ANALYSIS OF CREDIT RISK THROUGH THE TRANSITION MATRIX METHODOLOGY IN THE SAVINGS AND CREDIT COOPERATIVE "FERNANDO DAQUILEMA" LTDA

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ABSTRACT

The purpose of this research was to ANALYZE THE CREDIT RISK THROUGH THE TRANSITION MATRIX METHODOLOGY IN THE SAVINGS AND CREDIT COOPERATIVE "FERNANDO DAQUILEMA" LTDA., In order to strengthen the comprehensive risk management, based on requirements of models and procedures of monitoring required by the Superintendency of Popular and Solidarity Economy (SEPS) control entity, for the construction of the matrices historical information was compiled from the periods March 2018 - April 2019 monthly in order to know the improvement or deterioration of the qualification of an obligation.

The results achieved in the present investigation is to have known the current situation of the financial institution, given its weaknesses it was recommended to minimize its operating expenses to improve its profitability and efficiency, in addition a deficit of its portfolio provisions was found calculated the expected loss for which was suggested to review its methodology for granting credit in order to find weaknesses in the process.

Keywords: *Transition matrix, Probability of default, Expected loss, Credit risk*

1 INTRODUCTION

The purpose of this study is to analyze credit risk through the transition matrix methodology in the Savings and Credit Cooperative "Fernando Daquilema Ltda.".

When analyzing credit risk through the transition matrix methodology, it is intended that the institution under studymonitor credit risk in order to minimize losses due to deterioration of the credit portfolio.

It is expected that the realization of this study may be useful for consultation and discussion of those who can access the document as students and professionals related to the subject.

2 BACKGROUND

According to the research carried out by [1],(Villarreal & Medina, 2011) whose work is entitled "Estimation of transition matrices for the commercial portfolio of Ecuadorian financial entities controlled by the Superintendency of Banks and Insurance", the main objective of this research is "To elaborate a model that allows estimating the transition **matrices for the financial entities controlled by the Superintendency of Banks and Insurance",** During the investigative process, the following conclusions were reached:

- The methods used for the transition matrix are: discrete and continuous, showing that the continuous method is more efficient and has greater advantages than the discrete, since the continuous method has a smaller margin of error.
- Transition matrices are reliable and efficient tools, although the estimates made by the continuous method are more real than the results obtained after applying the discrete method.
- The continuous method does not underestimate the probabilities of performing indirect migrations however the application of the discrete method is simpler
- The theory of transition matrices provide elements of great relevance for the reduction of credit risk, this being one of the most important factors to forecast the change in quality in which credit portfolios are affected in a given period of time.

3 ADMINISTRATION OF RIESGOR REVENUE

According to [2] credit risk was, and remains, the main cause of the multiple critical episodes that the world's banking systems have experienced in the last twenty years. The goal of credit risk management is to maximize the risk-adjusted rate of return by keeping exposure to credit risk within acceptable limits. Institutions have to manage the credit risk inherent in the entire portfolio and the risk in individual credits or transactions. Effective credit risk management is a critical component of a comprehensive approach to risk management and is essential to the long-term success of any banking organization. Credit institutions must establish efficient schemes for the administration and control of the credit risk to which they are exposed in the development of the business, in resonance with their own risk profile, market segmentation, according to the characteristics of the markets in which they operate and the products they offer; Therefore, it is necessary for each entity to develop its own work scheme, which ensures the quality of its portfolios and also allows identifying, measuring, controlling / mitigating and monitoring counterparty risk exposures and expected losses, in order to maintain adequate coverage of provisions or technical equity.(Valencia & Zambrano, 2012)

4 CREDIT RISK IN BASEL II

[3] (Paredes Vallejos, 2018) It states that the most important standard issued by the Basel Committee is the Minimum Capital Accord in 1988.

This agreement established that financial institutions must maintain a level of own capital, at all times, equivalent to 8% of their risk-weighted assets.

At that time, the capital requirement was required to cover the credit risk of its assets and contingents.

