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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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THE TOTAL FACTOR PRODUCTIVITY GROWTH OF THE THREE-DIGIT MANUFACTURING INDUSTRIES IN THAILAND

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ABSTRACT

The paper estimates and analyzes the total factor productivity growth of the manufacturing industries in Thailand. It consists of two parts: one is on the three-digit-ISIC manufacturing industries using aggregative data, and the other is on the farm machinery industry using data at the firm level collected from our own surveys and interviews. The results show that even though the rates of total factor productivity growth of most industries are small compared to developed countries, they are increasing and moreover, the role of total factor productivity as a source of growth of real output becomes greater in significance over time.

INTRODUCTION

The growth of real output can be categorized to be from two main sources, the accumulation of resources and the increase in their productivity. In order to promote the growth of the industrial sector for economic development, it is necessary that more resources are allocated to the sector or the productivity of these resources is increased faster. Our study focuses on the growth of productivity of all factors or resources used for production in the manufacturing industrial sector with a special detail study on the farm machinery industry in Thailand.

The rate of total factor productivity growth, hereby called TFPG, is hard to define, measure and explicitly quantify its sources. Nonetheless, studies for many developed countries, led by Solow's seminal article for the U.S. nonfarm sector, show that it is a very important source of real output growth, by defining it to be the residual element in the production function.[1] As for developing countries, due partly to data limitations, there have been so few studies on the subject that not much is known. This research provides the first attempt to measure and analyze the TFPG of manufacturing industries of a developing country, Thailand.

The study is divided into two major inter-related parts: one is the measurement and the analysis of the TFPG of all manufacturing industries in Thailand using aggregative data, and the other is the study of the tractor industry using data of the firms. For the first part the study requires data such as input and output by industry. In Thailand, the annual industrial census which provide such data, categorize industries by a system called International Standard Industrial Classification (ISIC). An ISIC industrial code with more digits represents an industry which consists of firms which produce narrower ranges of products; the one with less digits can aggregate more firms into the group because it includes more varieties of products. Our purpose is to study the TFPG of manufacturing industries with ISIC codes aggregated at the three-digit level. The period under study is from 1963 to 1976, which are the years in which data are available. For the study on the tractor industry part, we use data collected from our own surveys and interviews with firms having ten or more workers. The period in the study which varies with firms, covers from the initial year of each firm to 1979.

In this paper, the following section discusses the methods of measuring TFPG and other real variables of all three-digit manufacturers including the farm machinery industry and the source of data used for their estimations. Section II provices a summary of the estimated TFPG and other real variables. The last section which is forthcoming is the discussion on the TFPG of tractor firms in detail.

Total Factor Productivity Growth and other real variables.

The measurement of TFPG is based on the unrestricted linear homogeneous smooth aggregate production function which allows the substitution possibilities of all inputs categorized to be labor, capital and raw material factors. Firstly we describe the i-th industry's production at time t by the following functional form:

$$Q_i(t) = f_i[L_i(t), K_i(t), M_i(t), t] \tag{1}$$

where $Q_i(t)$ = real output of the i-th industry at time t

$L_i(t)$ = labor employed by the i-th industry at time t

$K_i(t)$ = physical capital used by the i-th industry at time t

$M_i(t)$ = real raw materials used by the i-th industry at time t

and t = a "shift" variable subject to time.

Then we totally differentiate it with respect to time to obtain

$$\frac{\hat{Q}_i(t)}{Q_i(t)} = f_{i,L_i}(t), \frac{\hat{L}_i(t)}{Q_i(t)}, \frac{\hat{L}_i(t)}{L_i(t)}, + f_{i,K_i}(t), \frac{K_i(t)}{Q_i(t)}, \frac{\hat{K}_i(t)}{K_i(t)} + f_{i,m_i}(t), \frac{M_i(t)}{Q_i(t)}, \frac{\hat{M}_i(t)}{M_i(t)} + \frac{f_{i,t}(t)}{Q_i(t)} \tag{2}$$

where the hats denote the rate of change of the variables over time.

