DOI: 10.20472/IAC.2015.018.066

KASEM KUNASRI
Chiang Mai Rajabhat University, Thailand

SOMBAT SINGKHARAT
Chiang Mai Rajabhat University, Thailand

EFFICIENCY AND TECHNOLOGY GAP RATIO OF LENDING PERFORMANCE OF MICRO-CREDIT INSTITUTIONS IN THAILAND: THE META-FRONTIER ANALYSIS

Abstract:

Many types of state initiated micro-credit institution have been established in Thailand with the primary principle of extending low cost loans to low income individuals so as to eventually help improve their quality of life. However, these micro-credit institutions still have varying degree of operational drawbacks from the absence of supportive structure to ensure organizational sustainability and the lack of efficient and effective credit management systems as they have to function under the framework of specific act by which they are institutionalized. The present endeavor employed meta-frontier concept for determining technology gap ratio and lending efficiency of microcredit institutions operating under different organizational rules and regulations as well as credit management methods with the focus on agricultural cooperatives (AC), village funds (VF), and production-oriented savings groups (PSG). The needed data were collected from 600 samples of such micro-credit organizations. Meta-frontier efficiency scores were found to be different at 0.01 statistically significant level. The group having the highest average score of efficiency is agricultural cooperative (0.6116), followed by village fund (0.4370) and production-oriented savings group (0.4119), respectively. In terms of technology gap ratio, there are differences at 0.01 statistically significant level. The agricultural cooperative group has the highest score at 94.71% whereas the village fund group has the lowest score, 60.93%. The technology gap is a function of optimal group size and different lending systems, i.e., the agricultural cooperatives give on loans under the amount of share capital constraint but the village funds allocate credit for each borrower equally. The findings of this study have led to a recommendation concerning the increase in optimal group size, especially to sub-district level, because size and operational environment can contribute to efficiency enhancement. Moreover, government agencies should change their roles from providing funds to promoting community self-reliance.

Keywords:

Meta-frontier; technology gap ratio; micro-credit institutions

JEL Classification: G21, G29, A10

1. Introduction

Thailand is classified as a developing country because of its low per capita income compared with those of developed nations. One of its main economic problems has been the large number of its rural population, much more than the urban or town people, who live in remote areas working predominantly in agriculture or as hired labors and thus earn low income per capita which is recently at 20,808 baht or US$ 630.53 per year per person (National Statistical Office of Thailand, 2014). These rural farmers and hired labors are highly vulnerable to the depressed economic situation as they have to confront the rising costs of living and production inputs, which also mean they need more money for investment.

Although there are numerous formal credit sources in Thailand from both state and private financial institutions such as various government and commercial banks, the low income earners generally cannot get loans from these formal credit providers especially the commercial banks due to their lack of collaterals or they simply cannot afford the high interest rates (Yaron et al, 1998). Meanwhile, main government financial institutions still have quite limited coverage in terms of branches in remote rural areas and range of transactional services. The lack of qualifications of rural population at the grass roots level for borrowing (Banerjee & Duflo ,2005) is also considered to be a preeminent impediment to their access to formal credits.

Nevertheless, various attempts have been made to deal with the problem of inaccessibility of rural farmers and general waged workers to formal credits particularly for production and consumption purposes. Various government policies and programs have been designed with emphases on developing community strength and capability as well as building the opportunity for the impoverished everywhere to have access to basic government services including production loans so as to enable the improvement in their income and quality of life levels (Yaron et al ,1998). Formation of micro-credit institution in any form in a rural community to function as an alternative lending source will help widen the opportunity for the community members to borrow capital for improving their entrepreneurship (World Bank, 2008).

Many types of micro-credit institution are functioning in Thailand including agricultural cooperative, production-oriented savings group, credit union, village bank, village fund, and various interest-specific savings groups. Virtually all are state initiated organizations with a mission in providing loans to low income individuals so as to eventually help elevate the latter's quality of life. However, most micro-credit institutions still have problems related to the rigid organizational structure which can impair the sustainability and the lack of efficient credit management system. As different types of micro-credit institution are established by different laws which stipulate different ways and requirements for credit management, it is imperative to identify the most efficient input combinations or the best banking technology in credit provision and management under the present circumstances. The findings will form the basis for recommendations about what credit management technologies and how they can be applied to improve the long term efficiency and competitiveness of those institutions now operating below the best possible managerial performance (Untong & Kaosa-ard, 2009).

