ANALYSIS OF THE OPTIMAL LOCATION OF BANK AUTOMATED TELLER MACHINES (ATMS) IN TURKMENISTAN

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Abstract: *In recent years, Automated Teller Machines (ATMs) have become one of the most profitable areas of the banking system but at the same time they also represent an area of much debate regarding the future of the financial-banking industry. Placing ATMs in the right locations has become one of the main problems in present day society. For this reason, banks have started to study this issue from a scientific point of view, in order to validate and assess other criteria considered when making decisions regarding specific localization, criteria such as target market characteristics, visibility, security, competition, social considerations, a rigorous analysis must be conducted. Researchers have developed and proposed several models and theoretical approaches to solve this problem. In this article, a method of solving the problem of placing ATMs in effective locations is proposed and calculations are made on the basis of a regulatory analysis of ATMs operating in a specific country, namely Turkmenistan. The monthly income of an ATM in an optimal location is about 2.96 times higher than the monthly income of an ATM in a non-optimal location. The results of our research show that the loss of an ATM placed in a non-optimal location is approximately 66% of its total income for a certain period of time.*

Keywords: Automated teller machine, bank income, optimal location, Turkmenistan

JEL classification: C02, C10, G21

1. Introduction

The use of cash versus cashless payments has been a longstanding debate that has managed to span over several decades. It is important to objectively analyze these topics in order to determine the best path forward. Recently, themes such as sustainability, potential obsolescence of physical currency, financial exclusion, and erosion of privacy have gained momentum and prominence, igniting enthusiasm and concern across the global population. Undoubtedly, there are countries, especially those highly developed such as Norway, Finland, New Zealand, Hong Kong, Sweden, Denmark, the United Kingdom, and Singapore,

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that are nearing an entirely cashless society, where cash withdrawals via cards account for less than 10% of transactions. On the opposite side of the spectrum lie countries such as Bulgaria, Romania, and the Czech Republic in Europe, Morocco, Egypt, Kenya, and Nigeria in Africa, Peru, or Mexico in the Americas, as well as the Philippines, Indonesia, or Kazakhstan in Asia, countries that continue to show a significant dependence on physical currency (Rolfe, 2022).

As per the Worldpay Raport (2023), global cash transactions have declined significantly in recent years, exceeding initial expectations, and the COVID-19 pandemic has accomplished to expedite this drop by about three years. Although the decline is noticeable, various arguments suggest that at least 15% of the global population will primarily or exclusively rely on cash over the following ten-year period. Consequently, financial service providers (as well as central banks) must consider cash operations, including those conducted through ATMs.

Even more so, other recent reports and surveys have pointed that even in economically developed countries with an educated population and widespread possession of bank cards and internet usage, there are preferences (which are somewhat surprising) for the use of cash, such as in Germany (46% of respondents) or Spain (39%). (Euronet, 2022a).

A deduction arising from these analyses is that the use of cash should not be solely associated with the level of economic development or financial literacy of the population. The analysis should be expanded to consider elements such as the location and profile of communities, particularly small and isolated ones, the age of cash and card users, the relationship between customer expectations and the efficiency measures of banking locations, prudence, privacy-related aspects, as well as more sensitive issues such as preventing financial exclusion and, consequently, social exclusion of certain demographic groups. Lastly, the existence and normal functioning of communities and population groups should also be taken into account. Furthermore, a series of research studies argue that the choice of payment method for goods and services should be left to the discretion of the consumer and should not be guided by merchants (Payments Europe, 2021), (Euronet, 2022a).

2. The Future of ATMs - Opportunities or Obsolescence?

An automated teller machine (ATM) is an automated electronic device designed to receive and dispense cash by means of a plastic card and, at the same time, to realize payments for various services, repay loans and carry out other banking operations without the presence of a bank employee/bank teller (Tadesse, 2018).

