The Discriminant Analysis on Mortgage Defaults and Decision Making between Commercial Banks and Local Banks: An Application of Decision Making Trial and Evaluation Laboratory - Factor Decomposition Method

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ABSTRACT

The financial crisis affected the Taiwanese economy, substantially increasing overdue loans in banks. Since commercial banks (CBs) and local banks (LBs) involve varying operational conditions, the factors contributing to their mortgage defaults might also differ. In addition, differences in organizational and financial structures exist between CBs and LBs. Both types of banks maintain different views regarding loan policies; such views are reflected in operating performance. The present study developed a Decision Making Trial and Evaluation Laboratory Factor Decomposition Method that could structuralize mortgage defaults to further investigate the extent of the gap between various key factors.

Keywords: Mortgage Defaults, Commercial Banks, Local Banks, Decision Making Trial and Evaluation Laboratory - Factor Decomposition Method
JEL Classifications: G01, G32, G41

1. INTRODUCTION

The East Asian financial crisis of 1997 and the financial crisis of 2008 also affected the Taiwanese economy, substantially increasing overdue loans in banks. On the basis of involving different operational conditions for commercial banks (CBs hereafter) and local banks (LBs hereafter). The present study clarified the similarities and differences between the two patterns of mortgage defaults. We analyzed the characteristics and advantages that the Decision Making Trial and Evaluation Laboratory (DEMATEL hereafter) and the property of the factor decomposition model (FDM) before integrating them, forming a DEMATEL-FDM approach.

In the present study, the fifteen loan managers or cadres with engaging in lending business for more than ten years of CBs and LBs were also gathered to hold four symposiums and answer the questionnaire during the periods of March 2017–May 2017. We analyzed the characteristics and advantages that the DEMATEL

hereafter and the property of the FDM before integrating them, forming a DEMATEL-FDM approach.

2. LITERATURE REVIEW

A debt review denotes that when banks review loan applications, they generally consider borrower credit, repayment ability, and debt guarantee. Collateral provided by the borrower typically serves to guarantee the debt. When the borrower cannot fulfill repayment obligations, the bank can expropriate the collateral to recover its loan on schedule. The collateral is the so-called debt guarantee. However, when banks manage individual consumer loans, if they already have a full guarantee, then they may not demand that the borrower provide a guarantor.

Ritzer (1995) indicated that credit card companies and banks promote heavily to students without independent economic capacity because they trust that if a student cardholder cannot

manage debt or defaults, the student's parents will resolve the debt problems. In addition to the aforementioned studies, studies have analyzed the relationships among loan defaults and business cycles, money supply, unemployment rate, and inflation according to overall environmental changes (Hamilton, 2001; Berger and Udell, 2003, Agarwal and Liu, 2003). For example, because consumers suddenly encounter unemployment and pay cuts, increased unemployment rates and decreased income levels force banks to contend with substantially higher default rates (Paquin and Weiss, 1998; Covitz et al., 2000; Altman and Saunders, 2001; Zsamboki, 2002; Berger et al., 2001; Grieb et al., 2001). Wu et al. (2017) employed DEMATEL as a model for analyzing mortgage defaults, and the methods could verify the determinants of the mortgage defaults for both CBs and LBs.

The aforementioned studies involved using difference analysis, the probit regression model, the logistic regression model, standard backpropagation, the decision tree iterative dichotomizer-3 algorithm, and recursive partition analysis to analyze credit assessments by banks. In the present study, we employed DEMATEL as a model for analyzing loan defaults. DEMATEL is a multidimensional approach based on the decision-making trial and evaluation laboratory method that can be used to determine key factors among numerous criteria (Dytczak and Ginda, 2009; Li and Tzeng, 2009; Lin and Tzeng, 2009; Lee et al., 2010; Wu et al., 2010; Lin et al., 2011). Recently, a large and growing body of research has been applied the DEMATEL-based analytic network method (Chen et al., 2011; Hung et al., 2012; Hsu et al., 2012; Lu et al., 2013; Chiu et al., 2013; Hsu et al., 2013; Hsu and Liou, 2013; Liu et al., 2013; Liu et al., 2012; Hu et al., 2014; Huang et al., 2014; Liou et al., 2014; Shen et al., 2014). Additionally, there is a multi-themed DEMATEL approach (Wu et al., 2011; Lee et al., 2013; Wu et al., 2013a; Wu et al., 2013b). Traditional DEMATEL little mentioned the possibility for two analyzed groups to yield different key factors as subjected to identical evaluation criteria. To uncover the differences in the determinants that exist between two analyzed groups, we used the DEMATEL-FDM in the present study.

