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CENTER DISCUSSION PAPER NO. 758

THE TRADE-GROWTH NEXUS IN TAIWAN'S DEVELOPMENT

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The Trade-Growth Nexus in Taiwan's Development

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Abstract

This paper analyzes Taiwan's post-World War II development success as a consequence of the mutually beneficial interactions between its export performance and domestic growth. Not only does trade stimulate growth, but the reverse causality also holds true. Growth enhances trade performance by augmenting domestic response capabilities to new export opportunities, and by stimulating previously dormant demands for goods and services, thereby creating a two-way linkage.

The paper demonstrates that during the 1950s and early 1960s, Taiwan's processed food exports boomed as a result of domestically generated agricultural productivity growth. Next, it shows that as the Taiwanese economy shifted its focus towards export-oriented production during the 1960s, total factor productivity increased, induced by changes in human resource and technology policies. This permitted the rapid growth of labor intensive manufactured exports, stimulated by the surplus of cheap but disciplined labor, combining with simple imported technology and an educational emphasis on secondary, especially vocational, education. Finally, given the depletion of surplus labor in recent decades, the paper shows how exports, via foreign technology and human capital imports, continued to fuel domestic productivity change, and how changes in the micro-economic policy mix and in domestic R&D continued to propel Taiwan's exports by sustaining its international competitiveness.

Keywords: trade-growth linkages, development, Taiwan

The Trade-Growth Nexus
in Taiwan's Development*

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I. Introduction.

There are many convincing arguments in the development literature as to why trade is important for growth. These range from the well-known static gains from trade -- which Samuelson acknowledged to hold as possibly the only proposition in economics both non-trivial and true -- to such dynamic elements as accommodating the vent for surplus of previously idle resources (including labor) and to trade as the critical carrier of both the Smithian and Schumpeterian types of technology change.

But there are equally convincing arguments to be made as to why growth -- more specifically differences in the type of growth -- are critical for trade. These range from such obvious elements as reductions in transport costs, changes in the distribution of income, and breakthroughs in communication and information technology -- all of which likely to stimulate previously dormant demands for goods and services -- to internal

*Paper prepared for the May 3/4, 1996, Cornell Conference on Government and Market: The Relevance of the Taiwanese Performance (1945-1995) to Development Theory and Policy. The help of Amy Hwang of the Economics Institute, Academia Sinica, Taiwan, as well as the research assistance of Paul Hsu, Yale University, are gratefully acknowledged.

human capital and R&D accumulations, which, along with policy change, macro and micro, are likely to enhance the response capability of the domestic economy to growing trade opportunities.

It is for this reason, i.e. the two-way linkage between growth and trade -- that we view the concept of trade as a "leading sector" or the concept of "trade-led growth" to be wide of the mark, even in the case of a relative small country such as Taiwan. We find ourselves much more comfortable with the Kravis view of trade as a hand-maiden of growth, but would add that we also see growth as a hand-maiden of trade. It is useful to recall that the initial stimulus for the remarkable global trade/growth interactions of the 19th century was undoubtedly provided by the transport revolution of the post-1830s -- that it was the good performance of British agricultural productivity, plus domestically generated commercial surpluses, which provided the initial wherewithal for the required infrastructural and industrial expansion. The remarkable post-World War II experience of Taiwan should, we believe, be similarly viewed as the consequence of mutually beneficial trade-growth interactions. As Arthur Lewis has aptly put it, exports should be seen as a lubricant for growth -- and vica versa.

Such mutual interaction, with ill-defined lags, provides a challenge to any Granger causality test. The causal chain which runs from growth to exports must be examined in terms of the overall macro and micro-economic policy environment within which output is being generated, as well as the direct actions, public

and private, affecting the international competitiveness of that output via public and private investments in human capital, R&D, institutions, etc. The causal chain which runs from exports to growth must be examined in terms of the contribution of an overall enhanced level of discipline and competitiveness, as well as the direct contributions of imported human capital and of imported technology embodied in machines, licenses and blueprints, often associated with the direct foreign investment activities of multinational corporations.

The precise nature and impact of these two-way relationships is, moreover, bound to undergo substantial change over time. Section II of the paper is focussed on the 1950s and early 1960s when the Taiwan economy was still dominated by agricultural productivity growth, including a shift from traditional to non-traditional crops and policy changes yielding a boom in processed food exports. Section III focusses on the two-way relationship between total factor productivity (TFP) change, a function largely of domestic macro as well as structural policy change, and the labor intensive manufactured export boom of the 1960s and early 1970s. Section IV demonstrates the growing importance, in recent decades, of foreign technology imports and foreign capital, physical and human, along with domestic R&D and further changes in the micro-economic policy mix, in shaping the quantity and quality of growth and trade. Section V briefly sums up.

II. The Agricultural Growth/Export Nexus.

As is well-known, Taiwan was a major exporter of

agricultural produce to the Japanese motherland in the pre-war or colonial period. Indeed, until the 1930s when Japan, given its increasing domination by the military, came to view Taiwan as a potential secondary industrial base, colonial policy was focussed almost entirely on helping assure Japan of an adequate supply of rice and sugar. Nor did the agricultural revolution on Taiwan begin with post-war land reform and technology change; it had its institutional roots in the earlier (1905) redistribution of land and its technological roots in the continuing improvements in agricultural inputs and practices, yielding, for example, the Ponlai variety of rice during the pre-war period. Moreover, contrary to many other colonial experiences, agriculture and rural non-agriculture reinforced each other within a setting in which agricultural technology change and exports were interacting in a mutually symbiotic fashion. Especially relevant here were the modernizing elements within rural non-agricultural activities, or so-called Z-goods, permitting an almost 7% annual growth of industrial output between 1902 and 1938¹. This performance stands in marked contrast to the more "typical" LDC colonial experience under export expansion modelled by Hymer and Resnick² and documented by Resnick³. Colonial demands for

¹See G. Ranis and F. Stewart, 1993, "Rural Nonagricultural Activities in Development: Theory and Application," Journal of Development Economics 40, 75-101.

²S. Hymer and S. Resnick, 1969, "A Model of An Agrarian Economy with Nonagricultural Activities," The American Economic Review 59, 493-506.

³S. Resnick, 1970, "The Decline of Rural Industry under Export Expansion: A Comparison Among Burma, Philippines and Thailand, 1870-1938," Journal of Economic History 30, 51-73.

agricultural exports led to policy changes inducing the desired supply response.

As Thorbecke⁴ and Ho⁵ have pointed out, the stage for further, substantially enhanced, agricultural productivity increase in the post-war period was set by the prior Japanese colonial regime's attention to both physical infrastructure, i.e. roads, irrigation and drainage, and institutional infrastructure, i.e. primary education and the farmers' associations, as mutually reinforcing instruments for generating and disseminating new techniques, plus providing credit services. A literacy rate as high as 56% as early as 1950 (see Table 1) is an indication of the substantial human capital input into agriculture which at that time still comprised 48% of national product and more than 50% of the working population. While there persists a good deal of controversy in the literature concerning overall TFP growth in Taiwan, most observers will agree that technology change in agriculture during the 1950s and early 1960s was little short of dramatic by international standards. Indeed levels of total agricultural productivity rose steadily until 1966 (see Figure 1). Here the argument for the causation running mainly from domestically generated productivity change to agricultural export opportunities is unmistakably strong. Agricultural exports, including of the processed variety, grew from \$114 million in

⁴E. Thorbecke, 1979, "Agricultural Development," in W. Galenson, ed., Economic Growth and Structural Change in Taiwan: The Postwar Experience of the Republic of China, Chapter 2, Cornell University Press, Ithaca, N.Y.

⁵Samuel P.S. Ho, 1977, Economic Development of Taiwan, 1860-1970, Yale University Press, New Haven, CT.

Table 1: Literacy Rates, Age 6 and Over, Taiwan, 1950 - 1993

Source: Ministry of Education, ROC. *Educational Statistics, 1995*. p. 29.

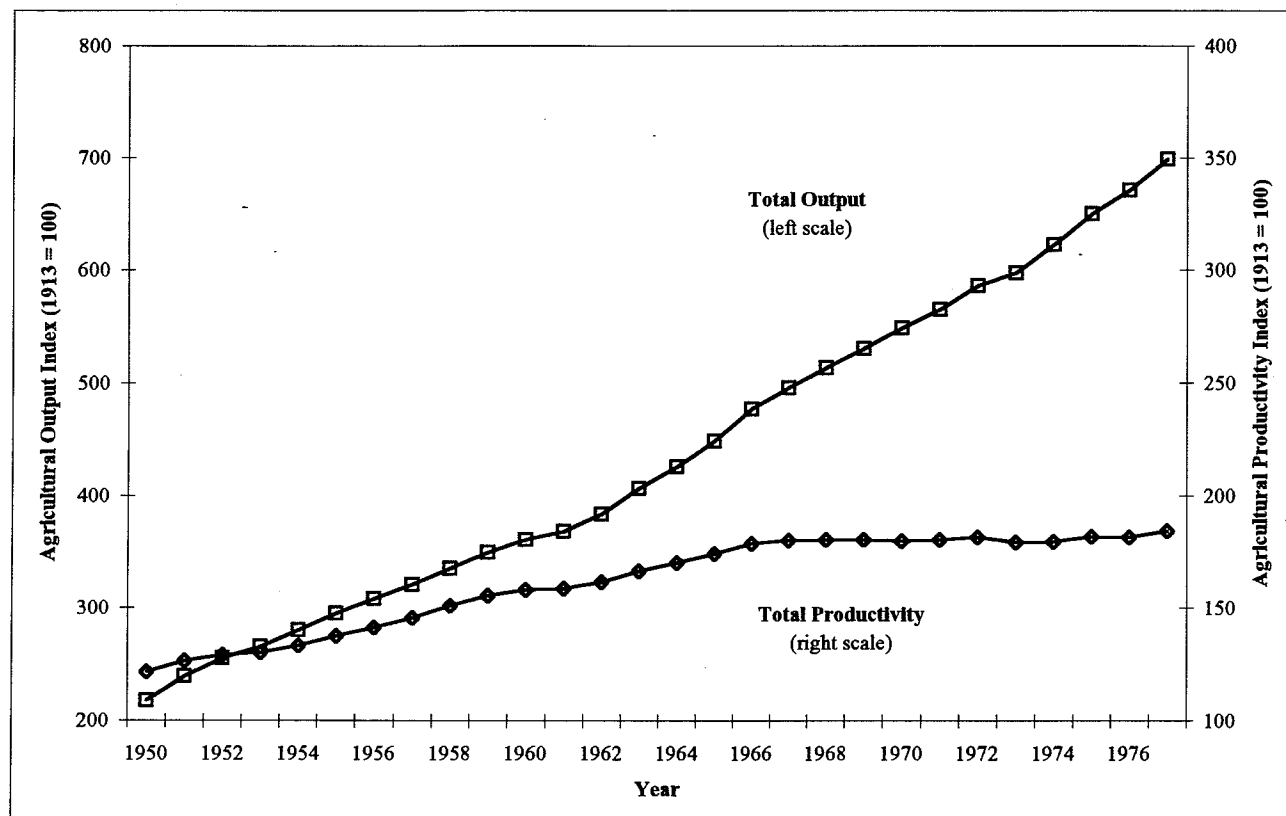
% of Population, Age 6 and Over.

<u>Year</u>	<u>Literacy Rate</u>	<u>Year</u>	<u>Literacy Rate</u>
1950	56.01	1983	90.85
1956	62.88	1984	91.16
1961	74.13	1985	91.54
1966	76.84	1986	91.92
1971	83.17	1987	92.21
1976	87.84	1988	92.57
1977	88.29	1989	92.90
1978	88.76	1990	93.22
1979	89.26	1991	93.59
1980	89.66	1992	93.85
1981	90.12	1993	94.02
1982	90.39		

Figure 1: Agricultural Output and Productivity Indexes, Taiwan, 1950 - 1977

Source: *Taiwan Agricultural Statistics, 1901 - 1965*. JCRR, 1966.

Taiwan Agricultural Yearbook. Taiwan Provincial Dept. of Agriculture and Forestry, annual.
as found in Chen, Yueh-eh, and You-tso Wang. "Secular Trends of Output, Inputs, and Productivity:
A Quantitative Analysis of Agricultural Development in Taiwan."
Conference on Agricultural Development in China, Japan and Korea. Dec. 1980. p. 657 - 8.



1952, comprising about 95% of total exports, to \$289 million in 1966 (see Tables 2 and 3). Moreover, it should be noted that the composition of agricultural output and exports changed dramatically over the years (see Table 4 and Figures 2.1, 2.2 and 2.3), a clear indication of high rates of technology change. We may note a relative decline in the importance of traditional commodities such as rice, tea and sugar, with an expansion of such non-traditional crops as bananas, pineapples, later mushrooms, asparagus and timber (see Table 4). Taiwan was clearly a price taker in all of these items and the sources of productivity change were almost entirely domestic in origin. Between 1954 and 1967 agricultural output grew at 4.4% annually, agricultural exports made up in excess of 70% of total exports, and inorganic and organic fertilizer inputs, associated with technology change, rose at annual rates of 5.7% and 3.3%, respectively.⁶ The rapidly increasing ability to capture foreign markets was clearly a function of increased international competitiveness occasioned by domestic productivity increase.

III. The Labor Intensive Industrial Growth/Export Nexus.

There is no need to detail the well-known major macro policy changes of the late 1950s and early 1960s which permitted Taiwan to shift from import substitution towards an export oriented production and export regime. It is, however, particularly appropriate on this occasion to quote Ian Little: "Much credit must go to T.C. Liu and S.C. Tsiang who first advocated in 1954

⁶Thorbecke, op. cit.

Table 2: Composition of Exports, Taiwan, 1952 - 1971, in US\$ Millions

Source: Compiled from Bank of Taiwan and the Central Bank of China.

found in Lee, T. H. and Yueh-eh Chen. "Diversification of Agricultural Exports."

Agriculture's Place in the Strategy of Development: The Taiwan Experience. T. H. Shen, ed. Taipei, Taiwan: JCRR, 1974. p. 339. Table 1.

