Productivity changes of Credit Department of Farmers¡¦ Associations of the NAN-TOU County in Taiwan:1995-2004

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Abstract

The objective of this article was to measure the productivity of CDFAs of the NAN-TOU County in Taiwan over the period of 1995-2004. This study calculated the Malmquist productivity index by using the nonparametric frontier approach, and decomposed the index into two components: technical change and efficiency change. Empirical results showed that the productivity change of CDFAs in NAN-TOU County ranged from DMU 2¡¦s -6.4% to DMU 8¡¦s -3.8% over the sampled period. The decomposition of Malmquist index into efficiency change and technical change showed that, on average, the productivity change was due to scale change rather than pure efficiency change.

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Introduction

The economists have accepted productivity measurement as a standard tool for evaluating the economic performance within firms, industries or whole economies. A comprehensive measurement of productivity is of great importance to both policy makers and businessmen.

Three approaches had been used for productivity measurement in the agricultural financial industry. First, the parametric method consisted of deriving productivity by estimating production, cost or profit functions econometrically. The second approach applied the Tornqvist- Theil index to measure productivity. Both approaches require, explicitly or implicitly, a specific assumption about the form of the production technology. It is difficult to determine how well a postulating parametric function approaches the unknown true technology because the maintained hypothesis of parametric form can never be tested directly (Varian, 1984). The parametric approach has additional problems due to the estimation of accurate parameters from scarce and imperfect data (Stier and Bengston, 1992). To aggregate inputs and outputs, the Tornqvist-Theil index requires cost or revenue shares, which are hard to obtain, especially in cross-nation analysis. The third approach, based on the weak axiom of profit maximization, calculated the distance functions by using programming methods.

In this article, apply recently developed techniques to the analysis of productivity growth for the CDFAs of the NAN-TOU County in Taiwan over the period of 1995-2004. A nonparametric Malmquist approach, proposed by Fare *et al.* (1989), is used to measure the productivity change. The Malmquist index is defined by using distance functions. The distance functions allow us to describe a multi-input, multi-output production technology without the need to specify the producer behavior (such as cost minimization or profit maximization). While the Tornqvist-Theil index presumes production is always efficient, the Malmquist productivity index allows for inefficient performance and does not presume an underlying functional form for technology. Thus, the obtained Malmquist index of productivity can be decomposed into changes in efficiency and changes in technology. The non-parametric Malmquist approach has been applied mostly in the analysis of productivity growth, technical progress, and efficiency change, for example, hospitals (Fare *et al.*, 1989), pharmacies (Fare *et al.*, 1992, 1995), and Fare *et al.* (1994) However, analyses of agricultural financial are still rare.

This article is organized as follows. Section Ⅱ presents the Methodology. Section III reports the results and the final section is the conclusions.

Methodology

The Malmquist productivity index is an indicator of productivity (Malmquist, 1953). This index allows us to break down productivity over time into two drivers: efficiency change and technological progress. The Malmquist index represents total factor productivity that is a product of two geometric means either input-oriented or output oriented. Thus, DEA can deal either with input-orientated or output-orientated efficiency measure for any entity (Coelli, 1996).

The Malmquist index measures the total factor productivity change (TFPC) between two data points over time by calculating the ratio of data point distances relative to a common technology. Fare *et al.* (1994) determined the components of distance function of the Malmquist index, using a non-parametric programming method. The technical change or innovation is defined as how much the world frontier shifts at each country's (or firm's) observed input mix. The output-orientated Malmquist productivity change index between period t and $t+1$ is illustrated following Fare *et al*. (1994), as follows:

$$M_0\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \frac{D_O^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_O^t\left(x^t, y^t\right)} \times \left[\frac{D_O^t\left(x^{t+1}, y^{t+1}\right)}{D_O^{t+1}\left(x^{t+1}, y^{t+1}\right)} \frac{D_O^t\left(x^t, y^t\right)}{D_O^{t+1}\left(x^t, y^t\right)}\right]^{\frac{1}{2}} \quad (1)$$