3. DEMATEL APPROACH

The examination on the determinants of mortgage defaults could be considered a multi-criteria decision-making (MCDM hereafter) problem because its factors contributing to mortgage defaults are highly complex and correlated. Concerning new MCDM concepts and development trends, they have been described in the previous studies (Liou and Tzeng, 2012; Liou, 2013; Peng and Tzeng, 2013). Wu (2008) pointed out that since problems with the MCDM involve multiple criteria, these criteria should all be considered to determine the most appropriate and feasible solution. Only when the appropriate MCDM technique is used, could problems be effectively solved.

The main steps for using MCDM consist of confirming the objective and decision, selecting the evaluation criteria and scale, acquiring and integrating expert opinions, and developing and analyzing the structural model (Wu et al., 2007). The DEMATEL-FDM developed in the present study could be entailed

confirming objectives and decisions, selecting evaluation criteria, identifying key factors, analyzing differences, and performing a comprehensive analysis.

3.1. Step 1: Confirming Objectives of Decisions

We explored the structuralizations of problems and the determinants contributing to credit loan influence each other from structuralizations. To do this, the DEMATEL approach is employed. DEMATEL belong geometry structure model (structural model) analysis techniques, and can the differences between the two groups then were examined to identify the feasible solutions for each problem. We used DEMATEL approach to identify the problem structuralizations and key factors and investigate the direct relationship and strength of relation. Further it would offer the feasible strategy for each problem.

3.2. Step 2: Selecting Evaluation Factor (Criteria)

The evaluation factor (criteria) were selected by referring to previous studies and expert interviews. We adopted a 5-point DEMATEL scale, which partitioned the level of influence into significant influence, high influence, moderate influence, minimal influence, and no influence, where the extents of influence were assigned scores of 4, 3, 2, 1, and 0, respectively.

The definitions of each factor (criteria) contributing the credit loan default are as follows:

A. Borrower financial stability (D1)
    Age (Factor 1): Standing for the age of a borrower. Borrower's age is a standard to judge the length of time to repay; gender (Factor 2); employment duration (Factor 3): Being an indicator of job duration; education level of borrowers (Factor 4): Being an indicators of observing stability of borrowers' employment; Marital status of borrowers (Factor 5): Indicating the responsibility of borrowers.

B. Reimbursement ability (D2)
    Borrower's income (Factor 6): Borrower's income stands for the borrower's income of borrowers which is relevant to borrowers' ability to pay; Income-salary ratio (Factor 7); loan commitments (Factor 8); occupation (Factor 9): Denoting the occupation of borrowers. The occupational category is relevant to the stability and security of employment; Residence ownership (Factor 10).

C. Debt review (D3)
    Credit loan term (Factor 11): Measuring the bank's credit rating for the credit loan and the size of the credit loan default risk; number of credit loans (Factor 12); credit balance of borrower (Factor 13): Being an indicator could probe that the borrowers bear the repayment ability in the future.

D. Credit Card Holders' Credit (Borrower's Cash Flow) (D4)
    Number of overdue card debt (Factor 14); amount of cash advance (Factor 15): Recent overdue credit card (Factor 16); amount of cash advance (Factor 17).

