticated industry, it caused two technical universities to be founded, as well as, adjacent to these, an Industrial Technology Research Institute.

This complex in 1980 was supplemented with the Science-Based Industrial Park, a concept which was initiated in Japan in the early 1970's, when the Tsukuba Park was built near Tokyo. The Taiwan venture, however, is modelled primarily after the Stanford Industrial Park in California, with which it shares the notion of catalyzing small to medium, high-technology and highly innovating industry. It is hoped that linkages, formed with relevant industry throughout Taiwan, will tend to upgrade component quality.

The Park's marketing department looks all over Europe and the U.S. to find suitable partners; West-Germany and Sweden so far seem to hold most promise, whilst a long-standing relationship is entertained with the U.S..

Ironically, Taiwan's doubtful reputation for piracy, which was deservedly earned in the days when U.S. designed computers such as the "Apple" were copied locally and sold at bargain prices in America, has served to make high-tech firms in that country aware of the potential capabilities which are cheaply available. Anyway, there are substantial incentives to invest in the Park; a consecutive 5-year tax holiday within the first nine years of operation; a 22% tax ceiling thereafter; a 49% participation by the Government which the investor has the option to buy back, and a 5-year free rental of land. Investors must, however, meet some rather strict requirements, laid down in the Statute, such as the production of goods which have potentiality for development and innovation, the establishment of a sizeable research department to engage in high-level innovation, research and development activities, and the obligation to introduce or train advanced technology personnel.

Priority is accorded investors in the field of electronics and information, precision instruments and machinery, high technology material science, energy science and biological engineering. At the time of this writing, 46 firms had been approved with a total investment of US$76.046.500 and 3200 staff were employed. Output by the end of 1983 is estimated to rise to US$100 million, which would yield a low capital-output ratio of 0.76 and a high capital-labour ratio of US$24.000.

Since not all firms have actually come on stream, these figures are, however, provisional. Current products include computers, semi-conductor devices, micro-processors, silicon wafers, laser components, ultra-sonic scanners and robots.

Very-Large-Scale-Integration research as well as robot design is being undertaken by the Industrial Technology Research Institute on the compound. The ITRI-E Robot has meanwhile been transferred for production to private industry; the ITRI-L Robot is being completed and further robots for small piece processing, conveying, welding and spray painting are scheduled to be completed by 1987.

Taiwan's chances in this field would seem to derive from the high degree of flexibility inherent in micro-processor guided production. Gone are the days when break-even points in mass production were achieved only after a veritable avalanche of items had been produced. The small, custom-made batch now is hardly more costly to produce than the mass-made series. An almost artisan-type activity, undertaken in small, specialized, yet fully automated factories, can be profitably pursued. The shortness of the product life-cycle: two years for an electronic calculator against fifteen for the mechanical version, may be a further advantage, since the proximity of the innovative reservoir renders rapid innovation feasible.

To some extent, Taiwan may still have a wage-level edge on other countries, in that any labour-intensive sequences of the production process, whether up-or downstream, that remain, will incur relatively low cost. So long as handling, packing, storing and transportation cannot or, cost-wise, need not be fully robotized, they still require labour, for instance in what are called first generation innovations, which incorporate micro-electronics into existing systems of production, but leave parts of the process unaffected.

The important asset here is, however, highly skilled labour. In the literature on the transfer of technology, the term "critical threshold" is used to indicate the minimum of technological competence required to render the adoption and implementation of a technique successful. Similarly, the 1979 U.N. conference on Science and Technology denoted "indigenous capacity" the major element of development activity in the forthcoming decade.