The analysis and comparison of operational efficiency across non-homogenous types of micro-credit institution which use different sets of organizational regulations and management procedures were viewed to be best conducted through meta-frontier

technique to estimate the impacts of different institutional settings and managerial technologies (Battese & Rao,2002; Huang & Fu, 2013; Bos and Schmiedel , 2003 ; Huang et al, 2014)

The present study thus applied the meta-frontier concept for analyzing and comparing the efficiency of three different types of micro-credit institution in Thailand which function under different legal framework and use dissimilar credit management methods, including agricultural cooperative (AC)[1], production-oriented savings group (PSG)[2], and village fund (VF)[3] Methodologically, a group frontier for each type of microcredit institution was constructed using data envelopment analysis (DEA) technique developed by Tone (2001) and Battese et al. (2004). Then, a meta-frontier was derived to cover all three group frontiers following the method of Battese and Rao (2002). The findings from this investigation are expected to be useful in designing appropriate policy and programs for each type of micro-credit institution to enhance its operational efficiency and to build the strength of micro-finance sector of Thailand as a whole.

2. Concepts and Models

2.1 Data Envelopment Analysis: DEA

Data Envelopment Analysis: DEA is a non-parametric technique for analyzing relative efficiency and operational performance of various multi-input and multi-output producers which, in DEA literature, are commonly referred to as Decision Making Units: DMUs following the seminal work by Charnes, A., Cooper, W.W., and Rhodes, E. (1978) In DEA, the efficient DMUs will be identified for use as standard criteria and for determining the inefficiency of other DMUs that use different input combinations. In other words, DEA generates from a set of existing data a frontier representing reference points of various efficient DMUs or those using the best practice production technology and the inefficiency of other producers operating below the frontier can then be calculated (Cooper et al, 2004)

Generally, there are many forms or models of DEA extended after the basic CCR model. The present interest is however on the BCC model developed by Banker; Charnes, and Cooper (1984) which is practical in application as it takes the form of variable returns to scale: VRS (Jemrić & Vujčić, 2002). In the BCC model (Banker; Charnes and Cooper, 1984), for envelopment of DMUs under VRS condition, it is necessary to include a convexity constraint by determining the weight for λ_j and $\sum_{j=1}^{n} \lambda_j = 1$. Specifically, the output – oriented BCC model evaluates the efficiency of DMU_0 by solving the following linear programming model (Coelli, Rao, O'Donnell, & Battese, 2005)

[1] (AC): Agricultural cooperative is the cooperative formed among farmers in a geographic area and registered as legal person with the Cooperative Registrar, for the purpose of cooperative and mutual undertakings which can help solve problems and difficulties in agricultural profession and improve the livelihoods of cooperative members.

[2] (PSG): Production-oriented savings group is formed among individuals for self-help and mutual-help in terms of finance, by saving a small amount of money to be deposited regularly in a group organization and the savings fund will be the source of lending to group members who are in need for money to make investment or improve family welfare.

[3] (VF) Village fund is established after the government policy that allocated one million baht seed money to every village community in Thailand for management and use as revolving fund for investment, employment and income generation, and occupational development among village community members.

$$\max \phi_i \tag{1}$$

subject to $$\sum_{j=1}^{J} \lambda_j y_{mj} - \phi y_{mi} \geq 0, \quad m = 1, 2, \ldots, M \tag{2}$$

$$x_{ni} - \sum_{j=1}^{J} \lambda_j x_{nj} \geq 0, \quad n = 1, 2, \ldots, N \tag{3}$$

$$\sum_{j=1}^{J} \lambda_j = 1 \tag{4}$$

$$\lambda_j \geq 0 \tag{5}$$

The efficiency scores obtained for various DMUs from BBC model estimation under the assumption of variable returns to scale are the pure technical efficiency scores as they purely reflect the managerial performance of the production units without scale efficiency. The above DEA model is in the multiplier form to make easier the calculation of efficiency scores of DMUs (Cooper, 2000).

2.2 Evaluating Efficiency by Meta-frontier Approach

Efficiency study using BBC model of DEA method might provide inaccurate results if various DMUs employ different technologies (Battese & Rao, 2002) or face different environmental characteristics (O'Donnell, Rao, & Battese, 2008) because heterogeneous groups of DMUs are unlikely to operate under the same production frontier. To overcome this shortcoming, Battese and Rao (2002) proposed the meta-frontier concept for efficiency analysis as presented in Table 2. The meta-frontier function is estimated to envelop various distinctive group frontiers as graphically presented in Figure 1. The technology gap ratio is thus measured by the distance between meta-frontier and individual group frontier.

