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Imperfect Competition, Economic Miracle, and Manufacturing Productivity Growth: Empirical Evidence from Taiwan

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Abstract

Several recent studies on total factor productivity (TFP) concluded that the East Asian economies benefited little from TFP growth. This study claims that the failure by previous studies to consider the effect of net indirect taxes and market imperfections resulted in the underestimation of the share of the contribution of labor input to factor income, which consequently led to the overestimation of capital share and understatement of TFP growth. Therefore, this study has modified the conventional approach of calculating factor shares by taking account of net indirect taxes and market imperfections and used the modified approach to estimate TFP growth in 16 Taiwanese manufacturing industries during the period 1979–1999. The conclusion drawn by the study is that TFP growth was the driving force behind the success of Taiwan's manufacturing industries, although many of these industries experienced a sharp decline in TFP during the 1990s. (JEL O47, O53)

Keywords: imperfect competition, growth accounting, total factor productivity growth, Taiwan, manufacturing industry

Introduction

Recent empirical studies by the World Bank [1993], Sarel [1995], Thomas and Wang [1996], Klenow and Rodriguez-Clare [1997], and Hsieh [2002] show that total factor productivity (TFP) growth was an important contributor to the rapid and sustained economic growth in East Asian economies. However, Krugman [1994], Kim and Lau [1994], Young [1992, 1995], and Collins and Bosworth [1996] have shown that the economic miracles of these countries can be sufficiently explained by factor accumulation, i.e., labor and capital. The implication of the findings is that such spectacular performance would not be sustainable in the long run due to little progress in TFP. While the conflicting findings can partly be ascribed to the different methodologies applied, industry aggregation, variable adjustments or data sources, low TFP growth for East Asian economies is most likely to be due to miscalculation of factor shares, which play a significant role in determining the extent of productivity growth. In most cases, the growth rate of capital input often exceeds that of labor input, the higher capital share implies lower TFP growth.

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How could the miscalculation of factor shares occur in many previous TFP studies? Failure to remove net indirect taxes and imperfect competition profits from value added underestimates the share of the contribution of labor input to factor income, which leads to overestimation of capital share and understatement of TFP growth.[1] As subsidies in value added contribute to production but indirect taxes do not, the importance of allowing for net indirect taxes need not be emphasized.[2] Not only does the extent of imperfect competition differ from sector to sector, few would disagree with the existence of market imperfection in Taiwan, predominantly, in the chemicals and plastic and petroleum sectors. Temple [1997, p. 281] also notices that the results of Young [1995] are subject to the possible effect of imperfect competition. Hsieh [2002] reminds that with imperfect competition, the TFP growth estimates of growth accounting will be biased. Put differently, the whole idea of growth accounting is built on two major assumptions comprising perfect competition and constant returns to scale. However, the existing data from the national accounts do not coincide with the assumptions in the theoretical model [Sun, 2004]. To ensure the validity of growth accounting, these issues must be considered in the estimation of the factor shares.[3]

From a policy perspective, the assessment of TFP growth is important as it serves as a guide for allocating resources and investment decision making. Another feature of the studies that have questioned the role of TFP progress in the East Asian economic miracle is that they predominantly focus on the performance of the overall economy and pay little attention to manufacturing industries. Therefore, the main objective of this paper is to re-examine the impact of net indirect taxes and imperfect competition on TFP growth with an application to 16 Taiwan's manufacturing industries over the 1979–1999 period. Although earlier TFP studies on Taiwan's manufacturing sector have examined TFP growth at the industrial level, including Chen and Tang [1990], Okuda [1994], Hu and Chan [1999], Liang and Jorgenson [1999], and Färe et al. [2001], none have taken into account the impact of net indirect taxes and imperfect competition to measure TFP growth. As a result, the studies miscalculate factor shares resulting in low estimated TFP growth due to the failure to take account of net indirect taxes and market imperfection. Other TFP studies, e.g., Young [1995], Chuang [1996], and Timmer and Szirmai [2000], have investigated TFP growth for the overall manufacturing sector without distinguishing individual industries.

The rest of the paper is organised as follows. The next section presents evidence of net indirect taxes and market imperfection over the 1979–1999 period and briefly reviews recent TFP studies on Taiwan's manufacturing sector. Then, the paper presents the empirical model and the significance of removing net indirect taxes and imperfect competition profit from value added in calculating factor shares. Empirical results are shown in the following section, and the summary and conclusion are made in the final section.

Evidence of Net Indirect Taxes and Imperfect Competition

The problem of ignoring net indirect taxes and market imperfection in calculating factor shares has recently been stressed by Barro [1999]. In addition, Young [1995, p. 648] states, "The absence of perfect competition, in the context of a constant returns to scale production function, could lead to mismeasurement of the elasticity of output with respect to each input, as factor shares need no longer reflect output elasticities. In particular, to the degree that monopoly profits are reflected in capital income, capital's income share will tend to overstate the elasticity of output with respect to capital." The consequence of mismeasurement is that the labor share is understated and results in the capital share being overestimated given the assumption of constant returns to scale.

Therefore, low estimated TFP growth in previous TFP studies is most likely attributable to the mismeasurement of capital share.

Table 1 provides evidence of average net indirect taxes as a share of manufacturing value added for 16 manufacturing industries in Taiwan over the period 1979–1999. The shares are notably high in a number of industries, such as food, beverage and tobacco, petroleum and coal, transport, and non-metallic industries. The higher share of net indirect taxes for the food, beverage and tobacco industry is mainly due to the fact that the state-owned sub-industries, tobacco and beverages (mainly wines), which have been operating monopolistically in Taiwan over the past several decades. Similarly, the oil-related products are heavily taxed and dominated by the state-owned petroleum industry. Since these two industries (tobacco and petroleum) operate as nearly monopolies in Taiwan, their output values are unavoidably inflated by monopoly profits and tax revenues [Färe et al., 2001]. The significance of deducting net indirect taxes can also be illustrated from the following example. Assume the labor share is 0.6 (i.e., capital share 0.4) and the ratio of net indirect taxes to GDP is 0.2. After excluding net indirect taxes from value added, the new labor share turns out to be $0.6 / (1 - 0.2) = 0.75$ (capital share 0.25).