3.3. Step 3 (Identifying Key Factors)

The initial influence matrix () could be obtained by dividing its element of by the maximal value of sum of each column as follows:

$$X_{ij}^* = \begin{bmatrix} 0 & x_{12}^* & \cdots & x_{1n}^* \\ x_{21}^* & 0 & \cdots & x_{2n}^* \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1}^* & x_{n2}^* & \cdots & 0 \end{bmatrix} \quad (1)$$

Where n is number of factors (criteria); the entry x_i denotes the level of total influence that factor (criterion) i. x_{ij} denotes the level of influence that factor (criterion) i has on factor (criterion) j. The standardized direct influence matrix ($X_{CB/LB}$) could be constructed as

$$X_{CB/LB} = \frac{1}{Max\left(\sum_{j=1}^{n} x_{ij}^* \ i = 1, \cdots, n\right)} X_{ij}^* \quad (2)$$

$$X_{CB/LB}^2 + X_{CB/LB}^3 + X_{CB/LB}^4 L = X_{CB/LB}^2 \left(I - X_{CB/LB}\right)^{-1} \quad (3)$$

The total influence relationship matrix (T) could be stated as $T = \{t_{ij}\}$, where I is the identity matrix.

$$T = \{t_{ij}\} = X_{CB/LB} + X_{CB/LB}^2 + X_{CB/LB}^3 + X_{CB/LB}^4 \quad (4)$$

The sum of its entries for each column in matrix T is D_{ij} while the sum of its entries for each row in matrix T is R_{ij}.

3.4. Step 4 (Analyzing Differences: Construction of DEMATEL-FDM)

Determining the key factors contributing to mortgage defaults for CBs and LBs and the differences between the two patterns of mortgage defaults (ΔT) by subtracting the total influence matrix of CBs (T_{CB}) from the total influence matrix of LBs (T_{LB}), the difference (ΔT) is derived as follows:

Assuming $T_{LB} = X_{LB} (I - X_{LB})^{-1}$ and $T_{CB} = X_{CB} (I - X_{CB})^{-1}$, then the difference between the two patterns of mortgage defaults (ΔT) could be written as

$$\Delta T = T_{CB} - T_{LB} = X_{CB} (I-X_{CB})^{-1} - X_{LB} (I-X_{LB})^{-1}$$

$$= X_{CB} (I-X_{CB})^{-1} + X_{LB} (I-X_{CB})^{-1} - X_{LB} (I-X_{CB})^{-1} - X_{LB} (I-X_{LB})^{-1}$$

$$= [X_{CB} (I-X_{CB})^{-1} - X_{LB} (I-X_{CB})^{-1}] + [X_{LB} (I-X_{CB})^{-1} - X_{LB} (I-X_{LB})^{-1}]$$

$$= (X_{CB}-X_{LB}) (I-X_{CB})^{-1} + X_{LB} [(I-X_{CB})^{-1} - (I-X_{LB})^{-1}] \quad (5)$$

Let $B_{CB} = (I-X_{CB})^{-1}$ and $B_{LB} = (I-X_{LB})^{-1}$, then the difference between the two patterns of mortgage defaults (ΔT) of equation (2) could be rewritten as

$$\Delta T = (X_{CB}-X_{LB}) B_{CB} + X_{LB} (B_{CB}-B_{LB}) \quad (6)$$

3.5. Step 5 (Performing a Comprehensive Analysis)

The formula at Step 4 demonstrated the key factors contributing to mortgage defaults for CBs and LBs and the differences between

these factors. Nevertheless, to ensure the feasibility of these results in practice, post expert interviews should be conducted and a comprehensive analysis should also be performed.

4. CASE STUDIES

The difference in the factors causing mortgage defaults for CBs and LBs were coming from direct effects and spillover effects. As reported in Table 1, concerning the difference in factor's prominence ($\Delta(D+R)$) of the direct effects, the values of $\Delta(D+R)$ in all factors are positive, indicating that the CBs' perception of the factors' prominence on mortgage defaults was greater than that perceived by LBs. On the other hand, regarding the difference in relations ($\Delta(D-R)$) of them, both positive and negative values were observed, illustrating that the CBs' and LBs' causal perceptions of factors contributing to mortgage defaults varied.