Equation (2) shows that the rate of growth of real output can be decomposed into the rate of growth of the weighted average of the rates of growth of labor input, physical capital and raw materials where the weights are the output elasticities of corresponding factors of production and the rate of growth of the shift variable.

Under a competitive equilibrium where each input gets paid according to its value of marginal product, Equation (2) can be rewritten as

$$\frac{\hat{Q}_i(t)}{Q_i(t)} = \frac{w_i(t)L_i(t)}{p_i(t)Q_i(t)} \cdot \frac{\hat{L}_i(t)}{L_i(t)} + \frac{r_i(t)k_i(t)}{p_i(t)Q_i(t)} \cdot \frac{\hat{K}_i(t)}{K_i(t)} + \frac{P_i^*(t)M_i(t)}{P_i(t)Q_i(t)} \cdot \frac{\hat{M}_i(t)}{M_i(t)} + \frac{f_{i,t}(t)}{Q_i(t)} \tag{3}$$

where $w_i(t)$ = nominal wage rate of the i-th industry at time t

$r_i(t)$ = nominal rental rate of capital of the i-th industry at time t

$P_i^*(t)$ = prices of raw materials of the i-th industry at time t

and $P_i(t)$ = prices of products of the i-th industry at time t

By letting α and β represent labor and raw material shares of the value of the i-th industry's total production respectively, Euler's theorem which makes use of the assumption of linear homogeneity of the production function implies that the capital share is equal to $(1-\alpha-\beta)$. Now we can write Equation (3) in the following form:

$$\frac{\hat{Q}_i(t)}{Q_i(t)} = \alpha(t)\frac{\hat{L}_i(t)}{L_i(t)} + \{1-\alpha(t)-\beta(t)\}\frac{\hat{K}_i(t)}{K_i(t)} + \beta(t)\frac{\hat{M}_i(t)}{M_i(t)} + \frac{f_{i,t}(t)}{Q_i(t)} \tag{4}$$

Notice that without estimating the production function or the output elasticities directly, we can measure the TFPG of the i-th industry from the following differential equation as if it is an "accounting identity:

$$\frac{f_{i,t}(t)}{Q(t)} = \frac{\hat{Q}_i(t)}{Q_i(t)} - \left[\alpha(t)\frac{\hat{L}_i(t)}{L_i(t)} + \{1-\alpha(t)-\beta(t)\}\frac{\hat{K}_i(t)}{K_i(t)} + \beta(t)\frac{\hat{M}_i(t)}{M_i(t)} \right] \quad (5)$$

In estimating the TFPG from Equation (5) we first need to measure real output, real inputs and shares of all factors of production for successive years. The measurement can be done primarily with the availability of data of variables including values of production, values of intermediate inputs, number of workers, the stock of fixed assets and input shares of total production. The data are obtained from two groups of sources, namely, annual industrial census conducted by the National Statistical Office of Thailand (NSO), and reports and publications from the Ministry of Industry (MI), the Ministry of Commerce (MC), the Bank of Thailand (BOT), and the National Economic and Social Development Bureau (NESDB).

The data available in the NSO's industrial census include most variables necessary for computing the TFPG. The census was started in 1964 and it has been continued almost yearly since 1969. The data for the years 1963, 1968 and 1970 from the census of the years 1964, 1969 and 1971 respectively have been published, but those for the years 1972, 1975 and 1976 are available in the form of raw firm data. In the latter case we have to compute the industry aggregates from the firm data. All of the data except fixed assets and depreciations from the published census are for ISIC industries aggregated up to five-digit level. The data of fixed assets and depreciations are for only industries with three-digit level of aggregation. The census cover firms with ten or more workers. All totals in the census are from firms which responded to the questionnaires and the response rate is about 75 percent for all years. In order to find the totals for all firms, we need to revise the data of the census by using the industrial statistics from other sources.

From other reports and publications,[2] the MI provides data on quantities of physical output produced by all firms for several commodities from the years 1968 to 1976. The MC, the BOT and the NESDB provide the same type of data for other commodities or other years. We will discuss below how we combine the information from all sources to obtain the data for all firms to compute real output including all other real variables, input shares and the TFPG.