Table 2 presents average operating surplus as a share of manufacturing value added in Taiwan over the period 1979–1999. The operating surplus comprises rent, payment to

TABLE 1
Average Net Indirect Taxes as a Share of Manufacturing Value Added in Taiwan (percent)

Industry	1979–1984	1985–1989	1990–1994	1995–1999	1979–1999
Food, beverage, and tobacco	47.6	40.3	39.8	27.1	39.1
Textile	5.5	3.0	2.2	4.6	3.9
Wearing apparel	1.3	1.3	2.1	2.0	1.7
Leather	5.9	2.7	4.7	7.5	5.2
Wood and furniture	5.4	2.8	2.4	2.8	3.5
Pulp and paper	6.6	3.7	2.3	4.7	4.4
Chemicals and plastic	9.0	5.3	4.6	4.9	6.1
Rubber	10.4	6.4	4.4	5.6	6.8
Petroleum and coal	39.1	17.2	40.1	40.1	34.4
Non-metallic	19.5	16.0	14.3	11.9	15.7
Basic metal	8.7	4.6	2.7	6.0	5.6
Fabricated metal	6.9	3.4	2.9	3.2	4.2
Machinery and equipment	8.8	4.5	2.8	3.1	5.0
Electrical and electronic machinery	7.9	5.8	4.5	5.7	6.1
Transport	20.4	19.9	21.8	21.0	20.7
Precision and miscellaneous	2.8	2.1	1.9	2.9	2.4

Value added is at constant 1996 price, and the share is a simple average over the sample period.
Source: Author's calculation based on the data from *National Income in Taiwan Area of the Republic of China*, published by Directorate–General Budget, Accounting and Statistics (DGBAS), the Republic of China, various issues.

TABLE 2
Average Operating Surplus as a Share of Manufacturing Value Added in Taiwan (percent)

Industry	1979–1984	1985–1989	1990–1994	1995–1999	1979–1999
Food, beverage, and tobacco	18.4	22.6	11.7	6.4	14.9
Textile	24.8	27.0	31.5	31.1	28.4
Wearing apparel	26.0	13.6	13.6	19.0	18.4
Leather	32.2	23.1	24.1	31.1	27.9
Wood and furniture	31.1	26.1	24.0	21.0	25.8
Pulp and paper	34.5	35.1	23.7	14.7	27.3
Chemicals and plastic	33.2	37.4	34.1	34.3	34.7
Petroleum and coal	37.6	61.9	31.2	22.3	38.2
Rubber	19.3	17.2	20.3	15.5	18.1
Non-metallic	25.5	28.0	32.6	17.1	25.8
Basic metal	39.3	45.7	42.0	42.1	42.1
Fabricated metal	26.9	32.0	25.2	27.7	27.9
Machinery and equipment	21.6	23.6	24.6	27.0	24.1
Electrical and electronic machinery	33.8	29.4	27.0	35.9	31.6
Transport	19.3	17.9	19.3	21.0	19.4
Precision and miscellaneous	29.0	27.2	24.3	24.5	26.4

Note and source: Same as Table 1.

capital, and profits. A high operating surplus share is partly attributed to profits, more specifically, imperfect competition profits. High operating surplus shares appeared in the basic metal, petroleum, and chemicals industries. In general, less competition tends to increase firms' profits. This statement is borne out in the case of the monopolistic petroleum and coal industry as well as the chemicals and plastic industry, which are mostly composed of several large oligopolies in Taiwan.

Despite the fact that imperfect competition profits as a share of value added vary from industry to industry, such information and data on profit shares are not explicitly available and need further investigation. Using the data from Taiwan Stock Exchange, this study assumes that firms' profit rates (taxed profit over sales) are similar to imperfect competition profit shares. For the rest six industries, imperfect competition profit rate is assumed to 10% of value added.[4] The average annual profit rates of firms are presented in Table 3.[5] The average profit rates between 1980 and 1999 ranged from 4.0% in the furniture industry to 12.3% in the steel and iron industry. Note that the assumption of 10% profit rate on average accounts for merely 3% of gross output in the manufacturing sector. Regardless of the small profit share, it influences the estimates of factor shares substantially. It should be noted that if the share of imperfect competition profits turns out to be larger, say more than 10%, the difference in the modified TFP would be greater.

With regard to earlier TFP studies on Taiwan's manufacturing sector, Chen and Tang [1990] found that four of the 16 industries over the 1968–1982 period experienced negative TFP growth and average annual TFP growth ranged from −0.76% in the lumber and furniture industry to 4.13% in the leather and fur industry. Using a

TABLE 3

Average Profit Rate of Firms Listed in Taiwan Stock Exchange, 1980–1999 (percent)

	Food	Textiles	Furniture	Paper and pulp	Chemical and plastics	Rubber	Steel and iron	Electric and machinery	Electronics	Transport
1980	5.6	10.1	NA	17.0	9.9	8.9	NA	12.4	8.9	9.9
1981	5.7	9.4	NA	7.6	8.6	7.2	NA	9.4	10.4	3.6
1982	5.4	5.7	NA	3.3	7.8	6.3	11.1	5.7	13.5	3.5
1983	7.0	7.0	NA	8.6	10.4	8.4	9.9	9.9	11.1	−0.6
1984	5.6	10.5	NA	15.4	10.5	8.2	4.4	9.4	9.2	2.9
1985	5.1	6.7	NA	5.5	7.3	6.9	12.0	7.0	8.9	3.6
1986	5.3	11.3	3.1	14.3	10.7	10.3	15.2	7.6	7.9	6.5
1987	4.6	12.9	0.3	14.6	10.5	8.9	17.9	7.9	6.3	9.1
1988	5.0	6.2	4.1	8.3	14.9	8.3	19.6	8.7	8.0	7.1
1989	4.7	4.5	4.5	7.8	10.3	7.9	18.5	8.5	7.1	5.7
1990	6.5	7.1	4.6	1.4	7.3	8.7	13.9	9.9	6.5	4.0
1991	5.9	10.9	5.3	1.8	6.7	9.0	12.3	10.2	5.6	4.2
1992	5.0	8.0	5.6	1.3	6.3	7.4	10.2	10.1	5.2	4.8
1993	4.5	3.5	6.3	1.6	6.2	6.9	10.8	10.3	8.4	2.3
1994	4.2	8.2	6.8	10.7	7.9	5.5	11.1	9.6	13.5	2.2
1995	4.9	8.7	3.4	8.1	8.6	8.9	14.9	2.3	15.3	2.4
1996	2.8	1.9	0.4	−1.7	7.5	9.2	9.0	7.9	11.8	3.0
1997	2.2	5.9	4.4	4.3	8.2	7.6	12.1	7.8	10.4	5.1
1998	0.9	2.4	5.8	−1.5	6.6	8.1	9.4	8.4	9.7	5.1
1999	2.9	2.1	2.0	5.2	7.5	6.4	8.9	7.9	9.9	3.8
Average	4.7	7.1	4.0	6.7	8.7	7.9	12.3	8.6	9.4	4.4

The profit rate is defined as a ratio of taxed profit to sales.