The top five factors (refer to the rank in column 3 of Table 1) that led to the substantial difference in prominence of the factor's direct effects were loan interest rates (14_{CB-LB}), loan-to-value ratio (9_{CB-LB}), loan period (10_{CB-LB}), borrower's age (1_{CB-LB}), and employment duration (2_{CB-LB}), depicting that CBs attach a higher prominence to these factors than LBs did. On the other hand, the top five factors (refer to the rank in column 4 of Table 1) that directly contributed to the relation differences were loan amount (11_{CB-LB}), loan interest rate (14_{CB-LB}), family income (6_{CB-LB}), credit history (8_{CB-LB}), and changes in house prices (17_{CB-LB}), where loan interest rates (14_{CB-LB}) were negative. It meant that the four factors (loan amount, family income, credit history and changes in house price) as cause factors and loan interest rates as an effect factor.

In respect of the spillover effects, the evidences show that the values of difference in factor's prominence ($\Delta(D+R)$) for CBs and LBs were exclusively positive, demonstrating that the CBs' perception of the factors' spillover effects on mortgage defaults was greater than that perceived by LBs. However, regarding the difference in relations ($\Delta(D-R)$) of the spillover effects, both positive and negative values were obtained, illustrating that the CBs and LBs had varied perceptions on the cause and effect of the factors contributing to mortgage defaults.

The top five factors (refer to the rank in column 5 of Table 1) that brought about the substantial difference in factor's prominence of the indirect effects were unemployment rate (16_{CB-LB}), loan-to-value ratio (9_{CB-LB}), borrower's age (1_{CB-LB}), credit balance (7_{CB-LB}), and loan period (10_{CB-LB}), showing that CBs attach a higher prominence to these factors on mortgage defaults than LBs did. The top five factors (refer to the rank in column 6 of Table 1) that contributed to relation differences were unemployment rate (16_{CB-LB}), economic growth rate (15_{CB-LB}), loan amount (11_{CB-LB}), education level (3_{CB-LB}), and loan-to-value ratio (9_{CB-LB}), where loan amounts (11_{CB-LB}) and loan-to-value ratio (9_{CB-LB}) were negative. It implied that CBs attach a higher relation to the three factors (unemployment rate, economic growth rate, and educational level) than LBs did and that CBs consider the three factors as the cause factors and the other two factors (loan amount and loan-to-value ratio) as the effect factors.

Table 1: Difference in factor contributing mortgage defaults for CBs and LBs

Dimensions	Factor	Direct effects		Spillover effects	
		Δ(D+R)	Δ(D-R)	Δ(D+R)	Δ(D-R)
D1	1_{CB-LB}	3.0204 (4)	−0.6322 (9)	4.6276 (3)	−0.0570 (16)
	2_{CB-LB}	2.8282 (5)	0.4582 (13)	4.0097 (10)	−0.2833 (8)
	3_{CB-LB}	1.9061 (11)	0.1989 (16)	3.9977 (11)	0.4465 (4)
	4_{CB-LB}	1.9304 (10)	0.5544 (11)	4.1555 (8)	0.1443 (13)
	5_{CB-LB}	0.3335 (17)	0.8103 (6)	1.8887 (17)	0.4137 (6)
	6_{CB-LB}	1.7987 (12)	0.9273 (3)	4.2433 (6)	−0.3517 (7)
	7_{CB-LB}	2.4873 (6)	0.3795 (14)	4.5671 (4)	−0.0555 (17)
	8_{CB-LB}	1.4895 (14)	0.8881 (4)	4.2085 (7)	−0.2553 (10)
D2	9_{CB-LB}	3.3510 (2)	0.5646 (10)	4.7870 (2)	−0.4362 (5)
	10_{CB-LB}	3.0481 (3)	0.5127 (12)	4.5326 (5)	−0.2580 (9)
	11_{CB-LB}	1.5737 (13)	1.4891 (1)	3.8287 (12)	−0.6263 (3)
	12_{CB-LB}	2.0775 (8)	−0.7915 (7)	3.6285 (13)	−0.2125 (11)
	13_{CB-LB}	1.3785 (15)	0.0379 (17)	2.6893 (16)	−0.1553 (12)
	14_{CB-LB}	3.6624 (1)	−1.0734 (2)	4.0997 (9)	−0.1293 (14)
D3	15_{CB-LB}	1.1338 (16)	0.3324 (15)	2.8492 (15)	0.7292 (2)
	16_{CB-LB}	2.3628 (7)	−0.6738 (8)	5.2334 (1)	1.1974 (1)
	17_{CB-LB}	2.0427 (9)	−0.8357 (5)	3.1583 (14)	−0.1107 (15)
Mean		2.1426	0.0000	3.9120	0.0000