1) The Meta frontier

Let x and y be nonnegative real input and output vectors of dimension N×1 and M×1, respectively. The Meta technology set contains all input-output combinations that are technologically feasible. Formally: (O'Donnell, Rao, & Battese, 2008)

$$T = \{(x, y) : x \geq 0; y \geq 0; x \text{ Can produce } y \} \tag{6}$$

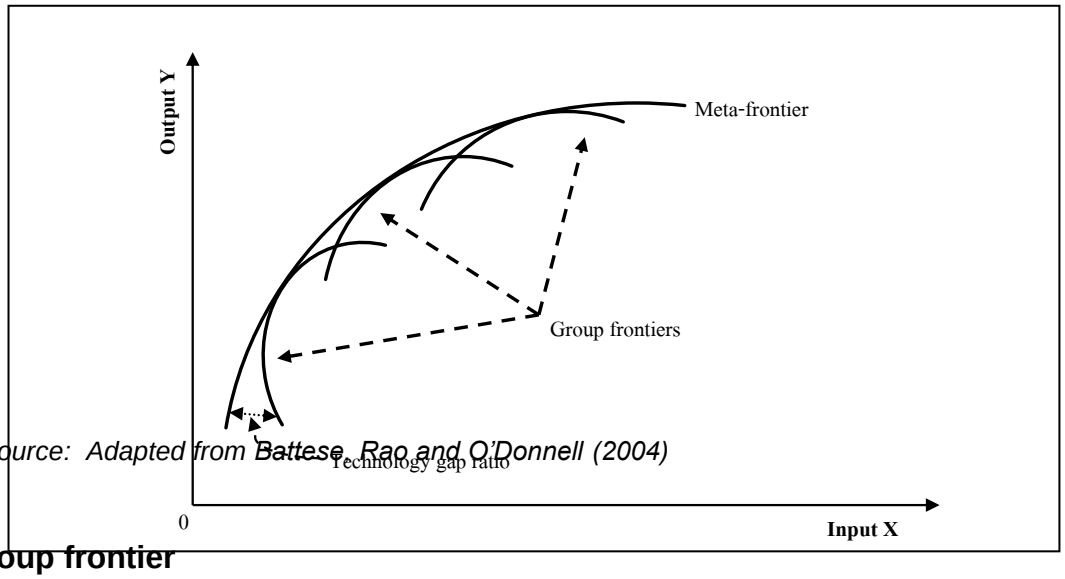
The input sets are defined for any output vector, y, as:

$$L(y) = \{x : (x, y) \in T\} \tag{7}$$

Let D (x,y) denote the input distance function for input meta distance function. It is defined by:

$$D(x, y) = \sup \lambda \{\lambda > 0 : (x / \lambda) \in L(y)\} \tag{8}$$

Figure 1: Meta-frontier and group frontiers.



Source: Adapted from Battese, Rao and O'Donnell (2004)

2) Group frontier

If all DMUs can be distinguished into *k* different groups due to their difference in terms of resource, limiting factor, or other environmental characteristics, the group frontier function for all *k* technologically specific groups can be defined, according to (O'Donnell, Rao, & Battese, 2008), as

T^k = {(x.y) : x ≥ 0; y ≥ 0; x can be used by firms in group k to produce y} (9)

Within a *k* technologically specific group, the representative input set can be expressed as

$L^k(y) = \{x : (x,y) \in T^k\}$, k=1,2,…,K; and (10)

$D^k(x,y) = \sup_\lambda \{\lambda > 0 : (x/\lambda) \in L^k(y)\}$, k=1,2,…,K. (11)

The boundary of the group-specific input set is thus referred to as group frontier of that group. For all *k*'s, if the input sets, L^k (y), k=1,2,…,K, , satisfy standard regularity properties then the distance functions, D^k (x,y), k=1,2,…,K,, also satisfy standard regularity properties (O'Donnell, Rao, & Battese, 2008). It can be concluded that

1) If $(x,y) \in T$ for any k then; $(x,y) \in T$
2) $(x,y) \in T$ then $(x,y) \in T$ for any k;
3) $T = \{T \cup T^2 \cup ...T^k\}$
4) $D^k(x,y) \geq D(x,y)$ for all k=1,2,…,K.

