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GROWTH AND TECHNOLOGY: INTERDEPENDENCE BETWEEN TAIWAN AND JAPAN

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PREFACE

Many of today's most significant socioeconomic problems, such as slower economic growth, the decline of some established industries, and shifts in patterns of foreign trade, are international or transnational in nature. But these problems manifest themselves in a variety of ways; both the intensities and the perceptions of the problems differ from one country to another, so that intercountry comparative analyses of recent historical developments are necessary. Through these analyses we attempt to identify the underlying processes of economic structural change and formulate useful hypotheses concerning future developments. The understanding of these processes and future prospects provides the focus for IIASA's project on Comparative Analysis of Economic Structure and Growth.

Our research concentrates primarily on the empirical analysis of interregional and intertemporal economic structural change, on the sources of and constraints on economic growth, on problems of adaptation to sudden changes, and especially on problems arising from changing patterns of international trade, resource availability, and technology. The project relies on IIASA's accumulated expertise in related fields and, in particular, on the data bases and systems of models that have been developed in the recent past.

In this paper, Mitsuo Saito and Ryoichi Nishimiya present a quantitative analysis of the trade patterns that have characterized the interdependence between Taiwan and Japan during the process of rapid industrial development. The method they adopt is the simulation of medium-scale econometric models for both countries, which are linked together by their export and import functions. It is shown that a difference in the rates of technical progress in the two countries has tended to strengthen the trade friction between them.

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Economic Structure and Growth

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1. INTRODUCTION

It is well known that Japan enjoyed a very high rate of economic growth during the 1960s; the average annual growth rate of GNP was about 10 percent. Within a period of twenty years Japan rose from being a developing country where the per capita GDP was 462 US dollars in 1960 to a developed country with a per capita GDP of 8,627 US dollars in 1979. It is interesting to note that high economic growth of this sort has recently also occurred in several other East and Southeast Asian countries, such as Hong Kong, Singapore, South Korea, and Taiwan. As shown in **Table 1**, the average annual growth rate of real GDP of these newly industrialized countries (NICs) was 8.8 to 10.4 percent before the oil crisis, and even after the oil crisis it was 7.3 to 9.6 percent; only in the case of Japan was it significantly lower (3.6 percent). It is important to note that all these countries have the following three features in common:

(1) They are relatively poor in natural resources, such as oil, coal, and metal ores. This implies that the advantage of natural resources is not a necessary precondition for high economic growth.

TABLE 1. The Growth of GDP of East and Southeast Asian Countries, 1960–73.

	Average growth rate of real GDP (%)		Per capita GDP (US dollars)		Per capita GDP (percentage of US value)	
	1960–73	1973–79	1960	1973	1960	1973
Hong Kong	9.0	8.6	348	3809	12.4	35.3
Japan	10.2	3.6	462	8627	16.5	80.1
Korea, Republic of	8.8	9.6	150	1613	5.4	15.0
Singapore	10.0	7.3	430	3829	15.3	35.5
Taiwan	10.4	8.3	153	1868	5.5	17.3

(2) They are open to foreign countries, in the sense that they are able to freely introduce scientific knowledge and techniques, and to import and export goods and services.

(3) They can draw upon abundant and well-disciplined labor forces.

One might argue that these three features have enabled the countries concerned to realize high economic growth through two mechanisms: borrowed technology on the supply side and wide foreign markets on the demand side.[1] It is quite natural that the rate of technical progress will be much faster in a country that introduces existing technology from abroad than in one that is exploring it for the first time. In a developing country, the level of technology can be high due to imported or borrowed technology, while the wage level remains very low. If a developing country succeeds in introducing foreign high technology for the production of a given commodity, e.g. a textile, and in acquiring a certain level of capacity for producing the commodity using this technology, its production costs will be very low compared with those in a developed country where the wage level may typically be ten times as high as in the developing country. The foreign demand for the low-price commodity from the developing country will be very

[1]S. Kuznets emphasizes "the existence of a technological backlog, the exploitation of which could generate accelerated advance elsewhere" in discussing conditions for strong economic performance in an LDC. He also writes that "given the power of modern technology and effectiveness of modern trade ties, the potential growth of an LDC should only moderately be constrained by scarcity of natural resources, or by scale problems because of smallness of the internal markets." S. Kuznets, *Modern Economic Growth and the Less Developed Countries*, a paper presented at the Conference on Experiences and Lessons of Economic Development in Taiwan, held in Taipei in December, 1981.

strong. Keeping pace with the increase in production capacity for the commodity, exports will continue to grow very rapidly, until the wage level of the developing country approaches that in the developed country. This sort of rapid growth in export demand will continue to be a strong driving force behind the economic growth of the developing country. It is true that this pattern, which has been discerned very generally in the so-called NICs during the last twenty years, has very important policy implications for development strategy. But several negative aspects must also be noted: social and economic maladjustments accompanying very rapid industrialization, environmental deterioration, and trade frictions due to the rapid growth in the exports from developing countries to the developed ones.

An example of the last type of problem arose between Japan and the United States during the 1960s and 1970s because of the rapid expansion in Japanese exports of textiles, steel, electronic appliances, and cars. Recently, similar trade frictions have arisen between Japan and Taiwan, and between Japan and South Korea.

The main purpose of this study is to make an econometric analysis of the underlying pattern of high economic growth. More specifically, we attempt to make a quantitative assessment of the contribution of borrowed technology to the recent rapid growth of the Taiwanese economy, and also to analyze quantitatively the recent trade friction between Taiwan and Japan. The procedure followed is first to construct an econometric model of Taiwan, then to make a comparison of growth patterns between Taiwan and Japan on the basis of econometric models of both economies,[2] and finally to study the trade friction between the two countries by linking together the two econometric models through export and import functions. Section 2 describes the main features of the econometric model of Taiwan, and discusses the implications of its estimated results. Section 3 is devoted to testing the explanatory power of the model for the past performance of the Taiwanese economy and examining its dynamic properties. Section 4 links the Taiwanese and Japanese models and then tests the explanatory power of the linked models and examines their dynamic properties. Finally, Section 5 presents a simulation study

[2]The econometric model of Japan is described in a companion IIASA Working Paper, *The Causes of the High Economic Growth of Japan* , published in 1985 by the International Institute for Applied Systems Analysis, Laxenburg, Austria.

of the impact of technological progress within one country on the economic performance of other countries as well as the impacts on the domestic economy.

2. MAIN FEATURES OF THE TAIWANESE MODEL

The model is essentially an annual aggregative model of the Keynesian type, whose sample period is 1960–81. The equations and variables of the estimated model are listed in the Appendix. In general, the method of estimation is ordinary least squares. $\bar{R}^2$ is the measure of goodness of fit adjusted for degrees of freedom; and D.W. is the Durbin–Watson statistic. The figure in parentheses below each regression coefficient indicates its t-value. Some of the equations are estimated by the Cochrane–Orcutt iterative method, where ρ is the serial correlation coefficient of the first order in error terms.

The first important characteristic of the model is the disaggregation of exports and imports, which enables us to deal with the trade relationship between Taiwan and Japan. Imports are then disaggregated into imports from Japan and those from countries other than Japan. Imports from Japan are further disaggregated into six items: (1) food and agricultural products, (2) chemicals, (3) textiles, (4) metals, (5) machinery, and (6) others. These imports are mainly explained in terms of the GDP of Taiwan, relative prices, and the level of capacity output of Taiwan (see eqs. (2.1) to (2.6)) The level of capacity output, representing the effect of import substitution, is calculated from the estimated production function, as explained below.

Imports from countries other than Japan are disaggregated into (1) fuels and (2) nonfuels. These are also explained in terms of the GDP of Taiwan and relative prices (eqs. (2.11) and (2.12)). There is a slight statistical discrepancy between the sum of disaggregated imports from Japan and the total import from Japan, *MGJPMO*, since the former is based on MITI trade statistics from Japan and the latter on trade statistics from Taiwan. The two figures are intercorrelated through a statistical equation (eq. (2.19)). The sum of commodity imports from Japan and nonfuel commodity imports from countries other than Japan is the total nonfuel commodity import, $MO \cdot PMO$, (eq. (2.18)), and the total commodity import and service imports add up to the imports of goods and services derived from the national income account, M, (eq. (2.14)).