Currently, ATMs are divided into three main types in terms of cash collection (Yu, 2012):

- Salary withdrawal ATM's – in the case of these types of ATMs, once a monthly salary has been paid, fixed assets are withdrawn within 2-3 days. This type of ATM greatly differs from the other ATM types given that it can store a large sum of cash.
- Street ATMs - this type of ATM is mainly placed in crowded places, in front of shopping centers, near residential complexes and in settlements. The main feature of outdoor ATMs is that their outer part is made of protective metal and equipped with a special air exchange system that ensures proper functionality at any given time.
- Weekday restricted ATMs - These ATMs are specific to a particular industry or institution and are usually located inside the building or institution.

ATMs prove more useful when the distance between two bank branches is long. Today, ATMs are located in various settlements of regions, cities, districts and towns and serve customers 24 hours a day. ATMs are equipped with the possibility of cashless payment of loans received from the country's banks and accrued interest, as well as payments for mobile communication services, CDMA mobile communication services, home telephone, Internet communication, Wi-Fi, household services, money transfer systems, etc.

Each customer is charged by the respective bank branch for the service and repairs/maintenance of the ATMs. ATM withdrawals are one of the main sources of income for a bank. For this reason, every banking institution tries to place its ATMs in various active points of cities, districts, towns, markets, shopping centers, in its own bank building, railway stations, airports, shops and residential complexes.

Thus, the question arises as to whether, in the context of digital expansion, the immense influence exerted by the payments industry toward a digital wallet mentality, as well as the pandemic experience that has limited direct interactions, there still exists a significant place for ATMs in the payments landscape.

ATMs have evolved in line with the social expectations and technologies of their times since the mid-20th century. However, they must now confront the realities of virtual banks, cardless cash withdrawals, and the proliferation of increasingly distant cashless mobile services and applications.

According to research by Euronet (2022) this could only mean that ATM providers, together with the choice regarding the places where they are to be placed, should consider several objectives:

- ATMs must take into account technological advancements to meet the demand for new payment technologies. Cash withdrawals are perhaps the most well-known service provided by these networks, but the functions of an ATM extend beyond cash distribution, encompassing balance inquiries, PIN changes, and the potential to offer a wide array of financial services.
- The ATM should have a more pleasant and attractive appearance, one that is closer to the functionality of a smartphone and contemporary designs.
- ATMs must keep pace with the rapid and widespread changes in payment technologies, embracing more functionality, taking advantage of the reduction in the number of physical bank branches, and even replacing them (to a certain extent). The ATM should transcend its status of a cash dispenser and provide the capability to make deposits, accept checks, process bill payments, dispense tickets, provide e-card services, and more. ATMs can read barcodes, QR codes, and numerical codes to initiate cash withdrawals, especially in emergency situations when card payments are not available.
- To secure a place as an integral part of the future of the banking system, the ATM must evolve into a multifunctional apparatus, complementing and diversifying payment options and technologies in an era of digitalization. It should be transformed into an intelligent device, aiding financial institutions and meeting the expectations of their clientele.

3. Theoretical background regarding optimal location for ATM

As mentioned earlier, one of the most important revenue streams for the banking system in recent years has been the service revenue generated by ATMs. Effective management of any ATM includes installation, programming, cash management, security, efficient location, remote monitoring and proactive customer service. Currently, scientists have developed and proposed several models and theoretical data to solve the problem of placing ATMs in the optimal location, which is one of the main problems. Many unique approaches to this problem have been proposed by existing literature.

According to the research conducted by Sadeghi & Farokhian (2011) or Trang et al (2019), the ATM network stands as one of the most crucial banking facilities, as it enables continuous customer access to their accounts and cash withdrawal. However, this advantage becomes inconsequential when the nearest ATM location exceeds a certain distance. In other words, one of the key advantages of ATMs is their accessibility or convenience. This assertion holds true, up to a certain point, for banks as well; through ATM networks, they can keep their customers in proximity (either physically or psychologically) and reduce their costs compared to a full-fledged branch (Genevois, et al., 2015), it retains

its traditional clientele while also attracting younger individuals interested in technology (Awaghade, et al., 2014), they can increase their visibility and promote their products. Clearly, not every location is conducive to these criteria, as visible and secure places are preferred, along with those that are convenient and accessible, with significant commercial, business, or recreational traffic (Awaghade, et al., 2014) (Genevois, et al., 2015).

