What Caused Ups and Downs of Japanese Agricultural Cooperatives? : A TFP Analysis

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1. Introduction

(1) Background of the problem

Agricultural Cooperatives are generally considered as very important organizations for farmers to raise their income and reduce their risk of price fluctuations or damage by disease or bad weather. Japanese agricultural cooperatives (to be abbreviated to JACs, hereafter) have been considered as one of the most successful cooperative sectors in the world. But in fact, they have experienced ups and downs in their history.

The JACs have several characteristics: multipurpose cooperatives that operate plural businesses such as credit, mutual insurance, supply, and marketing business; three-tier structure with local level cooperatives, prefectural level federations, and national federations; regular membership for farmers and semi-regular membership (associate membership) for non-farmers living in rural areas; and close relationship with the central and local governments. These characteristics have been considered to have some concern to the performance of JACs, but there has been almost no quantitative analysis of them.

Several index or ratios have measured the performance of JACs, and labor productivity has been considered as the most important measure[2]. However, labor productivity has some defects and total factor productivity (TFP) is a superior measurement of productivity. But there has been no paper measuring the TFP of JACs at this moment.

(2) Objectives

The main objectives of this paper are 1) to obtain the efficiency measurement of the JACs using total factor productivity (TFP), and 2) to identify the causes of the success and decline of JACs by a decomposition analysis of the TFP. These two objectives must be essential to consider the future of the JACs in the 21st century.

2. Analytical Framework

(1) TFP Measurement

Japanese agricultural cooperatives (JACs) are mostly multipurpose ones. As TFP concerns to aggregation of inputs and outputs, it is quite natural to apply the TFP method to measuring the efficiency of multipurpose agricultural cooperatives in Japan. TFP is defined as a ratio of (aggregate) total output index and (aggregate) total input index.

In this paper, the total input index and the total output index are calculated as log-change type indices. Notations are as follows:

z_1 : labor input
z_2 : capital input
q_1 : real output of the credit business
q_2 : real output of the insurance business
q_3 : real output of the supply business

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[2] The labor productivity of JACs was estimated and discussed in Kawamura (1996).

q_4 : real output of the marketing business
q_5 : real output of the other businesses
w_1 : input price index for labor
w_2 : input price index for capital
p_1 : output price index for the credit business
p_2 : output price index for the insurance business
p_3 : output price index for the supply business
p_4 : output price index for the marketing business
p_5 : output price index for the other businesses
s_i : share of the i-th input cost in the total cost
r_j : share of value-added of the j-th output sector in the total value-added

and subscript t is used to show the time period, if necessary.

Using these notations, the total input index Z_t is calculated as a log-change type index. The input index is:

$$Z_t = Z_0 \prod_{t=0}^{t} \{ \prod_{i=1}^{2} \left({z_{i,t}} / {z_{i,t-1}} \right)^{s_{i,t}} \} \qquad \text{(equation 1)}$$

In this paper, the input weights s_1 , s_2 are defined as :

$$s_{i,t} = \frac{\left[\left(w_{i,t-1} \Big/ \sum_k w_{k,t-1} \ z_{k,t-1} \right) + \left(w_{i,t} \Big/ \sum_k w_{k,t} \ z_{k,t} \right) \right]}{2} \qquad \text{(equation 2)}$$

Then, this total input index Z becomes the Tornqvist index of the input, that is classified in a log-change type chain index, and also a discrete approximation of Divisia index.[3]

The annual growth of Z at the period t is:

$$Z_t \Big/ Z_{t-1} = \exp \left[\sum_{i=1}^{2} s_{i,t} \ \log(z_{i,t} \big/ z_{i,t-1}) \right] \qquad \text{(equation 3)}$$

And the annual growth rate can be calculated as:

$$G(Z_t) = Z_t \Big/ Z_{t-1} - 1$$

Defining the index number of the base year as unity:

$$Z_0 = 1.0$$

and link the index according to the equation 3 to obtain the total output index number of each year, Z_t .

