

# Prediction of Credit Card Status Changes using Markov Analysis

**Reynald M. Rodriguez and Rex Aurelius C. Robielos**  
School of Industrial Engineering and Engineering Management  
Mapua University  
Intramuros, Manila, Philippines  
racrobielos@mapua.edu.ph

## Abstract

Credit cards is one of the most convenient tools when purchasing goods and services. Banks offer these cards to qualified individuals and gain profit by charging interest rates and fees. Profit and loss may occur depending on the changes in status of the card. To understand the behavior of credit card status changes and predict future probabilities, this study utilized Markov Analysis approach by gathering 6 months of information with 511,658 observations. The transition of the card status can either positively or negatively impact the business. Markov Analysis proved to be useful in understanding the behavior of people and systems. It provides probabilistic information about a current situation that can guide the decision makers in choosing the most valuable recommendation. In this study there is a high percentage of normal/active, delinquency and blocked cards which means an increase in the business revenue. Fraudulent and cancelled blocked cards projected a lower value and should maintain in that way because it may affect not just business earnings but its reputation as well. The analysis presented provides useful information to improve process performance that is current implemented in the business operations. Generally, the model can help the financial institution in terms of profitability, customer relationships and risk reduction.

## Keywords

banks, credit card, Markov analysis, credit risk

## 1. Introduction

An industry responsible for handling cash, credit and other financial transactions are banks. Aside from the fact that banks offer a safe place to store people's money, they also provide different kinds of financial services such as wealth management, currency exchange and safe deposit boxes (Amadeo, 2020). Depending on the financial services the bank is offering, banks can be categorized as Retail Bank, Commercial/Corporate Bank, and Investment Bank. Short-term cash or the money you deposited at the bank is used to loan to others for long-term debt such as car loans, credit cards, mortgages, and other debt vehicles resulting to creation of liquidity in the market which also creates money and keeps the supply going (Barone, 2020).

The measure of a person's capacity to pay back her dues on time are called Credit. A line of credit is the indicated amount allowed to utilize by spending monthly and get replenished by payments, and to access line of credit is through credit cards. Credit cards are type of payments where instead of using the account holder's deposited money, funds are coming from line of credit (www.bankrate.com).

There are already different types of credit cards available. Most of the financial institutions in the Philippines have at least one type of card they offer to their clients. All offers vary with rates, fees, benefits, and terms and conditions. However, many Filipinos see credit cards as a financial tool that can financially incapacitate people in the long run. If you know how to manage your spending, this is not actually something to be wary of as credit cards are very beneficial to an individual especially in times of need. If used frequently, credit cards can also come with some benefits (Credit Card Guide, 2019).

A study of preferred payment methods conducted in 2019, 11.3% of 1,760 of respondents claimed they prefer to pay with their credit cards (Sanchez, 2019). Financial institutions earn profit from individuals by charging basic interest rates and fees when users fail to pay off their credit at the end of the month. This could also include annual fees and late fees which also contributes to their profit. Credit card interest rates in the Philippines are currently among the

highest in the world. Credit risk is a possible loss that may rise from a borrower failing to make the required payment. As the number of memberships grows, the credit risk becomes higher. In business perspective, it means an interruption in cash flows and an increase in costs for collection (Tan, 2008).

Another activity that can happen to credit card holders is to encounter credit card fraud and scams, which is also connected to identity theft. Credit card fraud users' goal is to get funds from another credit cardholder's account (www.bsp.gov.ph). This can happen at any time and anywhere even when you think you store your card in the safest place. It is very much recommended to monitor all your credit card transactions regularly (Hayes, 2020).

One way to analyze credit card movement in terms of status is the use of Markov Analysis. Several studies have confirmed that the use of Markov Analysis is very useful in describing movements of people, switching of brands, investment evaluation, inventories etc. In particular, the study of Malik and Thomas about Consumer Credit Ratings was developed. Csercsik and Kiss studied and analyzed the probabilities of the depositor to withdraw from the bank. It aimed to observe the behavior of depositors depends on the factors such as previous state, the state of other connected depositors, and the strategy of the bank. The methodology and discussion of the result have similarity in the current study of the researchers; thus, this was used as reference of information (Csercsik, 2016).

Hence, this study aims to use the alternative data to 1) observe the behavior of the credit card account transition from one status to another and 2) identify which status has the highest probability of change which will either positively or adversely impact the business and customers.