Commodity exports are also disaggregated into exports to Japan and those to countries other than Japan. Exports to Japan are further disaggregated into (1) food and agricultural products, (2) chemicals, (3) machinery, and (4) others. The main explanatory variables for such exports are the GNP of Japan, relative prices, and the level of the capacity output of Taiwan (eqs. (2.7) to (2.10)). The second of these variables is introduced to take into account the fact that the capacity level may impose limits on the maximum amount of Taiwanese exports. A greater part of item (4) is textiles. Therefore, in the estimation of eq. (2.10) we used an estimate of 0.64 for the long-run elasticity of exports of this item with respect to the GNP of Japan; this estimate is the result of the calculation 1.26 × 0.79 × 0.64, where 1.26 and 0.79 are, respectively, estimates of the elasticity of consumer demand for textiles with respect to total consumption and the elasticity of total consumption with respect to personal disposable income, both of which were obtained from a cross-section study, and 0.64 is the ratio of personal disposable income to GNP.

Exports to countries other than Japan are explained in terms of the world trade index, relative prices, and the level of capacity output of Taiwan (eq. (2.13)). In the same way as for imports, eqs. (2.21) to (2.24) are identities and statistical discrepancy equations, by which individual export items add up to exports of goods and services derived from the national income account, X.

The second significant feature of the model is the system of price equations that relates the growth of exports and imports to the cost structure of domestic Taiwanese products. Corresponding to the disaggregation of imports, industry as a whole is disaggregated into eight industries: (1) primary, (2) food, (3) textiles, (4) chemicals, (5) petrochemicals, (6) metals, (7) machinery, and (8) construction, utilities, and services.

Using the framework of input–output analysis, we may write the price–cost relationship of industry i as:

$$P_i = \sum_{j=1}^{8} A(j,i)\cdot P_j + D(i)\cdot PI + LC(i)\cdot W + T(i)\cdot P_i + S(i)\cdot P_i \qquad \text{(A.1)}$$

Here P_i, W, and PI are, respectively, the price for industry i, the wage index, and the deflator for investment goods; $A(j,i)$, $LC(i)$, $D(i)$, $T(i)$, and $S(i)$ are material input coefficients, labor input coefficients, the depreciation ratio, the indirect tax ratio, and the surplus ratio, respectively. The coefficients, which represent the technical and institutional structure of each industry, are adopted from the Taiwanese input–output table for 1976. By solving each equation with respect to P_i, we may express the price of domestic product i as a function of the prices of other products and the wage:

$$P_iD = (\sum_{\substack{j=1 \\ j \neq i}}^{8} A(j,i) \cdot P_j + D(i) \cdot PI) \;/\; (1 - A(i,i) - T(i) - S(i))$$

$$+ (LC(i) \cdot W) \;/\; (1 - A(i,i) - T(i) - S(i)), \qquad \text{(A.2)}$$

where P_iD is the price of the domestic product. This equation implies that the cost of product i consists of two parts: the nonwage part (the first term on the right-hand side) and the wage part (the second term). Let us denote the former by P_iIO, as shown in eq. (4.2). The elasticity of P_iD with respect to P_iIO in the base year, when $P_i = 1.0$, is calculated as

$$(\sum_{\substack{j=1 \\ j \neq i}}^{8} A(j,i) + D(i)) \;/\; (1 - A(i,i) - T(i) - S(i)) \qquad \text{(A.3)}$$

In eqs. (4.3), (4.6), (4.7), (4.9), and (4.10) the coefficient of $\ln P_iIO$ is set at the value given by formula (A.3) from the 1976 input–output table. On the other hand, taking into account the distinct declining trend in $LC(i)$, we introduced the reciprocal of the labor productivity of industry as a whole into eqs. (4.3) to (4.10) as a variable representing the secular movement of the labor input coefficient of industry i. In this procedure we assume that there exists a stable relationship between the growth rates of labor productivity in industry as a whole and in the individual industry i.

The price as a cost item, or the purchasers' price, P_i, will be defined as a weighted average of the prices of the domestic product, P_iD, and the price of imported goods, P_iM (eq. (4.1)). The latter is also defined as a weighted average of the import price from Japan, $PMJ_i \cdot RATE$, and the import prices from countries other than Japan, PME and PMO (eqs. (4.27) to (4.34)).

The deflators of individual components of final demands, *PC*, etc., are related to a variable defined as a weighted average of the individual industry prices, *PCIO*, etc. (eqs. (4.12) to (4.16)), where the weight is calculated from the relative share of each industry's output in the relevant final demand (eq. (4.11)).

Export prices, PX_i, are explained in terms of the price of the industry corresponding to each export item (eqs. (4.17) to (4.20)). Import prices from Japan, PMJ_i, are determined by the wholesale price index of industry as a whole in US dollar terms, $PWHIJ \cdot RATJ$ (eqs. (4.21) to (4.26)); we assume that there exists a stable relationship between the trend of the price for industry as a whole and those for individual industries. Under the same assumption, the wholesale price index for each individual industry is related to that of industry as a whole (eqs. (J.1) to (J.4)).

The third important feature of the model is that the supply side of the economy is represented by a production function of the CES type:

$$GDPM = [\delta_1 (T \cdot L)^{-\vartheta} + \delta_2 KIF^{-\vartheta} + \delta_3 ME^{-\vartheta} + \delta_4 MO^{-\vartheta}]^{-1/\vartheta} \qquad (A.4)$$

where an output variable, *GDPM*, is the total supply, i.e., GDP plus imports, and *L*, *KIF*, *ME*, and *MO* are labor input, capital stock, fuel imports, and other imports, respectively; δ_i and ϑ are parameters and the elasticity of substitution is $1/(1+\vartheta)$. Technical progress of a labor-augmenting type is allowed for by a trend variable *T*. We assume that the level of technical knowledge is expressed by an index, $\exp(\lambda t)$, where t is a time trend, and that the level of embodied technique in existing plant and equipment at time t, T_t, is represented by a weighted average of $\exp(\lambda t)$ over the preceding ten years, where the weight is new investment over the same period (eq. (5.1)). Cost minimization under eq. (A.4) gives us a set of four log-linear marginal productivity relations, each of which has a different constant term but a common elasticity of substitution, σ. Pooling the productivity and price data for four inputs yields the estimated results in eq. (5.1), where the whole sample period is divided into two periods: before and after the oil crisis. Eq. (5.1) has the smallest residual sum of squares among the equations obtained by assigning to λ various values within a plausible range. Estimated results show that the average annual rate of progress in available technical knowledge, λ, is 7 and 6 percent per year for the years 1962–69 and 1974–81, respectively, while the elasticity of substitution, about 0.4, is almost the same for both periods.

Capacity output is defined as the value of *GDPM* obtained by substituting labor force *LFE* for L in the estimated version of eq. (A.4) (namely, eq. (5.2)).

Since *GDPM* is the output of the whole economy, labor input must include self-employed and family workers, *NU*, as well as employees, *NW*. In view of the large differential between the productivities of these types of input, however, labor input is defined here as the sum of *NW* and a discounted *NU*, where the discount rate is the income differential, *DFL* (eqs. (6.4) to (6.9)). The desired level of L, i.e. L^*, is calculated from the marginal productivity formula for labor (eqs. (5.1) and (6.1)). The actual level of L is regressed on this desired level and a lagged value of L (eq. (6.2)). Finally, a version of the Phillips curve is estimated to determine the wage level of employees (eq. (6.10)).

3. THE FINAL TEST AND DYNAMIC PROPERTIES OF THE MODEL

The explanatory effectiveness of the model over the period 1965–76 was examined by the so-called final method of *ex post* forecasting.[3] In this method forecast values of the endogenous variables for the starting year (1965) are obtained by using observed values of the exogenous variables and the lagged endogenous variables, while those for subsequent years are obtained by using observed values of the exogenous variables for each sample year and calculated values of the lagged endogenous variables obtained by past forecast. The results are presented in **Table 2.** In this simulation the variables relating to Japan, such as GNP, wholesale price indexes for industries, and the exchange rate, were treated as exogenous. In addition, the constant term of the employment equation was raised by 80 thousand persons, since the equation turned out to be unsuccessful in explaining the observed dynamic behavior of the unemployment rate.

Column (1) of the table shows the average absolute percentage error of selected endogenous variables. It can be seen that the errors for total supply, *GDPM*, and private consumption, C, are small, while those for exports, imports,

[3]See A. S. Goldberger, *Impact Multipliers and Dynamic Properties of the Klein–Goldberger Model* (North-Holland Publishing Co. 1959), pp. 49–51.

