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Prediction of default probability in banking industry using CAMELS index: A case study of Iranian banks

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A B S T R A C T

This study examines the relationship between CAMELS index and default probability among 20 Iranian banks. The proposed study gathers the necessary information from their financial statements over the period 2005-2011. The study uses logistic regression along with Pearson correlation analysis to consider the relationship between default probability and six independent variables including capital adequacy, asset quality, management quality, earning quality, liquidity quality and sensitivity of market risk. The results indicate that there were no meaningful relationship between default probability and three independent variables including capital adequacy, asset quality and sensitivity of market risk. However, the results of our statistical tests support such relationship between default probability and three other variables including management quality, earning quality and liquidity quality.

1. Introduction

The CAMEL ratings system is a technique of assessing the health of credit unions by the National Credit Union Administration(NCUA) (Basel Committee on Banking Supervision, 2005; Bessis, 2005; Vassalou & Xing, 2004). The rating is based on five critical elements of a credit union's operations including capital, asset quality, management, earnings and asset liability management. Measuring the effects of default probability plays an important role on making managerial financial decisions and there are literally many studies associated with this issue. Zeitun et al. (2007) investigated the impact of cash flow and free cash flow on corporate failure in the emerging market in particular Jordan using. They used the information of two samples including matched sample and a cross-sectional time-series over the period 1989-2003. They also used LOGIT models to study the relationship between firms' financial health and the probability of default. They reported that there was firm's free

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cash flow increases corporate failure and firm's cash flow decreased corporate failure. While firms' capital structures played essential role on predicting default, capital structure was observed as the main factor influencing the probability of default as it affected a firm's ability to access external sources of funds. They concluded that Jordanian firms depended on short-term debt for both short and long term financing.

According to Osherson et al. (1991), A probability is normally called "default" if it is neither derived from pre-established probabilities nor based on considerations of frequency or symmetry. Default probabilities is assumed to occur through reasoning based on causality and similarity. Osherson et al. (1991) advanced a technique of default probability based on a featural method to similarity and examined the accuracy of the model by comparing its predictions to the probabilities provided by undergraduates asked to reason about mammals.

Boyes et al. (1989) recommended that the traditional view that emphasizes default probability was too narrow and their model of credit assessment concentrated on expected earnings. They explained how maximum likelihood estimates of default probabilities could be achieved from a bivariate 'censored probit' framework based on a 'choice-based' sample originally intended for discriminant analysis. They concluded with recommendations for combining these default probability estimated with other parameters of the loan earnings process to compute a more meaningful model of credit assessment. Finally, Zhou (2001) in an investigation analyzed the relationship between default correlations and multiple defaults.

2. The proposed study

The proposed study of this paper examines the relationship between CAMELS index and default probability (Chiu, 2005) among 20 Iranian banks. The proposed study gathers the necessary information from their financial statements over the period 2005-2011. The study uses logistic regression along with Pearson correlation analysis to consider the relationship between default probability and six independent variables including capital adequacy, asset quality, management quality, earning quality, liquidity quality and sensitivity of market risk (Fiordelisi et al., 2010). The proposed study uses the following regression model,

$$DP_{i,t} = \beta_0 + \beta_1 CA_{i,t} + \beta_2 AQ_{i,t} + \beta_3 MQ_{i,t} + \beta_4 EQ_{i,t} + \beta_5 LQ_{i,t} + \beta_6 SM_{i,t} + \varepsilon_i,$$

where $DP_{i,t}$ represents default probability as dependent variable and $CA_{i,t}$, $\beta_2 AQ_{i,t}$, $MQ_{i,t}$, $\beta_4 EQ_{i,t}$, $LQ_{i,t}$ and $SM_{i,t}$ are capital adequacy, asset quality, management quality, earning quality, liquidity quality and sensitivity of market risk, respectively. In addition β_i, $i=0,\ldots,6$ represent coefficients to be estimated and ε_i represents residuals.

As stated, the proposed study uses the information of 20 different banks and Table 1 demonstrates the information of these banks in terms of ownership types in various years.

Table 1
The information of ownership type

Ownership	2005	2006	2007	2008	2009	2010	2011	Total
Governmental	9	9	9	9	10	7	7	60
Private	7	7	7	7	7	13	13	61
Total	16	16	16	16	17	20	20	121

As we can observe from the results of Table 1, the number of private banks has been increased from 7 to 13 over the period 2005-2011 and part of is due to privatization efforts accomplished by government. In addition, Table 2 demonstrates the results of some basic statistics on the data.