Equation 1 presents Malmquist productivity index *(M_0)*, which measures the TFP change over the production point (x_{t+1}, y_{t+1}) and the production point (x_t, y_t), as a ratio of the distance of each point relative to a common technology. This index uses period *t* (observation) technology and period *t+1* technology. TFP growth is the geometric mean of two output-based Malmquist-TFP indices from period *t* to period *t+1*. A TFP value greater than one indicates positive growth from period *t* to period *t+1*. Farrell (1957) defined this positive growth as efficient firms operating on the production frontier. Thus, inefficient production units are those operating below the production frontier with a TFP value lesser than one indicating a decrease in TFP growth or performance relative to the previous year.

An econometric approach cannot handle panel data. The DEA-Malmquist approach uses panel data to estimate changes in TFP. DEA method constructs a nonparametric envelopment frontier over the data points in all observations that either lie on or below the production frontier. The envelopment frontier exhibits the closeness (efficiency change) of a firm to the frontier. The amount of shifts each firm has in its input mix in the frontier is "technical change". TFP is broken down into technical efficiency and technological progress to show the "changes and shifts" as shown below (Fare *et al*., 1994):

Technical efficiency change =

$$\frac{D_O^t\left(X^{t+1}, Y^{t+1}\right)}{D_O^t(X^t, Y^t)} \quad (2)$$

Technical change =

$$\left[\frac{D_O^t\left(X^{t+1}, Y^{t+1}\right)}{D_O^{t+1}\left(X^{t+1}, Y^{t+1}\right)} \times \frac{D_O^t\left(X^t, Y^t\right)}{D_O^{t+1}\left(X^t, Y^t\right)}\right]^{\frac{1}{2}} \quad (3)$$

Technical efficiency change (Equation 2) measures the change in efficiency between period t and t+1; whilst, the technical change (Equation 3) captures the shift in a frontier technology. A value greater than one derived for both indices indicates a growth in productivity. Moreover, when $Mo > 1$, this reflects improvement; $Mo < 1$, declines in productive performance, and no improvement when $Mo = 1$.

From the frontier (reference technology) in period *t*, constant returns to scale (CRS) may be relaxed to assume variable returns to scale (VRS); that is, increasing, constant or decreasing returns to scale. Fare *et al.* (1994) used an enhanced decomposition of the Malmquist index to decompose technical efficiency change (TEC) under CRS into two components, namely: pure efficiency change (PEC) and scale change (SEC). The PECH can be calculated under the VRS. SEC represents changes in divergence between VRS and CRS technology. Technical change (TC) is measured under the CRS. The enhanced decomposition of Fare *et al*. (1994) is presented as:

$$M_0(y_{t+1}, x_{t+1}, y_t, x_t) = TC \times PEC \times SEC \quad (4)$$

Where: TEC = PEC × SEC. Thus, the Malmquist TFP growth can be decomposed and re-written as:

TFP Growth =Technical Efficiency Change (TEC) ×Technological Change (TC) (5)

The Malmquist decomposition helps us to determine the sources of a firm's efficiency and inefficiency. That is, it measures the technical change (TC). TC > 1 stands for technical progress; TC < 1 shows technical regress. EC > 1 means efficiency has improved; EC < 1 means efficiency has deteriorated. SEC > 1 shows that the industry is relatively approaching the long-term optimal scale at t + 1; SEC < 1 indicates that the industry is deviating from the long-term optimal scale.

