Discussion Paper #98-DOF-30

Is White-collar Productivity Low in Japan?

-Evidence from the Electrical Machinery Industry*-

Takanobu Nakajima

Yoshiaki Maeta

Kozo Kiyota

November 1998

*The results displayed in this paper are different from those in the earlier Japanese version, because we have made a little correction of the data processing. The empirical results in this English version are more reliable.

Abstract

In recent searches for a scapegoat for Japan's long-term recession since 1992, white-collar sections of firms have been singled out. The basis of this discussion is an unproven proposition: productivity of a white-collar section is extremely low in Japan. This proposition has been reinforced by questionnaire surveys' results from firms and seemingly significant correlations between macro statistics. In this paper, we try to estimate a white-collar section's Total Factor Productivity (TFP) by using a simple production model. Assuming that a firm's output is a combination of outputs from a production section and a non-production section, we can deduce a non-production section's TFP by subtracting a production section's contribution from the whole firm's TFP. The former can be captured from the data of *The Census of Manufactures* (*CM*) by MITI, and the latter from *The Annual Security Reports* (*SR*), by the Japanese commercial firms listed on the Stock Exchange.

The examined industry is the Japanese electrical machinery industry which, everyone believes, has been enjoying the highest productivity growth since Japan's rapid economic growth period. The observation period selected is from 1985 to 1993 because of the data availability. The empirical results are striking. During this period, including the time of the recession after the strong Yen period, the Bubble-Economy, and the recession after its collapse, a representative firm's TFP was declining by 0.70 percent. Out of this value, the contribution of a production section was -1.85 percentage points, and that of a non-production section was 1.16 percentage points. The results show that placing blame on the white-collar section is not accurate for Japan's electrical machinery industry from 1985 to 1993 — actually, the white-collar section relieved the firm's TFP from declining.

Is White-collar Productivity Low in Japan?

-Evidence from the Electrical Machinery Industry-

Takanobu Nakajima
Associate Professor, Faculty of Business and Commerce, Keio University
Special Research Fellow, Research Institute of International Trade and Industry

Yoshiaki Maeta
Research Fellow, Research Institute of International Trade and Industry

Kozo Kiyota
Research Associate, Faculty of Economics, Keio University
Visiting Researcher, Research Institute of International Trade and Industry

November 1998

Contents

1 Introduction 1
2 The Model 2
3 The Data Source 4
4 The Empirical Results 6
4.1 Estimation of α 6
4.2 Growth Accounting of a Firm's Total Output 7
4.3 Growth Accounting of a Firm's TFP 7
5 Factor of Productivity Fluctuation 8
5.1 TFP Regression 8
5.2 Test of Factor Utilization Effect on TFP 9
6 Concluding Remarks 10

1 Introduction

The purpose of this paper is to empirically verify or disclaim the common view that productivity from the white-collar section is low in Japan. Although there are considerable preceding works holding this view, none of them have yet applied direct empirical measurements to this hypothesis. The Ministry of Labor (1994) picked the following three reasons for the difficulty of measurement: (1) the white-collar job is too widely varied in range from management to clerical workers to uniformly define its productivity, (2) the white-collar job has little obvious relationship between input and output because output quantity is hard to measure directly, and (3) the contribution of a development section or a planning section to the rise in the productivity of the blue-collar job can hardly be evaluated independently. To summarize, the Ministry of Labor sees a bottleneck in how to define the white-collar workers' job output. For that reason preceding works have largely avoided measurements, but have gotten some fact-finding results through questionnaire surveys to companies [1] or discussions regarding the managerial methodology employed to raise white collar productivity.[2]

On the contrary, one can find several research papers that discuss white-collar job productivity issues on the basis of observations or evidence. The Ministry of International Trade and Industry (1998) derived the implication that the downsizing of the white-collar section leads to a rise in total labor productivity based on the following two observations: the correlation between the white-collar job ratio and labor productivity was weakly negative in the U.S. manufacturing industries from 1990 to 1995, and the growth rate of sales cost plus general administrative cost was lower than that of the sales amount at that time. Nishimura(1998a), showing a significant negative relationship between labor productivity and the ratio of value added to the labor cost of a white-collar section in companies capitalized at more than one billion yen, concludes that the high cost of an indirect section in firms causes a declining macro-economic productivity. This evidence, however, is hardly persuasive. There should be very small inferences from the negative correlation between the cost share of a white-collar section and labor productivity in a firm. The lack of discussion about blue-collar productivity and the effect of capital stock on labor productivity may cause a false evaluation of a firm's labor productivity.

[1]For example, *Investigation Report on White-collar's Productivity* by Productivity Research Institute issued in June 1994 aggregated questionnaires from firms to reach the conclusion that "the productivity of the white-collar job in Japan is lower than that of the blue-collar job and that of the white-collar job in the West. In addition, the productivity of white-collar is not thought to be progressed in time series. (p.23)" The products of the white-collar and blue-collar jobs are completely different from each other, which makes it nonsense to compare their productivity levels.

[2]Takahashi(1995) includes seven papers on the management of white-collar jobs, none of which gets to the measurement of the productivity. The Japan Institute of Labour(1995), stressing that the product of the white-collar job cannot be captured quantitatively, discussed the managerial methodology to raise its productivity based on questionnaire surveys sent to seven commercial firms.

On the other hand, there are some empirical works that recognize white-collar productivity. Enkawa and Ito (1996), focusing on white-collar jobs of design, development, and technology in car manufacturing firms, calculated the period needed to develop a new car both in the U.S. and Japan. According to their calculations, based on the technology in the 1980s, engineering time for a brand new car is 3.1 million hours in the U.S. and 1.7 million in Japan, and the time for development is 60 months and 46 months, respectively. They concluded that, at least until late in the 1980s, Japanese car manufacturers had an overwhelming advantage in productivity relative to U.S. car manufacturers. Abe and Kurosawa (1993) labeled a representative white-collar worker as "knowledge intensive staff (KIS)," estimated the elasticity of substitution between KIS and others, and made a simulation of how a whole firm's labor productivity could be raised by the substitution. These works are notable in the sense of approaching the productivity issue from an engineering viewpoint. However, a need to obtain precise information concerning a firm's confidential technology and a limitation of research to labor productivity may be an obstacle to further research.

This paper, in consideration of this incompleteness of previous research on the "ambiguous white-collar productivity," tries to measure total factor productivity (TFP) in a manufacturing company through a simple production model. First of all, we define a white-collar job as other than a job in the production section of a firm. A useful data source related to a production section can be obtained from *The Census of Manufactures* (*CM*), and that related to the whole firm listed on the stock exchange from *The Annual Securities Report* (*SR*). Assuming that the whole firm's output can be aggregated from outputs of production and non-production sections by a linear-homogeneous aggregate function, we can show that a firm's TFP growth is a weighted average of production and non-production section TFP growth. The non-production TFP can be estimated from the other two TFPs.

In section two, we present a production model for TFP measurement and consider the consistency of the model with available data sources. Section three describes details on the calculation process of adjusting the original data source for the model. In Section four we show the estimation results, utilizing the example of the Japanese electrical machinery industry, and attempt factor searching analysis in the following section. Finally, we present our concluding remarks and thoughts for future consideration.