Table 2
The summary of some basic statistics

	N Statistic	Mean Statistic	Std. Deviation Statistic	Variance Statistic
CA	121	0.116	0.139	0.019
AQ	121	14.074	6.762	45.725
MQ	121	0.590	0.304	0.437
EQ	121	0.474	0.239	0.057
LQ	121	0.538	0.208	0.043
SM	121	13.034	8.575	73.541
DP	121	0.50	0.502	0.252

We first perform Kolmogorov-Smirnov to understand whether the data are normally distributed or not and the results of observation are summarized in Table 3 as follows,

Table 3
The summary of Kolmogorov-Smirnov

	N	Statistics	Level of significance
CA	121	3.039	.000
AQ	121	.791	.558
MQ	121	2.762	.000
EQ	121	1.848	.002
LQ	121	2.339	.000
SM	121	.748	.631
DP	121	3.767	0.000

The results of Table 3 show that five variables of capital adequacy, management quality, earning quality, liquidity quality and default probability are not normally distributed but two variables of assets quality and default probability are normally distributed. We also need to make sure there is no strong correlations among independent variables and this can be accomplished using VIF test summarized in Table 4 as follows,

Table 4
The summary of VIF test

	N	Statistics	Level of significance
CA	121	2.770	.361
AQ	121	2.391	.418
MQ	121	1.593	.628
EQ	121	1.800	.555
LQ	121	1.219	.820
SM	121	1.535	.651

As we can observe from the results of Table 4, the VIF value for the first two items, capital adequacy and asset quality are greater than 2 and we can conclude there is a correlation between these two variables, which is mainly because of the existing inflation rate. However, according to VIF test results, the other variables are not linearly correlated.

3. The results

In this section, we present details of our investigation on testing various hypotheses and this survey. We first perform Pearson correlation test between default probability and six independent variables using the following hypothesis,

$$\begin{cases} H_0 : \rho = 0 \\ H_1 : \rho \neq 0 \end{cases}$$

where the null hypothesis states there is no correlation and alternative hypothesis states there is a correlation between default probability and independent variable. Table 5 demonstrates the results of our survey,

Table 5
The summary of Pearson correlation test

	N	Statistics	Level of significance
CA	121	0.146	.109
AQ	121	-0.143	.143
MQ	121	-0.218	.0216
EQ	121	-0.262	.004
LQ	121	0.180	.048
SM	121	0.115	.208

The results of Table 5 show that there is a meaningful relationship between earning quality, management quality as well as liquidity quality and default probability and there is no meaningful relationship default probability and capital adequacy, asset quality as well as sensitivity management and default probability. We have also investigated correlation ratio between independent variables and Table 6 summarizes the results of our survey.

Table 6
The summary of correlation test

Variable		CA	AQ	MQ	EQ	LQ	SM
CA	Coefficient	1	-0.711	0.580	-0.375	0.594	-0.513
	P-Value		0.000	0.000	0.000	0.000	0.000
AQ	Coefficient	-0.991	1	-0.443	0.255	-0.280	0.587
	P-Value	0.000		0.000	0.005	0.002	0.000
MQ	Coefficient	0.493	-0.493	1	0.122	0.582	-0.149
	P-Value	0.000	0.000		0.182	0.000	0.102
EQ	Coefficient	-0.208	0.193	0.267	1	0.094	0.654
	P-Value	0.022	0.034	0.003		0.304	0.000
LQ	Coefficient	0.248	-0.261	0.490	0.406	1	0.042
	P-Value	0.006	0.004	0.000	0.000		0.647
SM	Coefficient	-0.538	0.537	-0.036	0.684	0.269	1
	P-Value	0.000	0.000	0.696	0.000	0.003	

According to the results of Table 6, there are some meaningful relationships correlation between CA and AQ, MQ, EQ, LQ and SM. There is also a meaningful relationship between AQ and MQ, LQ and SM when the level of significance is five or even one percent.