A. Non-Agricultural versus Agricultural Exports, In US\$ Millions

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Total Exports	119.5	129.8	97.8	133.4	130.1	168.5	164.4	160.5	169.9	214.0	238.6	357.5	463.1	487.9	569.4	649.9	841.8	1110.6	1561.7	2135.5
Total Non-Agric. Exports	5.3	8.6	7.0	9.0	15.2	13.1	18.8	32.1	48.9	82.1	109.2	139.3	185.5	201.9	280.4	353.0	526.2	768.4	1169.5	1655.4
Total Agric. Exports	114.2	121.2	90.8	124.4	114.9	155.4	145.6	128.4	121.0	131.9	129.4	218.2	277.6	286.0	289.0	296.9	315.6	342.2	392.2	480.1

B. Primary versus Processed Agricultural Exports, In US\$ Millions

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Primary Agric. Exports	33.7	17.7	15.1	40.2	20.1	29.0	40.1	39.5	21.4	34.8	35.5	53.4	75.9	125.0	121.0	125.3	129.6	137.5	168.1	203.1
Rice	23.3	11.4	7.9	32.8	12.8	21.2	28.6	23.5	4.3	10.1	7.4	23.3	18.0	42.9	33.0	19.7	13.9	4.2	2.6	2.9
Bananas	6.6	3.4	4.7	4.0	3.2	3.8	6.2	6.6	6.9	10.6	8.0	8.6	33.3	55.3	52.6	62.0	57.2	59.2	38.1	44.2
Vegetables	0.8	1.1	0.8	0.8	1.3	1.2	1.1	1.6	2.5	4.4	5.7	8.7	9.0	9.2	10.8	16.7	23.6	20.5	31.4	37.2
Sea Products	0.0	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.4	0.4	0.7	1.5	2.2	2.0	7.4	8.7	13.1	24.8	61.4	81.2
Processed Agric. Exports	80.5	103.5	75.7	84.2	94.8	126.4	105.5	88.9	99.6	97.1	93.9	164.8	201.7	161.0	168.0	171.6	186.0	204.7	224.1	277.0
Sugar	69.7	90.3	58.6	67.9	76.1	110.8	84.7	65.9	74.4	61.1	49.6	106.0	135.4	68.0	61.7	43.7	50.8	48.0	47.5	67.3
Tea	5.8	6.9	9.4	5.6	5.1	5.8	6.8	7.1	6.3	8.9	7.9	8.1	8.4	9.7	11.1	12.4	11.7	13.6	14.3	14.2
Pineapples, canned	2.0	2.6	4.0	5.6	6.1	4.4	7.5	8.4	8.5	12.1	10.9	11.6	13.9	19.4	19.3	19.3	19.0	20.7	20.2	22.2
Mushrooms, canned							0.0	0.0	0.2	1.8	8.5	16.2	15.8	20.8	25.2	32.7	32.3	32.3	33.6	47.1
Asparagus, canned											0.0	0.0	0.4	11.1	14.2	24.0	25.4	31.6	33.3	35.0
Fruits, preserved	0.2	0.6	0.0	0.2	0.2	0.1	0.1	0.3	0.9	2.2	2.0	3.3	6.2	7.4	6.4	9.7	9.1	12.1	13.6	16.2
Timber & Lumber	0.0	0.3	0.2	0.7	0.6	0.5	1.9	2.8	2.8	3.7	5.6	9.3	13.6	15.6	23.7	25.2	30.6	42.3	53.9	63.0

C. Traditional versus Non-Traditional Agricultural Exports, In US\$ Millions

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Traditional Agric. Exports	93.0	101.7	66.5	100.7	88.9	132.0	113.3	89.4	78.7	71.2	57.0	129.3	153.4	110.9	94.7	63.4	64.7	52.2	50.1	70.2
Rice	23.3	11.4	7.9	32.8	12.8	21.2	28.6	23.5	4.3	10.1	7.4	23.3	18.0	42.9	33.0	19.7	13.9	4.2	2.6	2.9
Sugar	69.7	90.3	58.6	67.9	76.1	110.8	84.7	65.9	74.4	61.1	49.6	106.0	135.4	68.0	61.7	43.7	50.8	48.0	47.5	67.3
Non-Traditional Agric. Exports	15.4	15.2	19.4	17.2	16.8	16.0	23.8	27.1	28.5	44.1	49.3	67.3	102.8	150.5	170.7	210.7	222.0	257.1	299.8	360.3
Bananas	6.6	3.4	4.7	4.0	3.2	3.8	6.2	6.6	6.9	10.6	8.0	8.6	33.3	55.3	52.6	62.0	57.2	59.2	38.1	44.2
Vegetables	0.8	1.1	0.8	0.8	1.3	1.2	1.1	1.6	2.5	4.4	5.7	8.7	9.0	9.2	10.8	16.7	23.6	20.5	31.4	37.2
Sea Products	0.0	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.4	0.4	0.7	1.5	2.2	2.0	7.4	8.7	13.1	24.8	61.4	81.2
Tea	5.8	6.9	9.4	5.6	5.1	5.8	6.8	7.1	6.3	8.9	7.9	8.1	8.4	9.7	11.1	12.4	11.7	13.6	14.3	14.2
Pineapples, canned	2.0	2.6	4.0	5.6	6.1	4.4	7.5	8.4	8.5	12.1	10.9	11.6	13.9	19.4	19.3	19.3	19.0	20.7	20.2	22.2
Mushrooms, canned							0.0	0.0	0.2	1.8	8.5	16.2	15.8	20.8	25.2	32.7	32.3	32.3	33.6	47.1
Asparagus, canned											0.0	0.0	0.4	11.1	14.2	24.0	25.4	31.6	33.3	35.0
Fruits, preserved	0.2	0.6	0.0	0.2	0.2	0.1	0.1	0.3	0.9	2.2	2.0	3.3	6.2	7.4	6.4	9.7	9.1	12.1	13.6	16.2
Timber & Lumber	0.0	0.3	0.2	0.7	0.6	0.5	1.9	2.8	2.8	3.7	5.6	9.3	13.6	15.6	23.7	25.2	30.6	42.3	53.9	63.0

Table 3: Composition of Exports, Taiwan, 1952 - 1971, as % of Total Exports

Source: Compiled from Bank of Taiwan and the Central Bank of China.

found in Lee, T. H. and Yueh-eh Chen. "Diversification of Agricultural Exports."

Agriculture's Place in the Strategy of Development: The Taiwan Experience. T. H. Shen, ed. Taipei, Taiwan: JCRR, 1974. p. 339. Table 1.

A. Non-Agricultural versus Agricultural Exports, as % of Total Exports

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Total Exports	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total Non-Agric. Exports	4.4	6.6	7.2	6.7	11.7	7.8	11.4	20.0	28.8	38.4	45.8	39.0	40.1	41.4	49.2	54.3	62.5	69.2	74.9	77.5
Total Agric. Exports	95.6	93.4	92.8	93.3	88.3	92.2	88.6	80.0	71.2	61.6	54.2	61.0	59.9	58.6	50.8	45.7	37.5	30.8	25.1	22.5

B. Primary versus Processed Agricultural Exports, as % of Total Exports

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Primary Agric. Exports	28.2	13.6	15.4	30.1	15.4	17.2	24.4	24.6	12.6	16.3	14.9	14.9	16.4	25.6	21.3	19.3	15.4	12.4	10.8	9.5
Rice	19.5	8.8	8.1	24.6	9.8	12.6	17.4	14.6	2.5	4.7	3.1	6.5	3.9	8.8	5.8	3.0	1.7	0.4	0.2	0.1
Bananas	5.5	2.6	4.8	3.0	2.5	2.3	3.8	4.1	4.1	5.0	3.4	2.4	7.2	11.3	9.2	9.5	6.8	5.3	2.4	2.1
Vegetables	0.7	0.8	0.8	0.6	1.0	0.7	0.7	1.0	1.5	2.1	2.4	2.4	1.9	1.9	1.9	2.6	2.8	1.8	2.0	1.7
Sea Products	0.0	0.2	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.5	1.3	1.3	1.6	1.6	2.2	3.9	3.8
Processed Agric. Exports	67.4	79.7	77.4	63.1	72.9	75.0	64.2	55.4	58.6	45.4	39.4	46.1	43.6	33.0	29.5	26.4	22.1	18.4	14.3	13.0
Sugar	58.3	69.6	59.9	50.9	58.5	65.8	51.5	41.1	43.8	28.6	20.8	29.7	29.2	13.9	10.8	6.7	6.0	4.3	3.0	3.2
Tea	4.9	5.3	9.6	4.2	3.9	3.4	4.1	4.4	3.7	4.2	3.3	2.3	1.8	2.0	1.9	1.9	1.4	1.2	0.9	0.7
Pineapples, canned	1.7	2.0	4.1	4.2	4.7	2.6	4.6	5.2	5.0	5.7	4.6	3.2	3.0	4.0	3.4	3.0	2.3	1.9	1.3	1.0
Mushrooms, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	3.6	4.5	3.4	4.3	4.4	5.0	3.8	2.9	2.2	2.2
Asparagus, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	2.5	3.7	3.0	2.8	2.1	1.6
Fruits, preserved	0.2	0.5	0.0	0.1	0.2	0.1	0.1	0.2	0.5	1.0	0.8	0.9	1.3	1.5	1.1	1.5	1.1	1.1	0.9	0.8
Timber & Lumber	0.0	0.2	0.2	0.5	0.5	0.3	1.2	1.7	1.6	1.7	2.3	2.6	2.9	3.2	4.2	3.9	3.6	3.8	3.5	3.0

C. Traditional versus Non-Traditional Agricultural Exports, as % of Total Exports

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Traditional Agric. Exports	77.8	78.4	68.0	75.5	68.3	78.3	68.9	55.7	46.3	33.3	23.9	36.2	33.1	22.7	16.6	9.8	7.7	4.7	3.2	3.3
Rice	19.5	8.8	8.1	24.6	9.8	12.6	17.4	14.6	2.5	4.7	3.1	6.5	3.9	8.8	5.8	3.0	1.7	0.4	0.2	0.1
Sugar	58.3	69.6	59.9	50.9	58.5	65.8	51.5	41.1	43.8	28.6	20.8	29.7	29.2	13.9	10.8	6.7	6.0	4.3	3.0	3.2
Non-Traditional Agric. Exports	17.7	15.0	24.8	17.8	20.0	13.9	19.6	24.3	24.9	28.4	30.3	24.9	26.8	35.9	34.1	35.9	29.8	26.1	21.9	19.2
Bananas	5.5	2.6	4.8	3.0	2.5	2.3	3.8	4.1	4.1	5.0	3.4	2.4	7.2	11.3	9.2	9.5	6.8	5.3	2.4	2.1
Vegetables	0.7	0.8	0.8	0.6	1.0	0.7	0.7	1.0	1.5	2.1	2.4	2.4	1.9	1.9	1.9	2.6	2.8	1.8	2.0	1.7
Sea Products	0.0	0.2	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.5	1.3	1.3	1.6	1.6	2.2	3.9	3.8
Tea	4.9	5.3	9.6	4.2	3.9	3.4	4.1	4.4	3.7	4.2	3.3	2.3	1.8	2.0	1.9	1.9	1.4	1.2	0.9	0.7
Pineapples, canned	1.7	2.0	4.1	4.2	4.7	2.6	4.6	5.2	5.0	5.7	4.6	3.2	3.0	4.0	3.4	3.0	2.3	1.9	1.3	1.0
Mushrooms, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.8	3.6	4.5	3.4	4.3	4.4	5.0	3.8	2.9	2.2	2.2
Asparagus, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.3	2.5	3.7	3.0	2.8	2.1	1.6
Fruits, preserved	0.2	0.5	0.0	0.1	0.2	0.1	0.1	0.2	0.5	1.0	0.8	0.9	1.3	1.5	1.1	1.5	1.1	1.1	0.9	0.8
Timber & Lumber	0.0	0.2	0.2	0.5	0.5	0.3	1.2	1.7	1.6	1.7	2.3	2.6	2.9	3.2	4.2	3.9	3.6	3.8	3.5	3.0

Figure 2: Export Composition, Taiwan, 1952 - 1971

Source: Table 3.