2 The Model

We simply divide a firm's activity into a production section and a non-production section. A production section's activity, making a product from inputs can be described in the following production function.

$$(1) \qquad M = F_p(\boldsymbol{X}_p),$$

where M stands for the output and $\boldsymbol{X}_p$ stands for the input vector in a production section.[3]

The job of a non-production section is defined as the general efforts to raise the sales amount other than by making more products: e.g., to develop a new product, to improve a firm's image, to design a distribution and sales system, to create effective advertising, and so forth. The production function of a non-production section can be expressed as

$$(2) \qquad V = F_n(\boldsymbol{X}_n),$$

where V and $\boldsymbol{X}_n$ are output and input vector respectively.

The aggregate function of M and V to get a firm's final output Y, we assume, is written in Cobb=Douglas form as follows.[4]

$$(3) \qquad Y = A\ M^{\alpha}\ V^{1-\alpha}.$$

Using input quantity indexes of production and non-production sections, Q_p and Q_n respectively, (3) can be rewritten in terms of growth rate.

$$(4) \qquad \frac{d\ln Y}{dt} = \alpha\frac{d\ln Q_p}{dt} + \alpha\frac{d\ln T_p}{dt} + (1-\alpha)\frac{d\ln Q_n}{dt} + (1-\alpha)\frac{d\ln T_n}{dt},$$

where T stands for TFP level. The TFP growth rate of a whole firm (T_o) can be expressed as

$$(5) \qquad \frac{d\ln T_o}{dt} = \alpha\frac{d\ln T_p}{dt} + (1-\alpha)\frac{d\ln T_n}{dt}.$$

Figure 1 depicts the relationship between inputs, TFPs, and outputs of the two sections and the whole firm. The mesh areas are directly observable in data. By using (5) we can calculate unobservable non-production section TFP (T_n) growth by subtracting production section TFP's contribution from the whole firm's TFP growth. A data source of T_o is a firm's *SR* and that of T_p is *CM*. The input vector of a production section listed in *SR* is a simple summation of production and non-production sections, and is written as

$$(6) \qquad \boldsymbol{X}_o = \boldsymbol{X}_p + \boldsymbol{X}_n.$$

Following the relationship above, the growth rate of Q_o is derived as

$$(7) \qquad \frac{d\ln Q_o}{dt} = \sum_i S_{oi}\frac{d\ln X_{oi}}{dt} = \sum_i (S_{pi}W_p + S_{ni}W_n)\left(W_{pi}\frac{d\ln X_{pi}}{dt} + W_{ni}\frac{d\ln X_{ni}}{dt}\right).$$

[3] Although all the variables in the model can be expressed as functions in terms of time such as $M(t)$, to avoid the complexity we omit (t) except that the omission may cause ambiguity.

[4] We use Trans-log form (Theil=Trönqvist index formula) in the empirical study later.

Here the following variable definitions are assumed.

$$\begin{aligned}
S_{pi} &= \frac{P_{pi}X_{pi}}{C_p}, \qquad C_p = \sum_i P_{pi}X_{pi} \\
S_{ni} &= \frac{P_{ni}X_{ni}}{C_n}, \qquad C_n = \sum_i P_{ni}X_{ni} \\
W_{pi} &= \frac{P_{pi}X_{pi}}{P_{pi}X_{pi} + P_{ni}X_{ni}} \\
W_{ni} &= \frac{P_{ni}X_{ni}}{P_{pi}X_{pi} + P_{ni}X_{ni}} \\
W_p &= \frac{C_p}{C_p + C_n} \\
W_n &= \frac{C_n}{C_p + C_n},
\end{aligned}$$

where P shows the price corresponding to input X.

Based on (4) and (5), on the other hand, Q_o can also be obtained from

$$\alpha \frac{d \ln Q_p}{dt} + (1-\alpha)\frac{d \ln Q_n}{dt} = \sum_i \left(\alpha S_{pi} \frac{d \ln X_{pi}}{dt} + (1-\alpha) S_{ni} \frac{d \ln X_{ni}}{dt} \right). \tag{8}$$

Now we can get the following theorems:

> **[Theorem 1]** The aggregated input of (7) is equal to that of (8) under the sufficient condition, $\alpha = W_p$.

This sufficient condition is consistent with a firm's rational behavior subject to conditions.

> **[Theorem 2]** If both $F_p(\boldsymbol{X}_p)$ and $F_n(\boldsymbol{X}_n)$ are homogeneous functions with degree η, a firm's cost minimization behavior leads to the equality, $\alpha = W_p$.

In this paper, based on the theorems above, we assume that $\alpha = W_p$ holds.[5]

3 The Data Source

CM researches data from production sections of firms, providing information on factory input and output. A firm's *SR* is a source of information on the firm's input and output structure. For calculation samples, we chose 55 commercial firms from the Japanese electrical machinery industry listed in Table 1. Based on the firm's main product, 55 firms are divided into the three groups: heavy electric equipment (HEE), electronic and communication equipment (ECE), and other light electric equipment (OLEE). To examine the effect of company's scale, we also divide the 55 companies into the following two groups: six major companies (Big Six) and others (Other

[5]The proofs of the theorems are shown in appendix.

49). Big Six may represent the Japanese electrical machinery industry, underlined in the table.[6] The observation period is from 1985 to 1993.[7]

Here we have to check the consistency between the two data sources which together calculate the non-production section TFP. The link is based on the "state of facilities" table listed in a firm's security report which provides the number of workers and names of products for each factory. Based on this information, a firm's factory is attributed to a *CM* classification category. The additional explanations about the data processing are described in the following subsections.

Consistency between *SR* and *CM*

While *CM* is based on a calendar year, *SR* is based on a fiscal year which each firm independently decides. To minimize error we picked firms who only utilize a fiscal year from April to March.

- Products listed in the "state of facilities" table ocassionally spread across multiple industry categories in *CM*. In those cases we specified a main product based on information derived from *Japan List of Machinery Factory* (MITI) and internet homepages of these companies.

- In *CM* establishments are divided according to a worker scale in the following 7 classes: 30 to 49, 50 to 99, 100 to 199, 200 to 299, 300 to 499, 500 to 999, and over 1000. Therefore, numbers of input and output in *CM* corresponding to *SR* are for those of average establishments in labor scale classification. In other words, while *SR* is exactly a panel data, *CM* is a quasi-panel data.

Output and Material Price Index

The data source for price indexes is input-output price indexes from *Price Indexes Annual* (Bank of Japan), where indexes for HEE, ECE, and OLEE can be obtained. Since sales amount in *SR* does not correspond to their products, their sales in total sales is substituted for those calculated from output by 4-digit *CM* classification. The shares in sales and production are assumed to be practically the same. The same method is applied to materials. Finally, the three price indexes are aggregated by Theil−Trönqvist formula.

Capital Stock and Labor

The capital stock has the three categories: building, machines, and land. Their annual real values, starting with their bookvalues in 1985, are calculated by a perpetual inventory method

[6] The Big Six companies occupy about 60 percent of sales out of total sales of 55 firms.

[7] There are two reasons this period was specifically chosen. One is that the four-digit industry classification system in *CM* changed in 1994, and the consistency before and after the change is unable to be maintained. The other is that Hanshin-Awaji Earthquake Disaster in January 1995 prevented the statistic agent from gathering questionnaires for 1994.

with 5%, 15%, and 0% of depreciation rate, respectively.

The price indexes of buildings and machines are from *System of National Accounts* (Economic Planning Agency). Land price indexes are from *Publication of Land Price* (National Land Agency).[8]

The interest rate for capital cost is Over-the-Counter Standard Bond Quotations of Interest-bearing Bank Debentures (5 years) from *Economic Statistics Annual* (Bank of Japan).