3) Technical efficiencies and meta technology ratios

Generally, an input-oriented measure of technical efficiency of an input-output pair with respect to the meta-technology is:

$$TE(x,y) = D(x,y) \quad (12)$$

and we can also measure an input-oriented technical efficiency with respect to the group k technology from:

$$TE^{k}(x,y) = \frac{1}{\mathrm{D}^{\mathrm{k}}\ (\mathrm{x},\ \mathrm{y})} \tag{13}$$

It is clear from 13) above that the group k distance function, group-k, $D^{k}(x,y)$, can take the value no less than the meta-distance function, $D(x,y)$. This means the meta-frontier envelops the group frontier. We can then obtain the meta-technology ratio (O'Donnell. 2008) or technology gap ratio (Battese et al., 2004) from the following definition:

$$TGR^{k}(X,y) = \frac{\mathrm{D}(\mathrm{x},\ \mathrm{y})}{\mathrm{D}^{\mathrm{k}}(\mathrm{x},\ \mathrm{y})} = \frac{T(x,y)}{T^{k}(x,y)} = \frac{\mathrm{T}(\mathrm{x},\mathrm{y})}{\mathrm{T}^{\mathrm{k}}(\mathrm{x},\ \mathrm{y})} \tag{14}$$

From (12), technical efficiency of a particular input-output combination can be rewritten as:

$$TE(x,y) = TE^{k}(x,y) \times TGR^{k}(x,y) \tag{15}$$

3. Methodology

In this meta-frontier analysis of the operational efficiencies and technology gap ratios of different micro-credit institutions in Thailand that operate under different legal framework and use different management systems, the input and output variables were determined to be comparable with the works of other scholars in this field. Thus, the output variable is lending to members (Y1), similar to the works of Grifell et al. (1997); Jackson et al. (1998); Kirikal (2005) ; Nieto et al. (2009); Huang & Fu (2013); Serrano & Nieto (2014). The input variables, eight altogether, include working capital (X1), share capital (X2), member's savings deposit (X3), income from interest on loan (X4), interest related expenses (X5), physical assets (X6), non-interest expenses (X7), and membership (X8), similar to the works of Berger (1997); Athanassoupoulos (1997); Gutiérrez Nieto et al. (2008) Hang & Chinag (2006); Bos & Schmiedel (2007); Villano, Pauline & Euan (2008) Pasiouras & Sifodaskalaki (2007); Athanasoglou et al. (2009) ; Azizi & Ajirlu (2011) and Gebremichael & Rani (2012)

The study used secondary data for the year 2014 officially available from the Department of Cooperative Auditing, the Community Development Department, and the National Village and Urban Community Fund Office. Two hundred samples were identified by purposive sampling method for each type of micro-credit institution namely agricultural cooperative (AC), production-oriented savings group (PSG), and village fund (VF), making totally 600 observations. From basic statistics of various variables in this study (Table 1), it can be seen that averagely each micro-credit provider in group 1 (AC) has the largest volume of financial transactions and the largest number of members compared to the otherwise cases because an agricultural cooperative has its operational area coverage over a sub-district or district. Meanwhile, group 3 (VF) has the largest number of micro-credit providers because village funds are established at village level nationwide.

Table 1: Basic statistics of input and output variables of micro-credit institutions under study in 2014 business year

Variable	Group 1(AC)[4]		Group 2 (PSG)[5]		Group 3 (VF)[6]	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Lending to members (Y1)	**44,951,920**	**88,797,699**	**1,788,575**	**2,636,068**	**588,350**	**506,244**
Working capital (X1)	**32,910,137**	**60,063,741**	**185,912**	**307,404**	**307,013**	**304,528**
Share capital (X2)	**22,454,043**	**43,366,147**	**2,341,461**	**3,125,849**	**106,853**	**135,400**
Member's savings deposit (X3)	**55,715,267**	**113,218,897**	**51,721**	**78,113**	**32,945**	**65,723**
Income from interest on loan (X4)	**66,109,150**	**108,497,228**	**216,607**	**317,530**	**401,147**	**589,187**
Interest related expenses (X5)	**63,892,810.**	**105,690,442**	**1,928,058**	**3,017,014**	**366,287**	**569,366**
Physical assets (X6)	**7,758,501**	**14,959,215**	**632,194**	**843,979**	**34,489**	**101,191**
Non-interest expenses (X7)	**2,216,340**	**3,961,997**	**180,955**	**265,067**	**34,859**	**37,854**
Membership (X8)	**1,950**	**6,228**	**232**	**195**	**121**	**102**
Total number of organizations nationwide	**3,564**		**10,485**		79,255	