The University and the educational system in general was enumerated among the primary conditions for evoking technologies, geared to the particular country's special needs. Clearly, a country which has created her own facilities for the manufacture of micro-electronics, will have considerable advantage over countries

which, at best, can bargain for a package. For one thing, the rapid onset of technical obsolescence renders any turn-key investment precarious; even if the ignorant purchaser is not palmed off with previous generation equipment, (parts of) acquired equipment will become so, given only a short time. Even Japan has had to accept American gadgets in the form of "black boxes" that must be installed with the seals intact. X-raying of such equipment, ostensibly to check for damage sustained during shipment, is contractually forbidden.[48] Multinationals dominating the industry jealously guard their secrets. Hence, reverse engineering, this time-honoured method of the technological late-comer, is not readily feasible, the structure of micro-electronics devices being too complex to unravel without prior knowledge, which rests with the designer. For the uninitiated, it will be very difficult, if not totally intractable, to beat the advanced industrial nations at the electronics game The 1981 United Nations Conference in Tokyo referred to earlier, rightly concludes that a "full knowledge of the systems involved will require basic scientific education".[49]

BRAIN BREEDING AND BRAIN-DRAIN

Such education, whether through tradition or foresight, has been made available in Taiwan for many years. China, of course, since the Tang dynasty has known the competitive examination system and sinologists stress the Confucianist tendency to self-improvement, which inspires a zeal to learn.

In Japan, too, great store is set by education and in the 1930's the Japanese colonial administration initiated an intensive program to educate the Taiwanese. After Restoration, educational facilities were increasingly extended to the countryside, so that now over 90% literacy among the population has been reached, which, considering the ideogrammatic multiplicity of the written language, is a most commendable achievement.

Tuition is low and the number of students in secondary education has increased from 1.71% to 8.98% of the population between 1950 and 1980. The science and the mathematics curriculae in these schools strike the foreign observer as very rigorous. Some 25% of graduates prepare for the exacting college entrance examinations and, again between 1950 and 1980, the percentage of the population enrolled in higher education increased from 0.12% to 1.92%.[50]

For the purpose under discussion: the upgrading of Taiwan's technological know-how, the number of natural science and engineering graduates is obviously

of interest. These figures are given in Table VII. The consulting group of the Bank of America-Asia quotes the number of electrical engineers in 1980 as 4230 and that of electronic engineers as 3715.

This figure compares favourably with Korea, which had 1339 and 1007 respectively and Hong Kong with 187 and 243. The statistics for Singapore do not distinguish the categories, but the total number given is 832. On the occasion of the fifth Board Meeting of the Advisors for Science and Technology in April 1983, educational reforms were discussed to enhance programs in (basic) science and technology and to gear them to the new development goals. It was suggested that the faculty salary and promotion system be made more flexible, to motivate achievement in teaching and research. Also, loans extended to students are to be improved; non-permanent, interdisciplinary research centers will be established to link graduate education with post-doctoral research. If the centers' performance merits, they may be reorganized into permanent institutes. Graduate programs in science and technology are to be strengthened at selected universities and the number of graduate students augmented, so that within 5 to 10 years there be a 1:2 ratio of graduate students to undergraduates. It was even suggested that for students of outstanding ability in science, the university entrance exam be waived.

Some of these reforms are already being implemented and even if only past performance be maintained, the output of the university system can be termed satisfactory.

By international standards, this last assessment does not hold for the graduates' remuneration, which according to the Industrial Development Bureau is a mere 20-25% of the U.S. average, while the workweek was estimated at 60 hours. Some absolute figures could be obtained from the Hsinchu Science-Based Industrial Park, which quoted U.S.$3.600-5.500 for a technician, US$4.500.- 10.000 for a supervisor and US$7.500.- 20.000 for a department head.

Many Taiwanese pursue a part of their studies abroad, their numbers increasing from 978 in 1961 to 2558 in 1971 to 5363 in 1981. In light of the above discussion, it is not surprising that a considerable number of these students do not return to be employed in Taiwan, whilst those who have not earned a foreign degree, but hold one from a local reputable university are tempted to emigrate (see Table VIII). Taiwan shares this problem with other Third World countries; it is generally referred to as the "brain-drain".