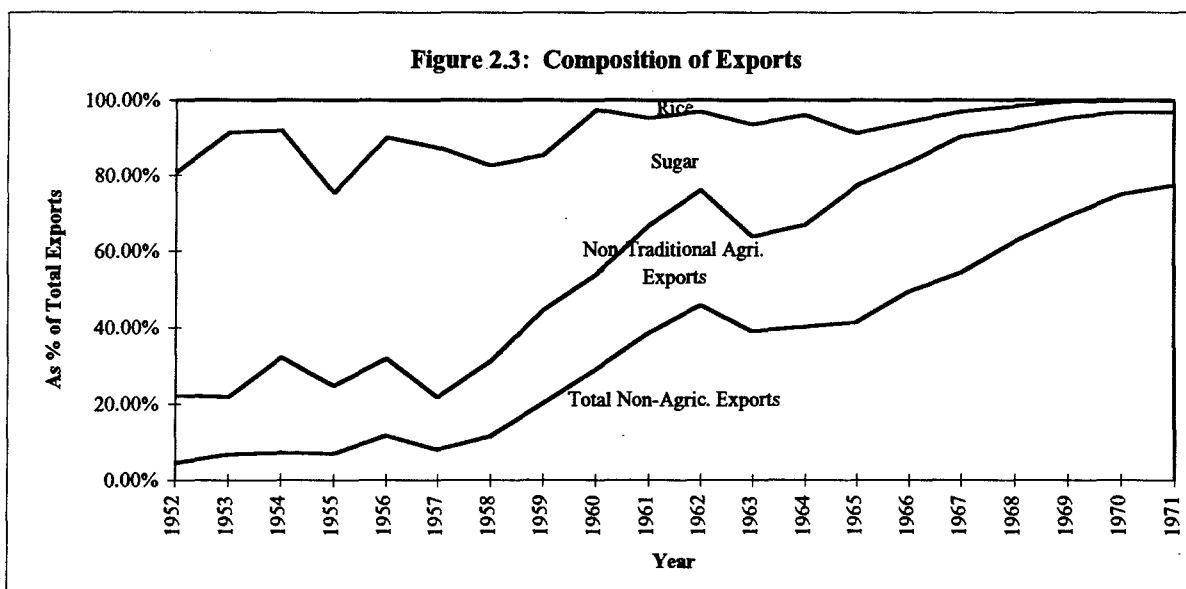
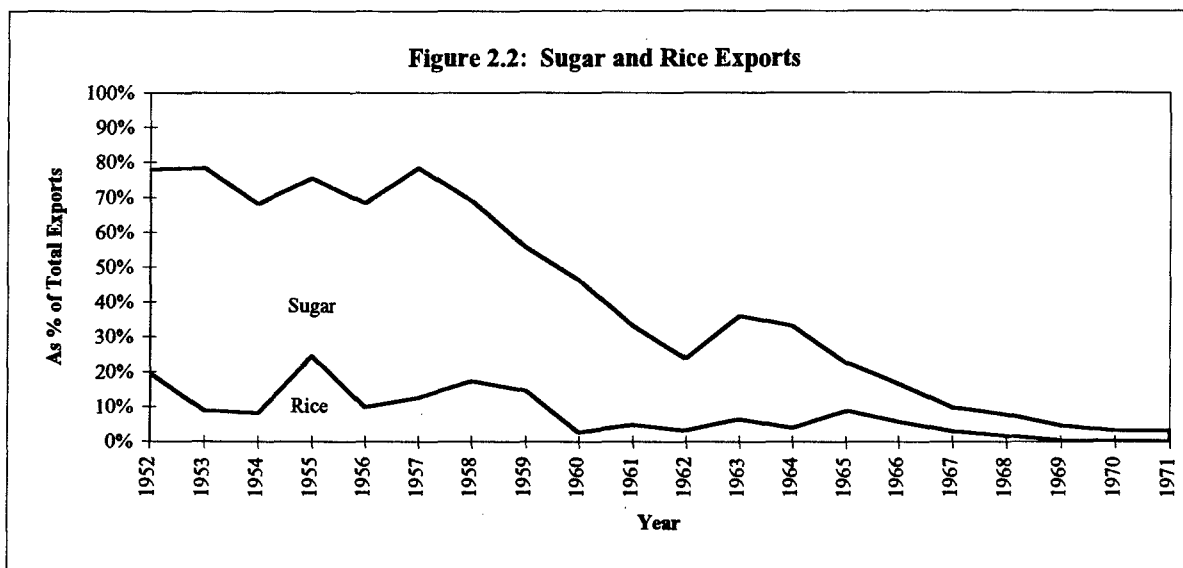
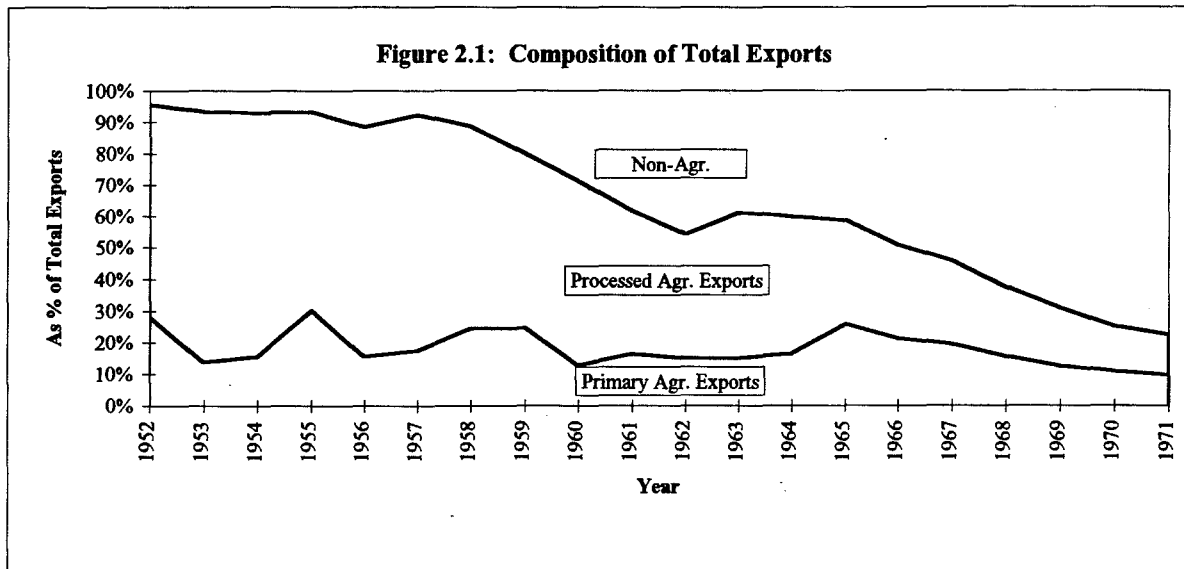


Table 4: Composition of Exports, Taiwan, 1952 - 1971, as % of Total Agricultural Exports

Source: Compiled from Bank of Taiwan and the Central Bank of China.

found in Lee, T. H. and Yueh-eh Chen. "Diversification of Agricultural Exports."

Agriculture's Place in the Strategy of Development: The Taiwan Experience. T. H. Shen, ed. Taipei, Taiwan: JCRR, 1974. p. 339. Table 1.

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Total Agric. Exports	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
A. Primary versus Processed Agricultural Exports, as % of Total Annual Agricultural Exports																				
	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Primary Agric. Exports	29.5	14.6	16.6	32.3	17.5	18.7	27.5	30.8	17.7	26.4	27.4	24.5	27.3	43.7	41.9	42.2	41.1	40.2	42.9	42.3
Rice	20.4	9.4	8.7	26.4	11.1	13.6	19.6	18.3	3.6	7.7	5.7	10.7	6.5	15.0	11.4	6.6	4.4	1.2	0.7	0.6
Bananas	5.8	2.8	5.2	3.2	2.8	2.4	4.3	5.1	5.7	8.0	6.2	3.9	12.0	19.3	18.2	20.9	18.1	17.3	9.7	9.2
Vegetables	0.7	0.9	0.9	0.6	1.1	0.8	0.8	1.2	2.1	3.3	4.4	4.0	3.2	3.2	3.7	5.6	7.5	6.0	8.0	7.7
Sea Products	0.0	0.2	0.3	0.2	0.3	0.1	0.1	0.2	0.3	0.3	0.5	0.7	0.8	0.7	2.6	2.9	4.2	7.2	15.7	16.9
Processed Agric. Exports	70.5	85.4	83.4	67.7	82.5	81.3	72.5	69.2	82.3	73.6	72.6	75.5	72.7	56.3	58.1	57.8	58.9	59.8	57.1	57.7
Sugar	61.0	74.5	64.5	54.6	66.2	71.3	58.2	51.3	61.5	46.3	38.3	48.6	48.8	23.8	21.3	14.7	16.1	14.0	12.1	14.0
Tea	5.1	5.7	10.4	4.5	4.4	3.7	4.7	5.5	5.2	6.7	6.1	3.7	3.0	3.4	3.8	4.2	3.7	4.0	3.6	3.0
Pineapples, canned	1.8	2.1	4.4	4.5	5.3	2.8	5.2	6.5	7.0	9.2	8.4	5.3	5.0	6.8	6.7	6.5	6.0	6.0	5.2	4.6
Mushrooms, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.4	6.6	7.4	5.7	7.3	8.7	11.0	10.2	9.4	8.6	9.8
Asparagus, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.9	4.9	8.1	8.0	9.2	8.5	7.3
Fruits, preserved	0.2	0.5	0.0	0.2	0.2	0.1	0.1	0.2	0.7	1.7	1.5	1.5	2.2	2.6	2.2	3.3	2.9	3.5	3.5	3.4
Timber & Lumber	0.0	0.2	0.2	0.6	0.5	0.3	1.3	2.2	2.3	2.8	4.3	4.3	4.9	5.5	8.2	8.5	9.7	12.4	13.7	13.1
B. Traditional versus Non-Traditional Agricultural Exports, as % of Total Annual Agricultural Exports																				
	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Traditional Agric. Exports	26.2	12.2	13.9	29.6	13.9	16.1	23.9	23.4	9.3	15.7	11.9	14.6	18.5	34.3	29.6	27.5	22.5	18.5	10.4	9.8
Rice	20.4	9.4	8.7	26.4	11.1	13.6	19.6	18.3	3.6	7.7	5.7	10.7	6.5	15.0	11.4	6.6	4.4	1.2	0.7	0.6
Sugar	5.8	2.8	5.2	3.2	2.8	2.4	4.3	5.1	5.7	8.0	6.2	3.9	12.0	19.3	18.2	20.9	18.1	17.3	9.7	9.2
Non-Traditional Agric. Exports	7.0	8.8	15.3	10.0	10.7	7.1	11.3	14.7	15.8	22.1	27.5	22.9	21.8	30.1	37.1	44.5	44.7	51.8	58.7	58.1
Bananas	5.8	2.8	5.2	3.2	2.8	2.4	4.3	5.1	5.7	8.0	6.2	3.9	12.0	19.3	18.2	20.9	18.1	17.3	9.7	9.2
Vegetables	0.7	0.9	0.9	0.6	1.1	0.8	0.8	1.2	2.1	3.3	4.4	4.0	3.2	3.2	3.7	5.6	7.5	6.0	8.0	7.7
Sea Products	0.0	0.2	0.3	0.2	0.3	0.1	0.1	0.2	0.3	0.3	0.5	0.7	0.8	0.7	2.6	2.9	4.2	7.2	15.7	16.9
Tea	5.1	5.7	10.4	4.5	4.4	3.7	4.7	5.5	5.2	6.7	6.1	3.7	3.0	3.4	3.8	4.2	3.7	4.0	3.6	3.0
Pineapples, canned	1.8	2.1	4.4	4.5	5.3	2.8	5.2	6.5	7.0	9.2	8.4	5.3	5.0	6.8	6.7	6.5	6.0	6.0	5.2	4.6
Mushrooms, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.4	6.6	7.4	5.7	7.3	8.7	11.0	10.2	9.4	8.6	9.8
Asparagus, canned	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.9	4.9	8.1	8.0	9.2	8.5	7.3
Fruits, preserved	0.2	0.5	0.0	0.2	0.2	0.1	0.1	0.2	0.7	1.7	1.5	1.5	2.2	2.6	2.2	3.3	2.9	3.5	3.5	3.4
Timber & Lumber	0.0	0.2	0.2	0.6	0.5	0.3	1.3	2.2	2.3	2.8	4.3	4.3	4.9	5.5	8.2	8.5	9.7	12.4	13.7	13.1

and continued to advocate ... the policies that were at last largely put into effect in 1959."⁷ Actually, as early as 1955 the system of rebates of indirect taxes for exports was put in place, followed by exchange rate unification and a series of devaluations in the 1958 to 1960 period, accompanied by the elimination of direct controls on trade, and a bit later by the establishment of export processing zones and bonded factories. Thus, while the rest of the Taiwan economy remained protected for some time to come, i.e. tariffs were not radically lowered until much later, the incentives for import substitutes and exports were more or less equalized on average, even if not for every industrial activity. Accompanied by approximate budgetary balance and a fairly restrictive monetary policy, these changes provided the backdrop for a dramatic shift in both output and export mixes accompanying an equally dramatic increase in the relative importance of exports relative to GDP. During the 1960s and early 1970s total exports grew almost 30% a year, compared to about 12% a year in the 1950s. Most pronounced was the shift from agricultural or land-based to industrial or labor-based exports, concentrated initially in textiles, synthetic fiber, apparel, wood, and leather products (see Table 5).

During this sub-phase of transition growth we undoubtedly witnessed the emergence of a genuinely two-way nexus between the two mutual handmaidens of domestic growth and export performance.

⁷Ian M. D. Little, 1979, "An Economic Reconnaissance," in W. Galenson, ed., Economic Growth and Structural Change in Taiwan: The Postwar Experience of the Republic of China, Chapter 7, Cornell University Press, Ithaca, NY.

Table 5: Export Composition by Commodity Classification, Taiwan, 1952 - 1994Source: CEPD. *Taiwan Statistical Data Book 1995*. p. 194 - 195.**As % of Total Annual Exports**

Year	Total	Food, Beverage, & Tobacco Preparations	Textile, Leather, Wood, Paper & Related Products	Non-metallic Mineral Products	Chemical & Pharmaceutical Products	Basic Metals	Metal Products	Machinery	Electrical Machinery & Apparatus	Transportation Equipment	Others
1952	100.00	83.62	0.86	0.00	3.45	0.86	0.00	0.00	0.00	0.00	11.21
1955	100.00	84.55	2.44	0.00	3.25	1.63	0.00	0.00	0.00	0.00	8.13
1960	100.00	58.54	17.07	1.83	4.88	3.66	0.61	0.00	0.61	0.00	12.80
1965	100.00	39.11	26.22	3.11	4.44	3.56	1.11	1.33	2.67	0.44	18.00
1966	100.00	30.22	29.66	4.85	4.10	3.92	1.68	2.24	4.85	0.37	18.10
1967	100.00	25.90	34.17	4.99	4.37	3.43	1.56	2.34	6.08	0.62	16.54
1968	100.00	16.49	29.08	2.76	2.29	1.72	1.14	2.10	7.34	0.57	36.51
1969	100.00	12.56	28.83	1.89	2.03	2.09	1.15	2.23	7.97	0.74	40.51
1970	100.00	9.37	30.34	2.48	1.75	3.16	1.36	2.33	8.83	0.63	39.76
1971	100.00	7.86	31.12	2.14	1.27	1.97	1.31	2.21	8.90	0.77	42.44
1972	100.00	7.03	24.49	0.80	1.29	2.21	1.25	1.18	11.84	1.41	48.49
1973	100.00	7.75	31.48	0.89	1.38	1.40	1.61	2.31	13.97	1.86	37.35
1974	100.00	12.02	37.80	1.26	2.83	2.56	2.73	4.39	14.24	2.49	19.68
1975	100.00	7.30	24.44	0.62	1.98	1.49	1.62	2.35	9.58	1.40	49.22
1976	100.00	7.26	33.21	1.07	2.98	1.43	2.60	3.11	13.64	2.12	32.58
1977	100.00	6.00	24.02	1.22	2.90	1.02	2.55	2.65	11.74	2.59	45.31
1978	100.00	6.05	25.90	1.34	3.45	2.00	3.13	2.79	13.10	2.65	39.58
1979	100.00	5.59	26.38	1.37	3.34	2.95	3.51	3.07	14.01	2.25	37.53
1980	100.00	5.90	27.21	1.69	3.59	1.76	3.81	3.29	15.92	2.84	33.99
1981	100.00	5.30	30.65	2.07	4.42	2.27	4.74	4.24	18.78	3.89	23.64
1982	100.00	4.83	26.20	1.92	4.03	2.64	4.06	3.36	15.57	4.33	33.07
1983	100.00	4.03	23.71	2.00	3.43	2.29	4.45	3.17	15.93	3.36	37.64
1984	100.00	4.23	27.55	2.30	4.05	2.40	5.66	3.72	21.42	3.93	24.74
1985	100.00	4.49	27.57	2.14	4.36	2.48	5.79	4.00	20.99	4.10	24.07
1986	100.00	4.89	26.58	1.98	3.71	1.76	5.92	4.01	22.35	4.39	24.40
1987	100.00	4.68	24.55	2.15	3.28	1.40	6.01	4.43	25.14	4.42	23.94
1988	100.00	3.88	22.32	2.06	4.04	2.17	5.75	5.26	27.44	4.16	22.94
1989	100.00	3.61	22.29	1.81	4.17	2.26	5.98	5.81	27.32	4.56	22.21
1990	100.00	3.46	20.59	1.66	4.46	2.03	6.02	6.30	26.61	5.11	23.76
1991	100.00	3.63	20.45	1.53	4.72	1.83	6.25	6.44	26.60	5.07	23.49
1992	100.00	3.26	17.52	1.49	4.84	1.78	6.51	7.03	27.28	4.97	25.31
1993	100.00	3.16	16.15	1.26	5.20	2.08	6.65	7.31	22.46	5.16	30.57
1994	100.00	3.05	16.18	1.09	5.78	2.17	6.67	6.97	22.49	4.16	31.44

As Riedel emphasizes⁸, both growth and exports depend on investment and technology change, with the proportions, of course, debatable. In the case of Taiwan there clearly existed an initial vent for surplus in the form of labor which permitted unit labor costs in food processing, an initially important export industry, to ultimately lag behind the trend in manufacturing; until the late 1970s this relative advantage shifted to apparel and textiles and electronics, as well as, somewhat surprisingly, to industrial chemicals which are, however, not significant. Unfortunately unit labor cost data for the earlier period were not available (see Table 6 and Figure 3).