TABLE 2. The Results of Ex Post Forecasting, 1965–73

		(1) Average absolute percentage error*	(2) Average growth rate: actual	(3) Average growth rate: computed	(4) Error: (3) – (2)
(1) *GDP*:	GDP	3.45	10.99	10.67	–0.32
(2) *GDPM*:	total supply	3.23	13.11	12.18	–0.93
(3) *C*:	private consumption	2.82	8.53	7.53	–1.00
(4) *I*:	fixed investment	7.29	17.88	16.54	–1.34
(5) *X*:	exports	5.89	24.62	23.43	–1.19
(6) *M*:	imports	8.53	14.05	11.46	–2.59
(7) *P*:	GDP deflator	6.87	5.16	4.20	–0.96
(8) *PC*:	consumption deflator	5.78	4.90	4.43	–0.47
(9) *W*:	wage earings	6.41	9.16	7.61	–1.55
(10) *N*:	persons engaged	1.11	4.26	4.03	–0.23
(11) *MGJPMO*:	imports from Japan	10.83	27.82	26.13	–1.69
(12) *XGJPXG*:	exports to Japan	19.90	21.70	10.26	–11.44

*The average absolute percentage error

$$= \left(\sum_{t=1}^{T} \left| (\hat{X}_t - X_t) / X_t \right| / T \right) \times 100,$$

where $\hat{X}_t$ = the calculated value of a variable in period t,

X_t = the actual value of a variable in period t,

T = the number of periods.

and price variables are relatively large. Columns (2) and (3) present the actual and forecast average growth rates of the variables over the period 1965–73. By and large, the forecast value of the average growth rate is fairly close to the observed value, implying that the general trends in most of the variables are followed by the model simulation.

Table 3 examines the multiplier effect of government expenditure. A dynamic path was calculated in which government consumption expenditure was raised by a one billion Taiwanese dollars (T$), other exogenous variables being kept at the same level as in the *ex post* forecast described above. The figures in **Table 3** are the difference between the *ex post* forecast solution (call it the "control" solution) and the expansionary one. As shown in Row (1), the value of the multiplier is 1.089 in the first year and reaches a peak value of 1.657 in the third year. These values are lower than those for Japan. The value of the multiplier for the Japanese model is 1.28 in the first year and reaches a peak of 1.92 in the seventh year.[4] The lower

[4]See M. Saito and T. Oono, *An Energy Model of the Japanese Economy, 1961–1979*.

value of the multiplier for Taiwan may be ascribed to the fact that "import leakage" is larger in Taiwan than in Japan: the ratio of imports to GNP in 1975 was 0.30 in Taiwan but only 0.11 in Japan. Other rows of **Table 3** show the effects of the increase in government consumption on selected variables in terms of the percentage change in the level of the control solution for each variable (see the footnote to Table 3).

TABLE 3. The Effect of a Sustained Increase of One Billion Taiwanese Dollars (T$) of Government Consumption, 1965–70

	1965	1966	1967	1968	1969	1970
(1) *GDP* (billion T$)	1.089	1.263	1.657	1.322	0.690	–0.746
(1)' *GDP* (%)	0.430	0.466	0.562	0.419	0.193	–0.187
(2) *GDPM* (billion T$)	1.248	1.548	2.322	2.549	2.727	2.304
(2)' *GDPM* (%)	0.404	0.461	0.621	0.615	0.581	0.437
(3) *C* (%)	0.138	0.245	0.389	0.499	0.605	0.668
(4) *I* (%)	0.000	0.193	1.020	1.035	1.072	0.618
(5) *X* (%)	0.075	0.056	0.003	–0.132	–0.327	–0.583
(6) *M* (%)	0.290	0.443	0.853	1.255	1.854	2.395
(7) *P* (%)	–0.319	–0.152	0.137	0.807	1.701	2.809
(8) *PC* (%)	–0.209	–0.070	0.159	0.693	1.389	2.214
(9) *W* (%)	0.026	0.158	0.472	0.969	1.674	2.474
(10) *N* (%)	0.016	0.041	0.073	0.108	0.139	0.162
(11) *MGJPMO*	0.452	0.572	0.815	0.874	0.883	0.717
(12) *XGJPXG*	–0.065	0.080	0.156	0.258	0.239	0.021

*(%) implies $\{ (X_t - \bar{X}_t) / \bar{X}_t \} \times 100$,

where X_t = the solution of a variable in period t for the "expansionary" economy,

$\bar{X}_t$ = the "control" solution of a variable in period t.

4. LINKING THE TAIWANESE AND JAPANESE MODELS

The Taiwanese and Japanese models were linked together by making the following variables common to both countries:[5]

PWHIJ: wholesale price index of the whole of Japanese industry

[5]For the purpose of linkage, exports from Japan were disaggregated into exports to Taiwan and those to other countries. Similarly, imports into Japan were disaggregated into imports from Taiwan and those from other countries.

PJ_i: wholesale price index of item i in Japan

RATJ: exchange rate of Japan

MGJPMO: imports of commodities from Japan

XGJPXG: exports of commodities to Japan

The explanatory effectiveness of the linked models over the period 1965–1973 was tested by the final method as described earlier. In **Table 4** the results of the linked models are compared with those of the unlinked Taiwanese model. Columns (1) and (2) of the table contain the average absolute percentage error of the linked models and its difference from that of the unlinked Taiwanese model,[6] respectively. It can be seen that, by and large, the average absolute percentage errors of the linked models are fairly close to those of the unlinked model. Columns (3) and (4) are the errors in the average growth rate for the linked models and the unlinked one, respectively. The figures are very close to each other, indicating that linking the Taiwanese model with the Japanese one does not give rise to any significant increase in errors. Columns (5) and (6) present, respectively, the average absolute percentage error and the error in the average growth rate of the Japanese variables obtained from the simulation of the linked models. Generally speaking, the errors in the real variables for Japan are larger than those for Taiwan, while the errors in the nominal variables (prices and wages) are smaller.

Now we examine the interdependence between the economies by estimating the multiplier in the linked models. **Table 5** presents the results of a simulation in which the government consumption expenditures of Taiwan are raised by one billion T$ over the period 1965–68. The first four columns of the table show the effects of the increase in government expenditure on the Taiwanese economy.[7] By comparing **Tables 5** and **3** it can be seen that there is practically no change in the multiplier effect between the unlinked and linked Taiwanese models. In addition, the last four columns of **Table 5**, which present the impact multiplier of Taiwanese government expenditure on the Japanese economy, show that a 0.4–0.6 percent increase in the GDP growth rate of Taiwan does not exert any significant influence

[6]The errors in the unlinked Taiwanese model are presented in Column (1) of **Table 2**.

[7]The solution of the unlinked Taiwanese model is presented in **Table 3**.

TABLE 4. The Results (Percentages) of Ex Post Forecasting Using the Linked Models, 1965–73

	Taiwan				Japan	
	(1) Average absolute percentage error*	(2) (1) - Error of unlinked model	(3) Error in the growth rate: Linked	(4) Error in the growth rate: unlinked	(5) Average absolute percentage error* (linked)	(6) Error in the growth rate (linked)
(1) *GDP***	3.68	+0.23	–0.36	–0.32	6.67	–0.69
(2) *GDPM***	3.31	+0.08	–0.94	–0.93	5.26	–0.58
(3) *C*	2.87	+0.05	–0.99	–1.00	4.86	–0.89
(4) *I*	7.58	+0.29	–1.46	–1.34	16.94	–0.71
(5) *X*	5.77	–0.12	–1.16	–1.19	9.99	–1.21
(6) *M*	8.02	–0.51	–2.49	–2.59	3.11	+0.00
(7) *P*	6.76	–0.11	–0.86	–0.96	5.21	+0.74
(8) *PC*	5.68	–0.10	–0.40	–0.47	3.96	+0.65
(9) *W*	6.54	–0.13	–1.57	–1.55	1.62	+0.00
(10) *N*	1.11	0.00	–0.23	–0.23	2.16	–0.56
(11) *MGJPMO*	9.79	–1.04	–1.57	–1.69	–	–
(12) *XGJPXG*	19.49	–0.41	–10.94	–11.44	–	–

*See **Table 2**.
**In the case of Japan, GNP or GNPM.

on Japanese economic activities.

On the other hand, **Table 6** presents the results of a simulation in which the government consumption expenditure of Japan is raised by one billion yen over the period 1965–68. The first four columns show the effects of Japanese expansion on the Taiwanese economy. On average over this four-year period a 1.813-percent annual increase in the growth rate of Japanese GNP will give rise to a 0.055-percent annual increase in that of Taiwan; i.e. a one-percent rise in the growth rate of Japanese GNP might be expected to yield a 0.030-percent rise in that of Taiwan. Therefore, it may be concluded that economic repercussions from Japan to Taiwan will be much larger than those from Taiwan to Japan.