The total output index Q is defined as the same manner as the total input index Z. The total output index Q_t is defined as:

$$Q_t = Q_0 \prod_{t=0}^{t} \{ \prod_{j=1}^{5} \left(q_{j,t} \big/ q_{j,t-1} \right)^{r_{j,t}} \} \qquad \text{(equation 4)}$$

And the output share $r_{j,t}$ is defined as:

3 See Allen (1975), Oniki *et.al.* (1993) and Tokoyama (1979).

$$r_{j,t} = \frac{\left[\left(q_{j,t-1} \Big/ \sum_l p_{l,t-1}\ q_{l,t-1} \right) + \left(q_{j,t} \Big/ \sum_l p_{l,t}\ q_{l,t} \right)\right]}{2}$$

and that makes a Tornqvist index.
The annual growth of the year t is:

$$Q_t \big/ Q_{t-1} = \exp\left[\sum_{j=1}^{5} r_{j,t}\ \log(q_{j,t} \big/ q_{j,t-1}) \right] \qquad \text{(equation 5)}$$

And annual growth rate is:

$$G(Q_t) = Q_t \big/ Q_{t-1} - 1 \qquad \text{(equation 6)}$$

Setting the index number of the base year as unity,

$$Q_0 = 1.0$$

and linking the annual growth (equation 5) gives the annual index number of the total output index.

The TFP index is defined as the ratio of the two total indices. That is:

$$TFP_t = Q_t \big/ Z_t \qquad \text{(equation 7)}$$

And the annual growth rate *G(TFP)* can be calculated as:

$$G(TFP_t) = G(Q_t) - G(Z_t) \qquad \text{(equation 8)}$$

The TFP index will be presented in a graph and the average growth rate will be presented in some tables in this paper.

(2) TFP Decomposition

The TFP growth is decomposed to several factors using elasticities of the cost function[4].

Assuming the cost minimization behavior of JACs, the total cost function is defined as:

$$TC = g\left(q_1,\ \ldots\ q_m,\ w_1,\ \ldots\ w_n,\ T_1,\ \ldots\ T_k,\ D_1,\ \ldots\ D_l\right) \qquad \text{(equation 9)}$$

where TC is the total cost, T_k represents a technical level, and D_l represents a time dummy of a specific time period or some other exogenous variables.

Differentiating the equation 9 by time,

$$\frac{\partial TC}{\partial t} = \sum \frac{\partial g}{\partial q_j}\frac{\partial q_j}{\partial t} + \sum \frac{\partial g}{\partial w_i}\frac{\partial w_i}{\partial t} + \sum \frac{\partial g}{\partial T_k}\frac{\partial T_k}{\partial t} + \sum \frac{\partial g}{\partial D_l}\frac{\partial D_l}{\partial t} \qquad \text{(equation 10)}$$

The first term of the equation 10 can be transformed as:

$$\sum \frac{\partial g}{\partial \ln g}\frac{\partial \ln g}{\partial \ln q_j}\frac{\partial \ln q_j}{\partial q_j}\frac{\partial q_j}{\partial t}$$

$$= \sum TC\ \frac{\partial \ln g}{\partial \ln q_j}\ \frac{1}{q_j}\ \frac{\partial q_j}{\partial t}$$

$$= \sum TC\ \frac{\partial \ln g}{\partial \ln q_j}\ G(q_j)$$

where *G( )* represents an operator of annual growth rate.

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[4] Oniki *et. al*. (1993) is the main source of the idea of the decomposition analysis in this section.

Using the Shephard's lemma, the second term of the equation 10 is:

$$\sum z_i \frac{\partial w_i}{\partial t}$$

$$= \sum w_i z_i \frac{\frac{\partial w_i}{\partial t}}{w_i}$$

$$= \sum w_i z_i \quad G(w_i)$$

The third and the fourth terms can be transformed as the same manner, and we obtain the following equation:

$$\frac{\partial TC}{\partial t} = \sum TC \frac{\partial \ln g}{\partial \ln q_j} G(q_i) + \sum w_i z_i \, G(w_i) + \sum TC \frac{\partial \ln g}{\partial \ln T_k} G(T_k) + \sum TC \frac{\partial \ln g}{\partial \ln D_l} G(D_l)$$