The determination of optimal locations for the placement of equipment such as ATMs, in order to meet demand requirements as well as efficiency standards of providers, generates significant interest among researchers and practitioners. This interest spans a diverse spectrum of disciplines, ranging from geographers and urban planners to engineers and architects, from economists and systems analysts to managers and policymakers (Mitra & Fortenberry, 1986), (Mourad, et al., 2012).

The Location-Allocation (LA) problem holds significant importance within the banking industry, as it is tasked with addressing constraints related to minimizing customer transportation costs to and from the respective equipment, as well as profitability, safety elements, social policies, and other related factors. Indeed, an ATM placed in a highly trafficked area, serving a substantial number of customers, can generate increased visibility in the target market for the respective bank. It can be regarded as a component of the network expansion strategy or a point for the collection of consumer information and preferences, among other functions (Gehrung, 2021).

The attention given to the finding of proper locations of/for ATMs has been somewhat uneven over time. Initially, it was deemed that the first ATMs should be primarily located within bank branches (Wilson, 1999), (Badulescu & Morutan, 2016); this has considerably delayed the research in finding other optimal locations. The increase in the number of ATMs parallel to the rise in the ownership of bank cards among the population has revived these concerns but has also placed banks in competition with each other. On numerous occasions, due to various constraints, banks have relinquished the management of ATM networks, outsourcing certain operations (maintenance, cash replenishment, etc.), or even the entire network, to specialized non-banking companies. The allocation of ATMs in a given territory requires a specific strategy, and the factors determining the (optimal) location of an ATM vary from one country to another, from one bank to another, and depend on a multitude of objectives and criteria, including market selection, visibility, ease of access, security of use, economic development level, ATM allocation cost, the presence of competition, proximity to companies using payroll cards, social considerations, and more (Mourad, et al., 2012), (Awaghade, et al., 2014).

Mourad et al. (2012) propose a solution to the location-allocation problem of ATMs by suggesting the utilization of a hybrid optimization model that incorporates ranking methods such as Analytic Hierarchy Process (AHP) and Location Set Ranking (LSR) in conjunction with the p-median optimization model. It contends that, following verification and refinement, the model can be successfully employed in a large city, citing the example of the city of Alexandria, Egypt. (Mourad, et al., 2012).

When choosing a location for a specific activity, such as the distribution of financial or banking services, but not limited to them, various factors are taken into consideration. These factors include the size and characteristics of the target market, the incomes of existing and potential customers, the complexity of the services provided, growth potential, costs (acquisition or rent), competition, and so forth (Awaghade, et al., 2014). Similarly, when installing an ATM in a particular location, these aspects must be taken into account, including the number of residents and businesses in the area, individual income levels and expenditures, consumption preferences, habits, as well as the services offered by the specific ATM, competition in general, and the number and placement of other ATMs in the same area. For example, Trang et al. (2019), by investigating a significant number of ATM users, have revealed that the characteristics of ATM locations are positively correlated with their usage, confirming the relationship between consumers' attitudes and intentions, and

the utilization of ATM services. Kubra et al. (2015) point out that it is necessary to increase the number of ATMs and to place them in efficient locations, by taking into account the interests of customers in their work. Their contribution notes that statistical methods such as factorial, cluster, regression and correlation are more suitable for the decision-making process regarding the placing of ATMs in the optimal location. As a result, the researchers choose the method of correlation and standard regression analysis to place ATMs at active points and to determine the operating points for ATM's by using this method (Kübra, et al., 2015). Somnath. et al (2017) offer two equally effective local and global models to solve the problem of efficient deployment of ATMs in hotspots. There is no common function linking the proposed models. I Putu et al. (2022) solve the problem of placing ATMs in efficient locations using K-means and intelligent analysis methods. A large database is required to solve the problem of determining the optimal location, and the method is controlled by specially developed software (I Putu, et al., 2022). Genevois et al. (2015) approach this problem in a fundamentally different way, creating a function that determines the movement of cash in ATMs based on the location of the ATMs. The article proposes a two-step approach to solving this problem. The first step is to determine the optimal location of ATM's, and the second step is to solve the cash management problem (Genevois, et al., 2015). Golabi et al (2017) propose to solve the problem of placing ATMs at optimal locations using a linear mathematical model. Using the model proposed by the researchers, it is expected that ATMs will reduce costs when placed in certain locations.