5. THE IMPACT OF TECHNICAL PROGRESS ON ECONOMIC PERFORMANCE

In this section we attempt to make a quantitative assessment of the effect of technical progress on economic performance. The method adopted here is simulation using the estimated models. The assessment is first made on the basis of the unlinked Taiwanese model, and then repeated using the linked models.

TABLE 5. The Effects of a Sustained Increase of One Billion Taiwanese Dollars (T$) in Taiwanese Government Consumption, 1965–68 (Linked Models)

	Taiwan				Japan			
	1965	1966	1967	1968	1965	1966	1967	1968
(1) *GDP* (billion T$ or yen)*	1.089	1.264	1.660	1.328	−0.781	−1.438	−2.547	−3.164
(1)' *GDP* (%)*	0.430	0.466	0.563	0.422	−0.001	−0.002	−0.003	−0.003
(2) *GDPM* (billion T$ or yen)*	1.247	1.547	2.323	2.552	−0.919	−1.546	−2.734	−3.338
(2)' *GDPM* (%)*	0.404	0.461	0.622	0.617	−0.001	−0.002	−0.003	−0.003
(3) *C* (%)	0.138	0.245	0.389	0.500	0.000	0.000	0.000	0.000
(4) *I* (%)	0.000	0.192	1.020	1.037	−0.002	−0.004	−0.005	−0.006
(5) *X* (%)	0.075	0.055	0.002	−0.130	−0.011	−0.015	−0.022	−0.022
(6) *M* (%)	0.290	0.443	0.854	1.255	−0.002	−0.001	−0.002	−0.002
(7) *P*	−0.319	−0.152	0.136	0.805	−0.000	−0.001	−0.001	−0.001
(8) *PC*	−0.209	−0.071	0.158	0.692	0.000	0.000	0.000	0.000
(9) *W*	0.026	0.158	0.472	0.970	0.000	0.000	0.000	0.000
(10) *N* (%)	0.016	0.042	0.074	0.108	−0.000	−0.001	−0.001	−0.001
(11) *MGJPMO* (%)	0.452	0.572	0.816	0.876	–	–	–	–
(12) *XGJPXG* (%)	−0.065	0.077	0.152	0.255	–	–	–	–

*In the case of Japan, GNP or GNPM.

TABLE 6. The Effects of a Sustained Increase of One Billion Yen in Japanese Government Consumption, 1965–68 (Linked Models)

	Taiwan				Japan			
	1965	1966	1967	1968	1965	1966	1967	1968
(1) *GDP* (billion T$ or yen)*	0.086	0.144	0.199	0.207	1.303	1.404	1.494	1.594
(1)' *GDP* (%)*	0.034	0.053	0.068	0.066	1.852	1.841	1.809	1.748
(2) *GDPM* (billion T$ or yen)*	0.123	0.203	0.315	0.433	1.424	1.538	1.640	1.757
(2)' *GDPM* (%)*	0.040	0.061	0.084	0.105	1.844	1.827	1.789	1.725
(3) *C* (%)	0.019	0.038	0.059	0.083	0.224	0.380	0.558	0.734
(4) *I* (%)	0.000	0.015	0.089	0.124	0.518	2.788	2.515	2.109
(5) *X* (%)	0.200	0.250	0.266	0.246	−0.097	−0.199	−0.285	−0.334
(6) *M* (%)	0.062	0.092	0.148	0.230	1.778	1.690	1.600	1.528
(7) *P*	−0.001	0.011	0.049	0.141	−0.178	−0.140	−0.039	0.072
(8) *PC*	0.006	0.039	0.113	0.228	0.125	0.162	0.199	0.274
(9) *W*	0.005	0.022	0.063	0.136	0.012	0.092	0.201	0.357
(10) *N* (%)	0.002	0.005	0.010	0.016	0.313	0.597	0.740	0.802
(11) *MGJPMO* (%)	0.110	0.135	0.177	0.236	–	–	–	–
(12) *XGJPXG* (%)	1.098	1.638	1.961	2.285	–	–	–	–

*In the case of Japan, GNP or GNPM.

5.1. The Unlinked Taiwanese Model

In the Taiwanese model the rate of labor-augmenting technical progress was estimated as 7 percent per year for 1961–73 in eq. (5.1) above. Suppose now that this rate is 6 percent per year, i.e. one percentage point lower than the initial estimate. A simulation for 1965–73 under this latter assumption, other things being kept unchanged, describes the growth path whose main features are presented in **Table 7**. Columns (1) and (2) of the table give the average growth rates of selected variables for the 6-percent path and their difference from the "control" solution (see Columns (3) of **Table 2**). It can be seen that a slowdown of one percent in the rate of Taiwanese technical progress will result in a decrease of 2.10 percent in the growth rate of GDP, an increase of 5.70 percent in the inflation rate of the GDP deflator, and an increase of 0.13 percent in the growth rate of employment. The annual increase of 0.13 percent in the average growth rate of employment for nine years, representing a fall of 1.18 percent in the unemployment rate in 1973 may be impossible, since the labor market of Taiwan reached a state of full employment around 1971 and the unemployment rate was 2.24 percent in 1973.[8] Therefore, if the rate of technical progress had been one percent slower, effective demand would have had to be reduced. Let us suppose that government expenditures were cut down so as to keep the unemployment rate at the level of the control solution. Columns (3) and (4) present the growth rate for the simulated path and the differences between this and the control solution, respectively. They show that a one-percent slowdown in the rate of technical progress would lead to a fall of 1.04 percent in the average growth rate of GDP and an increase of 0.95 percent in the inflation rate of the GDP deflator. One might argue, assuming the causal relationship outlined above to be linear, that if the rate of technical progress were zero percent, the Taiwanese economy would have experienced a fall of 7.28 percentage points in the growth rate of GDP, which is about two-thirds of the total GDP growth rate. Column (5) presents calculated values for the Japanese model corresponding to the Taiwanese figures of Column (4). The Japanese figures indicate that the effect on economic performance of the one-percent slowdown in the rate of technical progress is somewhat weaker in Japan than in Taiwan. In fact, a calculation showed that in the case of Japan, if the

[8]S.W.Y. Kuo, *The Taiwan Economy in Transition* (Westview Press, 1983, Chap.4).

rate of technical progress were zero percent, the Japanese economy would have experienced a drop of 6.12 percentage points in the growth rate of GNP, which is about 60 percent of the total GDP growth rate.

TABLE 7. The Effect of a One-Percent Slowdown in the Rate of Taiwanese Technical Progress, 1965–73 (Unlinked Model)

	(1) 1% fall in the rate of technical progress	(2) (1) – (control solution)	(3) (1) and slower growth of government consumption	(4) (3) – (control solution)	(5) Japanese figure comparable to (4)
(1) *GDP**	8.57	–2.10	9.63	–1.04	–0.68
(2) *GDPM**	11.55	–0.63	11.31	–0.87	–0.66
(3) *C*	7.77	+0.24	6.95	–0.58	–0.46
(4) *I*	14.41	–2.13	14.85	–1.69	–0.94
(5) *X*	22.05	–1.38	23.02	–0.41	–0.71
(6) *M*	14.52	+3.06	11.11	–0.35	–0.48
(7) *P*	9.90	+5.70	5.15	+0.95	+0.61
(8) *PC*	8.39	+3.96	5.10	+0.67	+0.52
(9) *W*	10.46	+2.85	7.55	–0.06	+0.10
(10)*N*	4.16	+0.13	4.01	–0.02	+0.02
(11)*MGJPMO*	25.07	–1.06	24.93	–1.20	–
(12)*XGJPXG*	9.11	–1.15	9.51	–0.75	–

*In the case of Japan, GNP or GNPM.

5.2. The Linked Models

Let us now turn to the linked models. **Table 8** presents the results of a simulation using the linked models, in which the rate of Taiwanese technical progress is set at 6 percent, i.e. one percent lower than the initial estimate, and Taiwanese government consumption is reduced so as to keep the unemployment rate at the same level as in the control solution. Column (1) shows the difference between the *Taiwanese* growth-rate values for each variable and the corresponding control solutions. It is clear that the impact of a one-percent slowdown in Taiwanese technical progress is practically the same as that obtained from the simulation of the unlinked Taiwanese model (see Column (4) of **Table 7**). Similarly, Column (2) of **Table 8** shows the difference between the *Japanese* growth rate values for each variable and the corresponding control solutions. We notice that the one-percent slowdown of Taiwanese technical progress would have led to a slight stimulus favorable to Japan, for example, a 0.01-percent rise in GNP growth rate, a 0.03-percent rise in the growth rate of exports, and a 0.85-percent fall in the imports-from-Taiwan growth rate. These figures seem very small. One might argue, however, assuming that the causal relationship is linear, that Japan would have experienced a 0.07 (= 0.01 × 7) percentage-point rise[9] in GNP growth, 0.21 percentage points more export growth, and 5.95 percentage points less growth in imports from Taiwan than if there had been no technical progress in Taiwan. The first two of these might have had an insignificant effect on the Japanese economy as a whole, but the 5.95 percentage-point change in imports from Taiwan would have had a substantial impact on the businesses concerned in both countries.