In Ecuador, a regulatory capital or solvency level of 9% is required and the indicator is calculated with the following formula: CONSTITUTED TECHNICAL ASSETS / RISK-WEIGHTED ASSETS AND CONTINGENTS >= 9%

In 2004, the Basel Committee decided to strengthen the 1988 Capital Accord, incorporating capital requirements for operational risk and market risk and a renewed approach that incorporates the need for adequate risk management.

This New Capital Agreement was called Basel II and consists of 3 pillars:

▪ Pillar I: Capital requirements

▪ Pillar II: Supervisory review

▪ Pillar III: Market discipline

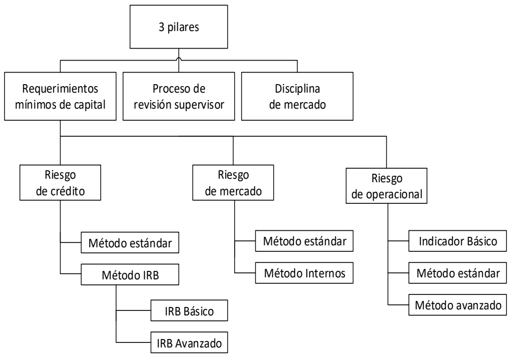

Figure 1 New Capital Framework
Source: Basel II, BCBS, 2004 and 2006

5 PROBABILITY OF DEFAULT (PD)

According to [4] (Paredes Vallejos, 2018) default occurs when the debtor does not pay what was agreed. Although it seems simple, it is not so simple in practice:

- Not necessarily an operation with a day of arrears is an unfulfilled operation.
- Delinquency is not the only factor that gives us the pattern of non-compliance. Non-compliance is also associated with the modification of the conditions initially agreed in the credit agreement.
- A borrower who seems to be in good standing on his payments may default. Ex: continuous refinancing to the debtor without which he could not pay what was agreed.
- A borrower who appears to be delinquent may not be; For example, if the non-payment is due to "technical" reasons, beyond its control, which can be remedied in the short term.

5 MATRIX OF TRANSICIÓN

The transition matrix is a tool that allows to determine the probability that a loan with a certain rating changes its credit rating during a specific period, allowing, in the case of a financial institution, to study the possible deterioration or improvement that its client portfolio could present in the future.

[5] (Támara & Aristizábal, 2010) He mentions that JP Morgan's Creditmetrics application was developed in 1997 and uses transition matrices to measure credit risk. For our case it is defined P_{ij} as the probability that a debtor with credit rating i can "migrate" or move to another credit rating j in a given time horizon. Based on the above, it is possible to construct a matrix of transition probabilities A with i rows and j columns, in such a way that they satisfy the following conditions:

1. All elements of the matrix are non-negative, therefore, $P_{ij} > 0$.
2. The sum of the elements of each row is equal to 1, therefore $\sum P_{ij} = 1$ for all i.

If we call A as the matrix of transition probabilities with a given time horizon, it can be represented in a general way as:

Table 1 Transition probability matrix

Categorys before transition	Category after transition				
	1	2	3	…	j (default)
1	P11	P12	P13		P1j

2	P21	P22	P23		P2j
…					…
…					…
i-1	P(i-1)1	P(i-1)2	P(i-1)3	…	P(i-1) j
i (default)	0	0		…	1

Fountain: (Támara & Aristizábal, 2010)
Prepared by: Pilco (2019)

Where P_{ij} represents the fraction of credits with grade i that have a month after grade j.

6 EXPECTED LOSS (PE)

According to [6] (Book I Control Standards for Financial Sector Entities, 2018, p. 1) it defines:

Expected loss e s theexpected value of credit risk loss over a given time horizon, resulting from the probability of default, the level of exposure at the time of default and the severity of loss:

$$PE = E * pi * (1 - r)$$

Credit risk exposure level (E). - It is the present value (at the time of default) of the flows expected to be received from credit operations.

Probability of Default (pi). - It is the possibility of partial or total breach of a payment obligation or the breaking of a credit agreement in a given period.

Recovery rate (r). - It is the percentage of the collection made on credit operations that have been defaulted.

Severity of loss (1 - r). - It is the measure of the loss that the controlled institution would suffer after having taken all the steps to recover the credits that have been breached, execute the guarantees or receive them as a dation in payment. The severity of the loss is equal to (1 -Recovery rate).