Table VII: The Number of Natural Science & Engineering Graduates

Year	Natural Science	Engineering	Total
1971	10,464	49,886	60,350
1972	12,051	55,705	67,756
1973	13,324	65,944	79,268
1974	15,030	76,057	91,087
1975	14,481	84,425	98,906
1976	13,796	87,823	101,619
1977	14,473	93,625	108,098
1978	14,537	98,336	112,873
1979	15,141	103,027	118,168
1980	15,428	109,843	125,271
1981	15,336	115,186	130,522
1982	24,379	120,441	144,820

Source: Taiwan Statistical Data Book (1982).

Table VIII: Rate of Outflow of College Graduates 1966–1980

	(1) Rate of Outflow* (%)	(2) Rate of Returned Students** (%)
1966	26.5	6.2
1967	24.6	6.2
1968	20.9	6.8
1969	23.8	6.6
1970	12.1	19.8
1971	14.9	14.2
1972	11.5	16.5
1973	9.9	22.6
1974	10.2	21.3
1975	9.4	24.7
1976	13.7	19.8
1977	12.9	16.2
1978	16.0	12.2
1979	19.0	8.2
1980	18.3	10.8

*Ratio of number of students approved for going abroad to number of graduates from Colleges and Universities.

**Ratio of number of returned students to number of students approved for going abroad.

Source: Educational Statistics of the Republic of China 1981, pp. 25, 32-34, 36-37.

The Government so far has adopted a laissez-faire attitude, allowing graduates to emigrate at will and making no attempt to coerce those who studied abroad to return. The policy which is now contemplated to attract overseas Taiwanese scientists by offering special arrangements, may conceivably invoke temptation for thus far sedentary graduates, to emigrate in order to induce their rerecruitment on more favourable terms. Raising tuition to offset the financial loss to Taiwan when graduates in whom considerable public funds have been invested emigrate, may equally motivate study at foreign State universities that charge only token fees.

On the other hand, anyone who visits the institutions mentioned in this text and talks to staff, concludes that there is a constant return flow of talent of overseas Chinese who, for whatever personal reasons, prefer to live and work in their home country. The present policy of workshops and seminars where likely talent is invited, may induce many a Taiwanese scholar to resettle in the island, where, if not financial betterment, at least a professionally desirable position may be in the offing.

Seeing that all in all, some 19.000 people are now engaged in research activities alone, of whom 8% have Ph.D. degrees, 16.3% MA degrees and 47.3% BA degrees, while the rest are qualified supporting workers, and considering also the substantial research program which is being undertaken, the conclusion seems valid that at least the critical minimum mass of expertise is there to provide the leverage for further technological advance.

DEAD RECKONING FOR FUTURE LIFE

One motivation to study (economic) history, apart from learning its lessons, is based on the linearity assumption: to forecast what the future holds in store and, a fortiori, to influence trends in a desired direction, understanding of the past is expedient. Taiwan's record of economic growth, set forth in previous paragraphs, has been far too solid and sustained for it to have been a transitory aberration, caused by what one observer called "an extraordinarily favourable international situation". [51] In 1952 Taiwan was as poor as any other Asian country: her population was badly nourished, death rates were high and disease widespread. The city's streets were unpaved, the housing ramshackle and the sewers open gutters. Public transport was by pedicab. While this description still fits other parts of Asia or, for that matter, just about the entire Third World, Taiwan pulled herself up from abject poverty and now ranks among the newly industrializing countries.

Deceleration of development occurred not because a one-track growth path had run its course but because consecutive oil shocks and a world recession affected Taiwan's economy. Even so, if just the more modest growth rates to which she has been reduced can be maintained, in the following decade Taiwan may enter the lower reaches of the World Bank's industrial countries category and be classified as a fully-fledged market economy.

One of the prime movers of Taiwan's economy was identified in the preceding pages, namely technical progress. Classical economic theory already recognized that, should technology remain stationary, the rate of return to capital would eventually approach zero and neither net saving nor net investment would occur.

Technical advance in that line of reasoning was relied upon to initiate a breakthrough, so that, to use a medical simile, another systole could follow the diastole.

A policy to that end implies an element of what has been derisorily called "betting on the strong".