Finally, **Table 9** presents the results of a simulation in which the rate of Japanese technical progress is set at 8 percent (i.e., one percentage point lower than in the initial estimate) and Japanese government consumption is reduced so as to keep the growth rate of employment at the same rate as in the control solution. Columns (1) and (2) are, respectively, the differences between the Taiwanese and Japanese growth rates of each variable and those of the control solution. The effect on the Japanese economy of the one percentage-point slowdown in Japanese technical progress is practically the same as that calculated using the unlinked Japanese model (Column (5) of **Table 7**), while its effect on the Taiwanese economy is very small. A comparison, however, of Column (2) of **Table 8** and Column (1) of **Table 9** reveals that the latter is significantly larger than the former, implying that the effect of Japanese technical progress on Taiwanese performance is much larger than the effect of Taiwanese technical progress on Japanese performance.

According to our estimates of the production functions for both countries, the average annual rate of Japanese technical progress fell from 9 percent to 3 percent after the 1973 oil crisis, while the rate of Taiwanese technical progress fell from 7 percent to 6 percent. The former implies a 0.36 (= 0.06 × 6)-percent fall in the GDP growth rate of Taiwan, a 4.02 (= 0.67 × 6)-percent fall in the GNP growth rate of Japan, and a 5.94 (= 0.99 × 6)-percent increase in the rate of growth of Taiwan-to-Japan exports, while the latter signifies a 0.85-percent decrease in the

[9]The estimate for the rate of Taiwanese technical progress was 7.0 percent.

TABLE 8. The Effects of a One-Percent Slowdown in the Rate of Taiwanese Technical Progress, 1965–73 (Linked Models)

	(1) The effect on Taiwan (slower technical progress) – (control solution)	(2) The effect on Japan (slower technical progress) – (control solution)
(1) *GDP**	−1.03	+0.01
(2) *GDPM**	−0.86	+0.01
(3) *C*	−0.58	+0.00
(4) *I*	−1.69	+0.01
(5) *X*	−0.42	+0.03
(6) *M*	−0.36	−0.00
(7) *P*	+0.93	+0.00
(8) *PC*	+0.66	+0.00
(9) *W*	−0.07	+0.00
(10) *N*	−0.02	+0.00
(11) *MGJPMO*	−1.20	–
(12) *XGJPXG*	−0.85	–

*In the case of Japan, GNP or GNPM.

TABLE 9. The Effects of a One-Percent Slowdown in the Rate of Japanese Technical Progress, 1965–73 (Linked Models)

	(1) The effect on Taiwan (slower technical progress) – (control solution)	(2) The effect on Japan (slower technical progress) – (control solution)
(1) *GDP**	−0.06	−0.67
(2) *GDPM**	+0.02	−0.70
(3) *C*	+0.04	−0.46
(4) *I*	−0.05	−0.96
(5) *X*	+0.02	−0.72
(6) *M*	+0.24	−0.48
(7) *P*	+0.61	+0.61
(8) *PC*	+0.52	+0.52
(9) *W*	+0.13	+0.09
(10) *N*	+0.01	+0.00
(11) *MGJPMO*	+0.34	–
(12) *XGJPXG*	+0.99	–

*In the case of Japan, GNP or GNPM.

respective rates. Therefore, the net effects are a 1.39-percent fall in the GDP growth rate of Taiwan, a 4.01-percent fall in the GNP growth rate of Japan, and a 5.09-percent increase in the growth rate of Taiwan-to-Japan exports. The first two effects explain the greater part of the fall in the GDP growth rates of both countries. The last effect must have been the main cause of the subsequent trade friction between the two countries.

APPENDIX

List of Variables

Notation	* exogenous	Explanation	Unit
C		private consumption expenditure	millions of 1976 NT$
CG	*	government consumption expenditure	millions of 1976 NT$
DEP		capital consumption allowances	millions of current NT$
DIV		dividends	millions of current NT$
GDP		gross domestic product	millions of 1976 NT$
GDPM		gross domestic supply	millions of 1976 NT$
GNPP		gross national product	millions of current NT$
I		gross domestic capital formation	millions of 1976 NT$
IBG	*	interest on public debt	millions of current NT$
J	*	increase in stocks	millions of 1976 NT$
M		imports of goods and services	millions of 1976 NT$
NFI	*	net factor income from the rest of the world	millions of current NT$
NI		national income at factor cost	millions of current NT$
P		deflator for gross domestic product	1976 = 1.0
PC		deflator for private consumption expenditure	1976 = 1.0
PCG		deflator for government consumption expenditure	1976 = 1.0
PI		deflator for gross domestic capital formation	1976 = 1.0
PM		deflator for imports of goods and services	1976 = 1.0
POP	*	population	thousands of persons
PX		deflator for exports of goods and services	1976 = 1.0
SUB		subsidies	millions of current NT$
TI		indirect business taxes	millions of current NT$
TRP	*	personal income tax and other household transfers	millions of current NT$
WN		employee compensation	millions of current NT$
X		exports of goods & services	millions of 1976 NT$
YC	*	corporate income before taxes	millions of current NT$
YDP		private disposable income	millions of current NT$
YG	*	general government income from property & government enterprises	millions of current NT$
YPP		personal income	millions of current NT$
YRP		private income from property	millions of current NT$
YUI		compound income	millions of current NT$

Notation	* exogenous	Explanation	Unit
JRATET	*	exchange rate of Japan	Yen/US$
ME		imports of fuels	millions of 1976 NT$
MG		imports of commodities	millions of 1976 NT$
MGJPMO		imports of commodities from Japan	millions of current NT$
MGR		imports of commodities other than fuels from countries other than Japan	millions of 1976 NT$
MJ		imports from Japan	billions of current Yen
MJi		imports of item *i* from Japan; *i* = 1 (foods), 2 (chemicals), 3 (textiles), 4 (metals), 5 (machinery), and 6 (others)	thousands of 1976 US$
MO		imports of commodities other than fuels	millions of 1976 NT$
MS	*	imports of services	millions of 1976 NT$
Pi		price index of industry *i*; *i* = 1 (primary), 2 (foods), 3 (textiles), 4 (chemicals), 5 (petrochemicals), 6 (metals), 7 (machinery), and 8 (construction, utilities, and services).	1976 = 1.0
PJ		deflator for increase in stocks	1976 = 1.0
PJi		wholesale price index of item *i* of Japan; see *XJi* for each item	1976 = 1.0
PME	*	deflator for imports of fuels	1976 = 1.0
PMG		deflator for commodity imports	1976 = 1.0
PMJi		import price index of item *i* from Japan; see *MJi* for each item	1976 = 1.0 (US$)
PMO	*	deflator for imports of commodities other than fuels	1976 = 1.0
PMS	*	deflator for service imports	1976 = 1.0
PXi		export price index of item *i*; see *XJi* for each item	1976 = 1.0 (NT$)
PXG		deflator for commodity exports	1976 = 1.0
PXS	*	deflator for service exports	1976 = 1.0
PWT	*	price index of world trade (US dollar base)	1975 = 1.0
RATE	*	index of exchange rate (NT$ per one US$)	1976 = 1.0
RATJ	*	index of exchange rate of Japan (Yen per one US$)	1976 = 1.0
VJ	*	index of gross national product in constant prices of Japan	1976 = 1.0
WT	*	quantity index of world trade	1975 = 1.0
XG		exports of commodities	millions of 1976 NT$
XGJPXG		exports of commodities to Japan	millions of current NT$
XGR		exports of commodities to countries other than Japan	millions of 1976 NT$
XJ		exports to Japan	billions of current Yen
XJi		exports of item *i* to Japan; *i* = 1 (foods and agricultural product), 2 (chemicals), 3 (machinery), and 4 (others)	thousands of 1976 US$
XS	*	exports of services	millions of 1976 NT$
YCD		corporate income before taxes, excluding dividents	millions of current NT$