## 2. Methodology

### 2.1. Data Gathering

The researcher uses a query script to extract the data from bank's data warehouse. The coverage of the data is 6 months starting from January 2020 to June 2020. The variables used are date time stamp, the "from status" or the original state of the card and the "to status" which is the new status of the card. There are two main tables used, the first one is the card details and the other one is the card update history to see the movement of the card status. The extracted file is in csv format for further analysis.

### 2.2. Data Cleanup

Consolidation of records from different files were the researchers' first method as data were extracted month per month. Null values for dates and statuses were removed as these propose no significance in the study. Then the researchers counted the number of observations and the state transitions; and arranged it according to date. The statuses were categorized into states based on its functionalities.

### 2.3. Development of Transition Matrix and Transition Diagram

#### 2.3.1. Transition Diagram

Transition diagram gives an overview of the probability of card status movements. It gives clear picture of its transition from one point to another. The different states are represented by circles, and the probability of going from one state to another is shown by using curves with arrows. The six states are Cards Pending for Activation, Normal/Active, Delinquent, Blocked, Closed/Cancelled and Fraudulent Account.

#### 2.3.2. Transition Matrix

Transition Matrix is the tabular representation of the transition diagram. It contains the detailed values needed for creation of the model. The absorbing and non-absorbing variables can be easily identified as well. Matrix multiplication can be performed to determine the trends and make necessary predictions. The transition matrix is the most important tool for analyzing Markov chains as shown in figure 1.

$$\begin{array}{c}
 \text{Transition Matrix} \\
 \\
 X_t \left\{ \begin{array}{l} \text{list} \\ \text{all} \\ \text{states} \end{array} \right. \left| \left( \begin{array}{c} \overbrace{\hspace{10em}}^{X_{t+1}} \\ \text{list all states} \\ \text{insert} \\ \text{probabilities} \\ p_{ij} \end{array} \right) \begin{array}{l} \text{--- rows add to 1} \\ \text{--- rows add to 1} \end{array}
 \end{array}$$

Figure 1. Transition Matrix

- the ROWS represent NOW, or FROM ( $X_t$ );
- the COLUMNS represent NEXT, or TO ( $X_{t+1}$ );
- entry  $(i, j)$  is the CONDITIONAL probability that NEXT =  $j$ , given that NOW =  $i$ : the probability of going FROM state  $i$  TO state  $j$

### 2.4. Assessment of Credit Card Status Changes

Predicting the status of cards in the succeeding months is essential for the organization to take corrective measures to either minimize any possible negative impact in the organization or to maintain and maximize positive output. In this study, initial state values and current month state values are the key variables in predicting the probability of cards' status being in each state which is defined by equation 1.

$$\sum_{i=1}^n q_i(k) = 1, \text{ for each } k \text{ and } \sum_i \pi_i = 1 \quad (1)$$

$i$  = the number of states;  
 $k$  = the number of transitions and  
 $q_i(k)$  = probability of the system being in state  $i$  on period  $k$

### 2.5. Absorption Probabilities

In this study, Closed/Cancelled Accounts and Fraudulent Accounts are the absorbing states. Once the non-absorbing states, Pending Account for Activation, Active/Normal, Delinquent and Blocked, have transitioned in one of these statuses, it will never return to its original status. Predicting the probability of non-absorbing states transitioning to absorbing states is relevant for the company to take necessary actions on how to minimize or prevent this from happening especially Cancellation/Closing of Accounts and cards getting tagged as a Fraudulent Account have negative impact in the business.