Unexpected loss (NSP). - It is the value not expected by the variations of the losses.

Economic capital. - Minimum capital that a financial institution must have in order to cover potential losses due to risk. It is the difference between unexpected loss and expected loss.

7 TRANSITION MATRIX CONSTRUCTION PROCEDURE

The transition matrices were prepared from the monthly ratings based on the days of maturity according to the regulations, for each operation registered in the period of one year (March 2018 – April 2019), according to the definitions given by the control body, SEPS.

Se established the following steps:

1. A database was formed with the variables from the C02 structure (Granted Operations) managed by the SEPS for the control of operations of the cooperatives of segment one (1). The fields used for drawingup the database are:

a) *Operation number (ccuenta).* - Unique code with which the financial institution identifies each operation it carries out.
b) *Type of credit (Tipo_Prestamo).* - Code that identifies the type of credit granted by the entity.
c) *Qualification (rating). - It is the rating assigned to the* risk category, according to the parameters established for rating risk assets.

d) *Debt balance (Total_deuda)*. - It is the current debt capital that accounts for the fields balance due fordue, balance that does not accrue interest and overdue balance.

Table 2 Credit operations granted

C_CUENTA	TIPO_PRESTAMO	CALIFICACION	TOTAL_DEUDA
062000000303	CONSUMO PRIORITARIO	A - 1	5963,44
064000095406	MICROCREDITO	E - 1	385,79
064000096406	MICROCREDITO	A - 1	1275,95
064000097406	MICROCREDITO	A - 1	1966,49
064000097296	MICROCREDITO	E - 1	696,11
062000000333	CONSUMO PRIORITARIO	A - 1	2424,03
064000097432	MICROCREDITO	E - 1	354,39
064000097608	MICROCREDITO	E - 1	6692,31
062000000301	CONSUMO PRIORITARIO	A - 2	6008,48
064000096360	MICROCREDITO	E - 1	451,22
064000096672	MICROCREDITO	E - 1	360,62
064000096468	MICROCREDITO	D - 1	624,03

Source: Credit portfolio bases COAC Fernando Daquilema (2019)
Prepared by: Pilco (2019)

2. With the "Rating" field described in point one (1), a monthly transition was made with respect to the previous month, where the states correspond to each of the nine risk categories (ratings) (A – 1, A – 2, A – 3, B – 1, B – 2, C – 1, C – 2, D – 1, D – 2, E – 1). This process was carried out for each month from March 2018 - April 2019.

Table 3 to April 2018

CCUENTA	TIPOPRESTAMO	mar-18	abr-18	Transición abril 2018	TOTALDEUDA
064000020378	MICROCREDITO	E - 1	E - 1	E - 1E - 1	$ 1,018.00
064000026366	MICROCREDITO	E - 1	E - 1	E - 1E - 1	$ 802.90
064000027500	MICROCREDITO	E - 1	E - 1	E - 1E - 1	$ 448.92
064000035846	MICROCREDITO	E - 1	E - 1	E - 1E - 1	$ 2,604.18
064000035680	MICROCREDITO	E - 1	E - 1	E - 1E - 1	$ 435.90

Source: Credit portfolio bases COAC Fernando Daquilema (2019)
Prepared by: Pilco (2019)

3. It is stored in a matrix, the pairs of grades for each grade category (nine categories), through a simple count of pairs with the formula contar.si (range, criterion) or using a pivot table.

A matrix is created for each month that we have built the transition

Table 4 Storage of transitions by category

LINEA MICROCREDITO	A-1	A-2	A-3	B-1	B-2	C-1	C-2	D-1	E-1	Cancelada
A-1	6533	195	70	0	0	0	0	0	0	5013
A-2	326	298	0	65	0	0	0	0	0	169
A-3	51	6	35	7	48	0	0	0	0	65
B-1	9	8	1	21	2	41	0	0	0	30
B-2	5	0	5	1	10	0	24	0	0	9
C-1	0	3	0	3	2	11	0	26	0	11
C-2	1	0	1	0	3	0	3	23	0	9
D-1	1	0	0	1	1	2	4	5	36	12
E-1	0	0	0	0	1	0	4	1	229	96