Notation	* exogenous	Explanation	Unit
DFL		income differential between employees and nonemployees, defined by eq. (6.5)	–
KIF		end-of-year stock of capital	millions of 1976 NT$
L		adjusted number of persons engaged of the whole economy	thousands of persons
L^*		desired level of L, defined by eq. (6.1)	thousands of persons
LF	*	number of labor force of the whole economy	thousands of persons
N		number of persons engaged of the whole economy	thousands of persons
NU		number of self-employed persons and family workers	thousands of persons
NW		number of employees	thousands of persons
PiD		price index of domestic product of industry *i*	1976 = 1.0
PiM		price index of import product of industry *i*	1976 = 1.0
PiIO		cost index of industry *i*, defined by eq. (4.2)	1976 = 1.0
PCIO		weighted average of industry prices, defined by eq. (4.11)	1976 = 1.0
PCGIO		weighted average of industry prices, defined by eq. (4.11)	1976 = 1.0
PGDPM		deflator for gross domestic supply	1976 = 1.0
PIIO		weighted average of industry prices, defined by eq. (4.11)	1976 = 1.0
PJIO		weighted average of industry prices, defined by eq. (4.11)	1976 = 1.0
PK		price index of capital services, defined by eq. (4.35)	1976 = 1.0
PO	*	wholesale price index of others	1976 = 1.0
PXGIO		weighted average of industry prices, defined by eq. (4.11)	1976 = 1.0
PWHIJ	*	wholesale price index of the whole industry of Japan	1976 = 1.0
R	*	maximum rate of medium- and long-term bank loan	per cent per year
T		index of technology level, defined by eq. (5.1)	–
UR		unemployment rate	percent
VMC		capacity level of gross domestic supply, defined by eq. (5.2)	millions of 1976 NT$
W		employee compensation per employee	thousands of NT$ per person
WU		compound income per person	thousands of NT$ per person

List of Coefficients

Notation	Explanation
$A(j,i)$	material input coefficient; i.e., the amount of output j required to produce one unit of output i
$D(i)$	capital consumption allowances per unit of output in industry i
$F(j,i)$	the proportion of the value of the ith industry output which corresponds to the jth final demand and category; j =1 (private consumption), 2 (government consumption), 3 (gross domestic capital formation), 4 (increase in stocks), and 5 (exports); see *Pi* for i = 1,2,...,8.
$T(i)$	ratio of indirect taxes less subsidies to output in industry i
$S(i)$	mark-up ratio, or the normal rate of business surpluses to output in industry i
$WD(i)$	weight of domestic price in the price index of industry i
$WM(i)$	weight of import price in the price index of industry i

List of Dummy Variables

Notation	Explanation
DUME	= 1 when the explained variable in eq. (5.1) is ln (*ME* / *GDPM*); = 0 otherwise
DUMK	= 1 when the explained variable in eq. (5.1) is ln (*KIF* / *GDPM*); = 0 otherwise
DUML	= 1 when the explained variable in eq. (5.1) is ln (*L* / *GDPM*) $\cdot T$; = 0 otherwise
DUMO	= 1 when the explained variable in eq. (5.1) is ln (*MO* / *GDPM*); =0 otherwise
*D*5159	= 1 for 1951–59; = 0 otherwise
*D*63	= 1 for 1963 ; = 0 otherwise
*D*6599	= 1 for 1965– ; = 0 otherwise
*D*6699	= 1 for 1966– ; = 0 otherwise
*D*72	= 1 for 1972 ; = 0 otherwise
*D*7499	= 1 for 1974– ; = 0 otherwise
*D*7599	= 1 for 1975– ; = 0 otherwise
*D*7799	= 1 for 1977– ; = 0 otherwise
*D*8099	= 1 for 1980– ; = 0 otherwise
*D*8199	= 1 for 1981– ; = 0 otherwise

List of Equations

Eq. No.	Equation	$\overline{R}^2$	D.W.	ρ	sample period
I. Expenditure					
Gross Domestic Product					
(1.1)	$GDP = C + CG + I + J + X - M$				
(1.2)	$GDP \cdot P = C \cdot PC + CG \cdot PCG + I \cdot PI + J \cdot PJ + X \cdot PX - M \cdot PM$				
(1.3)	$GDPM = GDP + M$				
(1.4)	$PGDPM = (GDP \cdot P + M \cdot PM) / GDPM$				
(1.5)	$GNPP = GDP \cdot P + NFI$				
Consumption					
(1.6)	$\ln (C/POP) = \underset{(8.39)}{0.429} \ln \{(YDP/PC)/POP\} + \underset{(8.64)}{0.511} \ln (C/POP)_{-1} + \underset{(1.46)}{0.0119}\, D5159 + \underset{(4.76)}{0.116}$	0.999	1.850		1953–81
Fixed Investment					
(1.7)	$\ln I = \underset{(1.06)}{0.449} \ln GDP_{-1} + \underset{(4.05)}{1.925} \ln GDP_{-2} - \underset{(6.09)}{0.921} \ln KIF_{-1} - \underset{(22.4)}{6.489}$	0.996	1.053		1961–81
(1.8)	$KIF = 0.97\, KIF_{-1} + I$				

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
II. The Foreign Sector					
Imports from Japan					
	(Foods and agricultural products)				
(2.1)	$\ln MJ1 = \underset{(2.22)}{1.634} \ln GDP - \underset{(3.46)}{0.803} \ln \{PMJ1/(P2/RATE)\} - \underset{(2.03)}{1.093} \ln VMC_{-1} + \underset{(0.61)}{4.425}$	0.968	1.633	0.87	1964–81
	(Chemicals)				
(2.2)	$\ln MJ2 = \underset{(1.71)}{1.738} \ln GDP - \underset{(0.16)}{0.107} \ln \{PMJ2/(P4/RATE)\} - \underset{(0.82)}{0.667} \ln VMC_{-1} - \underset{(0.16)}{1.360}$	0.940	1.921	0.83	1964–81
	(Textiles)				
(2.3)	$\ln MJ3 = \underset{(0.56)}{0.449} \ln GDP - \underset{(0.53)}{0.349} \ln \{PMJ3/(P3/RATE)\} - \underset{(0.39)}{0.241} \ln VMC_{-1} + \underset{(1.49)}{9.515}$	0.925	1.622	0.83	1964–81
	(Metals)				
(2.4)	$\ln MJ4 = \underset{(9.35)}{1.251} \ln GDP - \underset{(4.23)}{0.927} \ln \{PMJ4/P6/RATE)\} - \underset{(2.13)}{3.812}$	0.987	2.574	0.67	1964–81
	(Machinery)				
(2.5)	$\ln MJ5 = \underset{(5.67)}{1.499} \ln GDP - \underset{(1.82)}{0.686} \ln \{PMJ5/P7/RATE)\} - \underset{(1.76)}{6.227}$	0.974	2.313	0.70	1964–81
	(Others)				
(2.6)	$\ln MJ6 = \underset{(3.92)}{1.307} \ln GDP - \underset{(2.10)}{0.451} \ln \{PMJ6/(PO/RATE)\} - \underset{(1.18)}{5.395}$	0.989	1.511	0.85	1964–81
Exports to Japan					
	(Foods and agricultural products)				
(2.7)	$\ln XJ1 = \underset{(1.57)}{0.387} \ln VJ - \underset{(1.81)}{0.639} \ln \{PX1/RATE)/(PJ1/RATJ)\} + \underset{(2.01)}{0.431} \ln XJ1_{-1} + \underset{(2.67)}{7.389}$	0.725	1.365		1965–81
	(Chemicals)				
(2.8)	$\ln XJ2 = \underset{(0.57)}{1.013} \ln VJ - \underset{(1.51)}{0.557} \ln \{PX2/RATE)/(PJ2/RATJ)\} + \underset{(3.64)}{0.611} \ln XJ2_{-1} + \underset{(0.27)}{0.372} \ln VMC - \underset{(0.06)}{1.083}$	0.955	1.818		1965–81
	(Machinery)				
(2.9)	$\ln XJ3 = \underset{(3.42)}{4.737} \ln VJ - \underset{(0.66)}{0.777} \ln \{PX3/RATE)/(PJ3/RATJ)\} + \underset{(1.79)}{0.221} \ln XJ3_{-1} + \underset{(6.49)}{8.999}$	0.941	1.945		1965–81
	(Others)				
(2.10)	$\ln XJ4 - 0.64 \ln VJ = \underset{(1.14)}{1.135} \ln \{PX4/RATE)/(PJ4/RATJ)\} + \underset{(4.14)}{0.744} \ln XJ4_{-1} + \underset{(1.52)}{3.518}$	0.920	2.024		1965–81