## 3. Results

### 3.1. Transition Diagram

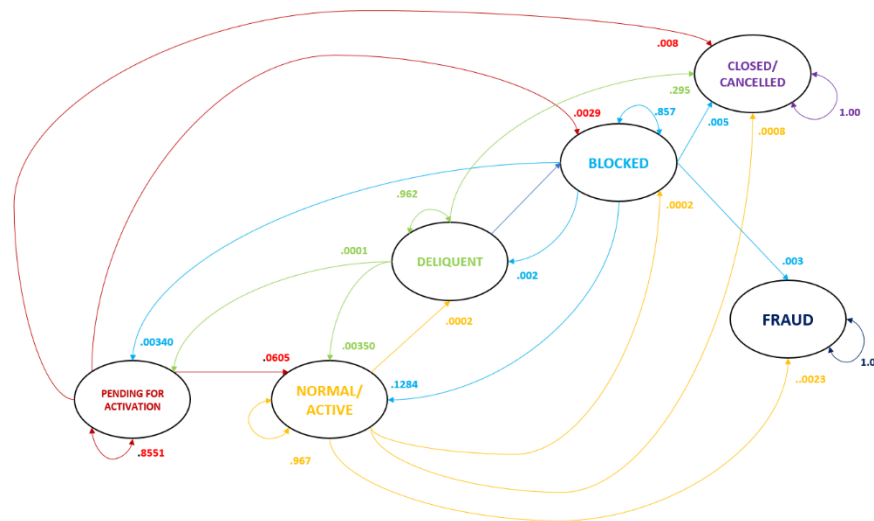


Figure 2. Transition Diagram

### 3.2. Transition Matrix

One of the interesting values is the transition of blocked accounts to Normal active with 12.84 percent which means that business was able to retrieve its customer. The Cards Pending for Activation movement to Normal/Active somehow very low which is only 6.05 percent compared to the one that remained Cards Pending for Activation with 85.51 percent. Fraudulent accounts remained at low values averaging .10 percent only. The highest rates are the state

wherein they maintain their current state are Cards Pending for Activation with 85.51 percent, Normal/Active with 96.7 percent and Blocked card status with 85.70 percent. The lowest rate of transition is the one that moved from Delinquent to Cards Pending for Activation with only .01 percent.

Table 1. Transition Matrix

FROM/TO	Cards Pending for Activation	Normal/Active	Delinquent	Blocked	Closed/Cancelled	Fraudulent Account
Cards Pending for Activation	85.51%	6.05%	0.00%	0.29%	8.16%	0.00%
Normal/Active	0.00%	96.70%	0.02%	2.24%	0.80%	0.23%
Delinquent	0.01%	0.35%	96.20%	2.95%	0.48%	0.00%
Blocked	0.34%	12.84%	0.28%	85.70%	0.53%	0.30%
Closed/Cancelled	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%
Fraudulent Account	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%

Table 1 shows us the current month's transition of one status to another. Detailed results are as follows:

- A. **Cards Pending for Activation:** 85.51% of cards remain at the pending for activation status as customers are either waiting for their cards to delivered at their registered address or the bank branch itself is waiting for the customer to claim their cards. After receiving the card, 5-7 banking days will take effect for the customers to activate their card. It is only logical to think that cards pending for activation's next step would be normal/active as also shown in the Figure 3.1. 6.05% in the current month have had their accounts activated. Credit card delinquency only occurs when a cardholder falls behind on making required monthly payments. As such, it is observed that no pending cards for activation had gone through this status. During the activation process, 0.29% of the cardholders were not able to use their cards properly due to failure of activation within the 5-7 banking days period, entered incorrect pin for activation or losing the pin attached in the envelope together with the card, cardholders then inform their branch of account and have them block it for the meantime. Failure to activate credit card accounts within a year would lead directly to closure/cancellation of credit card and 8.16% of the cardholders have experienced this state. The logic of delinquency status can also be applied to fraudulent cards. Cards with initiated transactions can only be tagged as cards with fraudulent activities.
- B. **Normal/Active:** Activated cards can no longer go back to pending for activation status. Most of the cards remain at their active status, 96.70%, for cardholder's management and utilization. 0.02% of the cardholder's are getting behind with their payments, resulting to delinquent status. 2.24% of the cardholder's had their cards blocked as they may have exceeded their credit card limit. 0.80% of the credit cardholders have had their cards closed due to personal reasons (priority in savings, lessen the temptation of unnecessary purchases etc.) There are 0.23% of the active cardholders are reportedly to have had transactions without their knowledge. Thus, 0.23% of these are tagged as accounts with fraudulent activities.
- C. **Delinquent:** Delinquent cards can either go back to pending for reactivation or to normal/active status. 0.01% of delinquent accounts had gone back to pending for reactivation due to some additional requirements may be needed to submit as cardholders cannot maintain to pay their dues monthly. 0.35% of the cardholders reverted to normal/active status as outstanding balances have been settled. While 96.20% of the cardholders in the current month remain at delinquent status waiting for the settlement of their outstanding balances. If outstanding balances persists and continue to add up, blocking of cards is necessary to minimize the payments of customers needed to settle and 2.95% of the cardholders from delinquent status have been blocked. As credit card companies cannot tolerate customers failing to pay their dues, this leaves the company with no choice but to cancel/close 0.48% of cards from delinquent status. No fraudulent activity had been observed in this status. But it is possible to tag cards as fraudulent from delinquent status.
- D. **Blocked:** Delinquent status' transition to pending for reactivation's logic can also be applied to blocked cards. There are 0.34% of the cardholders had gone back to pending as additional requirements are needed to suffice the company's records and set restrictions for their transactions. 12.84% are back to normal status due to settlement of balances and 0.28% back to delinquency as balances are partially settled. 85.70% remain at the blocked status waiting for their settlement of dues. 0.53% have failed to settle their dues and the bank have closed their accounts. And there are 0.30% of cards tagged with fraudulent activities.