Labor input is measured by the number of workers.[9]

4 The Empirical Results

4.1 Estimation of α

As described in the previous section, the value of α in (3) should be estimated to get non-production section TFP from (5). It is impossible to estimate (3) directly because V is un-observable. Assuming the homogeneity of degree η for F_p and F_n based on Theorem 1 and 2, we use observation of W_p for α. To simplify the argument, we have specified the production function as Cobb=Douglas form which implies that W_p is constant through time. However, this assumption is somewhat too strong because W_p actually changes over time. Therefore, in the following part, we use Trans-log form so that we can take the changes into account. In the case of Trans-log, the weight for aggregation, α, is defined as arithmetic mean of W_p for consecutive two years. (Diewert(1976)) Therefore, (5) is rewritten as

$$(9) \qquad \ln \frac{T_o(t+1)}{T_o(t)} = \frac{1}{2}[W_p(t+1) + W_p(t)] \ln \frac{T_p(t+1)}{T_p(t)} + \frac{1}{2}[W_n(t+1) + W_n(t)] \ln \frac{T_n(t+1)}{T_n(t)}.$$

For the calculation of $W_p (= C_p/(C_p + C_n))$, the production cost for C_p and sales cost plus general administrative cost for $C_p + C_n$ are used from *SR*.[10]

Table 2 shows W_p values. In time series a declining trend in production cost is found. A cross-sectional comparison leads to a lower weight for the production section in OLEE and Big Six.

[8] This paper uses three kinds of lands – commercial land, quasi-industrial land and industrial land. These kinds of land are aggregated by arithmetic mean. A more precise method may be advisable considering the violent fluctuation of land price during our observation period.

[9] Working hours are not a consideration, because they are not available for each firm. The time series fluctuation may affect the calculated results in this paper.

[10] Here we ignore an error that may occur because capital cost is not included both in the numerator and denominator.

4.2 Growth Accounting of a Firm's Total Output

The growth rate of Y is composed of the contribution of M and V as shown in (4). Theoretically, this breakdown is possible for each firm. However, considering that *CM* does not provide exact panel data, we show the calculation result in Table 3 for a representative firm which has a geometric mean of output values of 55 samples. The findings are summarized as follows:

- The firm's sales amount shows a great increase from the strong Yen Recession to the Bubble-Economy, although the trend reversed after the collapse of the Bubble.
- We can find some differences among the results of the three product categories. In HEE and OLEE the decline in sales after the collapse of the Bubble-Economy is mostly due to the decrease in output of a non-production section. On the other hand, in ECE the production section had a significant negative effect.
- In all the samples for the entire observation period, the contribution of a non-production section to a firm's sales is larger than that of a production section. The same finding is applied to HEE, ECE, and Other 49.

4.3 Growth Accounting of a Firm's TFP

Here a representative firm's TFP (FTFP) is divided into a production section TFP (PTFP) and a non-production section TFP (NTFP) according to (10).[11] Figures 2 through 7 show the results that are summarized.

- What can be observed in common with the all samples, HEE, ECE, and Other 49 is that FTFP growth is negative except for the three years during the Bubble-Economy.
- OLEE shows violent fluctuation both in PTFP and NTFP.
- Big Six shows the best performance in FTFP, to which NTFP has a large positive contribution.

Table 4, which summarizes the six graphs above, provides:

- Annual FTFP growth for the entire observation period is positive only in Big Six, and negative in the other categories.
- PTFP has negative growth in all the categories, while in contrast, NTFP is positive except OLEE.

[11] The definition of "representative firm" is owing to Caves, Christensen and Tretheway(1983), Good, Nadiri, Roeller and Sickles(1993).

- During the Bubble-Economy, TFP growth is negative for PTFP, and positive for FTFP and NTFP. In this representative firm, a large scale of TFP growth could not be observed at that time. Positive growth of PTFP is observed only in HEE and OLEE.

5 Factor of Productivity Fluctuation

5.1 TFP Regression

This subsection addresses a factor analysis of TFP growth using panel series of PTFP and NTFP.[12] The following cost function with a homogeneity of degree γ in output is presented.

$$(10) \qquad \ln C(t) = \beta + \ln P(t) + \gamma \ln Z(t), \qquad Z(t) = M(t) \quad \text{or} \quad V(t)$$

where $P(t)$ stands for input price index at time t. Subtracting $\ln P + \ln Z$ from both sides, we get

$$(11) \qquad -\ln T(t) = \beta + (\gamma - 1)\ln Z(t).$$

Assuming Hicks-neutral technical change and different rates of technical change and γ across product categories, (11) is rewritten as

$$(12) \qquad -\ln T(t) = \beta_0 + \beta_1 D + (\delta_0 + \delta_1 D)t + (\gamma_0 + \gamma_1 D - 1)\ln Z(t),$$

where D is a dummy variable for the product categories and Big Six. Taking a differential between $t+1$ and t, and redefining parameters will rewrite equation (12) as the following.

$$(13) \qquad \ln \frac{T(t+1)}{T(t)} = \zeta_0 + \zeta_1 D + (\psi_0 + \psi_1 D)\ln \frac{Z(t+1)}{Z(t)} + e(t, t+1).$$

For estimation purposes, a first order of serial correlation in a time series and a different variance-covariance matrix across firms are taken into account. We also present the two models: one with the same coefficient of AR(1) across firms and one with different coefficients. The estimation method is FGLS (Feasible Generalized Least Squares).[13] The results are shown in Table 5 and 6. In summary:

- from Table 5,
  - The constant term is significantly negative. The effect of Hicks-neutral technical change is -4% per year.
  - The effect of output on TFP is significantly positive.

[12] We should take into account that an establishment picked from *CM* is not precisely a panel data. For this reason we only use quasi-panel data of a "representative firm."
[13] For the details about FGLS, see Greene(1997), pp.511–

- The coefficients of the dummy variables that affect the output effect on TFP are significantly negative. OLEE shows the largest effect, and ECE and HEE have the next largest effect. The Big Six dummy effect is not significant.

- from Table 6,
  - The constant term is not significant. The effect of Hicks-neutral technical change can be ignored.
  - The effect of output on TFP is almost the same as that in Table 5.

5.2 Test of Factor Utilization Effect on TFP

One of the most outstanding results of the TFP regression is a large, positive output scale effect both on PTFP and NTFP, which indicates a high degree of scale economy in production and non-production sections. However, the results obtained in the previous subsection cannot be accepted at face value. As already pointed out in Basu(1996) and Park and Kwon(1995), the utilization effect of fixed input, such as capital stock, may affect TFP fluctuation and lead to biased estimates of output coefficients in Table 5 and 6. To partially solve this problem, one explanatory variable is added which can reflect utilization of fixed input. Basu(1996) showed that a material input can be an utilization indicator when it is a perfect complement for other inputs.[14] Based on the implication in Basu(1996), the following term can be added to (13).

$$(14) \qquad (\psi_0 + \psi_1 D) \ln \frac{Mat(t+1)/Q(t+1)}{Mat(t)/Q(t)},$$

where Mat stands for material input and Q for input quantity index. In the case that material cannot be substituted by other inputs, if the growth rate of material input is larger than that of others, the utilization of fixed input must be increased.[15] Here we apply this model to a production section where a utilization problem would be crucial in TFP regression.