Results

In the previous study (Liu, 2004), we found that the NAN-TOU County has the lowest efficiency score among the CDFAs in Taiwan. Thus, in this study further evaluated the productivity change of the 13 CDFAs of NAN-TOU County to increase its efficiency. According to Keeney and Raiffa (1993), a desirable set of measurement factors should be complete, decomposable, operational, nonredundant, and minimal. There exists considerable disagreement in finance literature on the definition of outputs and inputs of a financial institution. In general, two alternative approaches - i.e. ‘intermediation or asset’ and ‘value-added or production’ – have evolved (Ellinger *et al*., 1992). In terms of measuring efficiency, the production approach lays emphasis on the operating costs of the bank, and is suitable for measuring overall efficiency. Meanwhile, the intermediation approach, besides considering overall bank operating costs, also focuses on measuring bank competitiveness. This focus arises because the intermediation approach serves as the principle for determining the bounds of the input and output variables used in this study. Thus, two output items are obtained, namely, loans and non-interest income, along with two input items, namely, salaries, and non-interest expenditure. The present data are obtained from the annual reports for each level of farmers’ associations in Taiwan from 1995 to 2004.

Table 1 displays the calculated productivity changes in the NAN-TOU County CDFAs over the period 1995–2004, as represented by the Malmquist output-based productivity in Eq. (1). We also show the average productivity change for each CDFA and period. As noted earlier, a greater-than-one Malmquist index denotes improvement in the relevant performance. Over the last decade, only one periods (1995-1996) showing productivity gains. In the same period, there were twelve CDFAs productivity decreased. Between 2001 and 2004, all the CDFAs showed some regress in their performance. The productivity growth for period 1995-1996 was only 0.7%. However, there were twelve periods showing regress in performance, especially period 2002-2003 (-9.7%). Generally speaking, the CDFAs in NAN-TOU County had similar pattern of productivity regress.

[Table 1]

Table 2 shows the annual efficiency change. An industry, which has been efficient at time t and t+1, will naturally show no change in relative efficiency, i.e. efficiency scores in Table 2 would be equal to 1. We found DMU 1, DMU 3, DMU 4, DMU 6 and DMU 12 to be efficient in all time periods. For the rest of the CDFAs in NAN-TOU County, we found periods with decline in efficiency. For the sampled periods as a whole, the average efficiency change ranged from -11.6 to 1.8%. While for the countries as a whole, the average efficiency change ranged from –8.8% to 0%. There are eight CDFAs, DMU 2, DMU 5, DMU 7, DMU 8, DMU 9, DMU 10, DMU 11 and DMU 13, showed deterioration in efficiency.

[Table 2]

[Table 3]

Table 3 presents annual technical progress or regress. We found two periods with technical progress and seven with technical regress. Period 2001-2002 and 2002-2003 had technical progress, respectively, 4.8% and 3.4%. All or almost all the CDFAs showed technical regress in 1995-1996, 1996-1997, 1997-1998, 1998-1999, 1999-2000, and 2003-2004 periods. Between 2003 and 2004, all the CDFAs were technical progress. Average technical change for the period 2003-2004 was –8.5%, the worst technical regress over the whole period. Focusing on the technical change in each CDFA, we found that DMU 13 had the highest technical progress, 5.5%, over the whole period, followed by DMU 7's 3.4% and DMU 8's 3.2%. As indicated by Eq. (2, 3), the multiplication of efficiency change and technical change leads to the productivity growth. Therefore, we can tell from Tables 2 and 3 that whether the productivity growth came from efficiency improvement or technical progress, or both. For example, the United States efficiency declined by 0.6% (EC = 0.994, Table 2) and technical progress of 0.8% (TC = 1.008, Table 3) over all periods. This led to the productivity decrease of approximately 0.2% (in Table 1, the annual average productivity change for the United States was 1.002). For all of the observations, the average efficiency change and technical change were, respectively, -3.7% and -1.0%. Therefore, on average, the productivity change was due to both regresses in efficiency and technical change, but main source is regresses in efficiency. Allowing variable-return-to-scale technology, we further decomposed the efficiency change into pure efficiency change and scale change, respectively, as shown in Tables 4 and 5. For all of the observations, the average pure efficiency change and scale change were, respectively, 0.2% and –3.90%. Therefore, on average, the efficiency change was due to scale change rather than pure efficiency change.