Source: Monthly transition microcredit segment
Prepared by: Pilco (2019)

Table 5 Transition Storage with PivotTable

Cuenta de abr-19 as d										
Etiquetas de fil	**A-1**	**A-2**	**A-3**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**E-1**	**Cancelada**
A-1	6533	195	70							5013
A-2	326	298		65						169
A-3	51	6	35	7	48					65
B-1	9	8	1	21	2	41				30
B-2	5		5	1	10		24			9
C-1		3		3	2	11		26		11
C-2	1		1		3		3	23		9
D-1	1			1	1	2	4	5	36	12
E-1					1		4	1	229	96

Source: Monthly transition microcredit segment
Prepared by: Pilco (2019)

4. From the matrices with monthly frequencyis obtained , a unified matrix was obtained that takes the average of each pair established in the matrices.

Table 6 Average transition matrix Microcredit

	A - 1	A - 2	A - 3	B - 1	B - 2	C - 1	C - 2	D - 1	E - 1	Canceladas	Total
A - 1	6.847	233	73	2	-	-	-	-	-	3.932	11.088
A - 2	271	284	3	62	1	-	-	-	-	131	751
A - 3	41	5	31	5	42	0	-	-	-	44	169
B - 1	8	11	1	20	2	39	0	-	-	24	104
B - 2	5	0	4	1	10	0	26	1	-	9	56
C - 1	1	3	-	3	1	10	0	28	-	10	55
C - 2	1	0	1	-	2	0	4	24	1	8	41
D - 1	1	0	0	1	1	2	3	7	42	11	66
E - 1	1	0	-	0	1	0	2	1	683	156	844

Source: Monthly transition microcredit segment
Prepared by: Pilco (2019)

5. With the average matrix the conditional probability matrix is obtained, dividing each value of the cells of the matrix for the total of observations for the respective row, illustrated in the following:

Table 7 Conditional probability matrix

$$P = \begin{pmatrix} \frac{6.847}{11.088} & \frac{233}{11.088} & \frac{73}{11.088} & \frac{2}{11.088} & \frac{-}{11.088} & \frac{-}{11.088} & \frac{-}{11.088} & \frac{-}{11.088} & \frac{-}{11.088} & \frac{3.932}{11.088} \\ \frac{271}{751} & \frac{284}{751} & \frac{3}{751} & \frac{62}{751} & \frac{1}{751} & \frac{-}{751} & \frac{-}{751} & \frac{-}{751} & \frac{-}{751} & \frac{131}{751} \\ \frac{41}{169} & \frac{5}{169} & \frac{31}{169} & \frac{5}{169} & \frac{42}{169} & \frac{0}{169} & \frac{-}{169} & \frac{-}{169} & \frac{-}{169} & \frac{44}{169} \\ \frac{8}{104} & \frac{11}{104} & \frac{1}{104} & \frac{20}{104} & \frac{2}{104} & \frac{39}{104} & \frac{0}{104} & \frac{-}{104} & \frac{-}{104} & \frac{24}{104} \\ \frac{5}{56} & \frac{0}{56} & \frac{4}{56} & \frac{1}{56} & \frac{10}{56} & \frac{0}{56} & \frac{26}{56} & \frac{1}{56} & \frac{-}{56} & \frac{9}{56} \\ \frac{1}{55} & \frac{3}{55} & \frac{-}{55} & \frac{3}{55} & \frac{1}{55} & \frac{10}{55} & \frac{0}{55} & \frac{28}{55} & \frac{-}{55} & \frac{10}{55} \\ \frac{1}{41} & \frac{0}{41} & \frac{1}{41} & \frac{-}{41} & \frac{2}{41} & \frac{0}{41} & \frac{4}{41} & \frac{24}{41} & \frac{1}{41} & \frac{8}{41} \\ \frac{1}{66} & \frac{0}{66} & \frac{0}{66} & \frac{1}{66} & \frac{1}{66} & \frac{2}{66} & \frac{3}{66} & \frac{7}{66} & \frac{42}{66} & \frac{11}{66} \\ \frac{1}{844} & \frac{0}{844} & \frac{-}{844} & \frac{0}{844} & \frac{1}{844} & \frac{0}{844} & \frac{2}{844} & \frac{1}{844} & \frac{683}{844} & \frac{156}{844} \end{pmatrix}$$

Source: Monthly transition microcredit segment
Prepared by: Pilco (2019)

8 RESULTS OBTAINED

Below is the average transition matrix excluding cancelled operations, a result that was used to calculate the probability of default.