Another problem occurs in the estimation, however. Because of the high correlation between utilization rate and output, a simple addition of (14) may cause multi-collinearity in regression.[16] Therefore, we try to estimate PTFP regression only by utilization rate.[17] In other words, we assume constant returns to scale *a priori* by omitting output. The results are shown in Table 7. The parameter of utilization rate is estimated significantly in every case. In addition, constant term does not show statistical significance, while in the original case a significantly negative

[14] The perfect complementarity of material for other inputs means that, for example, one body and four tires are necessary for producing one car and unable to be substituted with labor and capital.

[15] If output grows and other inputs stay constant, provided that the firm does not waste material inputs, rise in other inputs utilization rate is inferred.

[16] In fact the correlation coefficient between growth rate of Mat/Q and M is 0.83.

[17] The utilization model is applied only to PTFP here, because it seems to be difficult to define and observe the utilization rate of fixed inputs in a non-production section. This problem can be left for the further research.

constant term was hard to understand. It might be difficult to attribute all the effect of output only to the utilization because its likelihood is smaller than in Table 5. Nevertheless, fixed input utilization may obviously have a great influence on the production section TFP.

6 Concluding Remarks

As described in the introduction of this paper, the Japanese white-collar section does not have a good reputation; not solely based on subjective observation but on self-evaluation by firms themselves. According to Productivity Research Institute(1994), the evaluation results of white-collar sections by personnel departments and production sections were awful. Repeated descriptions like "complacent (comfortable to be in a tepid water)" and "little progress in productivity" are common in questionnaire answers. On the other hand, the inherent difficulty in addressing these questions, motivates the respondents to make statements such as: "an intellectual job is too ambiguous to make a standard to evaluate the productivity" and "no criteria is established for the evaluation of white-collar productivity." In the meantime, the proposition that "white-collar productivity is low" is widely stated without proof. Similarly stated, "the Japanese firm puts a thick human fence around an efficient factory. It is now necessary to destroy the fence and allocate workers stuck inside to more productive jobs in a nationwide economic level." (Nishimura,1998b) The discussion leads to the conclusion that the white-collar section is a source of the current economic recession.

An observation is needed to provide objectivity to this ambiguous discussion. This paper has presented TFP estimation of the non-production section in the 55 Japanese firms of the electrical machinery industry from 1985 to 1993. What is remarkable is results showing that during that period the non-production section TFP puts a brake on a firm's declining TFP. For instance, annual average growth rate of FTFP is -0.70 percent, to which a production section has a contribution of -1.85 percentage points and a non-production section contributes 1.16 percentage points. This result is applied to all the classification categories by product and firm size in this paper: heavy electric equipment (HEE), electronic and communication equipment (ECE), other light electric equipment (OLEE), six major firms (Big Six), and the other 49 firms (Other 49). Considering that the cost share of a non-production section is 35 percent, its contribution to a firm's TFP should be greatly appreciated.

From the results of a TFP regression analysis, a negative Hicks-neutral technical change of -4 percent from 1985 to 93 and significant economies of scale are observed in a production section. In a non-production section, on the other hand, technical change is nearly zero, and the majority of the scale effects are positive. As is well known, scale effect in production sections is frequently due to utilization of fixed input. To clarify this discussion, in our estimations we regressed PTFP growth on an utilization rate indicator and got a large and positive parameter estimate. The result showed the existence of utilization effect on TFP in a production section.

The electrical machinery industry has been an honor student in the Japanese industry from the viewpoint of productivity since the high growth period. Nevertheless, during the violent business cycle since the strong Yen Recession through the Bubble-Economy up to the Heisei Depression, this industry had just shown slight *gains* in productivity. What is noticeable is a relatively constant level of productivity in the production section even during the Bubble-economy. This result showed an obvious contrast with that in Nakajima, Nakamura and Yoshioka(1998), where production section TFP in the electrical machinery industry was measured from the 1960s to early in the 1970s. At that time, more than 10 percent of annual output growth was observed, while TFP also experienced an annual increase of no less than 5 percent. On the contrary, production sections in the Bubble Economy realized output growth, not by the rise in productivity, but just by pouring in more materials, employing more workers, and enlarging capital stock. Companies had to pay for their bullish behavior. The rapid decline in demand made the utilization of fixed input slowdown and significantly decreased production section TFP. Our results showed the non-production section saved a firm's TFP, which is a rational conclusion. As is shown in Table 2, cost share of the non-production section trend has been increasing over time. The trend can be evidence of the importance of the non-production section in a firm. It is consistent with economic theory, in the sense that, more resources are allocated to a section with higher productivity.

The main focus of this paper is to calculate the TFP growth rate of a non-production section and to illustrate the contribution of that section to the firm's total TFP. Traditional factors explaining TFP movement, such as technical change, scale economy, utilization of fixed input, etc., can hardly be applied to a non-production section. Since a non-production section also includes the firm's upper management, the white-collar section should not be singled out as the sole element contributing to TFP from the non-production section.

There are several considerations left to be analyzed. One possible criticism might be raised concerning our methodology in deriving non-production section TFP by "getting another residual from two residuals." To this criticism we could pursue more precise consistency among the model, data sources, and data processing. Another important point may be a more detatiled examination regarding non-production section TFP.

This paper shows that the popular view that the non-production section is responsible for a firm's low productivity is without foundation. In fact, the TFP results show that the non-production section may have moderated the overall decline in productivity. These results should not imply that the production section should have made more of an effort during the entire observation period. An additional consideration to be analyzed as regards a firm's overall performance is the impact of the firm's top management actions.

Top management actions have an impact on both the white-collar and the blue-collar contributions to the firm's TFP and should be the source of further study. However, the present view that the non-production sections of firms are the source of the existing state of Japan's economic recession is a view without evidence. In the interest of broader analysis, more observations from other industries and over other periods are recommended.

Appendix

Proof of Theorem 1

Here we show a sufficient condition for (7) to be equal to (8), which means

$$(15) \qquad (S_{pi}W_p + S_{ni}W_n)W_{pi} = \alpha S_{pi},$$

$$(16) \qquad (S_{pi}W_p + S_{ni}W_n)W_{ni} = (1-\alpha)S_{ni}.$$

hold for all i. Rewriting the two equations above into linear equations in terms of S_{pi} and S_{ni}, we get

$$(17) \qquad (\alpha - W_pW_{pi})S_{pi} - W_nW_{pi}S_{ni} = 0,$$

$$(18) \qquad W_pW_{ni}S_{pi} - (1-\alpha - W_nW_{ni})S_{ni} = 0.$$

Therefore, above two equations are held for all: if and only if

$$(19) \qquad (\alpha - W_pW_{pi})S_{pi} = W_nW_{pi}S_{ni}, \quad \forall i$$

and

$$(20) \qquad \frac{W_nW_{pi}}{\alpha - W_pW_{pi}} = \frac{1-\alpha-W_nW_{ni}}{W_pW_{ni}}. \quad \forall i$$

To simplify them, (19) and (20) are written as follows.

$$(21) \qquad \alpha = W_p$$

and

$$(22) \qquad (\alpha - W_p)(\alpha - W_{pi}) = 0.$$

If $\alpha = W_{pi}$ holds for all i, $\alpha = W_p$ also holds. Therefore,

$$(23) \qquad \alpha = W_p$$

is a sufficient condition to be proven.