[Table 4]

[Table 5]

Conclusion

In this study, a Malmquist non-parametric approach was used to measure total factor productivity for CDFAs in NAN-TOU County over the 1995–2004 period. The Malmquist index was constructed from output-based distance functions without assuming specific technology and producer behavior. Furthermore, only quantity data were needed to solve the linear programming problems. The Malmquist productivity index can be fully decomposed into technical change, efficiency and scale change, so that we could have an insight into the factor, which had contributed to the productivity growth. Therefore, this approach could provide important complementary information to traditional methods. The results showed that, in last decade, the productivity change of CDFAs in NAN-TOU County ranged from DMU 2's -6.4% to DMU 8's -3.8%. We also found that the average productivity in the 1995-1996 period had the highest gain, 0.7%, during the sampled periods. All the CDFAs showed regress in their performance. The decomposition of Malmquist index into efficiency change and technical change showed that, on average, the productivity change was due to scale change rather than pure efficiency change. Productivity gains of DMU 1, DMU 3, DMU 4, DMU 6 and DMU 12 all came from the technical progress. For these countries whose production is right on the frontier (i.e. efficiency scores equal to 1), the strategy for increasing their productivity is to improve the technology (innovation). Scale inefficiency is main source for productivity regress. For the other CDFAs whose scale efficiency regress during the sampled periods, for example DMU 2, DMU 5, DMU 7, etc., scale adjustment by industrial vertical or horizontal integration might also be a good way to raise productivity. Some limitations of the Malmquist non-parametric approach should be noted. First, the measures of the total factor productivity used in this study are relative, but not absolute. Second, since the programming problems were solved by using DEA method, introducing additional CDFAs into the analysis would change the productivity indices if the added CDFAs shift the frontier.

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Table 1 Annual productivity change of CDFAs in NAN-TO from 1995-2004

DMU	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	Mean
1	0.979	0.947	1.064	0.902	0.900	0.941	0.988	0.932	0.964	0.958
2	1.098	0.989	0.914	0.950	0.940	0.789	0.946	0.847	0.956	0.936
3	1.049	0.937	0.975	0.989	0.955	1.000	0.883	0.904	0.938	0.959
4	1.013	1.014	0.965	0.948	0.931	0.918	0.940	0.870	0.958	0.951
5	0.973	1.015	0.920	0.956	0.929	0.941	0.946	0.897	0.890	0.941
6	1.064	0.962	0.982	0.991	0.913	0.940	0.874	0.949	0.832	0.945
7	1.022	1.004	0.932	0.939	0.938	0.939	0.860	0.883	0.944	0.940
8	0.997	0.945	1.000	0.993	1.023	0.934	0.913	0.950	0.906	0.962
9	0.985	0.977	0.989	0.948	0.975	0.978	0.927	0.917	0.806	0.945
10	0.938	0.950	1.007	0.967	0.991	0.940	0.939	0.901	0.902	0.948
11	1.001	1.047	0.938	1.015	0.907	1.016	0.880	0.866	0.888	0.951
12	1.011	0.950	0.949	0.993	0.934	0.936	0.957	0.869	0.917	0.946
13	0.959	0.952	0.966	0.939	1.013	0.904	0.938	0.952	0.933	0.951
Mean	1.007	0.976	0.969	0.964	0.950	0.936	0.922	0.903	0.910	0.949

Table 2 Annual efficiency change of CDFAs in NAN-TO from 1995-2004

DMU	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	Mean
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.007	0.956	0.966	0.959	1.033	0.971	0.874	0.865	1.078	0.968
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.067	0.996	0.994	1.000	0.973	0.915	0.823	0.815	0.956	0.949
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.066	0.995	0.968	0.954	0.902	0.848	0.763	0.755	0.990	0.916
8	1.012	0.989	0.991	0.978	0.965	0.907	0.816	0.808	0.962	0.937
9	1.000	0.978	0.959	0.947	0.929	1.000	0.900	0.891	1.000	0.956
10	1.008	0.991	0.976	1.000	0.968	0.910	0.819	0.811	0.958	0.938
11	1.074	0.989	0.979	0.968	0.963	0.905	0.815	0.807	1.000	0.944
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.003	0.985	0.950	0.941	0.995	0.836	0.752	0.745	1.000	0.912
Mean	1.018	0.991	0.983	0.981	0.979	0.946	0.889	0.884	0.996	0.963