Source: Calculation

As micro-credit institutions do not function for the purpose of profit maximization, the meta-frontier analysis of their efficiencies should be based on the input-oriented approach under the assumption of variable returns to scale (VRS) due to the presence of imperfect competition and improper lending constraints set by different institutions (Banker, Charnes et al, 1984). The efficiency scores for lending services performance from group frontier, meta-frontier, and technology gap ratio analyses will have values ranging from 0 to 1 Battese & Rao, 2002; Battese, Rao, & O'Donnell, 2004). Any DMU receiving a calculated technical efficiency (TE) score equal to 1 with reference to its group frontier will be the most efficient compared to other DMUs in the same group or those use the same technology. Under a meta-frontier, any DMU having TE equal to 1 will be efficient in comparison across groups that use different technologies. Likewise, any DMU with technology gap ratio (TGR) of 1 will be operating at a best practice point on the meta-frontier (O'Donnell, Rao, & Battese, 2008)

For testing of the statistically significant difference in technical efficiency and technology gap ratio among the three groups having the same size of samples, the non-parametric chi-square Kruskal – Wallis test and Median test were used.

[4] (CA)= agricultural cooperatives
[5] (PSG)=production-oriented savings group
[6] (VF)= village funds

4. Results

The meta-frontier constructed from BCC model of DEA enables the comparison of operational efficiency and technology gap ratio across groups of micro-credit institutions in Thailand by using the ratio or radial measurement. As shown in Table 2, technical efficiencies (TEs) estimated from group frontier and pooled frontier are higher than those obtained from other models while TEs from the respective meta-frontier analysis are lower than those from other models. These results suggest that the estimated TEs from group frontier and pooled frontier will be over-estimated when technological heterogeneity exists (Untong,2013).

By estimating individual group frontier for DMUs using the same technology, it is found that the average technical efficiency (TE – G) is relatively high in village fund (VF) and agricultural cooperative (AC) groups while low in production-oriented savings group (PSG) category as measured at 0.6588, 0.6566, and 0.5607 , respectively. Meanwhile, the grand or total TE – G was calculated at 0.5934 as shown in Table 2. From chi-square test for statistically significant difference at 0.01 level, it can be concluded that the average managerial performance is higher in both VF and AC groups, compared to the PSG counterpart.

To confirm the comparability of TEs obtained from different group frontiers, Orea and Kumbhakar (2004) proposed the use of results from pooled frontier estimation. In this study, the average TE from the use of pooled data for frontier construction was also relatively high for VF and AC groups and low for PSG group with the values of 0.6913, 0.6585, and 0.5894, respectively. The chi-square test also confirms that at 0.01 statistically significant level, with the use of pooled data, the operational efficiency of VFs and ACs in general is higher and different from that of PSGs.

The technology gap by ratio criteria (TGR) was found to be high on the average for AC and PSG groups and low for VF group at the values of 0.9471, 0.9337, and 0.6093, respectively while the total TGR was calculated at 0.7967. The chi-square test provided the result that there is a statistically significant difference at 0.01 level between the high and the low TGRs as presented in Table 2. The measured TGRs clearly reflect that AC and PSG groups are more advanced than VF group in terms of managerial technology or innovative lending operation. Both AC and PSG groups have as their loan approval criteria that their members can borrow up to the amount of the latter's share capital but not exceeding 100,000 – 500,000 baht for each borrower, that the lending is made upon collateral, and that the borrowing is for agricultural purpose. Such criteria help control the problem concerning loan repayments and outstanding debts of member borrowers, as also consistent with the findings in the studies by Morduch (2000) ; Carter, Galarza & Boucher (2007) and Gine, Townsend & Vickrey (2008). In VF group, loan approval for each member is within the limit of 20.000 – 40,000 baht without the collateral requirement, making various VFs face higher risk from the non-performing loans than ACs and PSGs and hence the low value of average TGR.