NA Not Available.

Source: Author's calculation is from the *Taiwan Economic Journal* database.

Törnqvist index, Okuda [1994] estimated the average annual TFP growth rate for the manufacturing sector at 2.6% between 1978 and 1991. In terms of individual industries, the electronics industry outperformed other industries with 5% annual TFP growth.[6] Liang [1995] applied the translog index with gross output and four inputs (labor, capital, materials, and energy) and found the average annual TFP growth rates of overall manufacturing turned out to be 0.12% and 1.41% during the periods 1973–1982 and 1982–1987, respectively.

Hu and Chan [1999] employed growth accounting in conjunction with human capital to estimate TFP progress for 15 Taiwan's manufacturing industries. Their study concluded that on average, the manufacturing sector's TFP grew at 3.1% per annum (employees as labor input) or 3.4% (hours worked as labor input) over the period 1979–1996.[7] Using a Törnqvist TFP index, an official publication, *The Trends in Multifactor Productivity*, Taiwan Area, Republic of China (2000) published by the Directorate-General Budget, Accounting, and Statistics (DGBAS) reported that the average annual TFP growth rate of 1.9% for the manufacturing sector over the period 1978–1998. However, the DGBAS [2000] did not allow for imperfect competition; as expected, those official figures understated the real TFP growth rates for Taiwan's manufacturing industries. Unlike most TFP studies, Chuang [1996] applied the regression approach to measure TFP growth for the entire manufacturing sector and found that it increased at an average annual rate of 1.9% between 1975 and 1990.

Aw et al. [2001] applied the multilateral TFP index to three sets of Industrial and Commercial Census data in 1981, 1986, and 1991 and found that all industries gained TFP growth between 7.8% (clothing) and 36.6% (chemicals) over the period 1981–1991 except for the transportation equipment industry. At the manufacturing level, weighted TFP growth was estimated to be 32.4% during the decade (or 3.2% per annum). Using the Data Envelopment Analysis (DEA) method, Färe et al. [1995] suggested that the TFP level of the overall manufacturing sector measured by a Malmquist TFP index progressed at 3.59% annually mainly due to technological progress during the period 1978–1989. Subsequently, Färe et al. [2001] extended their earlier study and calculated Malmquist productivity indexes for 16 of Taiwan's manufacturing industries between 1978 and 1992. They found that Taiwan's manufacturing sector had on average enhanced TFP by 2.89% per annum.

Empirical Model

Following Jorgenson et al. [1987], and Young [1995], value added is specified as a translog function of capital and labor inputs:

$$\ln Y = \alpha_0 + \alpha_K \ln K + \alpha_L \ln L + \alpha_T \cdot T + 1/2\beta_{KK}(\ln K)^2 + \beta_{KL} \ln K \ln L + \beta_{KT} \ln K \cdot T + 1/2\beta_{LL}(\ln L)^2 + \beta_{LT} \ln L \cdot T + 1/2\beta_{TT} \cdot T^2, \quad (1)$$

where Y, K, L, and T denote value added, capital input, labor input, and time. Under the assumption of constant returns to scale, the parameters satisfy the following conditions:

$$\alpha_K + \alpha_L = 1, \ \beta_{KK} + \beta_{KL} = \beta_{KT} + \beta_{LT} = \beta_{KL} + \beta_{LL} = 0. \quad (2)$$

Because the data sets are only available at discrete points of time, say T and $T-1$, the growth rate of output can be expressed as a first difference of $\ln Y(T)$ and $\ln Y(T-1)$:

$$\ln Y(T) - \ln Y(T-1) = \overline{S}_K[\ln K(T) - \ln K(T-1)] + \overline{S}_L[\ln L(T) - \ln L(T-1)] + \overline{TFP}_T, \tag{3}$$

where S_K and S_L represent the elasticities of output with respect to capital and labor inputs and $\overline{S}_i = [S_i(T) + S_i(T-1)]/2$, $i = K, L$ and $\overline{TFP}_T = [TFP(T) + TFP(T-1)]/2$. The expression of the average rate of technical change, $\overline{TFP}_{T+1}$, is also called as the translog index of the rate of total factor productivity growth, where $TFP(T)$ and $TFP(T-1)$ denote the level of total factor productivity at time T and $T-1$, respectively. The translog index is often referred to as the discrete version of Divisia index or the Törnqvist index. Under the assumption of perfect competition, the elasticity with respect to each input is equal to its share in total factor payments. Since the sum of capital and labor shares is unity, the capital share can be obtained by one less labor share.

Finally, if TFP growth is interpreted as a shift in an aggregate production, the associated variables have to be measured as flows. Therefore, the flow of labor services is assumed to be proportional to total hours of work, and the flow of capital services is proportional to the estimated capital stock, i.e., $L_n(T) = \gamma_{Ln}H_n(T)$ and $K_m(T) = \gamma_{km}C_m(T)$, with

$$\ln K(T) - \ln K(T-1) = \sum \bar{s}_{Km}[\ln C_m(T) - \ln C_m(T-1)], \tag{4}$$

$$\ln L(T) - \ln L(T-1) = \sum \bar{s}_{Ln}[\ln H_n(T) - \ln H_n(T-1)], \tag{5}$$

where s_{ij} denotes the elasticity of each aggregate input with respect to each of its component subinputs, i.e., assuming perfect competition, the share of each subinput in total payments to its aggregate factor, $i = K,L$, $j = m,n$, $m = 1,2,\mathrm{K}\,M$, and $n = 1,2,\mathrm{K}\,N$. H_n and C_m denote the total hours of work and estimated capital stock, respectively.