Real Output

For the initial year 1963, real output of the i-th industry is measured by the industry's value of production evaluated at the 1968 constant prices. It is obtained by multiplying the value of production at current prices by the inverse of the implicit price deflator. The source of data of values of production is the NSO's industrial census whereas the source of price deflators is the Ministry of Commerce's wholesale price index of industries.

Since real output in 1963 is measured from the NSO's census data, the values do not represent the production of all firms. In order to obtain the real output for the years 1964 to 1976 for all firms, we multiply the 1963 real output by the corresponding year's growth rates of physical output calculated from the data of other sources which represent all firms. The methods of calculation and the sources of the data are described below.

The computation of growth rates of physical output of three-digit ISIC industries is based on production data from two sources. The first is the Ministry of Industry, the Ministry of Commerce, the Bank of Thailand, and the NESDB, and the second is the NSO's census. The first source provides data on yearly production of all firms by commodity; the second provides the data by five-digit ISIC industry. The method of computation is done as follows. First, we calculate the output of five-digit ISIC industry by using the data from the first source. Second, we calculate each industry's growth rate. Finally, we compute the continuous growth rates of output of each three-digit ISIC industry by summing the growth rates of output of corresponding five-digit ISIC industry by summing the growth rates of output of corresponding five-digit ISIC industries using their value shares obtained from the second source as weights.

Explicitly, let:

$Y_{i,t}$ be the NSO's value of production of the i-th three-digit ISIC industry at time t

$Y_{ij,t}$ be the NSO's value of production of the j-th five-digit in the i-th three-digit ISIC industry at time t,

$Q_{ij,t}$ be the all-firm physical output of the j-th five-digit in the i-th three-digit ISIC industry at time t,

$Q_{ijk,t}$ be the all-firm physical output of the k-th commodity categorized in the j-th five-digit which belongs to the i-th three-digit ISIC industry at time t,

$P_{ijk,t}$ be the relative price of $Q_{ijk,t}$

$q_{ij,t}$ be the continous growth rates of $Q_{ij,t}$,

and $q_{ij,t}$ be the continuous growth rate of output of the i-th three-digit ISIC industry at time t,

where $i = 1, 2, \ldots, n$

$j = 1, 2, \ldots, m$

$k = 1, 2, \ldots, \ell$

and $t = 1, 2, \ldots, T$ we can obtain the following.

First, we obtain the NSO's value of production of three-digit ISIC industries. Each industry's production value at any period is found by aggregating the period's production values of all five-digit ISIC industries whose industrial codes share the same corresponding first three digits, i.e.,

$$Y_{i,t} = \sum_{j=1}^{m} Y_{ij,t} \qquad (6)$$

Second, we obtain the all-firm physical output of five-digit ISIC industries. Each industry's physical output at any period is found by aggregating the quantities of commodities which are grouped under the same five-digit ISIC industrial code by using their relative prices as

weights,[3] i.e.,

$$Q_{ij,\ t} = \sum_{k=1}^{l} P_{ijk,\ t}\ Q_{ijk,\ t} \qquad (7)$$

Third, we obtained the continuous growth rates of output of five-digit ISIC industries. Each industry's annual growth rate is the difference between the natural logarithm of output between two successive periods, i.e.,

$$q_{ij,\ t} = \ln Q_{ij,\ t} - \ln Q_{ij,\ t-1}. \qquad (8)$$

Finally, we obtain the growth rates of output of three-digit ISIC industries. Each industry's annual growth rate is found by weighted-averaging all the five-digit ISIC industries' output continuous growth rates which belong to the same corresponding three-digit category by using their value shares as weights, i.e.,

$$q_{i,\ t} = \sum_{j=1}^{m} \frac{Y_{ij,\ t}}{Y_{i,\ t}}\ q_{ij,\ t} \qquad (9)$$

In fact, $q_{i,\ t}$ is the discrete approximation of the continuous Divisia index. And we use these $q_{i,\ t}$'s for computing the real output of all firms from 1964-1976.