Proof of Theorem 2

Substituting (1) and (2) to (3), we get

$$(24) \qquad Y = [F_p(\boldsymbol{X}_p)]^{\alpha}\,[F_n(\boldsymbol{X}_n)]^{1-\alpha}.$$

A firm's cost minimization is to minimize $\boldsymbol{P}^T\boldsymbol{X}_p + \boldsymbol{P}^T\boldsymbol{X}_n$ at given Y. The necessary condition is

$$(25) \qquad P_i = \lambda\alpha\,[F_p(\boldsymbol{X}_p)]^{\alpha-1}\,[F_n(\boldsymbol{X}_n)]^{1-\alpha}\,\frac{\partial F_p}{\partial X_{pi}},$$

$$(26) \qquad P_i = \lambda(1-\alpha)\,[F_p(\boldsymbol{X}_p)]^{\alpha}\,[F_n(\boldsymbol{X}_n)]^{-\alpha}\,\frac{\partial F_n}{\partial X_{ni}},$$

where λ is a lagrange multiplier. Mutiplying X_{pi} and X_{ni} on both sides of (25) and (26) respectively and taking a summation, we get

$$\frac{C_p}{C_n} = \frac{\alpha}{1-\alpha} \frac{\sum_i \partial F_p / \partial X_{pi} \cdot X_{pi}/M}{\sum_i \partial F_n / \partial X_{ni} \cdot X_{ni}/V}. \quad (27)$$

It is obvious if both F_p and F_n are homogeneous of degree η,

$$\frac{C_p}{C_n} = \frac{\alpha}{1-\alpha} \quad (28)$$

holds.

References

[1] Abe,K. and K.Kurosawa(1993), "Contribution of Knowledge Intensive Staff Members (KIS) to Reduction of the Unit Labor Requirement — Japanese and U.S.Manufacturing Industries "*Productivity & Quality Management Frontiers-IV* Vol.1 pp.187–196

[2] Basu, S.(1996), "Procyclical Productivity: Increasing Returns or Cyclical Utilization?" *The Quarterly Journal of Economics*, Vol.3, No.3, pp.719–751.

[3] Caves, D., L. Christensen and M. Tretheway(1983), "Productivity Performance of U.S. Trunk and Local Service Airlines in the Era of Deregulation," *Economic Inquiry*, Vol.21, No.3, pp.312–324.

[4] Diewert, W.E.(1976), "Exact and Superlative Index Numbers," *Journal of Econometrics*, Vol.4, No.2, pp.115–145.

[5] Enkawa, T. and K. Ito(1996), "White-collar Productivity and Policy for Aging," *Rodo Jiho* No.579, pp.16–19.

[6] Good,D., I. Nadiri, L. H. Roeller and R.C. Sickles(1993), "Efficiency and Productivity Growth Comparisons of European and U.S/ Air Carriers: A First Look at the Data," *Journal of Productivity Analysis* 4, special issue, J.Mairesse and Z. Griliches, eds, pp.115–125.

[7] Greene, W.H.(1997), *Econometric Analysis*, Third Edition, Prentice Hall.

[8] Japan Institution of Labor(1995), *Integrated Research on White-collar Job and Productivity.*

[9] Ministry of Labor(1994), "Report on White-collar Productivity," *Romu Kenkyu*, Vol.47 No.11, pp.22-32.

[10] MITI(1998), *White Paper of International Trade and Industry: 1998 Edition.*

[11] Nishimura, K.(1998a) "The Japanese Economy from Viewpoint of Micro-structure," *Nihon-Keizai-Shimbun*, June 19 to 23 in 1998.

[12] Nishimura, K.(1998b) "Productivity of Maphia, Productivity of a Firm," *Economist*, April 14, pp.92–93.

[13] Park, Seung–Rok and J.K. Kwon(1995), "Rapid Economic Growth with Increasing Returns to Scale and Little or No Productivity Growth," *The Review of Economics and Statistics*, Vol.77, No.2, pp.332–351.

[14] Productivity Research Institute(1994), *An Investigation Report on White-collar Productivity.*

[15] Productivity Research Institute(1995), *Towards the Rise in White-collar Productivity.*

[16] Takahashi, Y. eds.(1995) *White-collar Job in Japan*, Ochanomizu Press.

[17] Yamagami, T.(1995), "Cutting down white-collar job does not lead to the rise in productivity," *Economist*, January 31, pp.70–73.

[18] Nakajima, T., M. Nakamura, and K. Yoshioka(1998), "An Index Number Method for Estimating Scale Economies and Technical Progress Using Time-Series of Cross-section Data: Sources of Total Factor Productivity Growth for Japanese Manufacturing, 1964–1988," *The Japanese Economic Review*, Vol.49, No.3, September pp.310–334.

Table 1: Sample Firms

	< Heavy Electric Equipment >	
Shinko Electric	Nissin Electric	Yaskawa Electric
Meidensha	Origin Electric	Fuji Electric
KOA	Omron	Takaoka Electric MFG
Hokuriku Electric Industry	Shibaura Engineering Works	Nippon Electric Industry
	< Electronic and Communication Equipment >	
Toshiba	Mitsubishi Electric	Hitachi
Horiba	Advantest	Chino
Yokogawa Electric	Nichicon	Fujitsu
Oki Electric Industry	NEC	Fanuc
Nitsuko	Toyo Communication Equipment	Ohkura Electric
Anritsu	Tamura Electric Works	Hitachi Electronics
Iwatsu Electric	Kokusai Electric	Japan Radio
Nohmi Bosai	Sanken Electric	Rohm
Tokin	Kinseki	Nippon Chemi-Con
Teikoku Tsushin Kogyo	Japan Aviation Electronics Industry	JEOL
Tamura	FDK	Alps Electric
Sumitomo Special Metals	Nitto Denko	Hosiden
Kyocera		
	< Other Light Electric Equipment >	
The Furukawa Battery	Ushio	Hitachi Maxell
Sharp	Shinko Electric Industries	Shin-kobe Electric Machinery

The underlined companies are chosen as a Big Six

Table 2: Cost Share of Production Section, W_p

	All Samples	HEE	ECE	OLEE	Big Six	Ohter 49
85	0.684	0.674	0.691	0.623	0.679	0.699
86	0.680	0.655	0.688	0.620	0.675	0.696
87	0.668	0.662	0.675	0.586	0.660	0.692
88	0.666	0.672	0.673	0.575	0.655	0.697
89	0.666	0.660	0.674	0.566	0.656	0.692
90	0.664	0.663	0.673	0.556	0.654	0.690
91	0.665	0.674	0.673	0.553	0.654	0.696
92	0.652	0.649	0.661	0.542	0.643	0.678
93	0.645	0.649	0.654	0.532	0.634	0.678

Table 3: Decomposition of a Representative Firm's Output Growth

		All Samples	HEE	ECE	OLEE	Big Six	Other 49
Growth Rate(%)							
Production Section (M)	85-88	4.68	0.04	6.51	2.63	9.26	4.11
	88-91	5.78	6.76	5.04	8.42	6.19	5.73
	91-93	-6.01	-0.44	-8.86	0.43	-6.46	-5.96
	85-93	2.42	2.44	2.12	4.25	4.18	2.20
Non-production Section (V)	85-88	12.35	21.36	10.53	4.98	7.81	13.47
	88-91	5.95	9.22	5.99	1.37	8.14	5.65
	91-93	1.75	-10.76	8.22	-7.93	8.03	1.56
	85-93	7.30	8.78	8.25	0.40	7.99	7.56
The whole firm (Y)	85-88	7.16	7.18	7.76	3.38	8.73	6.96
	88-91	5.84	7.60	5.35	5.39	6.87	5.72
	91-93	-3.35	-3.92	-3.16	-3.41	-1.34	-3.60
	85-93	4.04	4.56	4.13	2.44	5.51	3.86
Contribution(%point)							
Production Section (M)	85-88	3.11	0.02	4.40	1.40	6.13	2.85
	88-91	3.85	4.50	3.39	4.76	4.06	3.98
	91-93	-3.95	-0.28	-5.90	0.22	-4.18	-4.09
	85-93	1.62	1.62	1.45	2.36	2.78	1.54
Non-production Section (V)	85-88	4.04	7.16	3.36	1.98	2.60	4.11
	88-91	2.00	3.10	1.96	0.63	2.81	1.74
	91-93	0.60	-3.64	2.75	-3.63	2.84	0.49
	85-93	2.41	2.94	2.68	0.07	2.74	2.32