Capital and Labor Shares

To derive labor and capital shares, it is often easier to begin with labor because there is more information on wages and employment. Barro [1999, pp. 127–28] argues that if imposed taxes are proportional to value added, the labor share (S_L) should be calculated as the ratio of the compensation of labor input to factor income rather than value added:

$$Y = rK + wL + \alpha Y \text{ and } S_L = \frac{wL}{(1-\alpha)Y}, \tag{6}$$

where α and $(1-\alpha)Y$ denote the proportional tax rate to value added (Y) and factor income, respectively. Similarly, Young [1995, p. 655] states that the GDP used to calculate the share of labor in his paper is "midway between the GDP at factor costs and GDP at market prices" after net indirect taxes have been removed.

Which estimate of GDP should be used to compute factor shares? Factor income, value added, or the "midway"? In theory, under the assumption of perfect competition and constant returns to scale, GDP comprises the payments to capital and labor inputs. In reality, however, net indirect taxes, imperfect competition profits, and capital depreciation are included in GDP.[8] As emphasised earlier, in order to obtain the modified labor and capital shares, net indirect taxes and imperfect competition profits that should not be counted as part of the factor income must be removed. From the viewpoint of national accounts, GDP consists of the sum of compensation of employees, capital depreciation (consumption of fixed capital), net indirect taxes, and operating surplus. That is,

$$Y = wL + \delta K + T + M = wL + \delta K + T + (\pi + r'K), \tag{7}$$

where wL, δ, K, T and M denote the compensation of employees, rate of depreciation, capital stock, net indirect taxes, and operating surplus, respectively. In fact, operating surplus M can be further divided into two components, imperfect competition profits π and real payment to the capital input $r'K$. Assume the imperfect competition profits are proportional to value added, i.e., $\pi = \beta Y$, then Equation (7) can be written as

$$Y - T - \beta Y = wL + (r' + \delta)K = wL + RK, \tag{8}$$

where $R = r' + \delta$ denotes the marginal product of capital. With both sides divided by $(Y - T - \beta Y)$, the sum of the capital and labor shares becomes

$$1 = \frac{wL}{Y - T - \beta Y} + \frac{RK}{Y - T - \beta Y} = S'_L + S'_K, \tag{9}$$

where $S_L^{'}$ and $S_K^{'}$ represent the modified shares of capital and labor.

The comparison of the modified shares with the conventional shares $S_L = wL / Y$ and $S_K = rK / Y$ implies the following relationship:

$$S_L = \frac{wL}{Y} \leq \frac{wL}{Y - T - \beta Y} = S_L' \text{ and } S_K = 1 - S_L = \frac{rK}{Y} \geq \frac{RK}{Y - T - \beta Y} = 1 - S_L' = S_K', \tag{10}$$

where the both sides, S_L and S_L', will be equal if and only if $(T + \beta Y) = 0$. Equation (10) has clearly shown that the conventional labor share (S_L) has been understated when compared with the modified labor share (S_L').

Therefore, following Equation (9), two approaches are proposed to illustrate the calculation of the modified capital and labor shares. First, conventional approach (S_{LC}): ignoring the effects of net indirect taxes and imperfect competition profits, the estimation results of TFP growth are shown as $TFPG_C$ in Table 5. Using this approach, the conventional labor share is computed by the ratio of wage payment to value added, i.e., $S_{LC} = wL / Y$. As a result, it pulls down the modified labor share leading to an overestimation of capital share as seen in many of the TFP studies. Second, the modified factor shares approach (S_{LM}): remove both net indirect taxes and imperfect competition profits from value added to obtain the improved factor income and labor share, which means $S_{LM} = wL / (Y - T - \beta Y)$.[9] Next, labor share is computed by the compensation of employees over the factor income that has excluded net indirect taxes and imperfect competition profits. The difference between employees and employment is also adjusted in this study (see Appendix A).

Before discussing empirical results, it is informative to analyse the role of individual industries in overall manufacturing. Table 4 presents the shares of 16 industries in manufacturing value added in Taiwan over the 1979–1999 period. On the basis of average shares in manufacturing, the industry with the highest share of 15.2% was electrical and electronics, followed by chemicals and plastic with 14.0% and food and tobacco with 9.8%. On average, these three dominant industries accounted for approximately 47% of manufacturing value added during the past two decades. A number of traditional industries, such as textiles, wearing apparel, food, and tobacco,

TABLE 4
The Shares of 16 Industries in Manufacturing in Taiwan, 1979–1999 (percent)

Industry	1979–1984	1985–1989	1990–1994	1995–1999	1979–1999
Food, beverage, and tobacco	11.6	10.3	9.5	7.6	9.8
Textile	9.9	9.1	7.1	5.2	7.9
Wearing apparel	6.9	5.8	3.4	1.7	4.6
Leather	1.8	1.9	1.1	0.6	1.4
Wood and furniture	2.9	3.1	2.4	1.8	2.6
Pulp and paper	5.2	5.0	3.9	3.3	4.4
Chemicals and plastic	12.1	14.7	14.9	14.7	14.0
Petroleum and coal	6.9	5.2	5.1	6.5	6.0
Rubber	1.6	1.6	1.4	1.1	1.5
Non-metallic	4.1	3.5	4.2	3.9	3.9
Basic metal	5.7	5.5	6.4	6.6	6.0
Fabricated metal	4.4	5.8	7.6	7.1	6.1
Machinery and equipment	3.0	3.6	4.7	5.0	4.0
Electrical and electronic machinery	9.8	11.6	15.4	25.0	15.2
Transport	7.4	7.4	8.6	6.9	7.6
Precision and miscellaneous	6.4	6.0	4.3	3.0	5.0

Note and source: Same as Table 1.

experienced a decreasing share of manufacturing value added. On the other hand, the electrical and electronics industry substantially increased its share, as did the chemicals and plastic industry. Figure 1 presents the annual shares of the four leading industries in Taiwan between 1979 and 1999. The chemical and plastic industry share increased slightly from 12% to about 15%. The electrical and electronics industry share rose from