Real Intermediate Inputs

Real intermediate inputs can be obtained by aggregating all purchased inputs which are measured in real terms. If we had available the values of different types of purchases inputs used in industries, we would deflate each by its own price deflator and aggregate with proper weights to obtain the real intermediate inputs. Unfortunately, the values of purchased inputs reported in the NSO's industrial census are in an aggregated form. Our alternative is to deflate these aggregated figures by appropriate deflators. Each deflator of each industry is found by weighted-averaging the deflators of "major" purchased inputs used in the industry where weights are their corresponding value shares.[4] These value shares are computed from the input-output table for 1975[5] which is presently the only one available. Should there be no major change in purchased input coefficients or the structure within each three-digit ISIC industry during the period studied, these value shares would be able to be applied also to all other years.

The values of intermediate inputs from the NSO census are adjusted to the total value for all firms by multiplying each year's purchased-input/output coefficient by the reestimated total values of production of all firms.

Real Capital stock

Capital stock is classified into two types: buildings and structures; and machinery, equipment and vehicles. For each type at any period, real capital stock is obtained by adding current investment at constant prices to the real capital stock of previous period excluding real depreciations accumulated up to that period.

That is, if we let

$K_{ij,t}$ be the real capital stock of the j-th type of the i-th industry at time t

$I_{ij,t}$ be the investment flow on the j-th type of capital of the i-th industry at time t, evaluated at constant prices,

and δ_{ij} be the rate of replacement of the j-th type of capital stock of the i-th industry,

where $i = 1, 2, \ldots, n$, $j = 1, 2$ and $t = 0, 1, 2, \ldots, T$, then we obtain

$$K_{ij,\ t} = I_{ij,\ t} + (1-\delta_{ij})\ K_{ij,\ t-1}. \qquad (10)$$

By a process of iterative substitution of $K_{ij,\ t-1}$ we can write

$$K_{ij,\ t} = (1-\delta)^{t}\ K_{ij,\ 0} + \sum_{s=1}^{t} (1-\delta_{ij})^{t-s}\ I_{ij,\ t} \qquad (11)$$

where $K_{ij,\ 0}$ is the initial capital stock of the j-th type of the i-th industry.

In our estimation of real capital stock, we define the rates of replacement to be the reciprocal of the economic life of different types of capital. The estimation therefore needs a yearly measurement of four kinds of variables, namely, investment flows, investment deflators, initial real capital stock and economic life of all assets. The measurement methods and data sources are described below.

Investment data

The time series of investment data are not available. We estimate them by making use of the NSO's revised industrial census data, to represent all firms, of net book values of fixed assets and depreciations during the year. The nominal investment at a period is defined to be the change in net book values from previous period plus the depreciations accumulated up to that period. That is, by letting

$NBV_{ij,\ t}$ be the net book value of the j-th type of capital of the i-th three-digit ISIC industry at time t_1,

$D_{ij,\ t}$ be the depreciation of the j-th type of capital of the i-th three-digit ISIC industry during the period t

m_j be the life of the j-th type of capital that firms use for estimating depreciations[6]

and $NI_{ij,\ t}$ be the net nominal investment on the j-th type of capital of the i-th industry at period t,

we can write

$$NI_{ij,\ t} = NBV_{ij,\ t} - NBV_{ij,\ t-1} + (D_{ij,\ t} - D_{ij,\ t-m_j}) \qquad (12)$$

where $i = 1, 2, \ldots, n$, $j = 1, 2, t=1, 2, \ldots, T$.

The net book values of fixed assets and depreciations are not available for all years. Those of the missing years which includes 1964-1967, 1969, 1971, 1973-74, are interpolated by using the annual continuous growth rates of the known observations between two end-periods. In other words for any gap of periods, we estimate the missing observations to be on the logarithmic time trend of that gap. These estimates are best when the pattern of "true" observations fits this kind of nonlinear time trend.

Investment deflators

Investment deflators are obtained from the Ministry of Commerce and the base year is 1968. Those for buildings and structures are from the wholesale price indexes of construction materials; those for machinery, equipment and vehicles are from the weighted average of the indexes of machinery and equipments and transportation equipments and where the weights are their value shares of the total.[7]

Initial capital stock

According to our method of estimating real capital stock with investment data following an upward trend, it is noticeable from Equation (11) that the further back the initial year of capital stock we can have, the better estimates of the present capital stock we can obtain. This is because with the passage of time the investment of previous periods constitutes a smaller and smaller portion of the current capital stock. Should there be any errors on the investment data of initial years, they will affect our estimates of the current stock minorly.