Table3 Annual technical change of CDFAs in NAN-TO from 1995-2004

DMU	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	Mean
1	0.979	0.947	1.064	0.902	0.900	0.941	0.988	0.932	0.964	0.957
2	1.090	1.035	0.946	0.991	0.910	0.812	1.082	0.979	0.887	0.970
3	1.049	0.937	0.975	0.989	0.955	1.000	0.883	0.904	0.938	0.959
4	1.013	1.014	0.965	0.948	0.931	0.918	0.940	0.870	0.958	0.951
5	0.912	1.019	0.926	0.956	0.955	1.029	1.149	1.100	0.931	0.997
6	1.064	0.962	0.982	0.991	0.913	0.940	0.874	0.949	0.832	0.945
7	0.959	1.009	0.962	0.984	1.040	1.107	1.127	1.168	0.953	1.034
8	0.985	0.955	1.009	1.015	1.060	1.029	1.118	1.176	0.942	1.032
9	0.985	0.999	1.031	1.002	1.049	0.978	1.030	1.029	0.806	0.990
10	0.931	0.959	1.031	0.967	1.024	1.033	1.147	1.112	0.942	1.016
11	0.932	1.059	0.958	1.049	0.942	1.122	1.080	1.073	0.888	1.011
12	1.011	0.950	0.949	0.993	0.934	0.936	0.957	0.869	0.917	0.946
13	0.956	0.967	1.017	0.998	1.018	1.082	1.247	1.279	0.933	1.055
Mean	0.990	0.985	0.986	0.983	0.971	0.994	1.048	1.034	0.915	0.990

Table 4 Annual pure efficiency change of CDFAs in NAN-TO from 1995-2004

DMU	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	Mean
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.058	0.997	1.019	0.954	1.007	0.981	1.070	0.950	1.053	1.010
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.028	0.957	1.039	1.002	0.951	1.076	1.007	0.980	0.994	1.004
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	0.972	0.997	0.987	0.978	0.960	1.073	1.028	1.000	0.979	0.997
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.047	1.000	0.997	1.003	1.000	1.000	1.000	1.000	1.000	1.005
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	0.987	1.013	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.003	1.000	0.997	1.096	1.007	1.000	1.000	1.000	1.000	1.011
Mean	1.008	0.996	1.003	1.003	0.994	1.010	1.007	0.996	1.002	1.002

Table 5 Annual scale change of CDFAs in NAN-TO from 1995-2004

DMU	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	Mean
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	0.952	0.959	0.948	1.005	1.026	0.990	0.817	0.911	1.024	0.958
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.038	1.041	0.957	0.998	1.023	0.850	0.817	0.832	0.962	0.945
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.097	0.998	0.981	0.975	0.940	0.790	0.742	0.755	1.011	0.918
8	1.012	0.989	0.991	0.978	0.965	0.907	0.816	0.808	0.962	0.937
9	0.955	0.978	0.962	0.944	0.929	1.000	0.900	0.891	1.000	0.951
10	1.008	0.991	0.976	1.000	0.968	0.910	0.819	0.811	0.958	0.938
11	1.074	0.989	0.979	0.968	0.963	0.905	0.825	0.796	1.000	0.944
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.000	0.985	0.953	0.859	0.988	0.836	0.752	0.745	1.000	0.902
Mean	1.010	0.994	0.980	0.978	0.985	0.936	0.883	0.888	0.994	0.961