Table 2: Estimated Technical Efficiencies and Technology Gap Ratios

Micro-credit		Mean	Minimum	Maximum	St. Dev.	number of efficiency	
						number	Percentage
TE-G[7]	AC	0.6566	0.0270	1.0000	0.3137	59	29.50
	PSG	0.5607	0.0010	1.0000	0.3300	39	19.50
	VF	0.6588	0.0080	1.0000	0.3226	68	34.00
	total	0.5934	0.0010	1.0000	0.3343	166	27.67
TE-P[8]	AC	0.6585	0.0130	1.0000	0.3165	35	17.50
	PSG	0.5894	0.0010	1.0000	0.3192	33	16.50
	VF	0.6913	0.0090	1.0000	0.3205	76	38.00
	total	0.5607	0.0010	1.0000	0.3353	144	24.00
TGR[9]	AC	0.9471	0.0990	1.0000	0.2240	91	45.50
	PSG	0.9337	0.1400	1.0000	0.1213	73	36.50
	VF	0.6093	0.0151	1.0000	0.3077	34	17.00
	total	0.7967	0.0151	1.0000	0.2681	198	33.00
TE-Meta[10]	AC	0.6116	0.0063	1.0000	0.3387	35	17.50
	PSG	0.4119	0.0010	1.0000	0.3205	33	16.50
	VF	0.4370	0.0002	1.0000	0.3325	31	15.50
	total	0.4535	0.0002	1.0000	0.3328	99	16.50
Kruskal-Wallis Test (chi-square)			TE-G		42.180*		
			TE-P		57.852*		
			TGR		119.227*		
			TE-Meta		8.385*		
Median Test			TE-G		42.180*		

[7] (TE-G)= Technical efficiencies of Group frontier;
[8] (TE-P)= Technical efficiencies of Pool frontier
[9] (TGR)= technology gap ratio
[10] (TE-Meta)= Technical efficiencies of Meta frontier

(chi-square)	TE-P	57.852*
	TGR	119.227*
	TE-Meta	8.385*

Source: Calculation

The estimated technical efficiencies with reference to meta-frontier (TE – Meta) indicated that AC group outperformed VF and PSG groups substantially with the value of 0.6116, 0.4370, and 0.4119, respectively. The chi-square test at 0.01 statistically significant level proved that by comparison with reference to meta-frontier across different types of micro-credit institution which use different managerial technologies, the AC group has efficiency level different from those of the other groups. This is because the organization, registration, and operation of agricultural cooperatives are under the strict supervision, promotion, regulations, as well as monitoring and audit by authorized government agencies according to the Cooperatives Act, B.E. 2542. Any cooperative having problems in its operation will be ordered to temporarily discontinue its activities. Thus, in all types of cooperative and organization under this law, individual cooperative/organization has to adapt and develop itself to maintain its business competitiveness.

Also presented in Table 2 are the findings on relative and absolute efficiencies. By meta-frontier and technology gap measures, the numbers of efficient DMUs with TE-Meta = 1 and TGR = 1 in AC group, accounting for 17.50 and 45.50 % of the total samples respectively, are greater than those of PSG and VF groups. However, with reference to group frontiers, the numbers of village funds with TE – G = 1 and TE – P = 1 are relatively greater because VFs have appropriate scale of lending operation at the community especially the village level.

Table 3 shows the extent and the sources of inefficiency. All groups of micro-credit institutions appeared to have comparable proportions of inefficient DMUs, 82.50, 83.50, and 84.50 % in AC, PSG, and VF groups respectively.

Inefficiency is attributable to the presence of input slacks or the excessive use of inputs which can possibly be reduced without impairing the output performance. The AC group's major input slack problems are in terms of working capital and income from interest on loans as 51.50 and 26.00 % of ACs over-used these two respective inputs. DMUs in PSG group have input slacks in terms of share capital, interest-related expenses, physical assets, non-interest expenses, and memberships, at 59.50, 54.50, 79.00, 52.00, and 45.50 %, respectively. Meanwhile, 55.50 % of DMUs in VF group have input slack in the category of income from interest on loans. The inefficient microcredit providers can improve their operational performance by eliminating all input slacks and then become efficient.

Table 3: Input Slack Problems in Microcredit Institutions.

Input slack	Agricultural Cooperatives			Savings Groups for Manufacturing			Village Funds		
	number	percentage	average	number	percentage	average	number	percentage	average
X1	103	**51.50**	12,436,372	28	14.00	108,373	95	47.50	207,099

X2	94	47.00	9,535,974	119	**59.50**	1,433,905	49	24.50	64,393
X3	52	**26.00**	13,561,758	50	25.00	49,929	29	14.50	26,616
X4	91	45.50	25,100,563	77	38.50	79,091	111	**55.50**	202,583
X5	71	35.50	31,551,782	109	**54.50**	877,726	40	20.00	334,214
X6	91	45.50	7,152,981	158	**79.00**	294,426	37	18.50	23,893
X7	64	32.00	1,188,954	104	**52.00**	106,721	45	22.50	23,367
X8	84	42.00	614	91	**45.50**	116	63	31.50	87