Such policies have been critized for their reliance on the trickling-down mechanism to get the lower income strata to participate in the increased prosperity. In the majority of developing countries, the mechanism has been shown not to operate.[52] In Taiwan, however, the lower strata not only benefited from the general economic improvement, there are strong indications that their income increased proportionately faster, so that income distribution became more equitable. A very healthy savings and investment rate was sustained and directed, by market forces, but also at the Government's instigation, towards the momentarily most promising investment opportunity. While in the established industrial economies, Government interference in the industrial restructuring process has often taken the form of "bailing-out" ailing sectors in the interest of employment preservation, Taiwan's Administration has tended to support the potential leaders, withholding special treatment for the ones that fall behind: micro-electronics versus textile are a case in point.

Meanwhile in the new Four Year Plan, which basically is no more than an indicative exercise, "less Government intervention and more private participation" is called for, which should please those who have criticized the Government in the past for interfering too much and who have questioned the validity of the capital-intensive course now fostered. I. M. D. Little, for instance, wonders "whether the price-mechanism will not achieve greater capital-intensity more efficiently than deliberate industrial engineering". In a review of Little's publication, S. Ho voices affinity with

that view. "This warning is one that policy makers in Taiwan and elsewhere will do well to heed". [53]

The general pronouncement about "elsewhere' is a little hard to contest; but where Taiwan is concerned there is room for disagreement. For one thing, when it comes to major decisions whenever exogenous conditions necessitated a reorientation, the Government cannot be said to have stood idly by, while private initiative took the lead. Thus, the shift from inward to outward direction, the consecutive push of, respectively, processed foods, textiles, plastics and so forth, demonstrably have been launched by agencies in charge, whether in connection with aid-disbursement or otherwise. The submissive manner in which garment makers and shoe manufacturers follow foreign clues, a trait which can be observed throughout Taiwanese designs and products, does not justify the notion that entrepreneurial innovation would pour forth so soon as the Government would care to unfetter private enterprise.

Taiwanese manufacturers, in fact, tend to not even handle their own trade but to look to Japanese business to market their goods for them. It is true that Taiwan producers operate on a small scale, but that makes it more unlikely that they possess the expertise to properly perceive and to interprete international market signals and competently select the few areas most suited for Taiwanese industrial potential. Any weakness in market reconnaissance is a crucial shortcoming for a country whose foreign trade constitutes 98% of GNP.

The present mix of responsibilities whereby the Government broadly identifies the growth sector and provides incentives to local or foreign entrepreneurs who wish to exploit earmarked opportunities, seems a suitable solution to the question of who is entitled to formulate what strategy. If Japan is to be held out as an example for Taiwan- and the model is often implicit in the latter's policies- critics of Taiwan's Government intervention may be reminded of J. C. Abegglen's coinage of the term "Japan Inc.", indicating Tokyo's decisive role in guiding private business in what can safely be called a successful manner.

M. Moritani of the Nomura Research Institute has demarcated five stages in Japan's recent technological development, whose consecutive phasing in, and if altered conditions made it desirable, phasing out, was largely MITI's responsibility.

This redoubtable Institution, whose full name is the Ministry of International Trade and Industry, on the basis of long-term projections for various sectors of the economy and assessment of optimal production scales for relevant plant facilities,

induces private firms to produce suitable equipment and undertakes to shelter them while they go forward.