Table 4: Decomposition of a Representative Firm's TFP Growth

		All Samples	HEE	ECE	OLEE	Big Six	Other 49
			Growth Rate(%)				
Production Section (*PTFP*)	85-88	-3.07	-2.64	-3.15	-3.58	-2.02	-3.20
	88-91	-0.62	0.59	-1.20	0.90	-0.22	-0.68
	91-93	-5.58	-4.30	-6.32	-3.74	-7.12	-5.86
	85-93	-2.78	-1.84	-3.21	-1.94	-2.62	-2.92
Non-production Section (*NTFP*)	85-88	0.55	2.84	0.41	-4.05	6.81	-1.08
	88-91	4.81	2.66	5.78	4.92	5.06	7.73
	91-93	5.57	-2.72	9.36	-5.06	8.73	3.50
	85-93	3.40	1.38	4.66	-0.94	6.63	3.37
The whole firm (*FTFP*)	85-88	-1.89	-0.81	-2.01	-3.75	0.94	-2.56
	88-91	1.20	1.30	1.08	2.68	1.60	1.90
	91-93	-1.75	-3.77	-1.07	-4.36	-1.51	-2.93
	85-93	-0.70	-0.76	-0.62	-1.49	0.57	-0.98
			Contribution(%point)				
Production Section (*PTFP*)	85-88	-2.09	-1.75	-2.17	-2.23	-1.37	-2.23
	88-91	-0.41	0.39	-0.81	0.51	-0.15	-0.47
	91-93	-3.65	-2.81	-4.20	-2.04	-4.59	-4.01
	85-93	-1.85	-1.21	-2.17	-1.16	-1.71	-2.02
Non-production Section (*NTFP*)	85-88	0.21	0.94	0.16	-1.52	2.30	-0.33
	88-91	1.61	0.91	1.89	2.17	1.74	2.38
	91-93	1.90	-0.96	3.13	-2.33	3.09	1.08
	85-93	1.16	0.45	1.55	-0.34	2.29	1.04

Table 5: Estimation Results of (13): PTFP

Dependent Variable: Growth rate of PTFP						
Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant term	-0.039[a]	-0.047[a]	-0.038[a]	-0.041[a]	-0.046[a]	-0.041[a]
	(-13.486)	(-5.627)	(-12.643)	(-15.978)	(-6.344)	(-15.309)
Dummy variables						
HEE		0.023[b]			0.017[c]	
		(2.269)			(1.767)	
ECE		0.005			0.003	
		(0.548)			(0.432)	
Big Six			-0.003			-0.003
			(-0.264)			(-0.326)
Growth rate of *M*	0.360[a]	0.536[a]	0.361[a]	0.356[a]	0.523[a]	0.356[a]
	(31.153)	(16.333)	(30.905)	(33.631)	(16.576)	(33.294)
Dummy variables						
HEE		-0.297[a]			-0.283[a]	
		(-5.953)			(-5.937)	
ECE		-0.188[a]			-0.173[a]	
		(-5.350)			(-5.162)	
Big Six			-0.014			0.011
			(-0.152)			(0.136)
Log likelihood	806.752	828.217	806.861	831.124	844.686	831.158
Estimation Method	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS
AR(1) coefficient	common	common	common	firm specific	firm specific	firm specific
No. of observations	440	440	440	440	440	440
No. of firms	55	55	55	55	55	55
No. of time periods	8	8	8	8	8	8

Notes 1) For regression equation, see the text.
2) Estimation method is FGLS(Feasible Generalized Least Squares).
3) Suffix a, b, and c show siginificant level of 1%, 5%, 10% respectively. The number in parenthesis stands for t-value.

Table 6: Estimation Results of (13): NTFP

Dependent Variable: Growth rate of NTFP

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant term	0.013	0.054	0.010	0.022	0.059	0.020
	(0.705)	(0.924)	(0.500)	(1.399)	(1.032)	(1.215)
Dummy variables						
HEE		-0.047			-0.031	
		(-0.669)			(-0.465)	
ECE		-0.039			-0.042	
		(-0.632)			(-0.695)	
Big Six			0.023			0.192
			(0.335)			(0.330)
Growth rate of V	0.303[a]	0.562[a]	0.303[a]	0.328[a]	0.562[a]	0.327[a]
	(13.754)	(7.142)	(13.740)	(17.369)	(8.197)	(17.326)
Dummy variables						
HEE		-0.447[a]			-0.301[a]	
		(-4.618)			(-3.622)	
ECE		-0.247[a]			-0.248[a]	
		(-3.000)			(-3.459)	
Big Six			0.076			0.037
			(0.184)			(0.107)
Log likelihood	-8.242	1.685	-8.263	45.994	51.249	46.155
Estimation Method	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS
AR(1) coefficient	common	common	common	firm specific	firm specific	firm specific
No. of observations	440	440	440	440	440	440
No. of firms	55	55	55	55	55	55
No. of time periods	8	8	8	8	8	8

Notes 1) For regression equation, see the text.
2) Estimation method is FGLS(Feasible Generalized Least Squares).
3) Suffix a, b, and c show siginificant level of 1%, 5%, 10% respectively. The number in parenthesis stands for t-value.

Table 7: Utilization Model of PTFP
(14) instead of $\ln M$

Dependent Variable: Growth rate of PTFP

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant term	-0.021[a]	-0.005	-0.020[a]	-0.019[a]	-0.009	-0.018[a]
	(-5.463)	(-0.048)	(-5.059)	(-5.570)	(-1.135)	(-5.361)
Dummy variables						
HEE		-0.006			-0.006	
		(-0.422)			(-0.500)	
ECE		-0.021[c]			-0.014	
		(-1.695)			(-1.579)	
Big Six			-0.003			-0.007
			(-0.269)			(-0.459)
Utilization	0.724[a]	0.787[a]	0.722[a]	0.730[a]	0.759[a]	0.729[a]
	(18.014)	(7.561)	(17.914)	(18.971)	(7.450)	(18.852)
Dummy variables						
HEE		-0.190			-0.153	
		(-0.837)			(-0.698)	
ECE		-0.069			-0.018	
		(-0.609)			(-0.166)	
Big Six			0.242			0.194
			(0.485)			(0.420)
Log likelihood	675.028	678.660	675.290	700.387	694.135	700.603
Estimation Method	FGLS	FGLS	FGLS	FGLS	FGLS	FGLS
AR(1) coefficient	common	common	common	firm specific	firm specific	firm specific
No. of observations	440	440	440	440	440	440
No. of firms	55	55	55	55	55	55
No. of time periods	8	8	8	8	8	8

Notes 1) For regression equation, see the text.
2) Estimation method is FGLS(Feasible Generalized Least Squares).
3) Suffix a, b, and c show siginificant level of 1%, 5%, 10% respectively. The number in parenthesis stands for t-value.