Source: Calculation

5. Conclusions

This article deals with measuring technical efficiency and technology gap ratio of various types of micro-credit institutions in Thailand which function under different legal acts and use dissimilar credit management systems. The study employed the BBC model of data envelopment analysis approach, and the meta-frontier concept proposed by O'Donnell, Rao, & Battese, (2008). Data for the analysis are of secondary and cross sectional type, in 2014 business year, covering 200 purposively selected samples each of agricultural cooperatives (AC), production-oriented savings groups (PSG), and village funds (VF), and thus totally 600 observations. The findings should be useful for the design of appropriate policy and programs for each type of micro-credit institution to enhance the operational performance and build up the strength of micro-finance sector of Thailand.

The findings reveal that the mean TE of VF group is higher than those of the other groups indicating the generally high performance of DMUs using the same managerial technology or operating under the same frontier. This is because in promoting micro-credit institutions in Thailand, the government has paid special attention to assisting and supervising village funds by assigning specialized state-supported banks to serve as mentor for those strong village funds which are ready to elevate their status to become a village bank. The state role in this part should involve the setting up of criteria for the efficient village funds in transition into village banks to operate at appropriate scale and provide suitable banking services. Other types of micro-credit providers in Thailand still receive limited supports from the government.

By meta-frontier (TE – Meta) and technology gap ratio (TGR) measures, the AC group outperformed the others. This is because the organization, registration, and operation of agricultural cooperatives are under strict state supervision and regulations according to the Cooperatives Act, B.E. 2542. Any cooperative having problems in its operation will be ordered to temporarily discontinue its activities. Thus individual cooperative has to adapt and develop itself to maintain its business competitiveness. Furthermore, there is a specialized government agency namely the Cooperative Auditing Department tasked with auditing the accounts of cooperatives and devising the accounting systems as well as auditing standards appropriate for agricultural cooperatives. The CAD also requires agricultural cooperatives to prepare and use various financial indicators for the purposes of organizational performance and

sustainability assessment, and financial risk monitoring and surveillance. Various measures used by the CAD can be regarded as an enabling credit managerial technology for agricultural cooperatives to attain high efficiency. However, no government agency along this line has been established for serving other types of micro-credit institutions in Thailand.

The present investigation has led to a set of recommendations. Firstly, the size of various micro-credit providers should be enlarged to cover the whole sub-district area to enable the efficiency improvement. Secondly, government policy regarding micro-credit institutions should be type-specific because of their dissimilar management systems. Thirdly, relevant government agencies should shift their role as financial supporter to advocator for self-reliance of micro-credit providers and the inter-group exchange of credit management technology for further development and innovation. Finally, the government should establish a credit information system of small loans, deposit protection system at grassroots level, and an agency for extension of financial knowledge at community level to foster the provision of comprehensive community financial services.

6. Reference

Aigbe Akhigbea, James E. McNulty. (2011). Bank monitoring, profit efficiency and the commercial lending business model. *Journal of Economics and Business*, 63:531–551

Athanasoglou, P.P.; E.A. Georgiou and C.C. Staikouras. (2009). Assessing output and productivity growth in the banking industry. *The Quarterly Review of Economics and Finance*, 49: 1317–1340

Azizi, H., and Ajirlu, H. G. (2011). Measurement of the worst practice of decision-making units in the presence of non-discretionary factors and imprecise data. *Applied Mathematical Modelling*. 35: 4,149 – 4,156

Banerjee, Abhijit and Esther Dulfo. (2005). Growth theory through the lens of development economics. *Handbook of Economic Growth*, Vol 1A.

Banker, R. D., Charnes, A., Cooper, W. W.,(1984). Some models for estimating technical and scale inefficiencies in data dnvelopment analysis. *Management Science*, 30(9): 1078-1092.

Battese, G.E. and Rao, D.S.P. (2002). Technology gap, efficiency and a stochastic metafrontier function. *International Journal of Business and Economics* 1(2): 87-93.

_____, Rao D.S.P., O'Donnell C.J. (2004). A meta-frontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis*, 21: 91–103.

Bos, j.W.B. and H. Schmiedel. (2003). Comparing efficiency in european banking: a Mata frontier approach. *DNB Research series Supervision*, 57:1-32.