On the other hand, disinvestment may equally be propagated, as is illustrated by the policy pursued after 1973, when energy-intensive industries such as aluminium refining were confronted with a program amounting to their elimination. Earlier on, the labour-intensive textile industry had similarly fallen from grace and, by flooding the Japanese market with cheap imports, was forced out of low value-added lines, or out of business altogether. Japan's example is enlightening also, because Taiwan may meet the same obstacles along her growth path as does that country. The aggressive export policy, which has become known as the "Eastasian Model" is not appreciated by manufacturers in EEC countries and the U.S., where a steady inflow of such items as clothing, shoes and electronics is making it increasingly difficult for local industries to retain a market share above their break-even point output level. Since the recession is already playing havoc with consumer markets, unemployment regionally attaining 1930's magnitudes, thus far dormant protectionist spirits are being awakened and pressure is brought to bear on governments to thwart onerous imports. Various observers, having analyzed the situation, arrive at the conclusion that further expansion of (NI)-LDC exports to these parts of the world entailing even deeper market penetration, will not be feasible, as the saturation point is judged to be near.[54] It would seem, therefore, that Taiwan's search for a likely market gap needs to be extended to countries which have not as yet attained technological maturity. This, in fact, is a phenomenon which can be interpreted as proof that her economy is approaching the fully-fledged industrial level of the West, whose industries have equally come to rely on LDC markets. A study of employment effects of North-South trade under the auspices of the International Labour Office, has yielded the surprising result that more workplaces in European countries were gained through exports to LDC's than were lost through imports from LDC's. For U.S. employment, similarly, no less than 2 million jobs, one of eight in manufacturing, were found to be associated with production for export to LDC's.[55]

Other than for purposes of hard currency-earnings, there is no reason why NILDC's such as Taiwan should continue to direct export efforts to the industrial nations of the West, seeing that those nations have demonstrated the profitability of exporting the products of their industries to the LDC's.

Also, there is a strong correlation between prosperity in the industrial countries

and LDC export activity to those markets, meaning that pursuance of traditional South-North channels makes NILDC's precariously dependent on the vageries of the industrial business cycle. These considerations have lead W. A. Lewis to suggest that inter-LDC trade, which now amounts to a mere 19% of export of non-Opec LDC's, may take up the slack as trade flows to the industrial countries diminish.[56]

Underdeveloped countries which do not possess much of an industrial base have been importing goods from the West, such as fertilizers, cement and all kinds of machinery. NILDC's could well supply these products instead.

The machine tool industry of Taiwan is a case in point. It is an important sector, producing even in a bad year, such as 1982, a value of US$168.25 million. In the previous year, Taiwan held 18th place in the world for value of machine tool production and 14th place in terms of exports. Almost three-fourth of output is exported, the U.S. being the largest market, taking over 40% of machine tools. Lathes are the mainstay of machine tools, and eleven Taiwan companies have contrived numerically controlled lathes. The Industrial Technology Research Institute meanwhile has developed a robot, the ITRI-L, which is designed to operate in conjunction with two CNC lathes.

Taiwanese engineering products can be offered competitively to less developed countries, in the throes of building their own industry. Interestingly, Taiwan already has found a niche in the world system, exporting precision machine tools to developing countries in Southeast Asia. Factories in those areas are often owned by ethnic Chinese who tend to look to Taiwan for their equipment.

The small size of Taiwan machinery shops constitutes an advantage, in that machines can be custom-made to suit the needs of the user. These needs depend on the availability of labour, energy and raw materials in the country where the equipment will be operated. Excess capacity can be avoided, maintenance simplified and staff operational skills minimized. If local labour regulations do not exact costly safety devices, those are not installed. Turn-key projects comprising complete plants, answering to specifications of clients, have been successfully undertaken in diverse fields such as papermaking and monosodium glutamate production. In 1982 some 60 sets, worth US$31.456.000 were installed, among them plywood, plastics, textiles, cement and can-making plants, South-East Asian countries accounting for 83.6% of the market.[57]

In short, what the Taiwanese machinery products are offering their LDC clients

is appropriate technology. They set an example to Taiwanese industrialists in general in strengthening South-South economic relations, whilst mitigating dependency on the North.

Prosperity, the professed goal of all economic endeavour, is primarily attained through the augmentation of productivity. Technical ingenuity, reinforced by rigourous training, provides the instruments to achieve such augmentation. The act of provision has been called innovation; in the context of the present monograph this mainly means: the amelioration of the tools of industry, so that with lower inputs of labour, energy and raw materials, higher value-added products may fortify Taiwan's relative trade advantage. Since demand elasticity for such commodities continues to be high, increased volume implies increased earnings.

For a small, open economy, bereft of natural resources but endowed with industrial skills and innovative acumen, the policy here envisaged seems the only one to hold out the prospect of securing a fair share of world trade.