For Thailand, the earliest year the relevant data are available for estimating the initial capital stock by industry is 1949. We estimate it by firstly multiplying the industry's value-added per employee by its number of workers to obtain the value added. And then, by using the proportion of each industry's value-added to the total value-added of all industries as an approximation of the proportion of the industry's capital to the total stock,[8]

we multiply the proportion of the obtained value-added to the total value-added by the year's total fixed capital formation to find the industry's capital stock. For the data source the number of workers classified by industrial commodity is obtained from the Central Statistical Office's 1949 census.[9] The estimates of value-added per employee are from the United Nations Industrial Development Office (1963), and the total fixed capital formation by industry is estimated from the National Economic and Social Development Board (1952).[10]

After obtaining the total initial capital stock of all types for each industry, we separate it into components of buildings and structures; and machinery, equipment and vehicles. The proportion of each component is the average of the proportions across years in which the census data for fixed assets are available.

Economic lives of assets.

Buildings and structures are much more durable than machinery and equipment. The average life of structure is about 33 years. On the other hand, machinery and equipment have an average life of about 15 years.[11] Since the life of structures does not vary much across industries compared to machinery and equipment, we let all industries have the same life of 33 years for structures but the life of machinery and equipment varies with industries. The life for each industry is estimated from Park's estimates for the U.S. industries.[12] With the fact that the average life of the U. S. machinery and equipment is longer than Thailand, we scale down Park's estimates so that the weighted average for the whole manufacturing sector is 15 years.

Labor Input

The labor input of an industry is the number of workers employed in the industry during a year. The figures recorded from firms which responded are reestimated to represent all firms by keeping labor share and wages of the same year, before and after the adjustment of total production to represent all firms, intact. The data source is the NSO's industrial census.

Factor shares

The share of each factor of production of each industry is the weighted average of each year's share where weights are proportions of values of production in each year. The data for all input shares across years are from the NSO's industrial census.

Estimated Total Factor Productivity Growth of Manufacturing Industries

Table 1 shows the characteristics of all three-digit ISIC manufacturing industries in Thailand. All industries except beverages, tobacco and glass and glass products have the shares of intermediate inputs exceeding 50 percent of total output. Among the highest are ferrous metal and transport equipment industries which have the shares greater than 80 percent. The lowest is the beverage industry whose share is about 33 percent. Of all industries the average share is about 64 percent. For labor share, the value ranges from as low as four percent for the nonferrous metal industry to as high as 27 percent for the nonmetallic mineral industry. The average, though, is about ten percent. Over time the shares of labor of most industries seem to be quite stable. For the growth rates of real output, labor and capital during the period 1963-1976, the average of all industries the annual continuous growth rates are about 18, 13 and 16 percent respectively. It should be noted that our estimates of the growth rate of real output is close to the National Economic and Social Development Board's estimate of 17 percent for the whole sector.

The TFPG of all industries are shown in Table 2. The table shows the TFPG of two separated subperiods: 1963-1970 and 1970-1976, and the TFPG pf the entire period 1970-76. For the entire period, the TFPG ranges from a maximum of two-three percent for electrical machinery, nonferrous metal, and paper and paper product industries to a minimum of about minus two-three percent for glass and glass products and transport equipment industries. Of all industries the average of TFPG is about .38 percent which is quite low compared to developed countries. However, more than half of the industries have positive TFPG and the values range from one to three percent. Besides when we consider the two subperiods, it is found that the average TFPG has been increased from about .30 percent in the first subperiod to about .48 percent in the second subperiod. In fact about 40 percent of the industries have an increase in TFPG in the second subperiod.

As for the source of real output growth which can be decomposed into the growth of intermediate inputs, labor input, capital input and TFPG, our estimates show that during the first subperiod, the source of most industries' output growth is the accumulation of intermediate inputs. On the other hand, in the second subperiod increasing number of industries has the source shifted to TFPG. Therefore, even though the TFPG are quite small in the majority of industries, they are increasing over time and moreover their role as a source of growth of real output becomes greater in importance.