Figure 1: The Model Framework

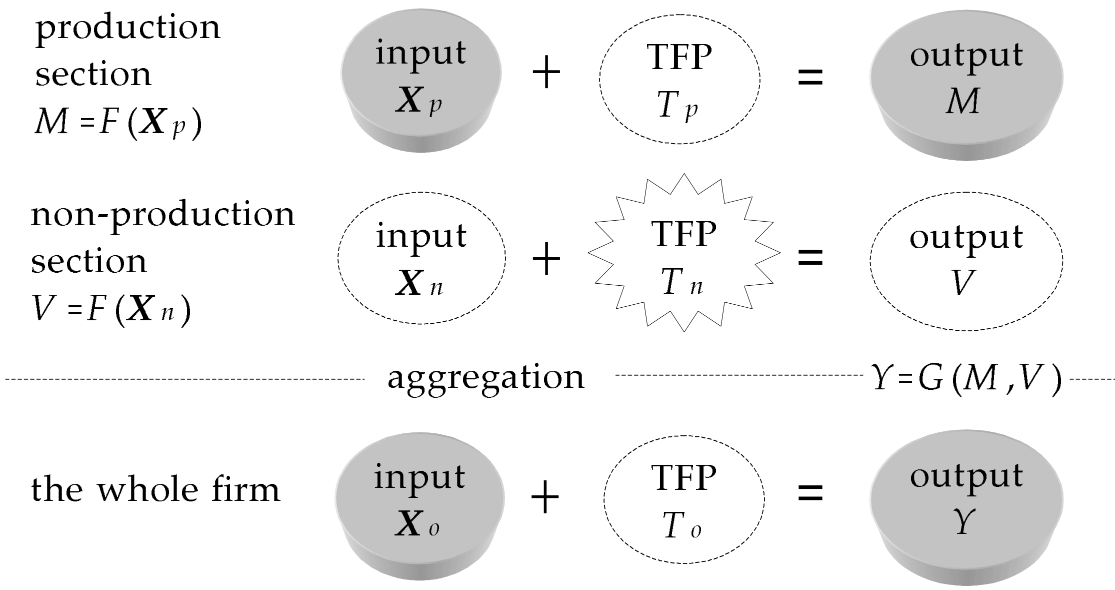

Figure 2: Decomposition of a Representative Firm's TFP Growth
All samples

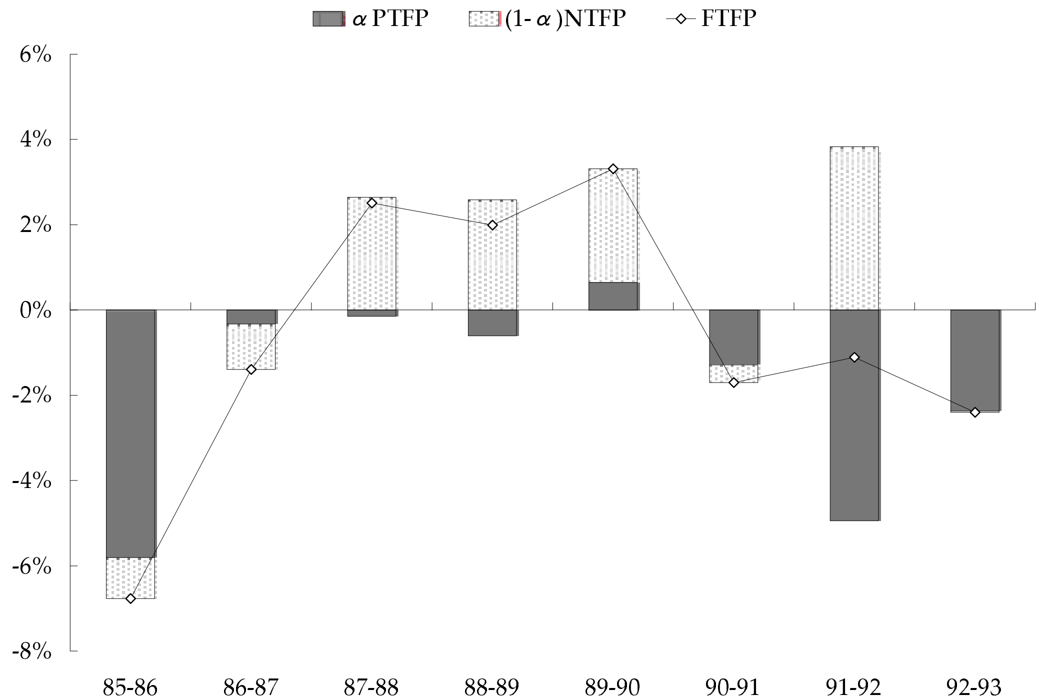

Figure 3: Decomposition of a Representative Firm's TFP Growth
Heavy electric equipment

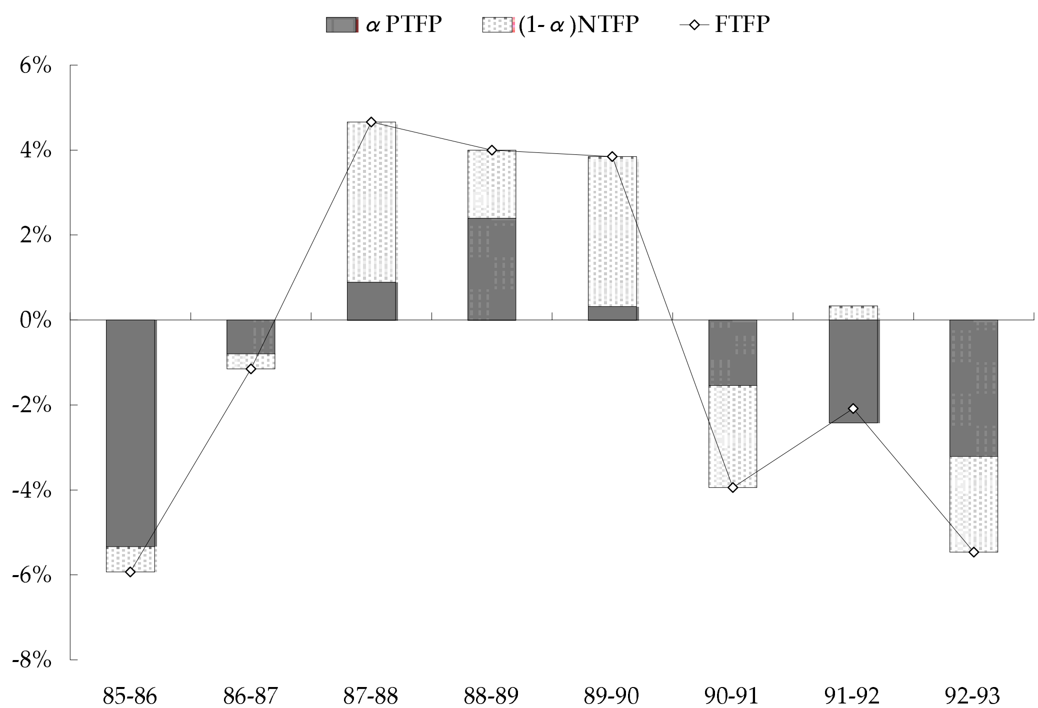

Figure 4: Decomposition of a Representative Firm's TFP Growth
Electronic and communication equipment