A shift in educational priorities over time should be noted here, with primary education giving way to secondary, including vocational education, in the mid-1960s. Indeed, compulsory education was raised from 6 to 9 years, with the first harbingers of unskilled labor shortage being experienced at the end of the 1960s. Overall, expenditures on education rose from 2.1% of GNP and 11% of the budget in 1955 to 4.6% of GNP and 20% of the budget by 1970. We may note the decline in the share of primary in total education expenditures from the outset and that the rise in the share of higher education was postponed until the 1980s (see Table 7). Expenditures on education per student increased six-fold between 1960 and 1975. The early signs of labor shortage also led to a much increased emphasis given to vocational, as opposed to academic, training at the secondary

⁸J. Riedel, 1984, "Trade as the Engine of Growth in Developing Countries, Revisited," Economic Journal, 94.

Table 6: Indexes of Unit Labor Costs of Manufacturing Establishments in Taiwan, 1974 - 1994

Source: DGBAS, Executive Yuan, ROC.

Monthly Bulletin of Earnings and Productivity Statistics, Taiwan Area, Republic of China. June 1995. Page 132 - 133.

*Source: CEPD. *Taiwan Statistical Data Book 1995*. Page 3.

Seasonally Adjusted, 1974 = 100.

Year	Manufacturing	Food	Textile	Apparel &	Industrial	Chemical	Rubber	Electrical &	Inflation Figures * (1974 = 100)	
		Manufacturing	Mill Products	Textile Products	Chemicals	Products	Products	Electronic Equip.	Consumer Prices	Wholesale Prices
1974	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.0	100.0
1975	105.01	102.31	93.23	114.11	94.85	106.18	131.23	112.25	105.1	95.0
1976	110.62	94.39	111.94	94.66	83.67	111.06	139.97	130.23	107.8	97.5
1977	127.05	111.08	127.68	114.11	83.87	128.52	180.39	141.37	115.4	100.3
1978	123.83	115.82	114.04	102.81	88.93	128.40	203.38	118.04	122.1	103.8
1979	146.60	125.99	141.20	110.33	99.30	153.80	227.90	143.14	133.9	118.1
1980	177.26	171.24	153.81	118.35	108.24	220.74	272.59	167.16	159.6	143.6
1981	203.60	190.18	187.12	143.96	113.31	249.23	329.59	168.63	185.5	154.6
1982	224.75	201.61	223.33	167.05	122.73	258.90	357.20	176.46	191.1	154.4
1983	222.20	194.28	227.45	186.36	105.96	260.57	368.22	167.47	193.5	152.5
1984	240.61	228.55	244.50	204.70	119.52	251.08	394.49	176.80	193.5	153.1
1985	253.05	228.34	258.57	202.57	124.71	258.71	381.83	191.33	193.3	149.2
1986	253.88	250.79	258.83	218.06	117.66	255.19	417.08	178.32	194.6	144.3
1987	257.80	253.77	268.64	224.19	128.08	243.36	410.33	171.77	195.5	139.5
1988	277.13	263.14	313.99	272.39	144.69	262.92	456.41	182.08	198.2	137.3
1989	293.68	306.31	306.95	282.69	155.04	281.83	487.98	197.87	206.9	136.9
1990	311.64	339.78	293.87	329.96	157.33	298.89	465.54	208.76	215.4	136.0
1991	318.98	350.75	291.97	356.25	158.81	309.02	496.52	210.53	223.2	136.2
1992	334.58	373.80	306.92	405.20	147.53	314.15	484.91	218.65	233.3	131.2
1993	348.96	391.20	334.60	479.30	155.22	331.15	541.46	219.54	240.0	134.6
1994	357.89	399.61	329.08	598.54	125.15	340.88	587.44	221.62	249.8	137.5

Figure 3: Labor Costs and Labor Productivity in Manufacturing, Taiwan, 1974 - 1994

Source: Table 5.

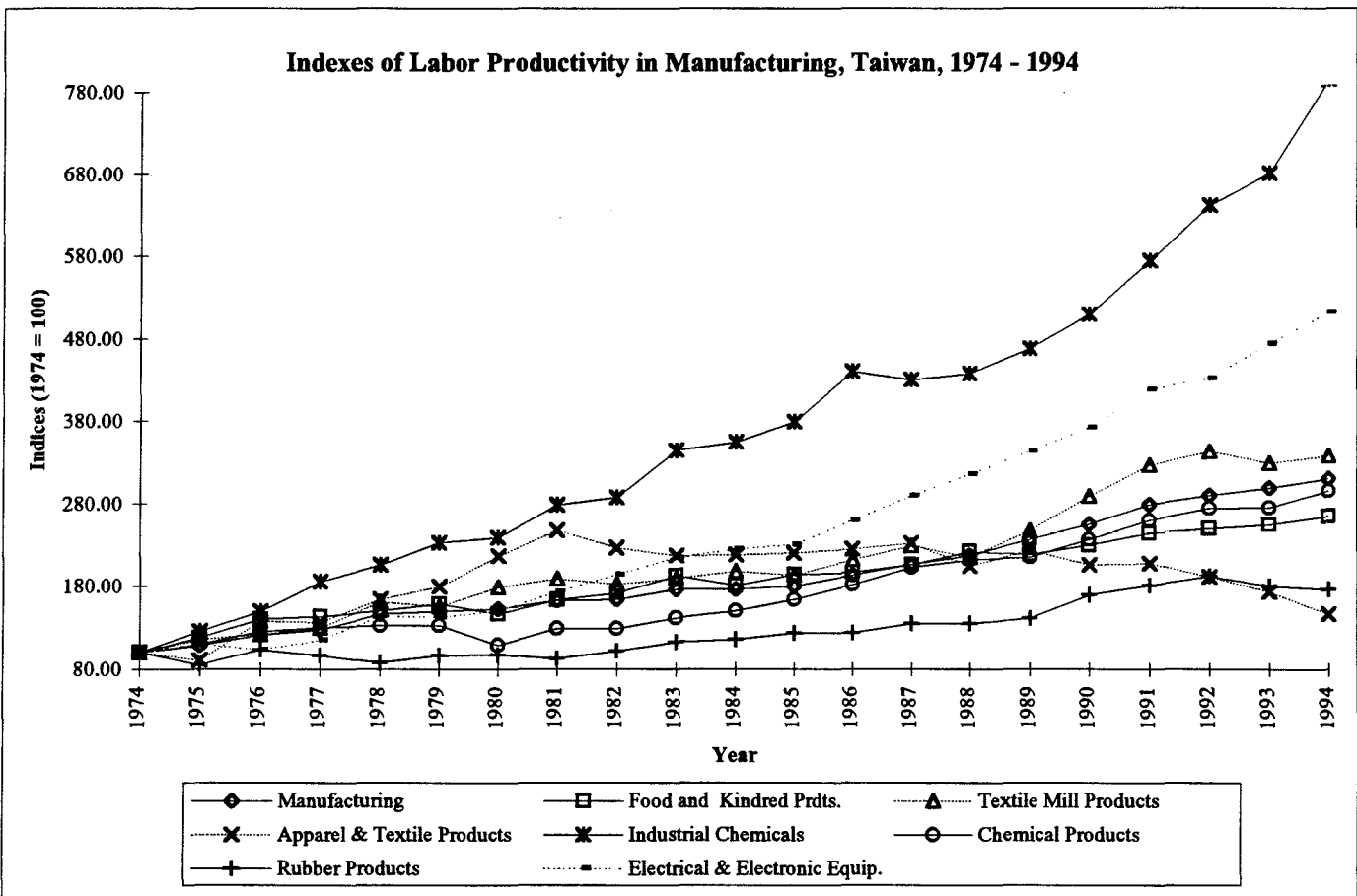
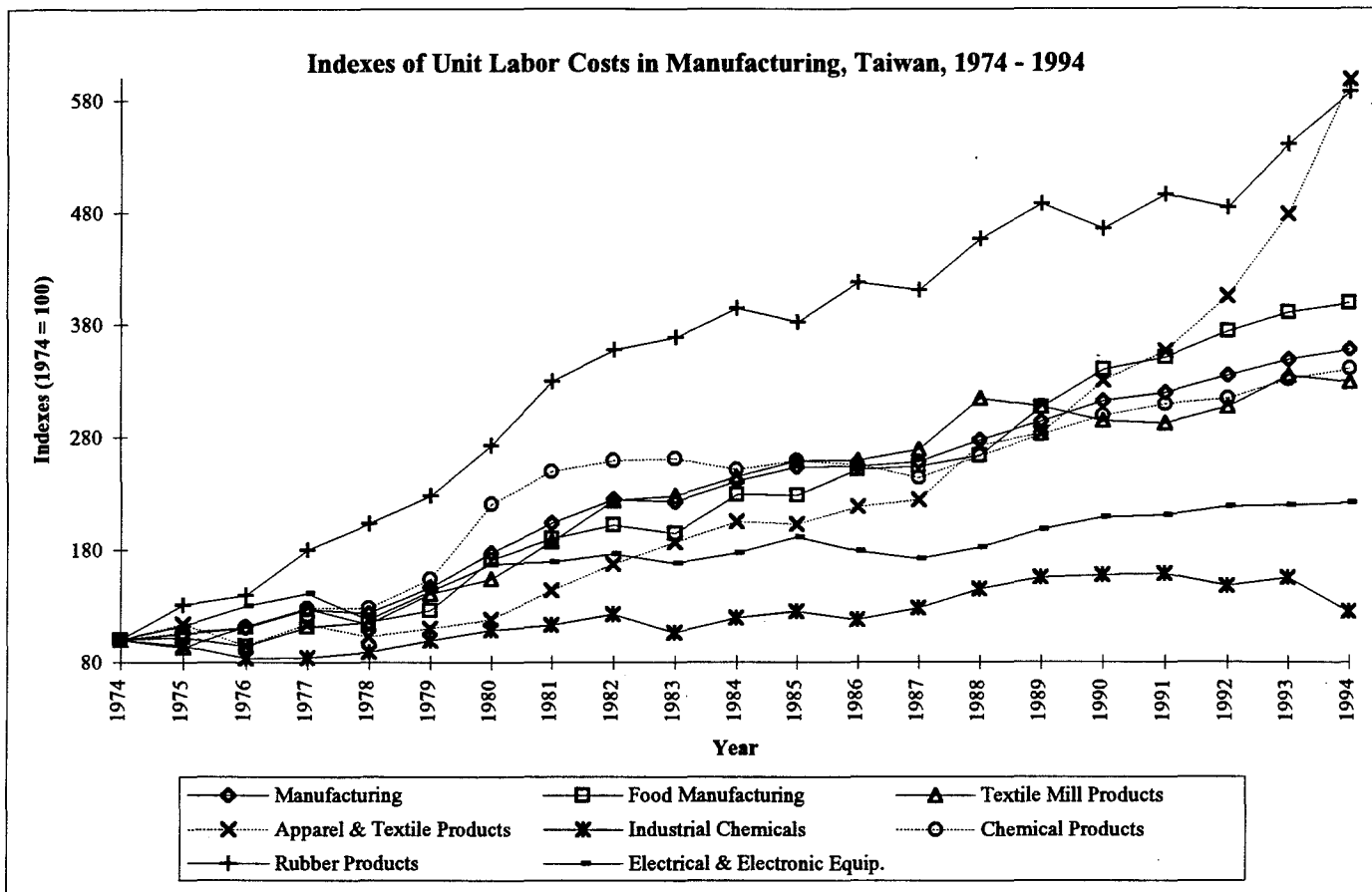
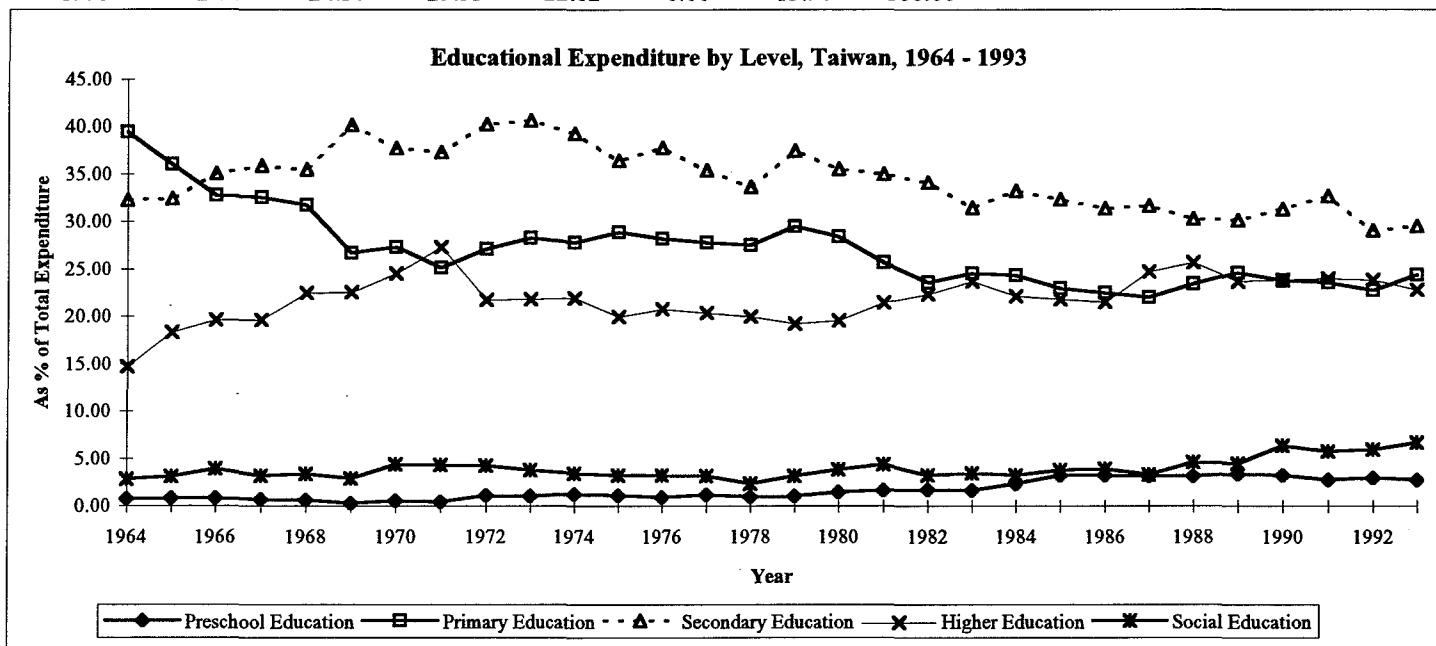


Table 7: Educational Expenditure at All Levels, 1964 - 1993

Source: DGBAS. *Social Indicators in Taiwan Area of the ROC, 1993*. p. 132.