Based on equation (1) and (2) in the text, we could measure direct effects and spillover effects. Δ(D+R) denotes the difference in factor's prominence; Δ(D-R) is the difference in factor's relations. The number in the parentheses denotes the rank each column. The rank is obtained by the absolute value of Δ(D+R) and Δ(D-R)

It follows from what has been said above that regarding the direct and spillover effects, the CBs' perception of the prominence on the factor contributing to mortgage defaults was greater than that perceived by the LBs. However, as for relations (D-R), the casual perception of CBs and LBs varied. Using the mean of the direct and spillover effects as the basis for measuring the difference in factor's prominence, we obtained the differences in the CBs' and LBs' perceptions of factor's prominence. The total effect (102.9294) consisted of the direct effects (36.4246) accounted for 35.39% and spillover effects (66.5048) accounted for 64.61%. It implied that spillover effects accounted for 64.61% of the reason why CBs and LBs perceived differences in the factor's prominence on mortgage defaults.

By combining the analytical results mentioned above with the expert interviews, we arrived at the conclusion that the DEMATEL-FDM proposed in this study could accurately identify the determinants of mortgage defaults for CBs and LBs as well as differences in their perception. The direct effects and spillover effects have on the perception differences could also be assessed. However, subsequent studies should also investigate the weight that the CBs and LBs attach to the key factors causing mortgage defaults and quantify their differences.

5. CONCLUSION

This study proposed the DEMATEL-FDM for exploring the factors related to mortgage defaults to structuralize the problem and to locate the key factors. We then recognized the differences between the two mortgage default patterns. The results showed the evidence that factors located in the first area(I), which were unemployment rate, borrower's age, and loan period, were determinants contributing to mortgage defaults for both CBs and LBs. As far as the most critical factor affecting mortgage defaults

concerned, it was loan interest rates for CBs and unemployment rate for LBs.

The present study explored DEMATEL-FDM by combining the unique characteristics and advantages of DEMATEL and FDM. It might effectively converts a group of complex factors into a structuralized problem and employs easy-to-read causal diagrams to help users to uncover the structural layout of the problems as well as their distribution, enabling readers to identify the determinants. Decision-makers could then focus on the key factors and reflect on the cause and effect relationship between these factors to enhance the quality of their decisions. It is noteworthy that the limitations of DEMATEL were overcome in the DEMATEL-FDM by combining it with FDM.

Our DEMATEL-FDM is maybe widely applicable; yet, should the evaluation factor increase or decrease, different analytical results and management implications might transpire. Concerning research recommendations for subsequent studies, we suggest the inclusion of weights in addition to the key factors contributing to mortgage defaults for CBs and LBs before similarities and differences are made. Moreover, future researchers should formulate the decisions based on the causal diagram for the two analyzed groups and compare their similarities and differences. Besides, prospective studies might evaluate whether the inclusion of the Five C's of Credit and/or the Five P's of Credit could enhance the results.

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