Dividing both sides by TC gives:

$$G(TC) = \sum \frac{\partial \ln g}{\partial \ln q_j} G(q_j) + \sum \frac{w_i z_i}{TC} G(w_i) + \sum \frac{\partial \ln g}{\partial \ln T_k} G(T_k) + \sum \frac{\partial \ln g}{\partial \ln D_l} G(D_l)$$

Defining the elasticities of the each variables of the total cost function as:

$$e_{q_j} = \frac{\partial \ln g}{\partial \ln q_j}$$

$$e_{T_k} = \frac{\partial \ln g}{\partial \ln T_k}$$

$$e_{D_l} = \frac{\partial \ln g}{\partial \ln D_l}$$

The growth rate of the total cost can be decomposed as:

$$G(TC) = \sum e_{q_j} G(q_j) + \sum \frac{w_i z_i}{TC} G(w_i) + \sum e_{T_k} G(T_k) + \sum e_{D_l} G(D_l) \quad \text{(equation 11)}$$

As $TC = \sum w_i z_i$, differentiation of TC by time gives:

$$G(TC) = \sum \frac{w_i z_i}{TC} G(w_i) + \sum \frac{w_i z_i}{TC} G(z_i) \qquad \text{(equation 12)}$$

Using the equation 11 and 12,

$$\sum \frac{w_i z_i}{TC} G(z_i) = \sum e_{q_j} G(q_j) + \sum e_{T_k} G(T_k) + \sum e_{D_l} G(D_l)$$

(equation 13)

And according to the equation 3, the growth rate of the total input index is:

$$G(Z_t) = \sum s_{i,t} G(z_{i,t})$$

And substituting the ($w_i z_i$/TC) in the left side of the equation 13 of the cost share s_i gives the equation:

$$G(Z_t) = \sum e_{q_j} G(q_j) + \sum e_{T_k} G(T_k) + \sum e_{D_l} G(D_l) \quad \text{(equation 14)}$$

Combining the equation 14, and the equation 7 and 8, the growth rate of the TFP is:

$$G(TFP) = G(Q) - \left(\sum e_{q_j} G(q_j) + \sum e_{T_k} G(T_k) + \sum e_{D_l} G(D_l)\right)$$

As $G(Q) = \sum r_j G(q_j)$, the growth rate of the TFP can be shown as:

$$G(TFP) = \sum r_j G(q_j) - \left(\sum e_{q_j} \ G(q_j) \ + \sum e_{T_k} \ G(T_k) + \sum e_{D_l} G(D_l)\right)$$
$$= \sum r_j \ G(q_j) \ - \ \sum e_{q_j} \ G(q_j) \ - \ \sum e_{T_k} \ G(T_k) \ - \ \sum e_{D_l} G(D_l)$$
$$= \sum \left(r_j - e_{q_j}\right) G(q_j) \ - \ \sum e_{T_k} \ G(T_k) \ - \ \sum e_{D_l} G(D_l) \qquad \text{(equation 15)}$$

The equation 15 is the decomposition equation of the TFP of the JACs. Theoretically, the changes in TFP can be decomposed into each term of the equation 15. But practically, there remains a residual that reflects the errors or factors that are not included in the cost function. For that reason, the decomposition equation in the empirical analysis is calculated as:

$$G(TFP) = \sum \left(r_j - e_{q_j}\right) G(q_j) \ - \ \sum e_{T_k} \ G(T_k) \ - \ \sum e_{D_l} G(D_l) \ + R \qquad \text{(equation 16)}$$

where R represents the residual.

And in a single output case, the equation is:

$$G(TFP) = \left(1 - e_Q\right) G(Q) \ - \ \sum e_{T_k} \ G(T_k) \ - \ \sum e_{D_l} G(D_l) \ + R \qquad \text{(equation 17)}$$

In the latter pat of this paper, the equation 17 will be utilized to decompose the TFP.

The first term of the equation 16 or 17 represents the TFP growth due to the scale economy and can be called the output effect.

The second term represents the effects due to the technical progress. In empirical analysis, a time trend variable is often utilized and in that case, this term represents the rate of the technical growth.

The third term represents the specific exogenous factors and the rate of the specific technical growth at the specific time period.

The last term represents the residual that may include the effects due to the unconventional inputs or due to the neglected factors and errors.