Table 8 Transition matrix Microcredit without cancelled operations

TOTAL _PROMEDIO	A - 1	A - 2	A - 3	B - 1	B - 2	C - 1	C - 2	D - 1	E - 1	Suman
A - 1	95,69%	3,26%	1,02%	0,03%	0,00%	0,00%	0,00%	0,00%	0,00%	100%
A - 2	43,66%	45,74%	0,41%	9,98%	0,21%	0,00%	0,00%	0,00%	0,00%	100%
A - 3	32,93%	4,13%	24,98%	3,73%	34,04%	0,19%	0,00%	0,00%	0,00%	100%
B - 1	10,20%	13,35%	1,05%	24,74%	1,95%	48,47%	0,24%	0,00%	0,00%	100%
B - 2	10,12%	0,33%	8,55%	1,56%	20,97%	0,99%	56,33%	1,15%	0,00%	100%
C - 1	2,01%	5,78%	0,00%	6,04%	2,93%	21,71%	0,92%	60,60%	0,00%	100%
C - 2	3,73%	0,12%	2,21%	0,00%	6,64%	0,35%	13,17%	72,26%	1,52%	100%
D - 1	1,93%	0,21%	0,21%	1,04%	1,31%	2,90%	4,70%	11,81%	75,90%	100%
E - 1	0,10%	0,04%	0,00%	0,03%	0,10%	0,03%	0,35%	0,13%	99,23%	100%

Source: Monthly transition microcredit segment
Prepared by: Pilco (2019)

To perform the analysis, the average transition matrix is presented, according to the monthly information obtained from the respective tables.

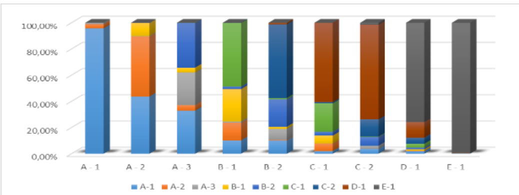

Figure 2 Average transition matrix
Source: Average transition matrix

ESTIMATION OF PROBABILITY OF DEFAULT

Based on the transition matrix, the probability of default or default point can be estimated, which indicates that, from that category, a partner can completely stop paying its obligations. The default point has been defined at 50%, therefore, when determining the probability of deterioration (sum of each row from the upper diagonal), the rating category that first exceeds the value of 50% will determine the default point. In the analyzed matrix, we can see that the default point is in category B-2, which indicates that a partner that reaches this category will stop honoring its obligations and the operation must provision 100%.

Table 9 One-step transition matrix

TOTAL _PROMEDIO	A - 1	A - 2	A - 3	B - 1	B - 2	C - 1	C - 2	D - 1	E - 1
A - 1	95,69%	3,26%	1,02%	0,03%	0,00%	0,00%	0,00%	0,00%	0,00%
A - 2	43,66%	45,74%	0,41%	9,98%	0,21%	0,00%	0,00%	0,00%	0,00%
A - 3	32,93%	4,13%	24,98%	3,73%	34,04%	0,19%	0,00%	0,00%	0,00%
B - 1	10,20%	13,35%	1,05%	24,74%	1,95%	48,47%	0,24%	0,00%	0,00%
B - 2	10,12%	0,33%	8,55%	1,56%	20,97%	0,99%	56,33%	1,15%	0,00%
C - 1	2,01%	5,78%	0,00%	6,04%	2,93%	21,71%	0,92%	60,60%	0,00%
C - 2	3,73%	0,12%	2,21%	0,00%	6,64%	0,35%	13,17%	72,26%	1,52%
D - 1	1,93%	0,21%	0,21%	1,04%	1,31%	2,90%	4,70%	11,81%	75,90%
E - 1	0,10%	0,04%	0,00%	0,03%	0,10%	0,03%	0,35%	0,13%	99,23%