The main hypothesis of this survey investigates whether we can predict default probability using CAMEL indexes or not. Therefore, we study the following hypothesis,

$$\begin{cases} H_0 : \beta_{X_1, \ldots, X_{10}} = 0 \\ H_1 : \beta_{X_1, \ldots, X_{10}} \neq 0 \end{cases}$$

In order to test the above hypothesis, we use "Omnibus Tests of Model Coefficients" statistical test. Table 7 summarizes the results of our survey.

Table 7
The summary of Omnibus Tests of Model Coefficients test

		Chi-square	Df	Sig.
Step 1	Step	16.902	6	0.010
	Block	16.902	6	0.010
	Model	16.902	6	0.010

The results of Omnibus Tests of Model Coefficients test indicate that independent variable influences dependent variable, significantly and we can precede the regression analysis. The results of Cox & Snell R Square and Nagelkerke R Square are 0.128 and 0.171, respectively. Therefore, we can perform the regression analysis and the results are summarized in Table 8 as follows,

Table 8
The summary of logistic regression analysis

Variable	B	S.E.	Wald	Df	Sig.	Exp(B)
Constant	0.687	1.432	0.230	1	0.613	1.988
CA	-3.257	3.043	1.146	1	0.284	0.038
AQ	-.026	0.052	0.261	1	0.610	0.974
MQ	-1.552	0.920	2.847	1	0.092	0.212
EQ	-3.132	1.588	3.890	1	0.047	0.044
LQ	5.004	2.270	4.858	1	0.028	148.998
SM	-.017	0.040	0.183	1	0.669	0.983

In Table 8, the column B represents the estimated coefficients of the proposed study. We have used the results of regression analysis and Table 9 shows the percentages of default and non-default probabilities.

Table 9
The results of default and non-default

		Regression results		Correct percentage
		Non-default	default	
Default regression	Non-default	36	24	63.1
	Default	20	41	66.7
Total percentage				67.4

According to the results of Table 9, default and non-default are predicted, properly with the probabilities of 66.7% and 63.1%, respectively. The results of Table 8 also indicate that three variables were not statistically significant and using stepwise regression technique, we modify the model and the results are summarized as follows,

Table 10
The summary of logistic regression analysis

Variable	B	S.E.	Wald	Df	Sig.	Exp(B)
Constant	0.104	0.950	0.12	1	0.913	1.110
MQ	-1.508	0.898	2.819	1	0.093	0.221
EQ	-2.800	1.153	5.900	1	0.015	0.061
LQ	3.969	1.912	4.308	1	0.038	52.930

In Table 10, the column B represents the estimated coefficients of the proposed study. We have used the results of regression analysis and Table 11 shows the percentages of default and non-default probabilities.

Table 11
The results of default and non-default

		Regression results		Correct percentage
		Non-default	default	
Default regression	Non-default	33	27	66.1
	Default	21	40	65.6
Total percentage				67.8

According to the results of Table 11, default and non-default are predicted, properly with the probabilities of 66.1% and 65.6%, respectively. The results indicate that there are no meaningful

relationship between default probability and three independent variables including capital adequacy, asset quality and sensitivity of market risk. However, the results of our statistical tests support such relationship between default probability and three other variables including management quality, earning quality and liquidity quality. Table 12 summarizes the results of our regression analysis.

Table 12
The summary of testing six hypotheses, Dependent variable = Default probability (DP)

	Variables		Regression analysis			
Hypothesis	Dependent	Independent	$\beta_X = 0$	$\beta_X \neq 0$	Path	Result
First	DP	CA	√	×	-	Not-confirmed
Second	DP	AQ	√	×	-	Not-confirmed
Third	DP	MQ	×	√	-	Confirmed
Fourth	DP	EQ	×	√	-	Confirmed
Fifth	DP	LQ	×	√	+	Confirmed
Sixth	DP	MS	√	×	-	Not-confirmed

4. Conclusion

In this paper, we have presented an empirical investigation to study the impacts of six factors on default probability in Iranian banking sector. The proposed study has gathered the necessary information from most private and governmental banks in Iran. The study has implemented logistic regression technique to examine different hypotheses. The results of logistic analysis on relationship between default probability and six independent variables including capital adequacy, asset quality, management quality, earning quality, liquidity quality and sensitivity of market risk have indicated that there were no meaningful relationship between default probability and three independent variables including capital adequacy, asset quality and sensitivity of market risk. However, the results of our statistical tests supported such relationship between default probability and three other variables including management quality, earning quality and liquidity quality.

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