Fiscal Year	%						Total
	Preschool Education	Primary Education	Secondary Education	Higher Education	Social Education	Other	
1964	0.78	39.43	32.26	14.70	2.79	10.04	100.00
1965	0.80	35.98	32.43	18.28	3.09	9.42	100.00
1966	0.80	32.72	35.09	19.63	3.90	7.86	100.00
1967	0.69	32.54	35.87	19.63	3.13	8.14	100.00
1968	0.64	31.72	35.45	22.45	3.32	6.42	100.00
1969	0.29	26.66	40.15	22.53	2.88	7.49	100.00
1970	0.53	27.28	37.69	24.53	4.33	5.64	100.00
1971	0.42	25.13	37.29	27.32	4.29	5.55	100.00
1972	1.10	27.12	40.26	21.72	4.21	5.59	100.00
1973	1.04	28.23	40.63	21.81	3.73	4.56	100.00
1974	1.21	27.79	39.26	21.89	3.39	6.46	100.00
1975	1.09	28.87	36.40	19.97	3.23	10.44	100.00
1976	0.91	28.20	37.76	20.75	3.21	9.17	100.00
1977	1.14	27.78	35.40	20.35	3.15	12.18	100.00
1978	0.94	27.50	33.62	19.98	2.30	15.66	100.00
1979	1.03	29.48	37.43	19.23	3.15	9.68	100.00
1980	1.42	28.41	35.53	19.57	3.79	11.28	100.00
1981	1.64	25.64	34.98	21.46	4.37	11.91	100.00
1982	1.73	23.55	34.10	22.34	3.23	15.05	100.00
1983	1.64	24.51	31.46	23.68	3.39	15.32	100.00
1984	2.32	24.31	33.23	22.12	3.21	14.81	100.00
1985	3.23	22.91	32.35	21.79	3.75	15.97	100.00
1986	3.21	22.48	31.36	21.51	3.85	17.59	100.00
1987	3.10	21.98	31.63	24.70	3.28	15.31	100.00
1988	3.12	23.42	30.32	25.64	4.56	12.94	100.00
1989	3.33	24.59	30.15	23.67	4.45	13.81	100.00
1990	3.20	23.74	31.35	23.85	6.33	11.53	100.00
1991	2.74	23.58	32.70	23.94	5.74	11.30	100.00
1992	2.90	22.72	29.10	23.80	5.94	15.54	100.00
1993	2.72	24.37	29.53	22.82	6.66	13.90	100.00



level. Between 1966 and 1974, during a period when the non-agricultural labor force increased by 80%, vocational training increased six fold. Only 40% of high school students were in the vocational track in 1963; this percentage was 52% in 1972, almost 70% by 1980. Approximately half of the vocational education was administered by private enterprises, the other half by government agencies. This changing mix between academic and vocational or technical high school education was influenced by government using differential tuitions as a carrot. Most important was that vocational education was highly diversified, flexible and continuously responsive to changing market demands.

It is, moreover, noteworthy (see Table 8) that the educational expenditures per student became as high for vocational as for academic secondary schools. At least half of the national vocational and training fund resources went to private enterprises for improved training programs, often in cooperation with vocational high schools; and, as Galenson has pointed out⁹, these non-academic education figures do not even include on-the-job training or learning by doing.

By the early 1970s the share of industry in GDP had risen to more than one-third and to more than 24% in terms of employment. Annual industrial growth rates which had faltered a bit by the end of the import substitution era in the early 1960s now climbed again into the range of 16% to 20% during the late 1960s and early 1970s, while the share of industrial exports in GDP continued to rise and stood close to 50% percent by 1973.

⁹Galenson, in Galenson, op. cit.

Table 8: Educational Expenditure Per Student at All Levels, Taiwan, 1976 - 1994

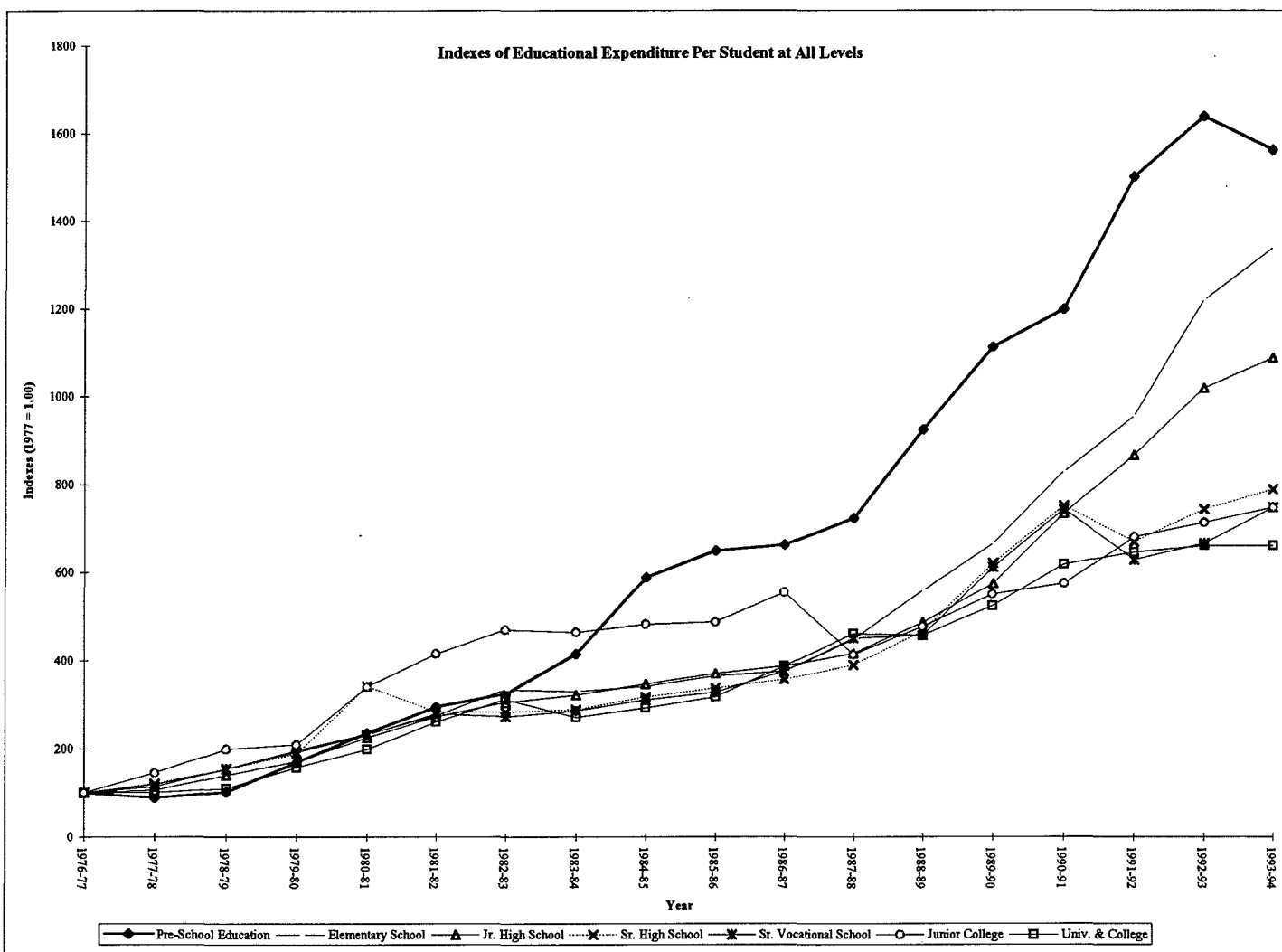
Source: CEPD. *Taiwan Statistical Data Book 1995*. Page 272.

I. In NTS/Student

Period	Pre-School Education	Elementary School	Jr. High School	Sr. High School	Sr. Vocational School	Junior College	Univ. & College
1976-77	2,899	3,660	5,728	8,860	10,480	11,645	30,734
1977-78	2,557	4,351	6,066	10,652	11,902	16,939	30,965
1978-79	2,953	5,597	8,014	13,557	16,254	23,176	33,551
1979-80	4,889	7,164	9,770	16,612	20,093	24,289	48,453
1980-81	6,821	8,506	12,855	30,190	24,276	39,573	61,006
1981-82	8,549	10,075	15,594	25,085	29,216	48,316	79,889
1982-83	9,412	12,213	17,461	25,043	28,590	54,622	95,632
1983-84	12,058	12,044	18,413	25,530	29,916	54,124	83,256
1984-85	17,092	12,487	19,869	28,073	32,574	56,260	89,704
1985-86	18,878	13,354	21,230	29,869	34,342	56,888	97,666
1986-87	19,241	13,765	22,225	31,606	39,356	64,689	119,285
1987-88	21,022	16,424	23,854	34,602	47,247	48,187	141,891
1988-89	26,840	20,489	27,900	41,322	47,958	55,549	140,782
1989-90	32,296	24,416	32,921	55,041	64,105	64,215	161,547
1990-91	34,788	30,412	42,104	66,691	78,092	67,022	190,402
1991-92	43,548	34,991	49,685	59,417	66,025	79,386	198,769
1992-93	47,530	44,665	58,397	65,978	69,839	83,224	203,121
1993-94	45,324	49,058	62,366	70,013	78,497	87,174	203,439

II. Indexes (1977 = 100)

Period	Pre-School Education	Elementary School	Jr. High School	Sr. High School	Sr. Vocational School	Junior College	Univ. & College
1976-77	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1977-78	88.20	118.88	105.90	120.23	113.57	145.46	100.75
1978-79	101.86	152.92	139.91	153.01	155.10	199.02	109.17
1979-80	168.64	195.74	170.57	187.49	191.73	208.58	157.65
1980-81	235.29	232.40	224.42	340.74	231.64	339.83	198.50
1981-82	294.89	275.27	272.24	283.13	278.78	414.91	259.94
1982-83	324.66	333.69	304.84	282.65	272.81	469.06	311.16
1983-84	415.94	329.07	321.46	288.15	285.46	464.78	270.89
1984-85	589.58	341.17	346.88	316.85	310.82	483.13	291.87
1985-86	651.19	364.86	370.64	337.12	327.69	488.52	317.78
1986-87	663.71	376.09	388.01	356.73	375.53	555.51	388.12
1987-88	725.15	448.74	416.45	390.54	450.83	413.80	461.67
1988-89	925.84	559.81	487.08	466.39	457.61	477.02	458.07
1989-90	1114.04	667.10	574.74	621.23	611.69	551.44	525.63
1990-91	1200.00	830.93	735.06	752.72	745.15	575.54	619.52
1991-92	1502.17	956.04	867.41	670.62	630.01	681.72	646.74
1992-93	1639.53	1220.36	1019.50	744.67	666.40	714.68	660.90
1993-94	1563.44	1340.38	1088.79	790.21	749.02	748.60	661.93



Additional important direct government actions were crucial to the emerging role of industrial growth and exports. The most important of these undoubtedly were the provision of rural transportation and power, permitting a markedly decentralized industrialization effort to develop, thus continuing policies pursued by the Japanese colonial government. Indeed Taiwan's railway system density was second only to Japan's in all of Asia. Power capacity was maintained well ahead of demand and distributed relatively equally throughout the island, establishing a uniform set of electricity rates between rural and urban locations. The government also established a number of industry-oriented technology and investment institutes quite early, e.g. the China Productivity and Trade Center, the Food Industry Research and Development Institute, the China Development Corporation, the Industrial Development and Investment Center, etc., most providing management, training and technical assistance, along with credit, for relatively small industrial entrepreneurs. Throughout the 1960s the government also set up a substantial number of rural industrial estates, providing the essential physical overheads for private industry.

While such efforts are often accompanied by less than full success in many developing countries, here they seemed to be particularly focussed on providing access to the preponderant group of medium and small scale firms, many of them moving out from earlier, primarily agricultural processing, pursuits. The early attention to food processing technology was diffused through the same JCRR/farmers' association structure which had

served agriculture so well in the earlier period. Industrial activity shifted from food processing to textiles, garments, leather goods, wood products, etc., which, together, amounted to 66% of total manufacturing production by the late 1950s.

Imported raw materials-based industries gradually took over from the agricultural-based exports, but with both still relying heavily on the absorption of unskilled labor. Indeed, the rate of growth of industrial employment, roughly 3% to 4% in the import substituting 1950s, rose to 6-8% in the 1960s. The unusually dispersed rural character of Taiwan's industrialization effort undoubtedly helped keep labor costs down, reduced the social costs of urbanization, and permitted an improvement in the distribution of income during this period of accelerated growth.