PUNTO DEFAULT	
A - 1	4,31%
A - 2	10,60%
A - 3	37,96%
B - 1	50,67%
B - 2	58,47%
C - 1	61,53%
C - 2	73,78%
D - 1	75,90%
E - 1	99,23%

Source: Microcredit segment transition matrix
Prepared by: Pilco (2019)

This matrix represents the first transition of monthly qualifications per operation, each matrix is called "one-step transition matrix" and constitutes the starting point for the transition process to one year through Markov chains. As our goal is to have the probability of non-compliance to one year, a transition matrix will be used in 12 steps, each step represents a monthly transition, since we have the monthly records of grades.

By properties of the transition matrix, cagives transition matrix to 1,2,3... 10,11,12 steps, is obtained by multiplying by itself the initial transition matrix P, that is, if I require a transition matrix to 6 steps, P6, the calculation will be as follows:

$$P^6 = P * P * P * P * P * P$$

Therefore, the matrix that we require at 12 months will be:

$$P^{12} = P * P * P * P * P * P * P * P * P$$

In this way, the transition matrix containing the probabilities of default on credit ratings is calculated, part of the calculated matrices is shown and the final transition matrix to 12 steps, thefinal matrix obtained is as follows:

Table 10 Microcredit Transition Matrix twelve (12) steps

TOTAL _PROMEDIO	A - 1	A - 2	A - 3	B - 1	B - 2	C - 1	C - 2	D - 1	E - 1
A - 1	78,69%	5,17%	1,21%	0,86%	0,65%	0,59%	0,53%	0,86%	11,44%
A - 2	71,26%	4,69%	1,10%	0,79%	0,61%	0,54%	0,53%	0,85%	19,64%
A - 3	52,72%	3,49%	0,82%	0,60%	0,50%	0,43%	0,54%	0,80%	40,08%
B - 1	35,89%	2,40%	0,57%	0,43%	0,41%	0,33%	0,54%	0,77%	58,66%
B - 2	26,57%	1,80%	0,43%	0,34%	0,35%	0,27%	0,55%	0,75%	68,94%
C - 1	17,01%	1,18%	0,29%	0,24%	0,30%	0,22%	0,55%	0,73%	79,49%
C - 2	13,20%	0,94%	0,24%	0,20%	0,27%	0,19%	0,55%	0,72%	83,68%
D - 1	7,58%	0,57%	0,15%	0,15%	0,24%	0,16%	0,56%	0,70%	89,89%
E - 1	4,22%	0,36%	0,10%	0,11%	0,22%	0,14%	0,56%	0,70%	93,59%

PUNTO DEFAULT	
A - 1	21,31%
A - 2	24,06%
A - 3	42,96%
B - 1	60,71%
B - 2	70,51%
C - 1	80,77%
C - 2	84,40%
D - 1	89,89%
E - 1	93,59%

Source: One-step transition matrix
Prepared by: Pilco (2019)

By having the forecast of the probability of default to one year, we can show that the default point changes category to B-1, from this category, the default will be 100%. The probability of non-compliance will be the sum of the upper diagonal for each category.

This information is one more component that will serve for the calculation of the expected loss.

Table 11 and probability of default

TOTAL _PROMEDIO	A - 1	A - 2	A - 3	B - 1
A - 1	78,69%	5,17%	1,21%	14,93%
A - 2	71,26%	4,69%	1,10%	22,96%
A - 3	52,72%	3,49%	0,82%	42,96%
B - 1	0,00%	0,00%	0,00%	100,00%

RIESGO	Probabilidad de incumplimiento a un año
A - 1	14,93%
A - 2	22,96%
A - 3	42,96%
B - 1	100,00%
B - 2	100,00%
C - 1	100,00%
C - 2	100,00%
D - 1	100,00%
E - 1	100,00%

Source: Twelve-step transition matrix

Prepared by: Pilco (2019)

CALCULATION OF EXPECTED LOSS

For thecalculation of the expected loss, the parametric method and the probability of non-compliance obtained through the transition matrices were used.