The estimates of Total Factor Productivity Growth of the Farm Machinery Industry.

There are about 100 firms producing farm machinery and equipment in Thailand. Most of them grew from small machine shops producing or repairing machine tools. More than half employ less than 20 workers. These small firms are not included in our survey due to the difficulties of obtaining data. Moreover their share of production is normally less than 15 percent of the total of all firms. Our survey includes firms with 20 or more workers located in the Central region of Thailand. Production by these firms with 20 to 50 workers are classified as "medium"; and those which employ between 50 to the maximum of 200 workers are labeled "large". There are eight medium firms and six large firms in the survey.

Table 3 shows the growth rates of output, input and total factor productivity of all surveyed firms from the initial year to 1979 including three subperiods. Most firms of medium size initiated production of farm machinery and equipment in the middle and late 1960s whereas half of the large firms initiated production in the early 1970s. Our estimates show that, for the average of all firms and all periods, about 5 percentage points of the growth rate of production of 28 percent is from the growth of total factor productivity. In other words, the total factor productivity growth accounted for about 19 percent of the growth rate of real output which is quite low compared to other developed countries. Among the three subperiods, output and TFPG grew faster between 1970 to 1976 and slower after 1976. Regarding the difference of TFPG between large and medium firms, Table 4 suggests no evidence that TFPG of large firms is greater for medium ones.

Footnotes

[1] For the case of the U.S., see Solow (1957); Christensen and Jorgenson (1970); and others who indicate that TFPG has a high percentage share of the real output growth during the postwar periods: Kendrick (1973) and Denison (1974). Parallel work in the case or Japan can be seen from Jorgenson and Ezaki (1973) and Nishimizu and Hulton (1978).

[2] See the Ministry of Industry, Industrial Economics and Planning Division (1979), Bank of Thailand (various years), Ministry of Commerce, Economic Research Division (various years), and National Economic and Social Development Board (various years).

[3] When the commodities' production values are available, the prices are found by dividing the values by the production quantities. But when the values are not available, the prices are substituted by either import or export prices, whichever found. For sources of these data, ibid.

4. The "major" purchased inputs include all inputs whose shares of total purchased inputs are at least as much as one percent, and at the same time, the sum total of whose values is at least as little as 90 percent. For detailed description of the rule for locating "major" purchased inputs, see Appendix 1. The rule can be shown to provide us the estimates of real intermediate inputs which are very close to the ones using the deflators of "all" purchased inputs. See the proof in Appendix 2.

[5] National Economic and Social Development Board (1980).

[6] It is assumed that, for their bookkeeping, firms estimate the life of buildings and structures to be 20 years, and all machinery, equipment, and vehicles to be at the average of five years. These figures are the legal maximum in Thailand.

[7] The weights are about two-thirds and one-third, respectively, on the average.

[8] It should be noted that the closer is the industry's capital-labor ratio to the capital-labor ratio of all industries, the better estimate is the approximation used above.

[9] National Economic Council, Central Statistical Office (1952).

[10] The data of total fixed capital formation are for all firms in the manufacturing industrial sector. Having figured out that more than

Footnotes.....cont'd

half of the values of fixed assets in the 1964 industrial census is from firms with ten or more workers, we decided to assume that the available capital formation figure from firms with ten ot more workers is approximately one-half.

[11] Assuming that structures and machinery and equipment of Thai manufacturers have life which is not significantly different from the Turkish, we estimate their average life from Krueger and Tuncer's estimates for the Turkish industries. See Krueger and Tuncer (1980).

[12] See Park (1973).