(3) Data

Most of the data source used in this analysis is "The Statistics Tables of Multipurpose Agricultural Cooperatives" by MAFF in Japan. As this statistics represents all the active JACs, this statistics is the most suitable data source for this study. However, there are some deficiencies to use the data for TFP analysis. For that reason, the output of each business sector q_{it} is defined as gross revenue minus direct cost (excluding the labor and capital cost) in this paper. And the total cost TC is defined as the indirect cost that consists of labor and capital costs, mainly.

As for the prices, “The Statistical Survey of Prices in Rural Areas” by MAFF in Japan is used mainly. But for the price of credit and insurance business, and other businesses, the GDP deflator is utilized.

The estimation period is from 1966 to 1996. It includes the period of the rapid economic growth (1966-1973) and the period of the financial liberalization (1990-1996). During the rapid economic growth period, the Japanese government operated a series of agricultural protection policy that might affect to the profitability of JACs as well as farmers. And financial liberalization might bring a severe competition to the JACs’ credit business and it might be an adverse effect to the JACs.

4. Results and Discussion

(1) TFP Measurement

Figure 1 shows the TFP index, and Table 1 shows the average annual growth rate of the TFP. They show that JACs grew very rapidly by 8.83% annually in 1960's, when Japanese economy was growing very rapidly. But after that, their growth rate declined to 4% annually or smaller. In 90's, the total output index shows negative growth and the TFP growth rate has been very low.

JACs have been considered as a successful case of cooperative movements. But this research shows the fact that the growth rate of TFP of JACs has been declining and almost no growth in 1990's.

(2) Decomposition of the Growth in TFP

The cost function of the JACs is estimated according to the following procedure. The cost function of this empirical study includes several exogenous variables. Time trend variable T is used as a proxy of technical level. And time period dummy for the rapid economic growth (DG; DG=1.0 for t=1966 to 1973, otherwise DG=0.0) and that for the financial liberalization (DF; DF=1.0 for t=1990 to 1996, otherwise DF=0.0) are also used. The sifters are semi-regular membership ratio (SM = semi-regular membership / total membership), loan-deposit ratio (LD), merger index (MG) that is the inverse of the number of the JACs, and dummy for the year with bad weather (DR; DR=1.0 for t=1980, 81, 93, otherwise DR=0.0). The SM corresponds to the urbanization of the rural area where JACs locate. And LD corresponds to the financial position of JACs as well as member farmers. And MG represents the situation of merger of JACs; larger MG means smaller number of JACs due to merger of JACs. The number of JACs is decreasing in the estimation period. In the estimation, a lagged variable *MG(-1)* is used to capture the merger effect correctly. These variables might affect the productivity of the JACs.

A translog specification for prices and outputs is used as the functional form of the cost function. And several log-linear terms of dummies and shifters are added as independent variables. And finally, the functional form of the cost function is determined as:

$$\begin{aligned}\ln TC = {} & A0 + A1 * \ln Q + AL * \ln w_l + AK * \ln w_k \\ & + \frac{1}{2}\left(B11 * (\ln Q)^2 + BLL * (\ln w_l)^2 + BKK * (\ln w_k)^2\right) \\ & + BL * \ln w_l * \ln w_k + B1L * \ln Q * \ln w_l + B1K * \ln Q * \ln w_k \\ & + CT * TIME + CSM * \ln SM + CLD * \ln LD + CMG * \ln MG(-1) \\ & + DTG * DG + DTF * DF + DDR * DR\end{aligned}$$

As this cost function does not use outputs of each sector explicitly, the equation 17 is used as the decomposition equation. And in this study, the TFP growth has been decomposed to eight factors: output effect; technical progress; urbanization, which corresponds to the increase of the semi-regular (associate) membership; loan-deposit ratio; merger of JACs; rapid economic growth; financial liberalization; and effect of bad weather.

In estimation of the cost function, the symmetry condition, the homogeneity condition and the additivity condition are posed. And parameters are estimated by seemingly unrelated regression (SUR) of the cost function and the labor cost share equation[5].

The estimated parameters of the cost function are shown in Table 2. The estimated cost share equation suggests some estimation problems to be improved. But the estimated cost function shows high R-squared and favorable D.W. statistics. And many of the estimated parameters are significant enough to decompose the TFP by using those estimates.