Recall that the expected loss is calculated as:

$$PE = E * pi * (1 - r)$$

PE = expected loss
E = balance exposed at the time of default
pi = probability of non-compliance
r = recovery percentage
(1- r) = percentage severity

Where the level of exposure (E) is determined by the balance of each operation at the date of the information cut-off. In the case of this study, it was carried out as of April 30, 2019.

The probability of default (pi) was defined with the transition matrices predicted at one year.

The recovery rate (r) was determined from the default points obtained through transition matrices, B – 1 (From 36 to 50 days of arrears).

With this premise, we proceeded to establish the balances of the operations thathave been breached; that is, balances of operations with a ratinggreater than or equal to B – 1 in the case of Microcredit. The recovery amount is defined as the difference between the balance of defaulted operations from the default point and the current balance. The recovery percentage was calculated as: recovered balance / balance of operations to be recovered.

In the case of Microcredit, there is the historical recovery for one year as shown in the following table

Table 12 Recovery rate Microcredit with default point B1

Tasa de recuperación MICROCRÉDITO					
Saldo >= B1					
Año	Mes	Saldo >= B1	Saldo actual	Recuperación	Tasa de recuperación
2018	Abril	$ 7,775,239.46	$ 3,289,919.39	$ 4,485,320.07	58%
	Mayo	$ 7,756,705.34	$ 3,325,838.53	$ 4,430,866.81	57%
	Junio	$ 7,701,518.70	$ 3,300,288.94	$ 4,401,229.76	57%
	Julio	$ 7,881,875.60	$ 3,397,666.18	$ 4,484,209.42	57%
	Agosto	$ 7,870,836.92	$ 3,398,169.13	$ 4,472,667.79	57%
	Septiembre	$ 8,029,816.75	$ 3,500,061.77	$ 4,529,754.98	56%
	Octubre	$ 8,093,269.22	$ 3,533,240.71	$ 4,560,028.51	56%
	Noviembre	$ 8,277,551.33	$ 3,643,843.54	$ 4,633,707.79	56%
	Diciembre	$ 8,102,279.10	$ 3,130,394.95	$ 4,971,884.15	61%
2019	Enero	$ 9,896,288.52	$ 4,096,297.94	$ 5,799,990.58	59%
	Febrero	$ 8,698,006.56	$ 3,565,150.13	$ 5,132,856.43	59%
	Marzo	$ 9,089,069.56	$ 3,663,208.05	$ 5,425,861.51	60%
	Abril	$ 9,551,357.79	$ 3,907,339.55	$ 5,644,018.24	59%

Source: Credit portfolio bases COAC Fernando Daquilema (2019)
Prepared by: Pilco (2019)

With the historical behavior of the recovery rate, a simple average is obtained which is defined as the recovery rate in a year.

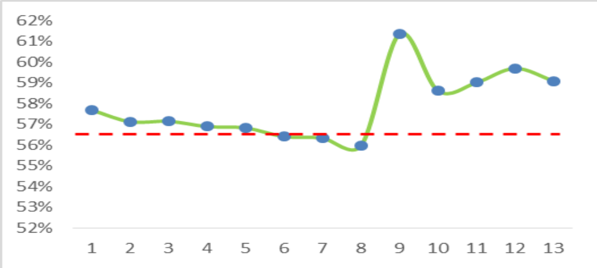

Figure 3 Historical recovery rate
Source: Table 25

Parametric method

For the calculation of the expected loss with the parametric method to April 2019, the formula was applied:

$$PE = E * pi * (1 - r)$$

To the data of the microcredit portfolio. Table 26 shows an excerpt from the calculation.