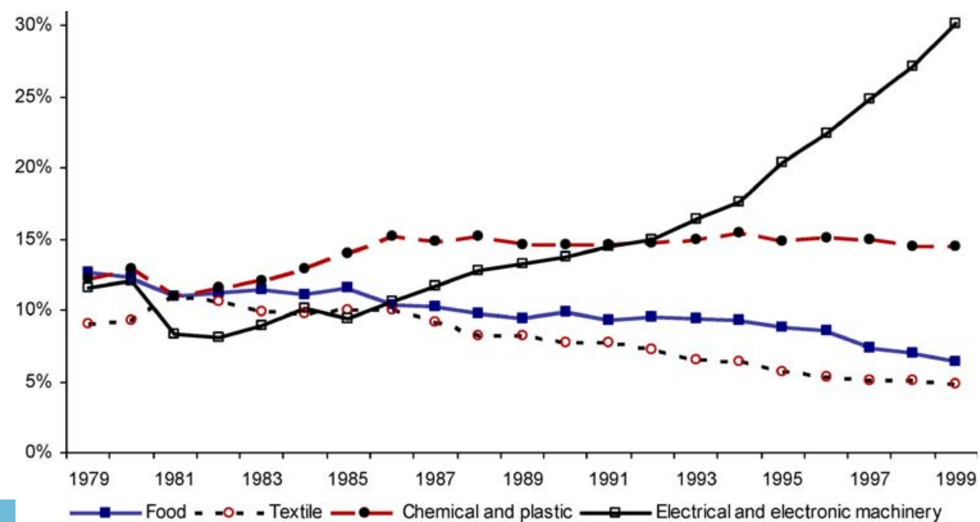

Figure 1. Shares of the Four Leading Industries in Taiwan, 1979–1999. Source: Same as Table 1.

about 10% in the earlier 1980s to 30% in 1999, while the shares of the food and textiles industries fell gradually to 7% and 5%, respectively, in 1999.

Empirical Results

Due to a change in industrial classification made in 1980 and industry aggregation, the combinations of several industries warrant the consistency of value added and capital stock data.[10] Data sources and variable constructions are presented in the Appendix A. The domestic environment for the manufacturing sector in Taiwan has undergone a dramatic change since the late 1980s due to the significant appreciation of the New Taiwanese dollar, the rising cost of labor, financial and industrial reforms, as well as a massive flow of indirect investment to mainland China in the early 1990s. To illustrate this change, TFP growth estimates are presented on the basis of two distinct phases, 1979–1989 and 1989–1999.

Table 5 shows the average annual growth rates of output, labor, capital, and TFP for 16 manufacturing industries in Taiwan during the period 1979–1989. The highest output growth rate of 15.3 occurred in the fabricated metal industry, followed by transport with 11.6%, and machinery and equipment with 10.9%. Not surprisingly, a number of traditional industries, such as textiles and wearing apparel, experienced

TABLE 5
Average Annual Growth Rates: Output, Labor, Capital, and TFP, 1979–1989

Industry	Output (%)	Labor (%)	Capital (%)	S_{LC}	$TFPG_C$ (%)	S_{LM}	$TFPG_M$ (%)
Food, beverage and tobacco	5.2	−0.2	6.7	0.311	0.7	0.575	2.5
Textile	7.1	−2.1	5.7	0.600	6.1	0.640	6.4
Wearing apparel	7.3	−0.1	2.7	0.808	7.3	0.836	7.3
Leather	6.9	3.8	16.4	0.691	−1.1	0.740	−0.4
Wood and furniture	5.3	0.6	6.7	0.670	2.7	0.706	2.9
Pulp and paper	8.4	4.4	9.3	0.538	1.8	0.590	2.0
Chemicals and plastic	10.0	2.6	8.4	0.487	4.5	0.545	4.8
Petroleum and coal	5.8	4.6	8.6	0.116	−2.2	0.184	−1.9
Rubber	9.9	2.7	8.9	0.674	5.0	0.747	5.5
Non-metallic	6.7	1.1	6.1	0.455	2.8	0.577	3.4
Basic metal	6.2	4.8	8.1	0.396	−0.4	0.445	−0.2
Fabricated metal	15.3	7.0	14.0	0.634	5.7	0.699	6.2
Machinery and equipment	10.9	4.2	10.1	0.687	4.8	0.750	5.3
Electrical and electronic mach.	9.5	3.9	12.9	0.582	1.7	0.644	2.3
Transport	11.6	2.5	7.6	0.576	6.9	0.731	7.7
Precision and miscellaneous	5.1	5.1	7.7	0.701	−0.7	0.740	−0.6
Manufacturing sector	8.1	2.1	8.1	0.546	3.3	0.667	4.0

The growth rates of labor and capital inputs have been adjusted for quality improvement; see Appendix A for details.

S_{LC}, S_{LM}, $TFPG_C$, and $TFPG_M$ denote conventional and modified labor share and conventional and modified TFP growth, respectively.

negative growth in labor input, whereas, the growth rates of capital input were positive across 16 industries.

In contrast to the conventional labor share (S_{LC}) and TFP growth ($TFPG_C$), the removal of net indirect taxes and imperfect competition profits from value added obtains the modified factor income and, subsequently, labor shares (S_{LM}), and modified TFP growth ($TFPG_M$) as shown in Table 5. The following discussion examines the results of the modified TFP growth in the industries under review. Four of the 16 industries experienced negative TFP growth whereas the transport, wearing apparel, and textiles industries gained average annual TFP growth rates of 7.7%, 7.3%, and 6.4%, respectively. Note that the TFP growth rates of traditional industries, such as textiles and wearing apparel, exceeded those of high-tech industries machinery and equipment (5.3%) and electrical and electronic machinery (2.3%). As the modified TFP growth differs from conventional TFP growth that suffers downward bias on account of the use of inaccurate factor shares, the distinctions between these two sets of estimates are significant in a number of industries. For instance, the average annual TFP growth rate in the food and tobacco industry increased by 1.8 percentage points to 2.5%, while the non-metallic industry rose by 0.6 percentage points to 3.4% annual TFP growth.

Table 6 shows the average annual growth rates of output, labor, capital, and TFP for 16 manufacturing industries under review between 1989 and 1999. Compared with Table 5, some considerable differences can be seen, for instance, the slowdown of output growth and labor input growth. Labor-intensive industries, including wood and furniture, leather, and wearing apparel, relocated manufacturing production during this