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Table 1. The TFPG of Three-digit ISIC Manufacturing Industries, 1963-1976

ISIC	Industry	Material Share	Labor Share	Growth Rate of: Output	Labor	Capital	TFPG
311	Food processing	.7137	.0511	12.16	9.41	8.41	1.25
312	Food products	.7984	.1022	25.26	21.25	20.91	-1.30
313	Beverages	.3329	.0690	16.02	12.20	12.50	1.38
314	Tobacco	.4318	.0520	6.82	3.04	3.33	1.44
321	Textiles	.5746	.1050	15.42	9.93	16.53	1.78
322	Wearing apparel	.5990	.1682	16.30	7.74	17.49	-0.37
323	Leather & leather products	.7210	.0717	16.30	14.16	13.72	1.98
324	Shoes	.6878	.1880	16.30	12.61	14.35	-1.06
331	Wood and cork	.6717	.1264	5.70	4.17	5.97	0.15
332	Furniture & fixtures	.7015	.1013	16.30	11.85	16.95	-1.41
341	Paper & paper products	.6765	.1012	16.76	11.03	9.99	2.98
342	Printing & publishing	.5595	.1493	16.30	9.92	13.26	3.00
351	Basic chemicals	.5661	.0669	20.81	22.01	13.83	1.57
352	Chemical products	.6316	.0901	11.45	7.14	8.49	1.16
353	Rubber & rubber products	.6944	.0530	25.16	20.20	27.15	1.05
361	Nonmetallic minerals	.6241	.2658	29.00	25.07	28.58	-1.99
362	Glass & glass products	.4816	.1312	14.55	13.19	18.66	-2.99
369	Other nonmetallic	.7086	.0871	11.46	5.29	11.98	-1.36
371	Ferrous metals	.8308	.0609	17.37	14.76	17.33	0.04
372	Nonferrous metals	.5775	.0421	26.68	12.94	14.88	3.18
381	Metal products	.7059	.0655	1.29	0.25	5.49	-0.39
382	Agricultural machinery & equipment	.6431	.0589	16.30	9.22	17.93	-1.36
383	Electrical machinery	.6911	.0809	53.15	45.89	45.87	3.22
384	Transport equipment	.8151	.0618	20.18	14.28	18.68	-2.09
390	Miscellaneous	.6341	.0991	16.30	10.20	16.21	-0.32
	Total	.6429	.0980	17.73	13.11	15.94	0.38

Table 2. The TFPG of Three-digit Manufacturing Industries: Two Subperiods

ISIC	Industry	1963-1970	1970-1976	1963-1976
311	Food processing	1.60	0.83	1.25
312	Food products	-4.56	2.50	-1.30
313	Beverages	-3.26	6.79	1.38
314	Tobacco	-2.63	6.19	1.44
321	Textiles	0.31	3.50	1.78
322	Wearing apparel	1.88	-3.00	-0.37
323	Leather & leather products	2.05	1.90	1.98
324	Shoes	-4.24	2.66	-1.06
331	Wood & oak	-0.10	0.43	0.15
332	Furniture & fixtures	0.74	-3.92	-1.41
341	Paper and paper products	4.75	0.90	2.98
342	Printing & publishing	2.89	3.13	3.00
351	Basic chemicals	3.29	-0.43	1.57
352	Chemical products	3.50	-1.56	1.16
355	Rubber & rubber products	-1.03	3.49	1.05
361	Nonmetallic mineral products	-0.35	-3.89	-1.99
362	Glass & glass products	-2.07	-4.07	-2.99
369	Other nonmetallic minerals	-5.05	2.95	-1.36
371	Ferrous metals	0.51	-0.51	0.04
372	Nonferrous metals	7.10	-1.40	3.18
381	Metal products	1.39	-2.48	-0.39
382	Agricultural machinery & equipment	-0.32	-2.57	-1.36
383	Electrical machinery	3.02	3.45	3.22
384	Transport equipment	-1.74	-2.50	-2.09
390	Miscellaneous	-0.15	-0.51	-0.32
	Total	0.30	0.48	0.38

Table 3. Output, Input and Productivity Growth of all Farm Machinery Firms: Three Subperiods

	Growth Rate of			
	Output	Labor	Capital	TFPG
Initial - 1970	12.15	23.21	9.67	5.91
1970 - 1976	38.02	20.56	22.22	8.29
1976 - 1979	34.94	6.18	11.96	-0.28
Initial - 1979	28.02	13.81	18.10	5.33