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
Imports from Countries other than Japan					
(Fuels)					
(2.11)	$\ln ME = 1.379 \ln GDP - 0.971 \ln (PME / P) - 0.271 \ln (PME / P)_{-1} - 7.947$	0.974	1.136		1961–81
	(27.4) (11.5) (2.58) (11.7)				
(Commodities other than fuels)					
(2.12)	$\ln MGR = 1.791 \ln GDP - 1.460 \ln (PMO / P) - 12.192$	0.982	1.078		1963–81
	(11.9) (5.07) (5.92)				
Exports to countries other than Japan					
(2.13)	$\ln XGR = 2.370 \ln WT - 0.193 \ln \{(PXG / RATE) / PWT\} + 0.182 \ln VMC_{-1} + 9.699$	0.994	1.198		1961–81
	(5.21) (1.04) (0.58) (2.22)				
Identities : Imports					
(2.14)	$M = MG + MS$				
(2.15)	$M \cdot PM = MG \cdot PMG + MS \cdot PMS$				
(2.16)	$MG = ME + MO$				
(2.17)	$MG \cdot PMG = ME \cdot PME + MO \cdot PMO$				
(2.18)	$MO \cdot PMO = MGJPMO + MGR \cdot PMO$				
(2.19)	$\ln MGJPMO = 1.021 \ln \{37.95\, RATE \sum_{i=1}^{6} MJi \cdot PMJi / 1000\} - 0.241$	0.994	1.426		1964–81
	(50.9) (1.12)				
(2.20)	$MJ = \{ MGJPMO / (37.95\, RATE) \} \cdot JRATET / 1000$				
Identities : Exports					
(2.21)	$X = XG + XS$				
(2.22)	$X \cdot PX = XG \cdot PXG + XS \cdot PXS$				
(2.23)	$XG \cdot PXG = XGJPXG + XGR \cdot PXG$				
(2.24)	$\ln XGJPXG = 0.998 \ln \{37.95\, RATE \sum_{i=1}^{4} XJi \cdot PXi / 1000\} - 0.117$	0.996	2.380		1963–81
	(70.0) (0.83)				
(2.25)	$XJ = \{ XGJPXG / (37.95\, RATE) \} \cdot JRATET / 1000$				

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
III. Distribution					
National Income					
(3.1)	$TI = 0.146\ GNPP - 559.7$ $(101.)\quad(0.69)$	0.997	1.278		1952–81
(3.2)	$SUB = 0.0023\ GNPP - 308.5$ $(5.49)\quad(1.28)$	0.501	1.331		1952–81
(3.3)	$DEP = 0.0782\ GNPP - 1574.8$ $(106.)\quad(3.81)$	0.998	1.507		1952–81
(3.4)	$NI = 0.779\ GNPP + 1826.0$ $(428.)\quad(1.78)$	0.999	1.079		1952–81
Unincorporated, Property and Corporate Income					
(3.5)	$YUI = 0.0555\ (NI + IBG - YG) + 11404.1$ $(18.2)\quad(8.80)$	0.920	0.270		1952–81
(3.6)	$YRP - DIV = 0.120\ (NI + IBG - YG) + 821.1$ $(96.2)\quad(1.55)$	0.997	1.201		1952–81
(3.7)	$YC = YCD - DIV$				
(3.8)	$DIV = 0.455\ YC + 0.0794\ YC_{-1} + 1724.0$ $(9.55)\quad(1.50)\quad(1.84)$	0.984	1.292		1952–81
(3.9)	$YPP = NI + IBG - YG - YCD$				
(3.10)	$YDP = YPP - TRP$				

Eq. No.	Equation

IV. The Price Sector

Industry Price

(4.1) $Pi = WD(i) \cdot PiD + WM(i) \cdot PiM, \quad i = 1,2, \cdots ,8$

$WD(i) =$	0.668	0.954	0.961	0.793	0.818	0.712	0.651	0.948
$WM(i) =$	0.332	0.046	0.039	0.207	0.182	0.288	0.349	0.052

(4.2) $PiIO = [\sum_{\substack{j=1 \\ j \neq i}}^{8} A(j,i) \cdot Pj + D(i) \cdot PI] \, / \, [\, 1 - A(i,i) - T(i) - S(i) \,], \quad i = 1,2, \cdots ,8$

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$[A(j,i)] =$	(1)	0.1475	0.5083	0.0714	0.0317	0.7086	0.0174	0.0021	0.0400
	(2)	0.1430	0.1204	0.0023	0.0040	0.0000	0.0000	0.0000	0.0056
	(3)	0.0023	0.0014	0.3909	0.0239	0.0000	0.0006	0.0010	0.0080
	(4)	0.0491	0.0166	0.1602	0.4678	0.0114	0.0220	0.0340	0.0319
	(5)	0.0264	0.0062	0.0088	0.0198	0.0419	0.0136	0.0048	0.0446
	(6)	0.0060	0.0161	0.0016	0.0122	0.0161	0.5447	0.1712	0.0283
	(7)	0.0126	0.0038	0.0097	0.0108	0.0044	0.0106	0.3429	0.0232
	(8)	0.0668	0.0763	0.1098	0.1324	0.0248	0.1714	0.1282	0.2182
$[D(i)] =$		0.0378	0.0114	0.0314	0.0484	0.0625	0.0179	0.0202	0.0491
$[T(i)] =$		0.0233	0.1412	0.0229	0.0427	0.1366	0.0456	0.0581	0.0353
$[S(i)] =$		0.1653	0.0410	0.0397	0.0951	−0.0260	0.0457	0.0858	0.1879

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
(4.3)	$\ln P1D - 0.518 \ln P1IO = 0.736 \ln (WL / GDP) + 0.701$	0.944	1.816	0.65	1964–81
	(6.65) (6.79)				
(4.4)	$\ln P2D = 0.419 \ln P2IO + 0.603 \ln (WL / GDP) + 0.077\ D63 + 0.168\ D72$	0.996	1.809		1963–81
	(2.10) (2.46) (2.50) (5.81)				
	$- 0.164\ D7999 + 0.417$				
	(6.85) (2.87)				
(4.5)	$\ln P3D - 0.660 \ln P3IO = 0.255 \ln W - 0.591 \ln (GDP / L) - 0.175\ D7499$	0.707	1.382		1963–81
	(0.69) (1.01) (0.98)				
	$- 0.213\ D8099 + 2.334$				
	(1.72) (1.52)				
(4.6)	$\ln P4D - 0.718 \ln P4IO = 1.276 \ln (WL / GDP) - 0.418$	0.849	2.150	0.96	1964–81
	(7.32) (1.13)				
(4.7)	$\ln P5D - 0.977 \ln P5IO = 0.641 \ln (WL / GDP) + 0.547$	0.733	1.975	0.86	1964–81
	(3.39) (3.12)				
(4.8)	$\ln P6D - 0.696 \ln P6IO = 0.507 \ln (WL / GDP) - 0.274\ D6699$	0.755	2.109		1963–81
	(5.29) (6.20)				
	$- 0.255\ D7599 - 0.435\ D8199 + 1.127$				
	(3.69) (5.79) (8.24)				
(4.9)	$\ln P7D - 0.704 \ln P7IO = 0.290 \ln (WL / GDP) + 0.006$	0.614	0.992	0.94	1963–71
	(1.68) (0.02)				
(4.10)	$\ln P8D - 0.430 \ln P8IO = 0.400 \ln (WL / GDP) + 1.062$	0.962	1.228	0.94	1964–81
	(2.70) (4.67)				

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period

Deflators for Final Demands

(4.11) $PFIO = F \cdot P$

$$[PFIO] = \begin{bmatrix} PCIO \\ PCGIO \\ PIIO \\ PJIO \\ PXGIO \end{bmatrix}, \quad P = \begin{bmatrix} P1 \\ P2 \\ \cdot \\ \cdot \\ \cdot \\ P8 \end{bmatrix}$$

$F =$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(*PC*)	0.0818	0.3087	0.0303	0.0253	0.0175	0.0031	0.0533	0.4801
(*PCG*)	0.0001	0.0010	0.0087	0.0088	0.0542	0.0083	0.0118	0.9069
(*PI*)	0.0112	0.0000	0.0013	0.0002	0.0000	0.0072	0.4024	0.5777
(*PJ*)	0.2191	0.1224	0.0709	0.1085	0.0286	0.0912	0.1637	0.1955
(*PXG*)	0.0370	0.0815	0.2178	0.1051	0.0210	0.0387	0.2162	0.2827