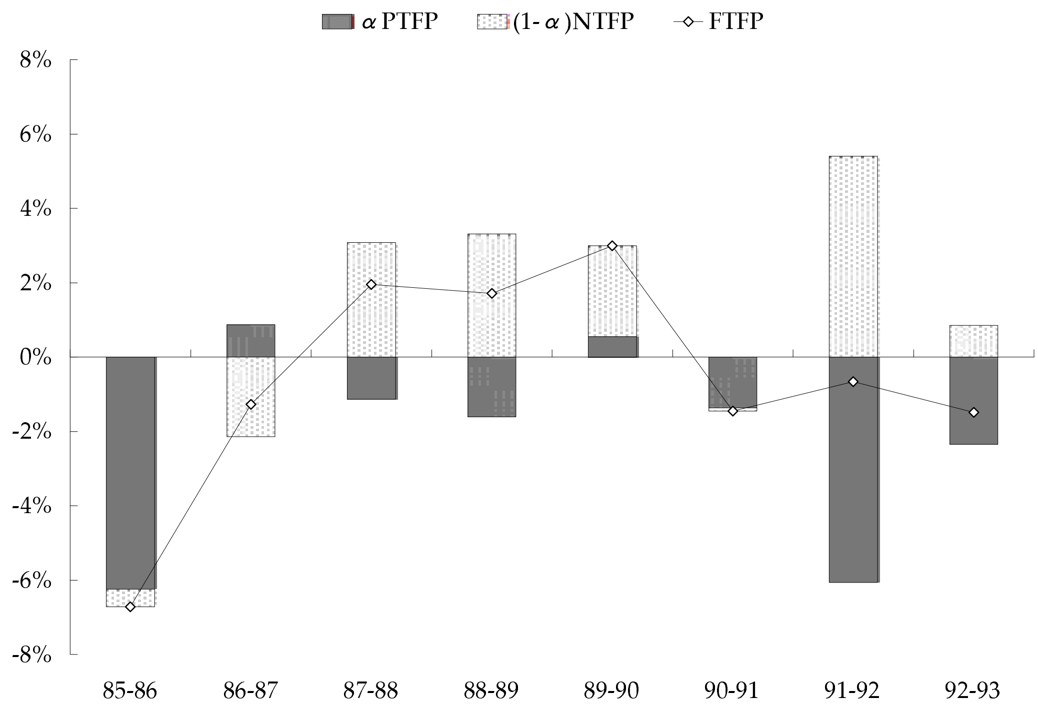

Figure 5: Decomposition of a Representative Firm's TFP Growth
Other light electric equipment

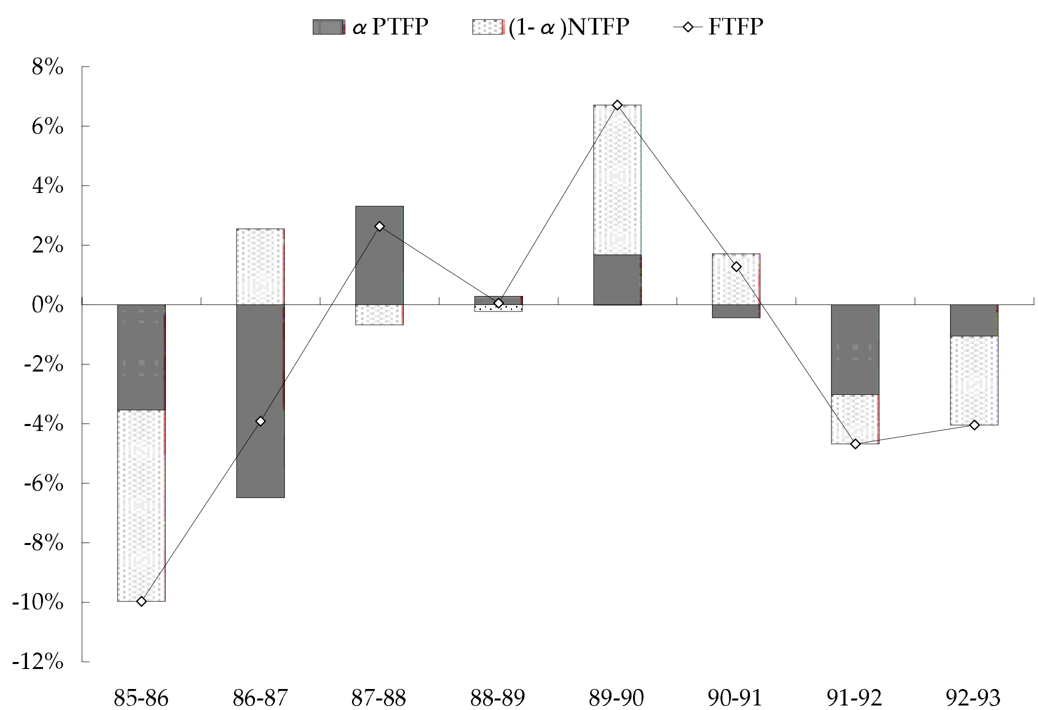

Figure 6: Decomposition of a Representative Firm's TFP Growth
Big Six

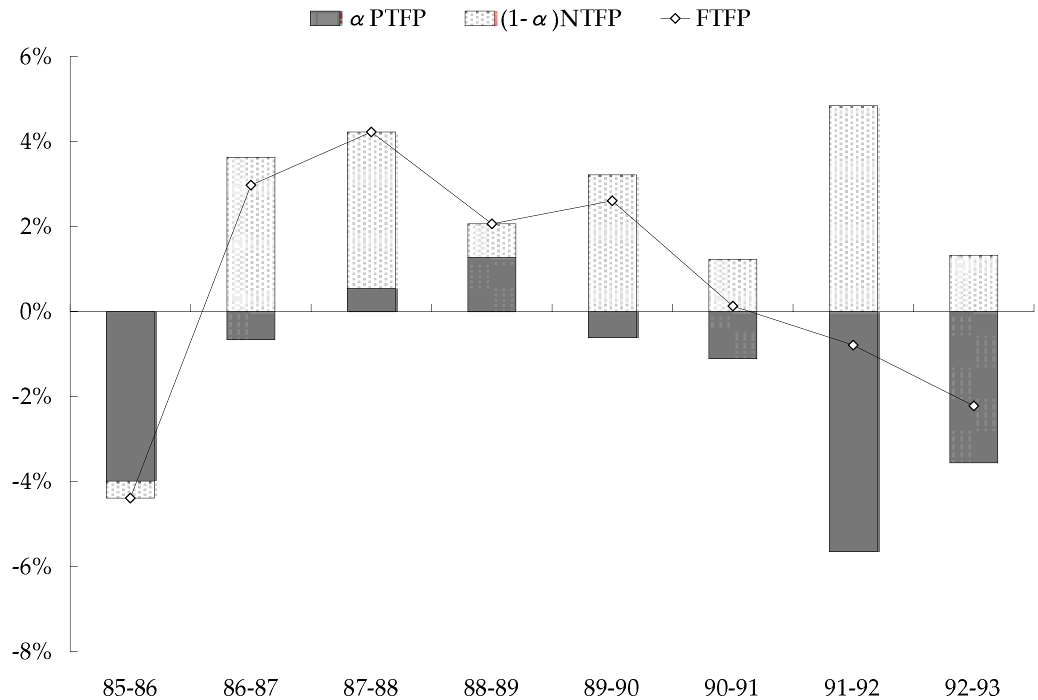

Figure 7: Decomposition of a Representative Firm's TFP Growth
Other 49