- E. **Closed/Cancelled:** Closed or cancelled accounts will remain in this status forever. It cannot be pending for reactivation and get re-activated. The bank always issues a customer a new credit card with new credit card details. As closed accounts cannot make any transactions, it is impossible for this status to have a delinquent status, get blocked or be tagged as cards with fraudulent activities.
- F. **Fraudulent Account:** Any cards tagged with fraudulent activities cannot be removed. These cards are closed for monitoring and investigation to further assess how these frauds are being done or how to prevent these kinds of activities from customer's previous transactions and activities.

### 3.3. Assessment of Credit Card Status Changes

Table 2. Credit Card Status Changes at a Particular Time Period

	<b>Cards Pending for Activation</b>	<b>Normal/Active</b>	<b>Delinquent</b>	<b>Blocked</b>	<b>Closed/Cancelled</b>	<b>Fraudulent Account</b>
<b>k = 1</b>	6.80%	47.30%	1.07%	5.20%	38.80%	0.83%
<b>k = 2</b>	5.85%	46.82%	1.05%	5.55%	39.76%	0.96%
<b>k = 3</b>	5.04%	46.35%	1.04%	5.83%	40.65%	1.08%

**k = 1** – next month; **k = 2** – next two months; **k = 3** – next 3 months

Cards Pending for Activation and Normal/Active Status will likely decrease in the next three months, having their highest number of cards at the start of first month; Card Pending for Activation with 6.80% and Normal/Active with 47.30%; and lowest at the end of third month; Card Pending for Activation ending with 5.04% and Normal/Active ending with 46.35%; resulting a negative impact for the company. Delinquency is expected to decrease from 1.07% to 1.04%, favoring company's reduced costs. As for blocked accounts, closed/cancelled cards and fraudulent accounts, these are expected to increase in the next three months. Highest percentage of these three statuses; Blocked 5.83%, Closed/Cancelled 40.65% and Fraudulent Account 1.08%; are at the end of third month which could also impact the business negatively. An increasing rate had been noticed in the Closed/Cancelled card status with the difference of .96 which is the highest figure of change and .86 for the second and third month sequentially. The lowest rate of change is the delinquent status with only .01 percent.

### 3.4. Absorption Probabilities

Table 3. Absorption Probabilities

<b>FROM/TO</b>	<b>Closed/Cancelled</b>	<b>Fraudulent Account</b>
<b>Cards Pending for Activation</b>	56.59%	0.13%
<b>Normal/Active</b>	0.72%	0.30%
<b>Delinquent</b>	13.67%	0.25%
<b>Blocked</b>	1.03%	0.28%

Table 3 shows the probability that Cards Pending for Activation, Normal/Active Status, Delinquent and Blocked cards will either get Closed/Cancelled or be tagged as a Fraudulent Account. There is a 56.59% chance that those pending for account activation will be closed/cancelled and 0.13% will be tagged as fraudulent account/card. A 0.72% probability that an active/normal card will be closed and 0.30% will be tagged as fraudulent account/card. Delinquent accounts have 13.67% chance that they would be closed right away and 0.25% will be tagged as a fraudulent account. And blocked accounts only have 1.03% probability that they would be closed and 0.28% will be tagged as a fraudulent account. The highest rate is the transition from Cards Pending for Activation to Closed/Cancelled while the lowest rate is from Blocked to Fraudulent Account.

## 4. Discussion

The movement of card status of the card holders affect both the business and the customer. The results show a large percentage of active status and delinquent status remaining on their state. It means a positive value in the profitability of the bank. Fees and charges are being collected for delinquent status while active status is responsible for the continuous cash flow of the institution.

On the other hand, delinquent status that transitions to pending for reactivation gets the lowest score with just .01 %. It shows that the company have a very low recovery rate of blocked cards status that are being reinstated. The company needs to review the current policy and implement a strategy that can motivate their customers to continue their business with the bank rather than completely closing their accounts.

The card transactions that moved to fraudulent status should have high importance and its number should be only minimal as it will have a huge impact on any financial institution's reputation. The security of the customer and its relationship with the bank anchors on it. The results show a low value the status that moved on this state. This should be closely monitored, and any volume observed must be subjected to a high alert investigation and rules could be implemented to prevent further harm in company's reputation and customer experience.