The decomposition analysis has been conducted using the empirical version of the equation 17. The result of the decomposition analysis is presented in Table 3. In each column of the Table 3, average annual growth rate of the TFP and its decompositions are presented for the period of rapid economic growth (1967-1973), the period of moderate economic growth (1973-1990), the period of the financial deregulation (1990-1996) and the whole estimation period

[5] Kawamura (1991) explained the procedure to estimate a cost function of JACs.

(1967-1996), respectively.

The results for the whole estimation period are presented in the last column. The average growth rate during the estimation period as a whole was 2.30% annually, and the sum of the decomposed effects was 2.02%. The residual in this decomposition analysis was 0.28%. This residual is sufficiently small and that means the decomposition analysis conducted in this study is quite successful. According to the decomposition results, major sources of the TFP growth were 1) urbanization; 2) merger of the agricultural cooperatives; and 3) technical progress. And output growth and deregulation in financial sector gave an adverse effect to the TFP growth.

In the time period of rapid economic growth, the average annual rate of the technical progress was 3.67% (=2.25% + 1.42%), and this technical progress was the main source of the TFP growth at that time. The rapid economic growth gave a favorable effect to the efficiency of JACs.

Urbanization helped JAC's credit business mainly. Urbanization caused escalation in land prices, and farmers gained huge amount of money by selling their field to developers, and that was deposited in JACs. They collected deposits at low cost for a long time. And it had been enhanced by the regulation and protection policies for JACs. The Ministry of Finance and the Bank of Japan had regulated the Japanese financial industry. The regulation was favorable to the smaller financial institutions such as JACs. So, JACs had to face difficult situations under the deregulation of the financial sector.

In the period of financial deregulation (1990-1996), the main source of the TFP growth has been the effect of the merger that counts 4.39%. The JACs have been struggling to survive under the severe stress of the financial deregulation. And they are promoting merger of local agricultural cooperatives as well as federations. In 1965, there were more than 9,000 multipurpose agricultural cooperatives in Japan, and that number has decreased to 3,600 in 1990, and it is 1,400 now (in 2000). The results of the decomposition analysis suggest that their merger strategy has been effective to improve the efficiency of the JACs.

5. Concluding remarks

In this paper, the author estimated the TFP of Japanese agricultural cooperatives (JACs) and decomposed the TFP change into the effects of several factors. Firstly, the method of the TFP estimation was summarized. And the TFP index was derived as a discrete approximate of the Divisia index. Secondly, a cost function of JACs was estimated and some elasticities were derived from the estimated parameters. And finally, the TFP was decomposed into several factors.

The most important fact shown in Figure 1 must be the stagnant trend of the TFP in recent years, which shows a clear contrast to the steady growth in the period of the rapid economic growth.

And from the decomposition analysis, the main source of the TFP growth during the rapid economic growth in Japan seemed to be the technical progress. And merger strategy has been playing an important role to improve the productivity under the pressure of the financial deregulation in 1990s.

The success story of JACs was partly due to the growth of the overall Japanese economy, and protection policies and regulations. JACs should reconsider their success story and they must have a clear vision for the future.