It should also be noted that the internal transport network was extremely well articulated with respect to the main ports and export processing zones, starting with Kaohsiung. This not only facilitated the export of domestic raw materials-intensive products, but was also of substantial importance in enhancing the system's export potential, once the overall policy environment had shifted in a favorable direction. With industrial output becoming increasingly unskilled labor and imported raw materials-oriented, the ability to attract labor to the proximity of the port cities and to locate industries rurally, either the entire operation or subcontracted units, became increasingly important. It was one of those features which made it possible for industrial labor to bicycle in for the day, returning to their rural households at night, minimizing transport and transaction

costs.

Institutions which had served agriculture earlier on now provided assistance to agriculture-linked industry and exports. The Joint Commission on Rural Reconstruction, for example, financed research and development efforts in support of fish canning at Kaohsiung. Farmers associations now included rural transport and the promotion of rural industries among the various services offered. Institutions such as the Forestry Research Institute, agricultural experiments stations and the Food Industries Research and Development Institute provided for further strengthening of the linkages between agriculture and non-agricultural activities in the rural areas.

As Liang and Liang reported¹⁰, using the Chenery decomposition technique, non-durable consumer goods exports accounted for almost 75% of total demand sources for manufacturing output growth from 1965 to 1970. Along with the shift from domestic raw materials-based to imported raw materials-based industries came a shift from domestic to exports as a source of demand for industrial output. Here again we should note, however, that the domestic market continued to grow vigorously, even while diminishing in relative importance. Domestic industrialization of a decentralized type and of an increasingly high labor intensity were crucially tied up with the achievement of increased international competitiveness. Ho indeed reports a remarkable relative decline in the urban

¹⁰"Exports and Employment in Taiwan," in Institute of Economics, Academia Sinica, Conference on Population and Economic Development in Taiwan, Taipei, 1976.

proportion of total industrial manufacturing employment between 1956 and 1966.¹¹

In the case of some industries such as food processing this pronouncedly rural location of industry was dictated in large part by the location of the domestic raw material; for others, like textiles and electronics, which imported their raw materials, the export processing zone device, plus access to cheap rural labor, played an important role. In all such cases, adoption of unskilled labor intensive production processes, plus the relative absence of economies of scale, induced a predominance of low cost medium and small-scale firms, yielding international competitiveness.

As we would expect, industries with the highest employment growth registered the highest output and export growth. Liang and Liang¹², using 1966 and 1971 input/output tables, found export industries had weighted capital-labor ratios substantially below those of import competing industries, as we would expect from Hecksher/Ohlin trade theory. Taiwan's main comparative advantage clearly resided in the abundance of her relatively cheap but efficient supply of labor. It should be no surprise that the system's labor intensive industrial consumer goods exports grew fastest during most of the 1960s. Examining the industrial censuses of 1954, 1961, and 1971, and ranking industries by their total capital-labor ratios, we find that the changes in output mix developed about as expected over time,

¹¹op. cit.

¹²op. cit.

gradually moving from non-durables to durables and intermediate goods.

While the center of gravity was thus clearly shifting to the industrial sector during the 1960s and early 1970s, it should not be forgotten that sustained steady advances in agricultural output continued to be important for avoiding premature rises in wage good prices and in industrial real wages which so often impedes countries from taking full advantage of their unskilled labor-based export capacity. Quite the contrary, domestic agricultural output and agricultural exports continued to support rather than to hinder sustained growth of the non-agricultural sector. As C.Y. Lin put it, "the competitiveness of Taiwan's labor supply is the ... result largely of successful agricultural development, which made the 'unlimited' supply of labor a reality."¹³ The unusual constancy of the domestic terms of trade in Taiwan, the fact that until the 1970s there continued to obtain a positive international trade balance in basic foods, is evidence of this continued importance of the agricultural sector in facilitating the successful interaction between an increasingly industry-focussed growth and export performance.

It should also be noted that the liberalization packages of the late 1950s and early 1960s, combined with the aforementioned success in domestic balanced growth, made the increased participation of foreign private capital increasingly attractive. Rapid wage increases in the United States, Europe, and especially

¹³C.-Y. Lin, 1973, Industrialization in Taiwan, 1946-72: Trade and Import-Substituting Policies for Developing Countries, Praeger, New York.

in Japan, Hong Kong and Singapore during the 1960s, induced increasing numbers of multinationals to seek taking advantage of Taiwan's abundant labor supply, virtually free of union activities, disputes, and strikes. Good levels of health and education, adequate transportation and cheap electric power were the advantages most often noted by foreign investors, initially mainly overseas Chinese and later U.S. and Japanese in origin, who entered in increasing numbers during the 1970s and 1980s.

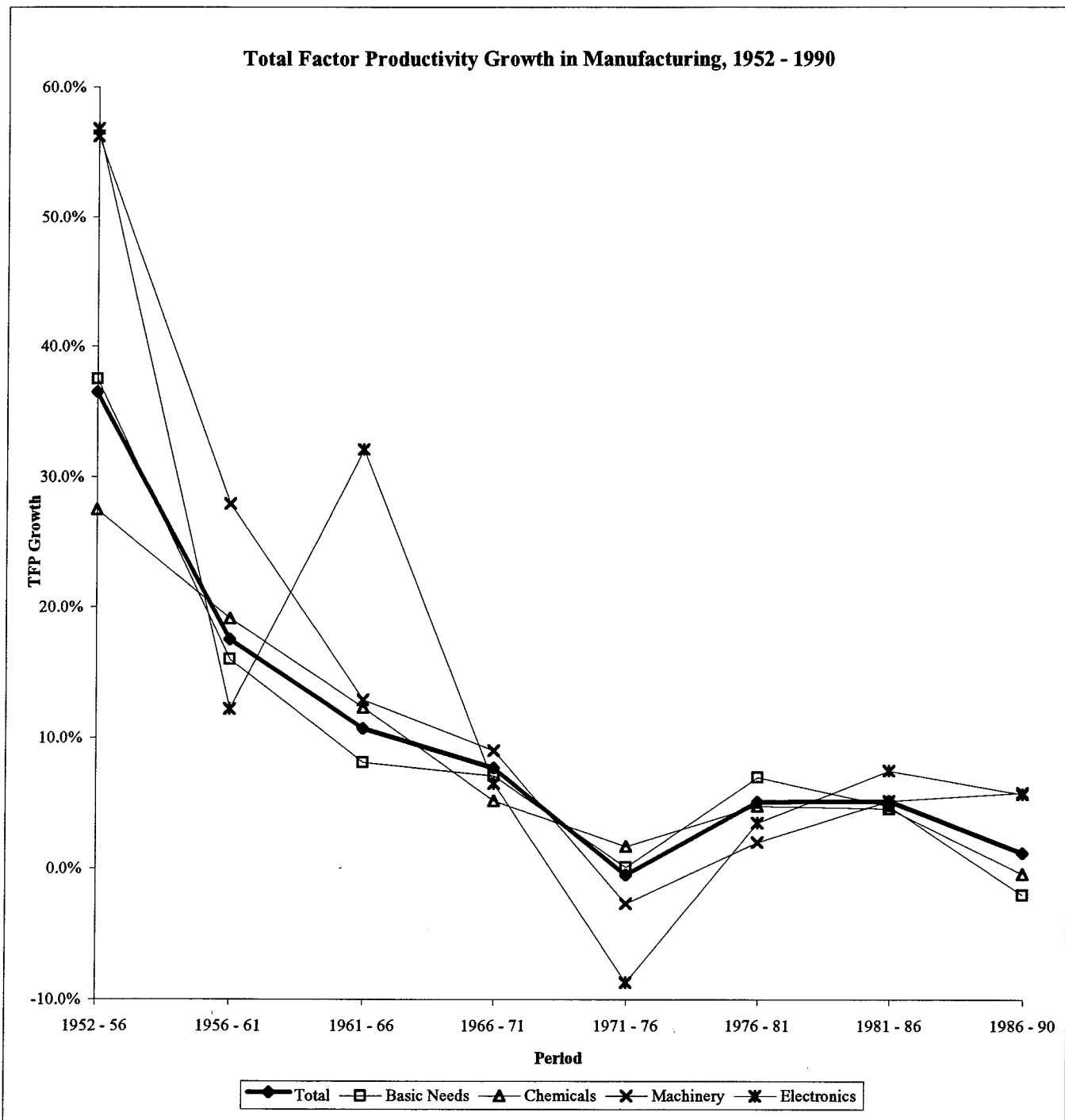
Taiwan's export processing zones not only helped to attract foreign investment but also provided important technological spillovers as a byproduct of the export generation process. For example, Kaohsiung attracted 30% of Taiwan's total direct foreign investment in 1966 and 39% in 1972, even as its share of total exports rose from 1.3% to 8%. It should, moreover, be noted that the export processing zones' procurement of domestic raw materials comprised only 8% of the total in 1970 but reached 40% by 1979, indicating the increased spillover effects, even as, with continued overall liberalization, the relative importance of export processing zones began to diminish.

There can be little doubt that during the 1960s and early 1970s Taiwan's exports were substantially enhanced by the actions of her domestic entrepreneurs, supported by the increasing participation of foreign investors in the export processing zones and bonded factories throughout the island. TFP change in manufacturing remained substantial (see Figure 4), even if not as high as in the earlier period when the economy was still dominated by agriculture. This helps to explain why the

Figure 4: Total Factor Productivity Growth in Manufacturing, 1952 - 1990

Source: Liu, Paul K. C., Ying-Chuan Liu, and Hui-Lin Wu. "Emergence of New Business Organization and Management in Taiwan." *Industry of Free China*. Vol 82, No. 11. Nov. 1994. p. 40.

Period	Total	Basic Needs	Chemicals	Machinery	Electronics
1952 - 56	36.5%	37.5%	27.5%	56.2%	56.8%
1956 - 61	17.5%	16.0%	19.1%	27.9%	12.2%
1961 - 66	10.7%	8.1%	12.3%	12.9%	32.1%
1966 - 71	7.7%	7.1%	5.2%	9.0%	6.5%
1971 - 76	-0.5%	0.1%	1.7%	-2.7%	-8.7%
1976 - 81	5.1%	7.0%	4.8%	2.0%	3.5%
1981 - 86	5.2%	4.8%	4.6%	5.2%	7.5%
1986 - 90	1.2%	-2.0%	-0.4%	5.8%	5.7%



production of exportables, along with the industrial sector as a whole, was able to avoid diminishing returns in the face of high and rising rates of investment. Those who claim that high savings rates are sufficient to explain the Taiwan "Miracle" need to be able to explain why these high rates of investment continued to be accompanied by such still respectable levels of productivity changes. While we could encounter equally high or even higher investment rates elsewhere, for example, in Scandinavia and, earlier, in the Soviet Union, these were associated with much higher capital-output ratios and much lower export performance. As Pack points out¹⁴, the level of TFP in the export industries of Taiwan was certainly higher than in the domestically oriented industries, even if not remarkable by international standards.

IV. The Science and Technology Dominated Growth/Export Nexus.

There can be little doubt that the mutual support of exports and growth in Taiwan has become most pronounced during the period between 1976 and the present. Once labor surplus had been exhausted, Taiwan's output and export mixes became increasingly skilled labor, capital and, ultimately, technology intensive, as one would expect, once again, from the application of dynamic comparative advantage theory. We may note the advent of an increasing labor shortage via rising wages (see Figure 5) and rising female participation rates (from 33% in 1965 to 35% in

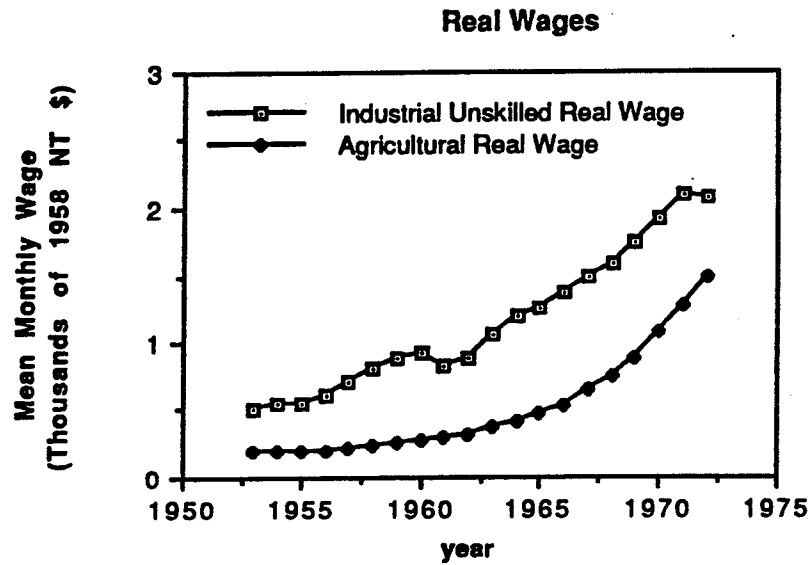
¹⁴H. Pack, 1992, "New Perspectives on Industrial Growth in Taiwan," in G. Ranis, ed., Taiwan: From Developing to Mature Economy, Westview Press, Boulder, CO.

1969 to 39% by 1975 and 45% by 1994). As a consequence, there was a gradual increase in the relative size of intermediate and capital goods industries, including the shifting of electronics assembly processes both forward and backward. Such shifts entailed a substantial change in the industrial output and export mixes, along with an enhanced demand for embodied education and capital, i.e. increasing skilled labor requirements and industrial capital-labor ratios.

During these last two decades a number of additional government actions can be cited, enhancing the flexibility and adjustment capacity of the domestic production structure in terms of continuing the aforementioned shift in product cycle terms. For example, the ten major public sector projects of the early 1970s and those included in the current six year plan were partly addressed to solving emerging transportation bottlenecks, partly to circumventing the still inadequate financial intermediation sector, linking small savers to large project investment requirements. Probably even more important were the further shifts in educational policy. In the 1980s Taiwan began to increasingly emphasize tertiary education (see Table 9) and, within tertiary education, to move resources towards science and technology oriented fields. Overall, education expenditures as a percentage of GNP began to rise to the vicinity of 5% (see Table 10).