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
(4.12)	$\ln PC = 1.047 \ln PCIO - 0.014$ (39.9) (1.03)	0.997	1.662	0.51	1964–81
(4.13)	$\ln PCG = 0.882 \ln PCGIO + 0.080$ (9.37) (0.53)	0.995	1.038	0.93	1964–81
(4.14)	$\ln PI = 1.030 \ln PIIO - 0.058$ (17.2) (2.13)	0.990	1.248	0.63	1964–81
(4.15)	$\ln PJ = 1.264 \ln PJIO - 0.094$ (14.0) (0.58)	0.993	1.851	0.94	1964–81
(4.16)	$\ln PXG = 1.199 \ln PXGIO - 0.027$ (24.3) (1.36)	0.987	1.764	0.36	1964–81

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
Export Prices					
(4.17)	$\ln PX1 = \underset{(18.0)}{1.0576} \ln P2 + \underset{(2.12)}{0.0621}$	0.950	1.054		1964–81
(4.18)	$\ln PX2 = \underset{(12.1)}{1.2135} \ln P4 + \underset{(0.70)}{0.0319}$	0.895	0.991		1964–81
(4.19)	$\ln PX3 = \underset{(23.1)}{1.4554} \ln P7 - \underset{(1.88)}{0.038}$	0.969	1.592		1964–81
(4.20)	$\ln PX4 = \underset{(14.4)}{1.4943} (0.85 \ln P3 + 0.15 \ln P6) + \underset{(1.04)}{0.0277}$	0.924	0.851		1964–81
Import Prices from Japan					
(4.21)	$\ln PMJ1 = \underset{(18.4)}{1.118} \ln (PWHIJ \cdot RATJ) + \underset{(1.37)}{0.0476}$	0.941	0.738		1960–81
(4.22)	$\ln PMJ2 = \underset{(12.9)}{0.754} \ln (PWHIJ \cdot RATJ) + \underset{(2.12)}{0.0707}$	0.887	0.975		1960–81
(4.23)	$\ln PMJ3 = \underset{(29.8)}{0.594} \ln (PWHIJ \cdot RATJ) + \underset{(0.96)}{0.0110}$	0.977	2.023		1960–81
(4.24)	$\ln PMJ4 = \underset{(25.2)}{0.930} \ln (PWHIJ \cdot RATJ) + \underset{(0.14)}{0.0029}$	0.968	1.508		1960–81
(4.25)	$\ln PMJ5 = \underset{(22.3)}{0.547} \ln (PWHIJ \cdot RATJ) + \underset{(0.85)}{0.0118}$	0.960	1.124		1960–81
(4.26)	$\ln PMJ6 = \underset{(38.3)}{0.958} \ln (PWHIJ \cdot RATJ) + \underset{(3.91)}{0.0556}$	0.986	1.347		1960–81

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
Wholesale price index					
(J.1)	$\ln PJ1 = 1.813 \ln PWHIJ + 0.0558$ (16.0) (1.37)	0.924	1.067		1961–81
(J.2)	$\ln PJ2 = 1.491 \ln PWHIJ + 0.0876$ (13.5) (2.22)	0.897	1.335		1961–81
(J.3)	$\ln PJ3 = 1.054 \ln PWHIJ + 0.0708$ (13.2) (2.48)	0.892	1.248		1961–81
(J.4)	$\ln PJ4 = 2.176 \ln PWHIJ + 0.1255$ (22.9) (3.67)	0.961	1.190		1961–81
Import Prices, Industry Category					
(4.27)	$P1M = 0.07\ PMJ6 \cdot RATE + 0.45\ PME + 0.48\ PMO$				
(4.28)	$P2M = 0.09\ PMJ1 \cdot RATE + 0.91\ PMO$				
(4.29)	$P3M = 0.66\ PMJ3 \cdot RATE + 0.34\ PMO$				
(4.30)	$P4M = 0.45\ PMJ2 \cdot RATE + 0.55\ PMO$				
(4.31)	$P5M = 0.07\ PMJ6 \cdot RATE + 0.93\ PME$				
(4.32)	$P6M = 0.66\ PMJ4 \cdot RATE + 0.34\ PMO$				
(4.33)	$P7M = 0.43\ PMJ5 \cdot RATE + 0.57\ PMO$				
(4.34)	$P8M = 0.07\ PMJ6 \cdot RATE + 0.93\ PMO$				
Price of Capital Services					
(4.35)	$PK = PI \cdot \{(R / 100) + 0.035\} / 0.165$				

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period

V. Production Function

(5.1) $\ln\{(L / GDPM) \cdot T\} = const + \sigma\left[\frac{1}{2}\ln(PGDPM / W)_{-1} + \frac{1}{2}\ln(PGDPM / W)_{-2} + \ln T\right]$

$\ln(KIF / GDPM) = const + \sigma\left[\frac{1}{2}\ln(PGDPM / PK)_{-1} + \frac{1}{2}\ln(PGDPM / PK)_{-2}\right]$

$\ln(ME / GDPM) = const + \sigma\left[\frac{1}{2}\ln(PGDPM / PME)_{-1} + \frac{1}{2}\ln(PGDPM / PME)_{-2}\right]$

$\ln(MO / GDPM) = const + \sigma\left[\frac{1}{2}\ln(PGDPM / PMO)_{-1} + \frac{1}{2}\ln(PGDPM / PMO)_{-2}\right]$

Equation	$\bar{R}^2$	D.W.	ρ	sample period
$\sigma = 0.3825$ (1.01) $const = -2.8953\ DUML - 0.8049\ DUMK - 2.6162\ DUME - 2.4260\ DUMO$	0.995			1962–69
$\sigma = 0.3942$ (3.72) $const = -2.9151\ DUML - 0.8227\ DUMK - 3.2821\ DUME - 1.3304\ DUMO$	0.995			1974–81

$$T_t = \frac{\sum_{i=0}^{9} \exp[0.070(t-i) - 0.010D \cdot (t-i-22)] \cdot I_{t-i}}{\sum_{i=0}^{9} I_{t-i}}$$

t = time (1953 = 1.0)
$D = 0$ for $t-i < 22$ (i.e., before 1973); $=1$ for $t-i \geq 22$ (i.e., after 1974)

Capacity Output

Equation	sample period
(5.2) $VMC = 1.15\,[0.5159\times10^{-3}(T \cdot LFE)^{-\vartheta} + 0.1219(KIF_{-1})^{-\vartheta} + 1.0703\times10^{-3}(ME)^{-\vartheta} + 1.7599\times10^{-3}(MO)^{-\vartheta}]^{-1/\vartheta}$, $\vartheta = 1.6144$	1962–73
$VMC = 1.15\,[0.6143\times10^{-3}(T \cdot LFE)^{-\vartheta} + 0.1241(KIF_{-1})^{-\vartheta} + 0.2421\times10^{-3}(ME)^{-\vartheta} + 0.03422(MO)^{-\vartheta}]^{-1/\vartheta}$, $\vartheta = 1.5368$	1974–81

Eq. No.	Equation	$\bar{R}^2$	D.W.	ρ	sample period
	VI. Employment and Wage				
(6.1)	$\ln L^{*} = -2.8953 + \sigma \left[\frac{1}{2} \ln (PGDPM / W)_{-1} + \frac{1}{2} \ln (PGDPM / W)_{-2} + \ln T \right] + \ln GDPM - \ln T$ $\sigma = 0.3825$ for 1962–69, 0.3942 for 1974–81				
(6.2)	$\ln L = \underset{(4.03)}{0.332} \ln L^{*} + \underset{(7.34)}{0.659} \ln L_{-1} + \underset{(0.61)}{0.0884}$	0.994	1.632		1960–81
(6.3)	$\ln NW = \underset{(0.91)}{0.212} \ln L + \underset{(5.30)}{0.861} \ln NW_{-1} - \underset{(0.92)}{0.5759}$	0.995	0.654		1960–81
(6.4)	$L = NW + NU \cdot DFL$				
(6.5)	$DFL = WU / W$				
(6.6)	$N = NW + NU$				
(6.7)	$UR = 1 - (N / LF)$				
(6.8)	$W = WN / NW$				
(6.9)	$WU = YUI / NU$				
(6.10)	$(W - W_{-1}) / W_{-1} = \underset{(2.06)}{0.323} \cdot \frac{1}{2} \{ (PC - PC_{-1}) / PC_{-1} + (PC_{-1} - PC_{-2}) / PC_{-2} \}$ $- \underset{(3.32)}{0.038} \, UR - \underset{(2.88)}{0.125} \, D6599 + \underset{(1.35)}{0.056} \, D64 + \underset{(4.34)}{0.200} \, D74 + \underset{(4.24)}{0.322}$	0.783	1.426		1961–81