Carter, M.R., F. Galarza, and S. Boucher. (2007).*Underwriting area-based yield insurance to crowd-in credit supply and demand. Forthcoming in Savings and Development.* Draft available at <repositories.cdlib.org/are/ arewp/07-003/>

Charnes, A.; W.W. Cooper, and E. Rhodes. (1978). Measuring the efficiency of decision making units. *European Journal of Operations Research*, 2:429-444.

Chen, K.H. and Yang, H.Y. (2011). A Cross-country comparison of productivity growth using the generalised meta-frontier Malmquist productivity index: With application to banking industries in Taiwan and China. *Journal of Productivity Analysis*,35(3) :197-212.

Coelli, T., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis* (2nd ed.). New York: Springer.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2004). *Handbook on data envelopment analysis. New York*: Khuwer Academic Publishers.

Gebremichael, B.Z., Rani, D.L., (2012). Total factor productivity change of ethiopian

microfinance institutions (MFIs): a Malmquist productivity index approach (MPI). *Eur. J. Bus. Manag*, 4 (3):105–114.

Giné, X., R. Townsend and J. Vickery. (2007). Patterns of Rainfall Insurance Participation in Rural India, *Working Paper*. World Bank, April.

Gutiérrez Nieto, B., Serrano Cinca, C., Mar Molinero, C. (2007). Microfinance institutions and efficiency. Omega: *International Journal of Management Science* 35(2):131-142

_____, Serrano-Cinca C and Mar-Molinero C (2009). Social efficiency in microfinance institutions. *Journal of the Operational Research Society*,60(1): 104–119.

Huang, Mei-Ying. and Fu, Tsu-Tan. (2013). An examination of the cost efficiency of banks in Taiwan and China using the metafrontier cost function. *Journal of Productivity Analysis*. 40(3): 387-406.

_____., et al. 2014. Meta-frontier cost Malmquist productivity index: an application to Taiwanese and Chinese commercial banks. *Journal of Productivity Analysis*. 9(17): 1-15.

Jackson, P.M.; M.D. Fethi and G. Inal. (1998). Efficiency and productivity growth in turkish commercial banking sector: a non-parametric approach. European Symposium on: Data Envelopment Analysis – Recent Developments and Applications, Wernigerode, Germany, 16-18 October, 1998.

Jacob Yaron, McDonald Benjamin and Stephanie Charitonenko. (1998). Promoting efficient rural financial intermediation, *World Bank Research Observer*,13: 147-170.

jemric and B. Vujcic. (2002). Efficiency of banks in croatia, A DEA approach. *Comparative Economic Studies*, 44:169-193.

Kirikal, L. 2005. Productivity, the Malmquist Index and the empirical study of banks in estonia", PhD Thesis, Tallinn Technical University.Tallinn: Tallinn Technical University

Morduch J. (2000). The microfinance schism. *World Development* 28(4): 617–629.

O'Donnell, C., Rao, D.S.P. and Battese, G.E. (2008). Met frontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics*, 34(2): 231-255.

_____ &Griffiths, W.E. (2006). Estimating state-contingent production frontiers. *American Journal of Agricultural Economics*, 88(1): 249-266.

Orea, L. and Kumbhakar, S.C. (2004). Efficiency measurement using a latent class stochastic frontier model. *Empirical Economics*, 29(1): 169-183.

Pasiouras F. and E. Sifodaskalakis. (2007). Total factor productivity change of greek cooperative banks. *University of Bath School of Management Working Paper* Series No.13.

Serrano-Cinca, C. and Gutierrez-Nieto, B. (2014): Microfinance, the long tail and mission drift. *International Business Review*, 23 (1): 181-194

Tone, K. (2001). A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research*, 130(3): 498-509.

Untong, A. (2013). Operational Efffiiciency and Technology Gap Ratio of Hotels under Different Environments (in Thai) .*Applied Economics Journal*, 20 (2): 37-54.

_____. (2004). *Efficiency of hotel and guesthouse in upper north of Thailand*. [Lecture note]. Special lecture at the Faculty of Management and Information Sciences, Naresuan University, January 16, 2004. (in Thai)

Villano, R., Fleming, E. and Fleming, P. (2008). Measuring regional productivity differences in the Australian Wool industry: A meta frontier approach . AARES 52 and Annual Conference. February 5-8, 2008, Canberra, Australia.

World Bank. (2008). *Finance for All? Policies and Pitfalls in Expanding Access.* Washington, D.C.: The World Bank.