TABLE 6
Average Annual Growth Rates: Output, Labor, Capital, and TFP, 1989–1999

Industry	Output (%)	Labor (%)	Capital (%)	S_{LC}	$TFPG_C$ (%)	S_{LM}	$TFPG_M$ (%)
Food, beverage, and tobacco	0.5	−1.2	5.5	0.476	−1.9	0.734	−0.2
Textile	−0.9	−1.8	6.0	0.577	−2.3	0.605	−2.1
Wearing apparel	−7.7	−6.8	5.9	0.851	−3.1	0.882	−2.7
Leather	−8.0	−5.1	3.6	0.670	−5.7	0.731	−5.1
Wood and furniture	−2.3	−6.3	0.5	0.746	2.2	0.773	2.4
Pulp and paper	0.4	1.3	8.6	0.686	−3.2	0.713	−3.1
Chemicals and plastic	4.3	−1.4	7.8	0.521	1.3	0.560	1.6
Petroleum and coal	7.1	−0.9	5.4	0.182	2.9	0.325	3.6
Rubber	0.7	−2.9	9.7	0.735	0.3	0.782	0.9
Non-metallic	3.6	−1.6	6.9	0.532	1.3	0.629	2.1
Basic metal	6.5	0.9	9.8	0.425	0.5	0.461	0.9
Fabricated metal	4.3	2.7	8.3	0.691	−0.1	0.733	0.1
Machinery and equipment	6.0	2.8	10.1	0.719	1.2	0.756	1.4
Electrical and electronic mach.	12.7	1.9	17.6	0.592	3.9	0.640	4.7
Transport	1.1	0.3	10.2	0.533	−3.9	0.692	−2.3
Precision and miscellaneous	−3.7	−5.1	3.3	0.729	−0.9	0.764	−0.6
Manufacturing sector	4.4	−1.0	9.2	0.581	1.1	0.689	2.2

Note: Same as Table 5.

period to mainland China or Southeast Asia due to the rising cost of labor. As a result, the manufacturing share of these industries fell rapidly and ten industries exhibited negative growth in labor input. Although five out of 16 industries had negative output growth, output growth of the petroleum and coal, and electrical and electronic machinery industries was higher than in the previous decade. The electrical and electronic machinery was the fastest growing industry with an average annual output growth rate of 12.7%.

Despite the slowdown of TFP growth being common over the period 1989–1999, four industries still managed to improve TFP level, notably, petroleum and coal, and electrical and electronic machinery. The former enjoyed an average annual TFP growth rate of 3.6% and the latter 4.7%. Similarly, the extent of the underestimation of TFP growth due to ignorance of net indirect taxes and market imperfection profits was considerable in the food and tobacco, non-metallic, and electrical and electronic machinery industries. The average annual TFP growth for the food and tobacco industry increased from −1.9 ($TFPG_C$) to −0.2% ($TFPG_M$) and from 1.3 to 2.1% in the non-metallic industry.

Table 7 shows the results of output, labor, capital, and TFP growth over the period 1979–1999. Overall, when the impact of market imperfection and net indirect taxes is considered, the low TFP growth estimates cited in recent TFP studies have been substantially revised upwards in the food and tobacco, non-metallic, electrical and

TABLE 7

Average Annual Growth Rates: Output, Labor, Capital, and TFP, 1979–1999 (percent)

Industry	Output	Labor	Capital	S_{LC}	$TFPG_C$	S_{LM}	$TFPG_M$
Food, beverage, and tobacco	2.9	−0.7	6.1	0.393	−0.6	0.655	1.2 (42%)
Textile	3.1	−2.0	5.8	0.588	1.9	0.623	2.2 (70%)
Wearing apparel	−0.2	−3.4	4.3	0.830	2.1	0.859	2.3
Leather	−0.6	−0.7	10	0.680	−3.4	0.736	−2.8
Wood and furniture	1.5	−2.8	3.6	0.708	2.4	0.739	2.6 (171%)
Pulp and paper	4.4	2.9	9.0	0.612	−0.7	0.652	−0.5
Chemicals and plastic	7.2	0.6	8.1	0.504	2.9	0.552	3.2 (45%)
Petroleum and coal	6.5	1.9	7.0	0.149	0.3	0.255	0.9 (14%)
Rubber	5.3	−0.1	9.3	0.705	2.6	0.764	3.2 (60%)
Non-metallic	5.2	−0.2	6.5	0.493	2.1	0.603	2.8 (54%)
Basic metal	6.4	2.9	8.9	0.410	0.1	0.453	0.4 (6%)
Fabricated metal	9.8	4.9	11.1	0.663	2.8	0.716	3.1 (32%)
Machinery and equipment	8.5	3.5	10.1	0.703	3.0	0.753	3.4 (40%)
Electrical & electronic mach.	11.1	2.9	15.3	0.587	2.8	0.642	3.5 (31%)
Transport	6.3	1.4	8.9	0.554	1.5	0.711	2.7 (43%)
Precision and miscellaneous	0.7	0	5.5	0.715	−0.8	0.752	−0.6
Manufacturing sector	6.3	0.5	8.9	0.563	2.1	0.678	3.1 (49%)

Notes: Same as Table 5.

The figures in parentheses indicate the contribution of TFP growth to output growth. The calculation of relative contribution to output growth is omitted if negative TFP growth or output growth occurs.

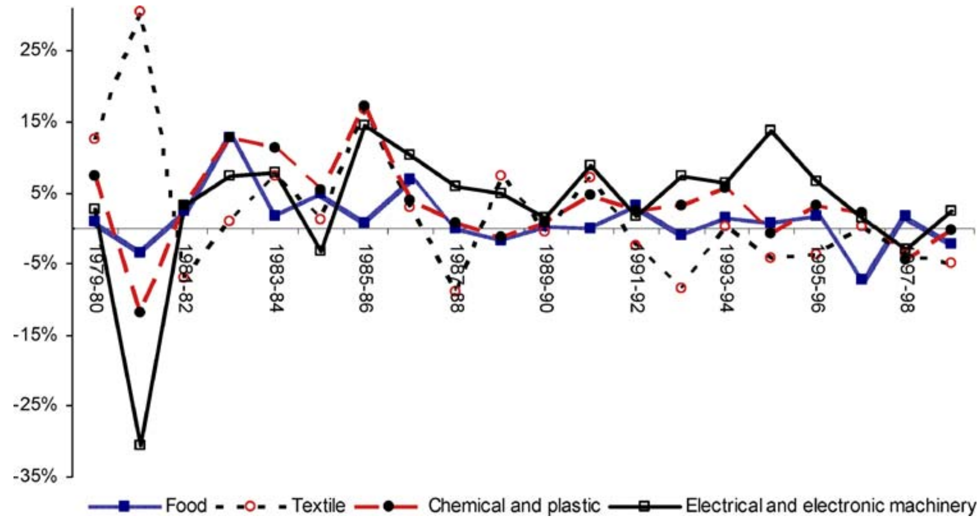

Figure 2. Estimates of Annual TFP Growth for the Four Major Industries in Taiwan, 1979–1999. Source: Author’s calculation. The estimates of annual TFP growth rates are available upon request from author.

electronic machinery, and transport industries. Examination of the contribution of the components to output growth finds that TFP growth was crucial to most industries, including textiles (70%), rubber (60%), and non-metallic (54%). TFP growth wholly accounted for output growth in the wood and furniture industry, while the increase in labor and capital inputs was mainly responsible for output growth in the basic metal industry, which experienced little TFP progress. Estimates of annual TFP growth for the four major leading industries are shown in Figure 2.