Pending credit cards for activation are pending opportunities for banks to earn profit. The researchers' observation displays a lot of credit cards have not been activated yet. Gathering customer feedback is highly encouraged to further assess as to why many credit cards remain at this state. It could be an issue in delivery of the card, poor customer service or better terms and conditions have been offered by a competitor. The company can then use the gathered feedback to strategize on how to reduce the credit cards pending for activation.

Closing of credit card accounts is the last thing any bank would want to happen. As observed, the rate of customers getting their accounts closed are getting higher as time passes. This could pose a threat to company's profitability, reputation and stability.

The model created will enable the bank to track their current performance based on the transition rates of their credit cards. Depending on which state requires attending to, the company may implement new policies and procedures, innovative decision-making and even gathering of information could be essential to company's increased profitability, better customer satisfaction and maintain company's best reputation.

## 5. Conclusion

To observe the behavior of the credit card status changes and identify which status has the highest probability of change, Markov Analysis approach was used for the business to determine the effect of each status changes. Analyzing the credit card statuses and identifying which status has the highest and lowest probability of change, the business can strategize on how to minimize future negative impact of these cards and maintain and maximize the positive output the business is doing.

Depending on where the credit card status transitions to, it is observed that these transitions can either positively or negatively impact the business. Having the initial state values of the card to predict the future outcomes, gives the company an edge on how to act according to which transition poses a threat to the business. This paper has described how the information can be used to predict future probabilities and take strategic measures to further improve the business.

The researchers recommend utilizing Markov Analysis for businesses who wants to understand the behavior of their systems. Systems such as credit card status changes, movements of people, customer brand switching, inventories etc. It is important to note that having the initial state values first is essential for the prediction of future probabilities. Deep analysis must be done to fully understand on how and why the changes are happening. This approach would be useful to identify the risk and opportunities and improve the business' current position.

## References

- Amadeo, K. (2020, July 07). Can You Imagine a World Without Banks? Retrieved October 06, 2020, from <https://www.thebalance.com/what-is-banking-3305812>
- Barone, A. (2020, September 17). Bank. Retrieved October 06, 2020, from <https://www.investopedia.com/terms/b/bank.asp>
- Credit Card. Credit Card Fraud and Scam, bsp.gov.ph
- Credit card Definition. (n.d.). Retrieved October 06, 2020, from <https://www.bankrate.com/glossary/c/credit-card/>
- Csercsik, D., & Kiss, H. J. (2016). Optimal Payments to Connected Depositors in Turbulent Times - A Markov Chain Approach. *SSRN Electronic Journal*. doi:10.2139/ssrn.2784692
- Everything You Need To Know About Credit Cards in the Philippines. (n.d.). Retrieved October 06, 2020, from <https://www.gobear.com/ph/guide/credit-card/credit-card-guide>
- Hayes, M. (2020, September 29). The Many Different Forms of Identity Theft. Retrieved October 06, 2020, from <https://www.experian.com/blogs/ask-experian/20-types-of-identity-theft-and-fraud/>
- Malik, M., & Thomas, L. C. (2010). Transition Matrix Models of Consumer Credit Ratings. *SSRN Electronic Journal*. doi:10.2139/ssrn.1543465
- Sanchez, P., & 18, J. (2019, June 18). Philippines: Preferred payment methods 2019. Retrieved October 06, 2020, from <https://www.statista.com/statistics/997257/philippines-preferred-payment-methods/>
- Tan, W. (2008). "Consumer credit in the Philippines". BIS Papers No 46 pp. 117

## Biographies

**Rex Aurelius C. Robielos** is the Dean of the School of Industrial Engineering and Engineering Management at Mapua University. Before joining Mapua, he was Section Manager of Operations Research Group, Analog Devices General Trias. He has a BS in Applied Mathematics from the University of the Philippines Los Baños, and a Diploma and MS in Industrial Engineering from the University of the Philippines Diliman. He is pursuing Ph.D in Industrial Management (candidate) at National Taiwan University of Science and Technology in Taiwan. He is the current Secretary of Human Factors and Ergonomics Society of the Philippines and Director of the Philippine Institute of Industrial Engineers and Operations Research Society of the Philippines.

**Reynald M. Rodriguez** is currently with ING Business Shared Services as an Analyst. He is pursuing Masters in Business Analytics at Mapua University. He graduated with a degree of Bachelor of Science in Business Administration major in General Management at Mapua University.