Another important contribution to maintaining international competitiveness in Taiwan was, of course, the increasing impact of domestic R&D expenditures. We may note the substantial

Figure 5

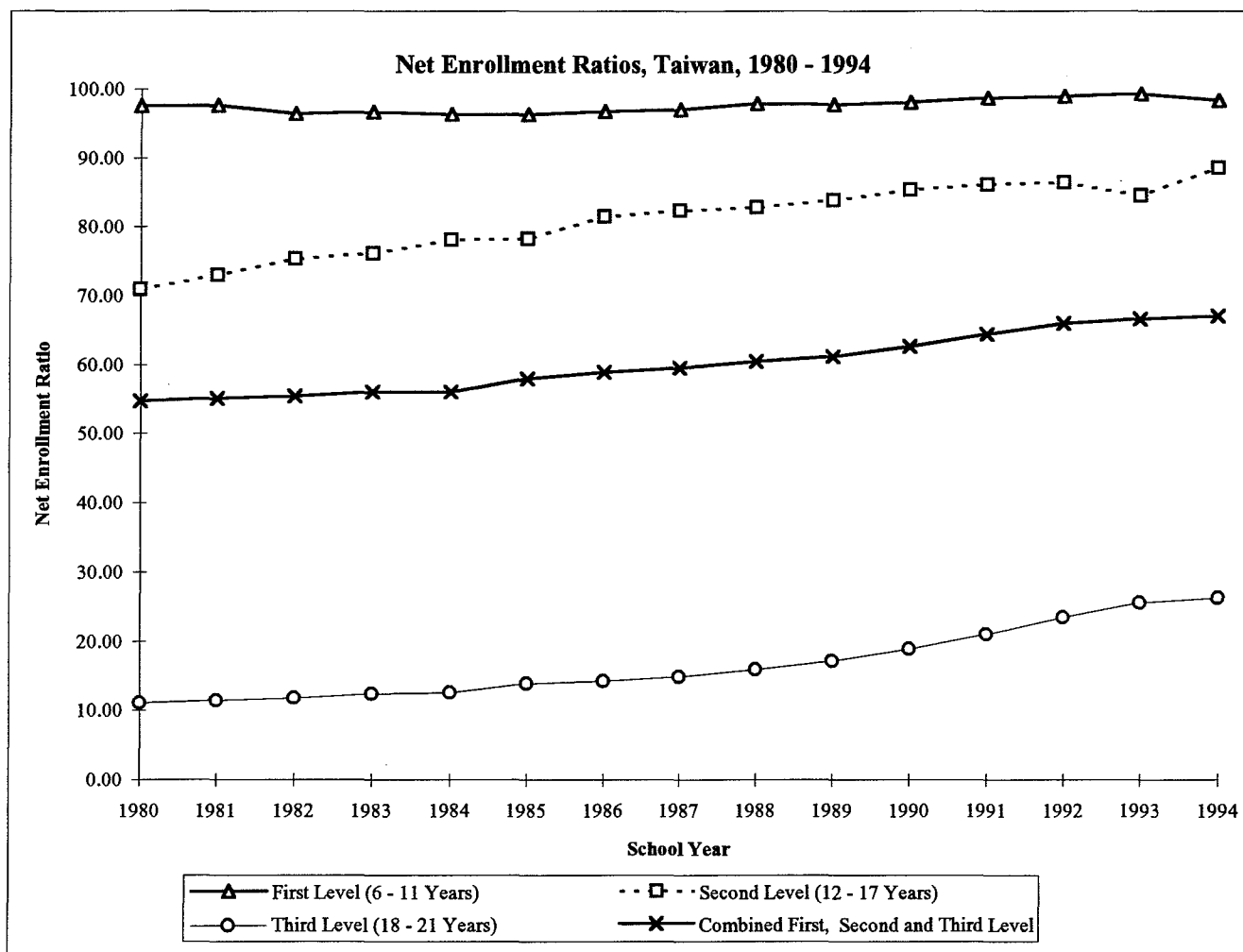


Sources: Kuo, S., The Taiwan Economy in Transition, Westview Press, Boulder, CO..
Taiwan Statistical Data Book, Council for Economic Planning and Development, Republic of China, 1990.

Table 9: Net Enrollment Ratios, Taiwan, 1980 - 1994

Source: *Monthly Bulletin of Statistics of the Republic of China*. DGBAS. Sept. 1995. Page 13.

School Year	First Level (6 - 11 Years)	Second Level (12 - 17 Years)	Third Level (18 - 21 Years)	Combined First, Second and Third Level
1980	97.56	70.98	11.07	54.69
1981	97.59	72.96	11.47	55.08
1982	96.42	75.40	11.80	55.41
1983	96.70	76.14	12.40	55.99
1984	96.29	78.11	12.57	56.02
1985	96.30	78.29	13.88	57.95
1986	96.75	81.50	14.23	58.96
1987	96.97	82.39	14.82	59.51
1988	97.92	82.88	15.95	60.55
1989	97.74	83.88	17.18	61.18
1990	98.04	85.44	18.93	62.69
1991	98.70	86.19	21.01	64.47
1992	98.92	86.46	23.47	66.01
1993	99.31	84.61	25.61	66.67
1994	98.36	88.59	26.26	67.07



Net Enrollment Ratio: The number of students enrolled in a level of education who belong in the relevant age group, as a percentage of the population in that age group.

Table 10: Expenditures on Education, Social Welfare, and R&D, Taiwan, 1964 - 1993

Sources: *Social Indicators in Taiwan Area of the Republic of China 1993*. DGBAS, Executive Yuan, Republic of China. Pages 112 - 113.

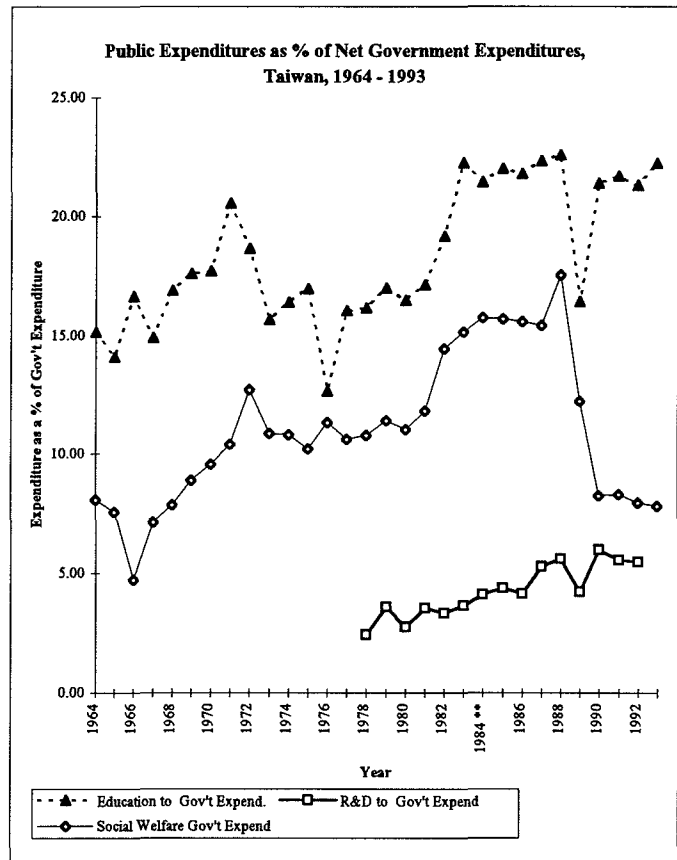
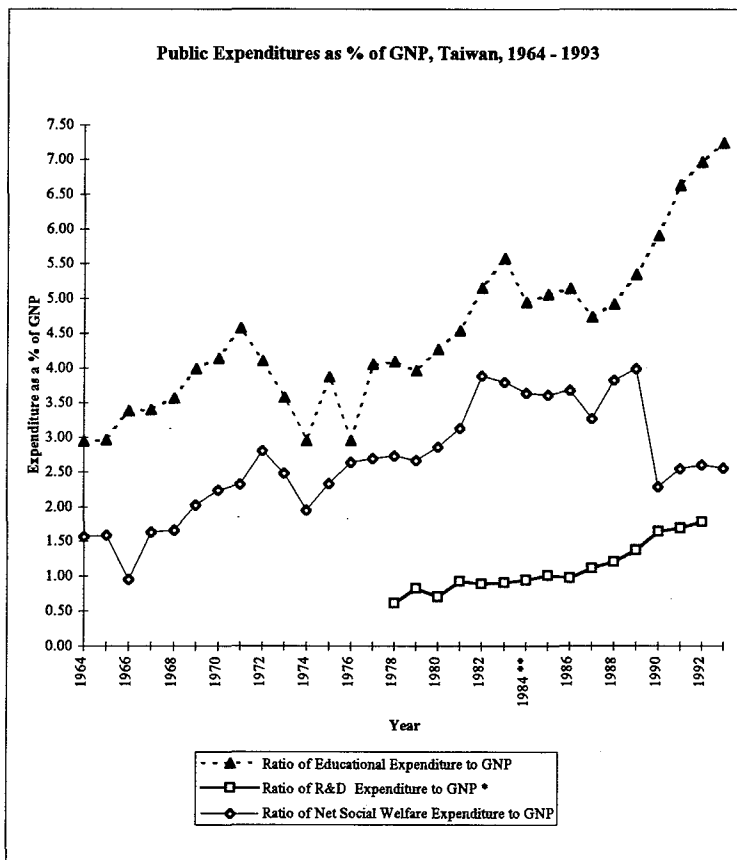
Statistical Yearbook of the Republic of China 1994. DGBAS, Executive Yuan, Republic of China. Page 156.

Taiwan Statistical Yearbook. CEPPD, Republic of China. Page 27, 30-31.

Year	Ratios to GNP				Ratios to Net Government Expenditure			
	Ratio of Educational Expenditure to GNP	Ratio of R&D Expenditure to GNP *	Ratio of Net Social Welfare Expenditure to GNP	Real Growth Rate of GNP	Net Gov't Expenditure/GNP	Education to Gov't Expend.	R&D to Gov't Expend	Social Welfare to Gov't Expend
1964	2.94		1.57	12.3	19.4	15.15		8.09
1965	2.96		1.59	11.0	21.0	14.10		7.57
1966	3.38		0.96	9.0	20.3	16.65		4.73
1967	3.40		1.63	10.6	22.8	14.91		7.15
1968	3.56		1.66	9.1	21.1	16.87		7.87
1969	3.99		2.02	11.3	22.7	17.58		8.90
1970	4.14		2.24	13.0	23.4	17.69		9.57
1971	4.58		2.32	13.4	22.3	20.54		10.40
1972	4.10		2.80	12.8	22.0	18.64		12.73
1973	3.57		2.48	1.2	22.8	15.66		10.88
1974	2.95		1.95	4.4	18.0	16.39		10.83
1975	3.87		2.33	13.7	22.8	16.97		10.22
1976	2.95		2.64	10.3	23.3	12.66		11.33
1977	4.06		2.69	14.0	25.3	16.05		10.63
1978	4.09	0.61	2.73	8.5	25.3	16.17	2.41	10.79
1979	3.96	0.83	2.66	7.1	23.3	17.00	3.56	11.42
1980	4.27	0.71	2.86	5.8	25.9	16.49	2.74	11.04
1981	4.54	0.93	3.13	4.1	26.5	17.13	3.51	11.81
1982	5.15	0.89	3.89	8.7	26.9	19.14	3.31	14.46
1983	5.58	0.91	3.80	11.6	25.1	22.23	3.63	15.14
1984 **	4.95	0.95	3.64	5.6	23.1	21.43	4.11	15.76
1985	5.06	1.01	3.61	12.6	23.0	22.00	4.39	15.70
1986	5.14	0.98	3.68	12.3	23.6	21.78	4.15	15.59
1987	4.73	1.12	3.27	8.3	21.2	22.31	5.28	15.42
1988	4.92	1.22	3.82	8.0	21.8	22.57	5.60	17.52
1989	5.35	1.38	3.99	5.5	32.6	16.41	4.23	12.24
1990	5.90	1.65	2.28	7.6	27.6	21.38	5.98	8.26
1991	6.63	1.70	2.54	6.2	30.6	21.67	5.56	8.30
1992	6.96	1.79	2.60	6.0	32.7	21.28	5.47	7.95
1993	7.24		2.55	6.1	32.6	22.21		7.82
Mean	4.50	1.11	2.66	9.0				

* These statistics exclude information on defense-related science and technology.

** Beginning in 1984, the R&D in humanities and social sciences was included.



increases in R&D as a percentage of both GNP and of total government expenditures (see Table 10). Note also that these numbers do not include military or defense-related R&D spillovers nor the important informal R&D efforts of small firms, the so-called blue-collar R&D, not at all captured in the official statistics. In 1984 tax incentives were provided for manufacturers to allocate a larger percentage of their revenues to R&D. But the bulk of the innovative activities undoubtedly took place unrecorded in the repair shops and floors of Taiwan's thousands of decentralized medium and small-scale firms.

While, as Wang points out, in-house research continued to be much more important,¹⁵ the government also attempted to assist Taiwan's predominantly medium and small-scale firms by establishing a number of research institutes, science parks, etc. Government's involvement in creating such complementary science and technology institutional infrastructure included the establishment of the National Science Council in 1967, of the Chung Shan Institute of Science and Technology in 1965, of the Industrial Training and Research Institute (ITRI) in 1973, and of the Hsin Chu Science-Based Industrial Park, as well as of the Information Industry Institute, both in 1979. ITRI, initially fully funded by the government, increasingly received private contracts from local enterprises and is generally considered responsible for developing many key technologies ultimately transferred to private local industry, thus facilitating Taiwan's

¹⁵J. C. Wang, 1994, "Cooperative Research in a Newly Industrialized Country: Taiwan," Research Policy 23, 697-774.

technological development. The Hsin Chu Science-Based Industrial Park has been responsible for a succession of new ventures in high-tech export-oriented areas by providing public facilities to small and medium-sized firms on favorable terms, including five year tax exemptions, a ceiling on taxes thereafter, subsidized rent, credit facilities and other amenities. It also guaranteed close physical and intellectual contact with academic and private commercial interests. As shown in Table 11, total R&D expenditures increased in virtually every industry group between 1986 and 1992, but most markedly in those high tech areas assuming an increasing role in Taiwan's exports, e.g. machinery and equipment, electric and electronic machinery, chemical materials and, most pronouncedly, precision instruments. As Table 12 indicates, these industries also had the highest R&D expenditures per unit of total sales, increasingly export-oriented. Another way of making the point, whichever way the causation runs, is illustrated in Table 13. When we separate industries by the destination of their output we may note the clearly higher levels of TFP for those with higher export shares.