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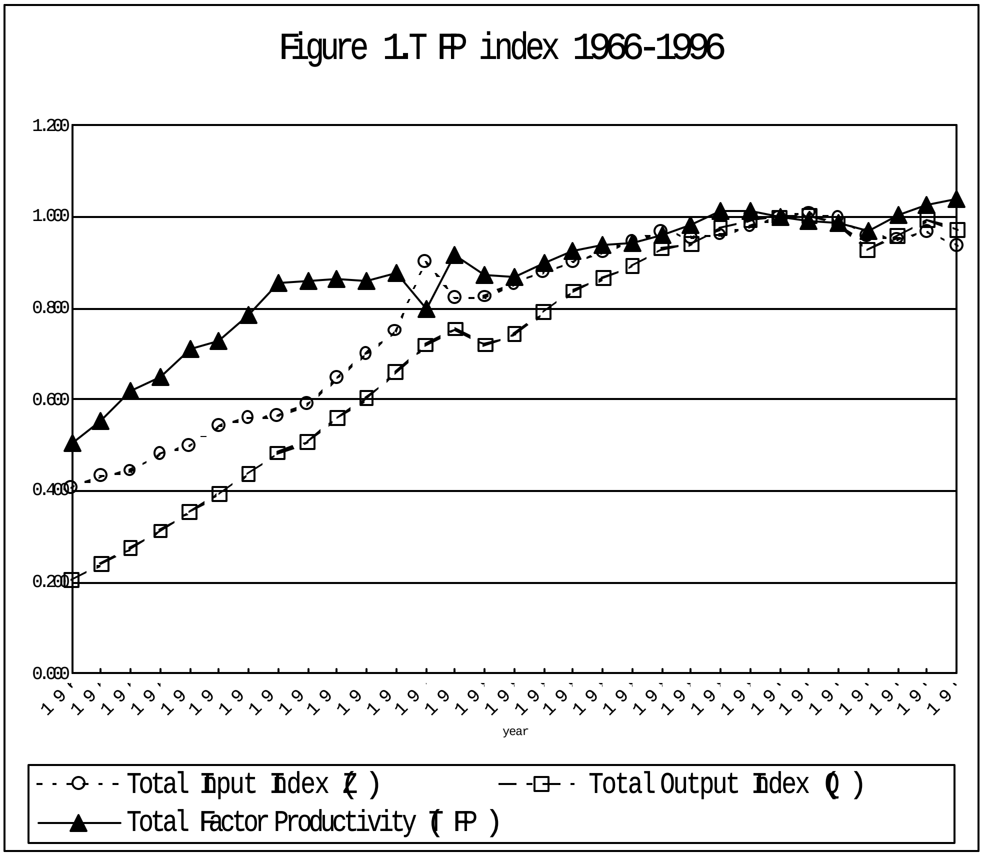

Table 1. Average Annual Growth Rate of TFP (Unit: %)

Year	Total Input Index	Total Output Index	TFP
1966-1970	5.13	14.42	8.83
1970-1975	5.42	9.60	3.96
1975-1980	4.92	5.15	0.22
1980-1985	2.81	4.40	1.55
1985-1990	1.09	2.27	1.17
1990-1996	-1.09	-0.46	0.64
1966-1996	2.81	5.30	2.42

Table 2. Estimated Cost Function

parameter	estimate	std. error	t-statistics
A0	13.191	0.206	63.891
A1	1.423	0.226	6.306
AL	0.735	0.004	205.231
AK	0.265		
B11	0.104	0.192	0.539
BLL	-0.064		
BKK	-0.064		
BLK	0.064	0.040	1.625
B1L	0.035	0.017	2.076
B1K	-0.035		
CT	-0.023	0.013	-1.737
CSM	-0.881	0.633	-1.393
CLD	-0.353	0.245	-1.441
CMG	-0.612	0.345	-1.775
DTG	-0.014	0.006	-2.411
DTF	0.051	0.024	2.107
DDR	0.070	0.019	3.575
cost function			
R-squared	0.999		
D.W. statistics	1.966		
cost share equation			
R-squared	0.197		
D.W. statistics	0.234		

Note: Estimates without std. error are derived using restrictions.

Table 3. Decomposition of TFP Growth Rate by Period: 1967-1996 (Unit: %)

Factors	1967-73 %	1973-90 %	1990-96 %	***1967-1996 %***
Output Effect	-5.23	-2.83	-3.55	***-3.47***
Technical Progress	2.25	2.25	2.25	***2.25***
Urbanization Effect	5.42	2.34	1.89	***2.88***
Loan/Deposit Ratio	0.08	-1.31	0.81	***-0.58***
Merger Effect	2.52	1.43	4.39	***2.27***
Rapid Economic Growth	1.42	-0.67	0.00	***-0.10***
Financial Deregulation	0.00	-0.30	-5.11	***-1.23***
Damage by Cold Weather	0.00	0.00	0.00	***0.00***
Sum of the Above Factors	6.47	0.92	0.69	***2.02***
Residual	1.07	0.11	-0.03	***0.28***
Growth Rate of TFP	7.54	1.02	0.66	***2.30***

Note: The difference between the growth rates in Table 1 and Table 3 is due to approximation.