Table 13 Calculation of expected loss. Detail by operation

No.	No. Operación	Tipo_prestamo	Calificacion_banco	Total_deuda	Probabilidad de incumplimiento *(Pi)*	Tasa de recuperación *(r)*	Perdida Esperada *(PE)*	Pérdida Cartera Acumulada	Varianza
1	64000152085	MICROCREDITO	A1	1.112,23	14,93%	57,86%	69,96	1.112,23	27.896,27
2	64000152087	MICROCREDITO	A1	5.551,17	14,93%	57,86%	349,19	5.551,17	694.905,89
3	64000152091	MICROCREDITO	A1	744,13	14,93%	57,86%	46,81	744,13	12.486,90
4	64000152095	MICROCREDITO	A1	26.359,66	14,93%	57,86%	1658,11	26.359,66	15.668.829,12
5	64000152099	MICROCREDITO	A2	1,45	22,96%	57,86%	0,14	1,45	0,07
6	64000152101	MICROCREDITO	A2	1.496,16	22,96%	57,86%	144,74	1.496,16	70.304,31
7	64000152103	MICROCREDITO	A1	5.343,35	14,93%	57,86%	336,11	5.343,35	643.849,23
8	64000152109	MICROCREDITO	A1	4.432,98	14,93%	57,86%	278,85	4.432,98	443.147,68
9	64000152115	MICROCREDITO	A1	1.476,18	14,93%	57,86%	92,86	1.476,18	49.140,05
10	64000152119	MICROCREDITO	A1	8.268,62	14,93%	57,86%	520,12	8.268,62	1.541.782,11
11	64000152121	MICROCREDITO	A1	2.229,18	14,93%	57,86%	140,22	2.229,18	112.059,12

Source: Expected Loss Spreadsheet
Prepared by: Pilco (2019)

Counting on the calculation of the expected loss per operation, the results are unified by applying the formula:

$$VaR = \bar{x} + (s * z)$$

Asubsuming normality in the data.

Table 14 Calculation of expected loss with the parametric method

PÉRDIDAS (Método Paramétrico)	
Varianza:	33.459.537.414,05
Desviación estándar:	182.919,48
Mejor Perdida:	0,00
Peor Perdida:	122.120.858,21
Pérdida Esperada	8.882.195,91
Z (99%)	2,33
Perdida Inesperada al 99%	9.307.730,26
Capital Económico	**425.534,35**

Source: Expected Loss Spreadsheet
Prepared by: Pilco (2019)

The variance for each operation is obtained as:

Variance: (debt balance (1-recovery rate)^2) * (probability of default*(1-probability of default))*

Where = 33. 459. 537,414.05

From the sum of the variances of each operation the standard deviation is obtained.

Standard deviation = 186. 919.48

Additionally, the expected loss is the average of the set of expected losses per record and the unexpected loss from *VaR* = $\bar{x} + (s \ * z)$:

Expected loss = 8. 882. 195.91

99% Unexpected Loss = 9. 307. 730.26

The results obtained by means of transition matrices for the calculation of the expected loss determine more precisely the credit behavior of the partners since they allow to refine the constitution of provisions.

Thus, once the operations have been carried out, it is determined that there is a portfolio provision deficit in the Cooperative for a total of 2,869,193.22 according to the difference between the result of the expected loss (8,882,195.91) and the provision constituted by the Cooperative as of April 2019 (6,013,002.69), this leading to a better distribution of resources for regulatory compliance and especially for the Institution.

Although arrears are an indicator of portfolio deterioration, it is a current picture of the cooperative, while transition matrices allow us to warn of a possible deterioration and be one step ahead of possible defaults.

It should be borne in mind that transition matrices are a tool for risk prevention and management, while arrears only show how the portfolio is after default.

9 CONCLUSIONS

- The current financial situation of the Cooperative presents a considerable increase in the Operating Expenses category, directly impacting the profitability and efficiency indicators; In addition, its solvency is affected by the disproportionate growth between assets and liabilities directly affecting institutional equity.
- The analysis of credit risk in the Cooperative is not carried out through financial models but empirically, which shows that it does not have a transition matrix for the realization of this activity.
- The probability of non-compliance due to days of default is determined in the band of the B-1 rating category where it exceeds 50%, from that category the provision of 100% should be made.
- The elements for the calculation of expected loss are:
  E = balance exposed at the time of default,
  pi = probability of non-compliance,
  r = percentage of recovery,
  (1- r) = percentage of severity.

As a result of the operation, a deficit in the provision of USD credit portfolio was determined. $ 2,869,193.22 dollars. (Result of the application of the internal model of expected loss ratings).

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