Finally, the results of the sensitivity analysis of TFP growth with varying rates of imperfect competition profits are set out in Table 8. Rates of imperfect competition profits are assumed to be in turn 5%, 8%, 10%, 12%, 15%, and 20% of value added, and the growth of TFP under these assumed rates for the manufacturing sector is tabulated for each period. As expected, the estimated TFP growth is larger for higher assumed rates, and the source of the variation comes entirely from the difference in factor share. Nevertheless, the growth of TFP for the two decades (ranging from 2.9% to 3.8%), under all the assumed rates, turns out higher than the conventional estimate (2.1%, Table 7).

TABLE 8
Sensitivity Analysis of TFP Growth with Varying Rates of Imperfect Competition Profits (percent)

Manufacturing sector	5%	8%	10%	12%	15%	20%
	TFPG	TFPG	TFPG	TFPG	TFPG	TFPG
1979–1989	3.7	3.8	3.9	4.0	4.2	4.5
1989–1999	2.2	2.4	2.4	2.5	2.7	3.0
1979–1999	2.9	3.1	3.2	3.3	3.4	3.8

Notes: Due to rounding, figures may not add up precisely.
Annual TFP growth, 3.2%, derived from the assumption of 10% profit rate is slightly different from the weighted TFP growth in Table 7.

Therefore, although the degree of TFP growth is sensitive to the assumed rate of imperfect competition profits, the inference of higher TFP growth for the manufacturing sector in comparison with earlier studies seems valid.

Summary and Conclusion

Those concerned with economic growth and development generally agree that TFP growth plays an important role in the process. Under the framework of growth accounting, economic growth is traditionally attributed to growth in factor inputs and change in TFP; hence, some of the earlier TFP literature suggest the economic miracle in East Asia was predominantly achieved by factor accumulation in the absence of significant TFP progress. In reality, previous TFP growth estimates in East Asia were understated to a large extent because they were based on miscalculated factor shares. The results of earlier TFP studies may be fragile if estimated factor shares did not take into account the impact of market imperfection and net indirect taxes. Therefore, this study reexamines 16 manufacturing industries in Taiwan over the period 1979–1999 using growth accounting and the modified factor shares approach. The findings are summarised as follows.

First, the effect of ignoring the impact of net indirect taxes and market imperfection has underestimated labor share and subsequently lowered TFP growth. The understatement of TFP growth was more significant in the food and tobacco, non-metallic, electrical and electronic machinery, and transport industries. Second, over the period 1979–1999, the electrical and electronic machinery industry experienced the highest annual TFP growth rate of 3.5%, followed by machinery and equipment with 3.4%, and chemicals and plastic with 3.2%. By contrast, the worst TFP performance occurred in the leather industry with −2.8%. Third, in terms of the contribution of the components to output growth, it is suggested that TFP growth accounted for over 70% of output growth in the textile industry, 60% in the rubber industry, and 54% in the non-metallic industry. In the case of the wood and furniture industry, output growth was totally attributed to TFP growth. In general, TFP growth was crucial to output growth in 11 out of the 16 industries. Finally, the slowdown in TFP growth occurred in most manufacturing industries including food and tobacco, textiles, and chemicals and plastic. Although the unrealistic assumption of perfect competition by growth accounting has been avoided in this study, more research on the issue of measuring TFP growth is needed. For instance, it would be desirable to apply the modified factor shares approach to reexamine other East Asian economies and manufacturing sectors.

APPENDIX A

Data Sources

Manufacturing value added and compensation of employees are from *National Income in Taiwan Area of the Republic of China* published by the DGBAS, the Republic of China, various issues. The data of number of employees and monthly working hours are obtained from *Yearbook of Earnings and Productivity Statistics*, Taiwan Area, Republic of China, 1999, published by DGBAS, Executive Yuan, Republic of China, May 2000. The data of employed persons (employment) in the manufacturing sector are available from Table 12 of *Yearbook of Manpower Survey Statistics*, Taiwan Area, Republic of China, 2000, published by DGBAS, Executive Yuan, the Republic of China, 2001. Gross fixed capital formation (GFCF) data are from the DGBAS of Taiwan.

Coverage of Industries

Despite the availability of data of value added from 1951 and GFCF from 1966 for 16 manufacturing industries, respectively, this study focuses on the period 1979–1999 due to the limitation of labor data. The number of industries examined in this study is confined to 16 as a result of the change of industrial classification in 1980. The details of old and new industrial classification are presented in Appendix B. There were initially 17 industries between 1951 and 1980 and 22 during the 1981–1999 period. However, the beverages and tobacco industries were grouped as a single industry before 1981, and after that, the beverages and food industries were classified as one. To make the results comparable and consistent, the food, beverages, and tobacco industries have been combined into one industry in this study.

Variable Constructions and Adjustments

It is essential to adjust the quality improvement embodied in labor and capital inputs. If the average education level rises over time, the procedure described by Jorgenson et al. [1987] will capture the quality improvement of labor input by assigning a higher weight for category n because of the higher wage, w_n. Due to the unavailability of detailed labor data by various quality levels, for example, sex, age, education, employment status, and occupation of employees for each manufacturing industry, the quality-adjusted growth rate of labor input is calculated by the sum of the growth rate of total hours worked plus an annual labor quality improvement of 0.4% suggested by Young [1995].

The study applies the perpetual inventory approach to obtain the capital stock for each sector. Due to lack of detailed components for GFCF data in each industry, a simple average depreciation rate (δ) of 0.0925 is used to depreciate capital stock for Taiwanese manufacturing industries.[11] Under the assumption of smooth investment in the past, initial capital stock equals initial investment divided by the rate of depreciation (δ) plus the growth rate (g) of investment for the entire period, that is, $C(0) = I(0) / (\delta + g)$.[12] Once initial capital stock is derived, the estimation of capital stock (C_T) in each manufacturing industry at time T follows the perpetual inventory method with geometric depreciation:

$$C_T = \sum [C_{T-1}(1-\delta) + I_{T-1}]. \tag{A.1}$$

Likewise, it would be best to divide the GFCF into several categories, such as non-residential, transport equipment, and machinery, to implement the adjustment of quality improvement. Yet, due to lack of detailed data, the quality-adjusted growth rate of capital input is calculated by the sum of the growth rate of capital stock plus an average annual capital improvement of 0.2% derived by Young [1995].