Taiwan, in each of her successive stages of development, ever since she adopted an outward-directed stance, has consistently aimed at that objective, having gradually extended and improved her industrial equipment.

All the industrial world now faces the upheaval of the micro-electronics revolution- so does Taiwan. Participation in the vanguard carries potential penalties: exposure to unknown risks, a venture into uncharted territory.

Yet, the position is much preferable to bringing up the rear, as do so many countries of the Third World. If the past record is any pointer, Taiwan's economic future can be viewed with confidence.

SUMMARY

Taiwan's economic performance is well documented and has received worldwide recognition. Growth rates like those registered here in the past 30 years have been achieved by precious few developing countries, or for that matter, developed ones.

The fruits of growth, moreover, have been spread equitably among the population. It is the theme of the present monograph that these targets, which must be deemed desirable for any Third World country, have been achieved though the pursuit of a fairly orthodox economic policy, in which a considered choice of technology kept the growth engine running smoothly throughout the successive stages of inward-,

then outward – directed development.

Although substantial foreign aid initially was received, the amounts as such are demonstrated to have been less crucial than the spirit in which aid was disbursed to strengthen the market economy, through the establishment of mostly small-scale, labour-intensive industry. With hindsight, it can be said that in the early development stage, capitalization strategy was geared to what, in later years, came to be called "appropriate technology".

In the absence of natural resource endowment, the single comparative advantage of cheap labour was exploited, at first to satisfy Taiwan's own needs of consumer goods through import substitution and later, when home markets neared saturation, by offering commodities for export.

Already in that early stage, requirements of product quality and sophistication led to increased capital-intensity, as is evidenced by mutations in the labour-absorption rate and the capital-output ratio. Interviews with entrepreneurs consistently revealed investment decisions which closely followed the principle of substitution: as market prices for the various factors of production shifted, the relative quantity of their application was adjusted accordingly. A new turning point is approached as Taiwan's comparative advantage of a low wage level is thus being eroded, while other less developed countries, by virtue of their slower growth having retained that advantage, offer increasingly fierce competition in world markets. The policy envisaged amounts to a wholesale industrial readjustment, whereby Taiwan's existing plants will be automated and a new industry, manufacturing automation equipment, is to be initiated. Capital intensity, through the application of micro-processors and robotics, in that stage will be further augmented. Inevitably, ensuing labour redundancy will need to be reabsorbed in the new automation industry and in derived-growth sectors elsewhere in the economy.

Apart from a decisive lowering of unit cost, micro-technology will reduce requirements of energy and other resources which Taiwan is lacking. The one vital resource, however, technological know-how, is in relatively satisfactory supply here, although enhancement through upgrading of science and engineering skills is called for, whilst ready availability of such skills can be achieved by inducing reversal of the brain-drain.

Once full-scale application of advanced technology is achieved, output levels will substantially increase. Product diversification may avoid market saturation, but

a redirection of trade flows from developed towards less developed countries commends itself, to offset dependency and to widen Taiwan's future export scope.

NOTES

(1)Figures derived from: *Economic Outlook Conference*, Chung Hua Institution for Economic Research, August 1982. Also: K. T. Li: The State of the Economic Contest; *Industry of Free China*, October 1982. Also: Prospects for Economic Development – Targets and measures; *Industry of Free China*, March 1982.

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(7)The assumption that the second article was written by the same author is inspired by generosity. The argument in both articles is well-nigh identical and occasionally couched in identical terms. Possibly, however, conformity with the prescript Publish or Perish may have moved another author to present a rewrite, on the reasonable assumption that few readers subscribe to both Modern China and the Monthly Review. A. H. Amsden: *Taiwan's Economic History; Modern China*, Vol. 5, no. 3, July 1979, p. 341.

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(16)T. B. Gold: *op. cit.* p. 240, 243 and 246.

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(28)S. W. Y. Kuo, *op. cit.* 1983, p. 225.

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S. Wynn follows much the same argument in the *Monthly Review.* Cp. note 7.

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