Table 4. Output, Input and Productivity Growth of Large and Medium Farm Machinery Firms: Three Subperiods

	Growth Rate of							
	Output		Labor		Capital		TFPG	
Periods	Large	Medium	Large	Medium	Large	Medium	Large	Medium
Initial - 1970	46.05	33.94	53.65	18.14	14.08	9.67	5.72	5.91
1970 - 1976	40.05	38.02	20.73	20.56	31.76	22.22	5.74	8.29
1976 - 1979	10.73	12.15	7.75	6.18	11.75	11.96	0.52	-0.28
Initial - 1979	25.56	29.55	16.48	12.15	19.81	17.03	3.71	6.35

Appendix 1: The rule for choosing "major" purchased inputs for estimating their deflators is:

Let M_{ij} be the value of the j-th purchased input used in the i-th three-digit-ISIC industry, $j = 1, 2, \ldots, m$,

and M_{ik} be the value of purchased input which has the k-th largest share of total intermediate inputs used in the i-th industry, $k = 1, 2, \ldots, m$,

where $\sum_{j=1}^{m} M_{ij} = \sum_{k=1}^{m} M_{ik}$.

The rule is to choose a "minimum" index ℓ, $\ell = 1, 2, \ldots, m$ such that

$$\frac{M_{i1}}{\sum_{k=1}^{1} M_{ik}} \leq .01$$

and at the same time

$$\frac{\sum_{i=1}^{\ell} M_{ik}}{\sum_{j=1}^{m} M_{ij}} \geq .90.$$

Appendix 2: Bias of estimated intermediate input deflators

If we let

$PI^m_{ik,\,t}$ be the price index of the k-th purchased input used in the i-th industry in the t-th period,

$\sum_{k=1}^{m} \frac{M_{ik}}{\sum_{k=1}^{m} M_{ik}} PI^m_{ik,\,t}$ be the weighted average of price indexes of "all" intermediate inputs used in the i-th industry in the t-th period, called "true" deflator, and

$\sum_{k=1}^{1} \frac{M_{ik}}{\sum_{k=1}^{1} M_{ik}} PI^m_{ik,\,t}$ be the weighted average of "major" intermediate inputs used in the i-th industry in the t-th period, called "estimated" deflator, it is clear that the bias of the estimated deflator is equal to

the amount which it overestimates $\sum_{k=1}^{1} \frac{M_{ik}}{\sum_{k=1}^{m} M_{ik}} PI^m_{ik,\,t}$

plus the amount which $\sum_{k=1}^{1} \frac{M_{ik}}{\sum_{k=1}^{m} M_{ik}} PI^m_{ik,\,t}$ underestimates $\sum_{k=1}^{m} \frac{M_{ik}}{\sum_{k=1}^{m} M_{ik}} PI^m_{ik,\,t}$.

Suppose we let $\frac{M_{i1}}{\sum_{i=1}^{1} M_{ik}}$ be equal to the maximum of .01 and

$\frac{\sum_{k=1}^{i} M_{ik}}{\sum_{k=1}^{m} M_{ik}}$ be equal to the minimum of .9, the overestimation term will be

equal to the maximum of ten percent of the estimated deflator, namely,

$$(.1) \times \sum_{k=1}^{l} \frac{M_{ik}}{\sum_{k=1}^{l} M_{ik}} PI^{m}_{ik};$$ and the underestimation term will be equal to

$$.009 \sum_{k=l+1}^{m} \frac{M_{ik}}{M_{il}} P^{m}_{ik}$$

where $\left\{ \frac{M_{ik}}{M_{il}} \right\}_{k=l+1}^{m}$ is the sequence of decreasing numbers, all have values between 0 and 1.

Let us consider the maximum bias of the estimated deflator that could possibly occur. Let the estimated deflator be equal to the maximum of 250, P^{m}_{ik}'s are all equal to the maximum of 300, m-ℓ-1 be equal to the maximum of 20, and $\frac{M_{ik}}{M_{il}}$'s are all equal to the average of .5. Then the amount of bias will be equal to two which is less than one percent of the true deflator. With this maximum bias, we can say that the estimated deflator is close to the true one.

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