The adjustment of the difference between the number of employees and employment, which takes account of employers, own-account workers, and family workers, is also carried out.[13] Due to lack of wage data for these three types of workers, it is assumed that employers, own-account workers, and unpaid family workers earn the same wage as employees. Then, the payment to labor input is calculated as the compensation of employees multiplied by one plus the ratio of the sum of employers, own-account, and unpaid family workers to the number of employees in each sector [Young, 1992, 1995].

APPENDIX B

TABLE B.1
The Industrial Classifications in Taiwan

Old classification (1951–1980)	New classification (1981–1999)	After combination (1979–1999)
Food products	Food and beverages	Food, beverages and tobacco
Tobacco and beverages	Tobacco	
Textile mill products	Textile mill products	Textile mill products
Wearing apparel, accessories and other textile products	Wearing apparel, accessories and other textile products	Wearing apparel, accessories and other textile products
Leather, fur and products	Leather, fur and products	Leather, fur and products
Wood and bamboo products and furniture	Wood and bamboo products	Wood and furniture
	Furniture and fixtures	
Pulp, paper and paper products printing processing	Pulp, paper and paper products	Paper and printing
	Printing processing	
Chemical products, chemical material and plastic product	Chemical material	Chemical and plastic products
	Chemical products	
	Plastic products	
Petroleum and coal products	Petroleum and coal products	Petroleum and coal products
Rubber products	Rubber products	Rubber products
Non-metallic mineral products	Non-metallic mineral products	Non-metallic mineral products
Basic metal industries	Basic metal industries	Basic metal industries
Fabricated metal products	Fabricated metal products	Fabricated metal products
Machinery and equipment	Machinery and equipment	Machinery and equipment
Electrical and electronic machinery	Electrical and electronic machinery	Electrical and electronic machinery
Transport equipment	Transport equipment	Transport equipment
Other industrial products and precision instruments	Precision instruments	Other industrial products and precision instruments
	Other industrial products	

Source: Same as Table 1.

Footnotes

[1]Gollin [2002] provides an alternative explanation by arguing that "the usual naive calculation of labor shares-using employee compensation as a fraction of GDP-makes an obvious and important error in falling to account for labor income of the self-employed and other entrepreneurs."

[2]Net indirect taxes are the result of indirect taxes less subsidies while imperfect competition profits are generated under imperfect competition and counted as part of GDP (value added).

[3]Note that TFP growth on the basis of growth accounting is defined as disembodied and exogenous technological change so that it should not be synonymously regarded as technological change. Therefore, if part of technological progress embodied in recent vintages of capital (due to better quality than old vintages) is substantial, then the estimation of embodied technological change cannot be ignored. For instance, Sakellaris and Wilson [2004] find evidence that equipment-embodied technological change accounted for about two-thirds of total technological change in U.S. manufacturing plants during 1972–1996.

[4]Aw [1993] suggests that the 95% confidence interval of the estimated markup of price over marginal cost is 0.13 to 0.29 for Taiwanese footwear industry in the German market during the period 1974–1985. Nadiri and Kim [1996] provide some estimates of markup rates, 17% for the U.S., 20% for the Japanese and roughly 30% for Korean manufacturing industries. Although definitions of these two terms, the share of imperfect competition profit and markup rate, are different, the estimated markup rates have implicitly justified the assumed degree of profit shares to calculate the estimation of TFP growth.

[5]If firm's profit rate is calculated as taxed profit over value added, the profit rates in Table 3 should be (much) larger.

[6]The original 18 industries were combined into 11 industries in order to be consistent with other statistics. The detailed aggregation of industries is available in Table VI of Okuda [1994, p. 433].

[7]Hu and Chan [1999] also report that human capital adjusted TFP growth rates of the manufacturing sector were correspondingly higher at 5.5% and 6.0% during the sample period.

[8]The capital depreciation or consumption of fixed capital is a cost of producing the output of the economy [Mankiw, 1997, p. 30]. Therefore, it is included as a part of the payment to capital.

[9]For example, if imperfect competition profits account for 10% of factor income, the manipulation of Young [1995, Tables V–VIII, pp. 657–661] shows that the estimates of average annual TFP growth rate increases from 2.3% to 2.7% for Hong Kong, from 1.7% to 2.3% for Korea, and from 2.6% to 3.3% for Taiwan. Note that this implementation comes from Young's [1995, p.648] proposition, where he suggests "the reader can make an easy correction for this factor by adjusting the aggregate shares of capital and labor." Although Young does not believe such a correction will improve productivity growth estimates for the East Asian economies significantly, the results show that it does make a difference. Unfortunately, the factor shares estimates are not available in most TFP studies on Taiwan's manufacturing sector, making it difficult to evaluate their empirical results.

[10]The growth rates of output, labor, and capital in this study are calculated using a logarithmic difference in two consecutive years not geometric. Hence, the estimates of output growth rate reported here could be slightly different from the official publications. All variables are deflated at constant 1996 prices.

[11]According to Hulten and Wykoff [1981], the simple average depreciation rate of 0.0925 is computed from the four depreciation rates of capital subinputs comprising non-residential (0.029), construction (0.021), transports (0.182), and machinery (0.138), where land is excluded from the construction of capital stock.

[12]If the average real growth rate of GFCF were chosen from individual manufacturing industries, in some cases, the initial capital stock could become negative due to the dramatic fluctuations of the growth rate of GFCF in several manufacturing industries. Hence, the average annual real growth rate of GFCF of 0.111 from the entire manufacturing sector over the period 1966–1999 is used to calculate the initial capital stock for each manufacturing industry. Note that the average annual growth rates of GFCF are geometric not logarithmic.

[13]Moreover, it is noted that the two publications from the DGBAS may provide different statistical figures regarding the number of employees in Taiwan because two different samples (households and establishments) are chosen to conduct the surveys. To be consistent, the *Monthly Bulletin of Manpower Statistics*, Taiwan Area, Republic of China is the main data source to implement the adjustment.

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