The break-down between R&D carried on within industry, in S&T institutes and in the universities by major field (see Table 14) shows a surprisingly large role for the S&T institutes; these served mainly the medium and small-scale industries, especially in the critical engineering area, where they comprised approximately 25% of the total. If we were able to add R&D of the private blue-collar variety, Taiwan's total R&D levels as a % of sales or GDP would probably begin to approach DC standards.

**Table 11: Indexes of All R&D Expenditures,
by Industry, Taiwan, 1986 - 1992**

Source: *Indicators of Science and Technology in the ROC*. National Science Council, Taiwan. Pages 108 - 109.

Index (1986 = 100)

Industry	Year						
	1992	1991	1990	1989	1988	1987	1986
Food	116.14	113.01	135.23	124.03	162.11	120.23	100.00
Beverage & Tobacco	71.43	74.18	153.30	47.80	37.91	63.19	100.00
Textiles	238.96	292.05	271.92	65.75	124.68	308.77	100.00
Wearing Apparel & Accessories	58.72	169.72	160.55	53.21	92.66	221.10	100.00
Leather, Fur, & Products	113.29	197.47	24.05	132.91	9.49	29.75	100.00
Wood & Bamboo Products	189.80	51.02	73.47	159.18	122.45	361.22	100.00
Paper, Pulp & Print	115.54	225.68	215.54	184.46	129.73	201.35	100.00
Chemical Materials	446.96	341.74	352.03	263.77	171.88	51.88	100.00
Chemical Products	119.67	66.74	62.83	52.30	67.78	147.49	100.00
Petroleum & Coal Products	207.72	154.74	125.96	92.28	185.03	89.82	100.00
Rubber Products	219.49	146.67	73.33	275.38	87.69	109.23	100.00
Plastic Products	345.79	224.91	75.32	114.54	23.79	115.81	100.00
Non-Metallic Mineral Products	114.19	61.94	111.07	565.40	272.66	240.83	100.00
Basic Metals	351.83	242.43	250.69	185.78	196.33	118.58	100.00
Fabricated Metal Products	212.78	139.38	157.32	156.29	137.32	130.93	100.00
Machinery & Equipment	475.08	337.08	268.39	388.15	251.06	209.73	100.00
Electric & Electronic Machinery	553.45	551.76	561.08	339.71	206.53	158.03	100.00
Transport Equipment	498.59	428.30	409.99	462.61	211.78	216.77	100.00
Precision Instruments	922.47	339.33	191.01	198.88	432.58	342.70	100.00
Miscellaneous Industry	206.49	129.46	298.92	306.22	121.08	30.54	100.00
Manufacturing Subtotal	344.23	300.49	288.21	225.80	154.13	147.05	100.00
Non-Manufacturing	6.69	19.90	2.78	7.69	35.02	78.52	100.00
Information Services							
Total R&D Expenditures	312.99	258.73	265.41	192.82	136.12	136.69	100.00

Table 12: R&D Expenditures, as % of Annual Sales, by Industry, Taiwan, 1986 - 1992

Source: *Indicators of Science and Technology in the ROC*. National Science Council, Taiwan. Pages 118 - 119.

A. As a % of Annual Sales

Industry	1992		1991		1990		1989		1988		1987		1986		1986 - 1992 Ave	
	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private	Total	Private
Food	0.38	0.25	0.43	0.27	0.53	0.38	0.50	0.35	0.69	0.74	0.44	0.32	0.48	0.32	0.49	0.40
Beverage & Tobacco	0.10	0.37	0.13	0.50	0.28	0.94	0.08	0.30	0.07	0.03	0.21	0.56	0.23	0.22	0.16	0.40
Textiles	0.40	0.40	0.55	0.55	0.52	0.52	0.13	0.13	0.24	0.24	0.34	0.31	0.16	0.15	0.33	0.35
Wearing Apparel & Accessories	0.08	0.08	0.24	0.24	0.24	0.24	0.07	0.07	0.12	0.12	0.35	0.33	0.12	0.11	0.17	0.18
Leather, Fur, & Products	0.26	0.25	0.45	0.46	0.06	0.06	0.34	0.34	0.03	0.02	0.20	0.19	0.24	0.22	0.23	0.20
Wood & Bamboo Products	0.10	0.10	0.03	0.03	0.04	0.04	0.08	0.08	0.06	0.06	0.26	0.22	0.11	0.08	0.10	0.08
Paper, Pulp & Print	0.10	0.10	0.21	0.22	0.20	0.21	0.19	0.19	0.14	0.14	0.42	0.40	0.16	0.15	0.20	0.20
Chemical Materials	1.08	1.11	0.84	0.87	0.88	0.90	0.53	0.66	0.40	0.29	0.46	0.43	1.07	0.99	0.75	0.77
Chemical Products	1.24	1.22	0.89	0.87	0.86	0.86	0.78	0.79	1.06	1.03	1.10	0.97	0.80	0.74	0.96	0.92
Petroleum & Coal Products	1.13	0.00	0.86	0.06	0.73	0.06	0.48	0.02	0.77	0.01	0.39	0.52	0.41	0.43	0.68	0.23
Rubber Products	0.75	0.72	0.52	0.53	0.27	0.27	0.96	0.96	0.30	0.30	0.92	0.86	0.51	0.47	0.60	0.55
Plastic Products	1.57	1.56	1.12	1.13	0.39	0.38	0.55	0.55	0.11	0.11	0.68	0.64	0.72	0.66	0.73	0.68
Non-Metallic Mineral Products	0.15	0.15	0.11	0.12	0.21	0.21	1.15	1.16	0.62	0.62	1.00	0.94	0.27	0.25	0.50	0.46
Basic Metals	0.37	0.05	0.32	0.01	0.33	0.13	0.27	0.08	0.32	0.05	0.47	0.07	0.29	0.03	0.34	0.09
Fabricated Metal Products	0.30	0.30	0.25	0.25	0.29	0.30	0.32	0.32	0.30	0.27	0.44	0.40	0.36	0.34	0.32	0.31
Machinery & Equipment	0.60	0.60	0.55	0.55	0.44	0.44	0.66	0.66	0.47	0.46	1.56	1.55	0.86	0.87	0.73	0.70
Electric & Electronic Machinery	2.05	1.89	2.41	2.20	2.53	2.29	1.59	1.35	1.04	0.98	1.00	0.94	0.65	0.60	1.61	1.60
Transport Equipment	0.93	0.96	1.01	1.07	0.99	1.05	1.18	1.24	0.62	0.61	1.17	1.16	0.48	0.46	0.91	0.94
Precision Instruments	1.27	1.27	0.68	0.69	0.39	0.40	0.43	0.43	0.91	0.91	2.09	1.96	0.48	0.44	0.89	0.81
Miscellaneous Industry	0.53	0.53	0.35	0.35	0.82	0.82	0.73	0.87	0.33	0.33	0.31	0.29	0.74	0.68	0.54	0.59
Manufacturing Subtotal	0.92	0.87	0.94	0.91	0.92	0.89	0.86	0.71	0.52	0.68	0.64	0.62	0.47	0.42	0.75	0.75
Non-Manufacturing	0.37	0.15	0.17	0.01	0.19	0.09	0.59	0.15	0.51	0.74	0.20	0.11	0.20	0.09	0.32	0.19
Information Services	3.26	3.26	4.21	4.21	4.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

Table 13: Export Share and TFP by Industry, 1986

2-DIGIT INDUSTRIES	EXPORT SHARE	TFP	
		EXPORTING INDUSTRY	IMPORT-COMPETING INDUSTRY
20 Food	21.47		2.58 (23.81)
21 Beverages & Tobacco	0.74		2.84 (9.92)
22 Textile	61.64	7.53 (12.65) ¹	
23 Wearing Apparel	79.53	13.96 (18.93)	
24 Leather	72.48	11.79 (16.00)	
25 Lumber & Furniture	62.65	10.46 (17.32)	
26 Paper & Printing	9.85		11.51 (22.96)
27 Chemical Materials	20.30		2.48 (4.48)
28 Chemical Products	11.08		4.12 (7.85)
29 Petroleum & Coal Products	7.91		2.17 (3.60)
30 Rubber Products	50.72	9.82 (16.46)	
31 Plastic Products	57.07	8.80 (13.50)	
32 Non-Metallic Mineral Products	19.54		6.90 (12.50)
33 Basic Metal	15.35		6.27 (11.68)
34 Metal Products	44.79		9.41 (17.44)
35 Machinery	38.19		8.02 (13.22)
36 Electrical Machinery & Appliances	74.80	10.74 (20.61)	
37 Transport Equipment	27.96		7.45 (15.83)
38 Precision Instruments	74.82	12.38 (18.80)	
39 Miscellaneous Industries	75.15	14.54 (110.22)	

Source: Calculated by Hwang (1994) "Exports, Returns to Scale, and Total Factor Productivity: The Case of Manufacturing Industries in Taiwan".

¹The numbers in parentheses are the standard errors.

**Table 14: R&D Expenditures by Sector of Performance
and Field of Research, Taiwan, 1992**

Source: *Indicators of Science and Technology in the ROC*. National Science Council, Taiwan. Pages 80 - 81.

A. Allocation of R&D Expenditures, As % of Sector Totals

Sector	Field	Natural Sciences	Engineering	Medical Sciences	Agricultural Sciences	Humanities & Social Sci.	Totals
Industry							
Subtotal		1.5	94.8	1.1	2.6		100.0
Public		7.1	85.3	0.5	7.1		100.0
Private		0.7	96.1	1.2	2.0		100.0
S&T Research Institute							
Subtotal		14.6	57.4	4.3	17.7	6.0	100.0
Public		33.2	11.9	7.5	41.3	6.1	100.0
Private		0.0	0.0	95.1	0.8	4.1	100.0
Non-Profit		4.5	82.4	2.1	5.0	6.0	100.0
University and Colleges							
Subtotal		18.0	39.7	19.1	16.3	6.9	100.0
Public		20.7	41.7	11.5	19.1	7.0	100.0
Private		8.3	32.5	46.7	5.9	6.6	100.0
Total		8.2	74.5	4.8	9.5	3.0	100.0

B. Allocation of R&D Expenditures, As % of Field Totals

Sector	Field	Natural Sciences	Engineering	Medical Sciences	Agricultural Sciences	Humanities & Social Sci.	Totals
Industry							
Subtotal		52.5	66.9	12.5	14.2	0.0	52.5
Public		6.1	6.9	0.7	4.5	0.0	6.1
Private		46.5	59.9	11.8	9.7	0.0	46.5
S&T Research Institute							
Subtotal		33.0	25.4	30.1	61.2	66.7	33.0
Public		11.5	1.8	18.1	50.0	23.5	11.5
Private		0.1	0.0	2.6	0.0	0.2	0.1
Non-Profit		21.3	23.6	9.5	11.2	43.1	21.3
University and Colleges							
Subtotal		14.4	7.7	57.4	24.6	33.3	14.4
Public		11.3	6.3	27.2	22.7	26.4	11.3
Private		3.1	1.4	30.3	1.9	6.9	3.1
Total		100.0	100.0	100.0	100.0	100.0	100.0

It should be noted that official R&D normally runs below the .5% of GNP level in LDC's, in contrast to 5% of GNP for developed countries.

It is in this most recent period that the causal chain running from exports to domestic competitiveness is probably most pronounced. As the East Asian Miracle authors point out "we believe that rapid growth of exports, as a result of the export push policies ... , combined with the superior performance of the East Asian economies in creating and allocating human capital, provided the means by which they obtained high rates of ... total factor productivity growth."¹⁶ Whether or not we believe in these high rates of TFP growth or something more modest, a subject of substantial current controversy, it is clear that the impact of exports on domestic productivity via associated equipment imports, technological licensing, and the enhanced flow of DFI, became increasingly important and facilitated an accelerated move up the product cycle quality ladder. To this should be added the substantial volume of advice proffered by customers abroad concerning desirable design, quality and product modifications, already a feature in the earlier, labor intensive period. These opportunities for both product and process innovation were additionally enhanced by the concerted effort to attract previously "brain-drained" Taiwanese engineers and scientists from Silicon Valley and elsewhere to participate in the domestic production and export drive. Fully 70% of the

¹⁶World Bank, 1993, The East Asian Miracle: Economic Growth and Public Policy, Oxford University Press, New York.

companies in the Hsin Chu Science-Based Industrial Park have in recent years been led by returned overseas Chinese. It is estimated that almost 10,000 Taiwanese graduates of U.S. universities have returned in recent years, the vast majority taking up positions in high tech export-oriented industries. It should be clear that the combination of an increasingly highly skilled labor force and R&D investments became the dominant component of the interaction between productivity change and exports in recent years.

V. Conclusion

Trade and growth are seen to be mutually supportive throughout Taiwan's highly successful transition growth effort. The tendency in the recent literature to ascribe a "leading sector" role to trade is as misleading as earlier tendencies to focus exclusively on domestic development patterns. Early on, technology change and the mobilization of agriculture were at center stage, enabling agricultural and processed agricultural exports to expand rapidly and change their composition radically. Later on, as the economy's center of gravity shifted to an unskilled but literate labor-based output mix, the mutual reinforcements between domestic productivity increase and rapidly expanding light industry exports took over. Policy changes freeing up exports from import substitution regime controls and an extremely flexible labor market permitted Taiwan to utilize its low labor costs, combined with adaptations of imported technology, to take advantage of an expanding world economy.

Technology imports were mainly of the simple non-proprietary and easily adaptable variety. Subsequently, Taiwan responded promptly to the early harbingers of labor shortage by shifting emphasis from primary to secondary, especially vocational, education, as well as to science and technology infrastructure, including the encouragement of private and public sector R&D. In recent years Taiwan has tried to prolong the life of her labor intensive exports by way of investing in neighboring countries, including Mainland China; at home she moved upstream and began to export increasingly high tech commodities. Increasingly, technology imports were now carried by machines, multinational company patents and licenses, i.e. of a proprietary character, inducing substantial "reverse engineering" or "pirating" among Taiwan's many medium and small-scale firms. Exports continued to grow and export composition to change continuously. But persistent domestic learning by doing processes, relatively neglected by the authors of the East Asian Miracle volume, continued to induce exports -- as much as exports induced further domestic productivity change.