4. The use of ATMs and financial banking modernization trends in Turkmenistan

The development of the financial banking system in the Turkmenistan is a crucial objective of state policy. There are numerous programs intended to fully digitize the country's banking system, to develop the national economy and to launch a qualitatively new phase of economic policy implementation aimed at bringing it (the banking system) to new heights. Programs such as: "Program of the President of Turkmenistan for the socio-economic development of the country in 2022-2028" and "Revival of a new era of the powerful state: The National Program of Social and Economic Development of Turkmenistan in 2022-2052" are a clear demonstration for this engagement (Ministry of Finance and Economy of Turkmenistan, 2023). The financial base of Turkmenistan's banking system has been strengthened and develop, being nowadays equipped with innovative digital technologies that meet modern standards (Akmyradov & Nokerov, 2022) (Akmyradov & Nokerov, 2023). ATMs are one of the main technical bases of the banking system, which is being improved during the transition of the national economy to the digital system.

Customers can carry out their necessary banking transactions at banks offering different services. At a first glance, it can be said that the more bank branches, the better it is for customers. However, in order to meet the needs of customers, many bank branches cannot be opened in cities, villages and other places from the point of view of security and prevention of inappropriate spending. But they can certainly be replaced by ATMs, which are an integral part of banks.

The Central Bank of Turkmenistan, SCB "Turkmenistan", SCB "Dayhanbank", JSCB "Senagat", JSCB "Rysgal", JSCB "Halkbank", JSCB "Türkmenbashi", "Turkmen-Turkish JSCB" and "SB for FEA" have all installed their own ATMs to provide banking services to citizens and business in different locations throughout Turkmenistan. As of 1st of May 2013, a total number of 2139 ATMs have been installed in the country (Figure 1). If in January 2016 there were 924 ATMs to provide banking services to citizens in different parts of Turkmenistan, a 132% growth has been achieved since the 2016 time interval (Central Bank of Turkmenistan, 2023), (Turkmenportal, 2023). This will be depicted in in Figure 2.

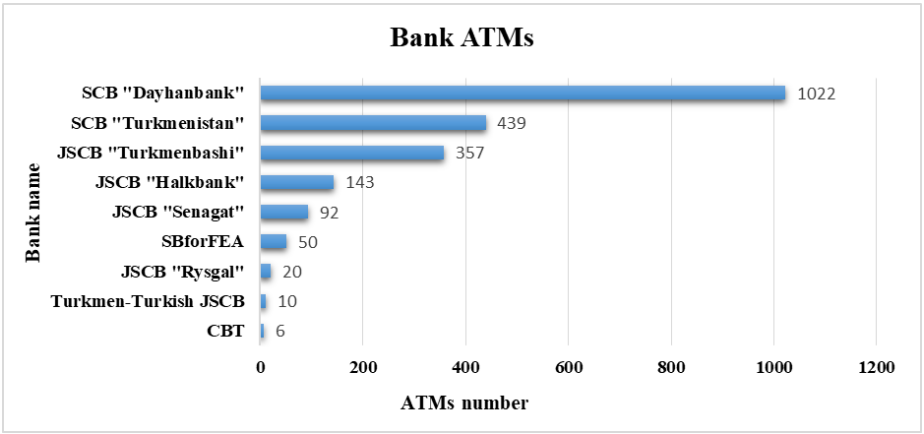

Figure 1: Number of ATM's per bank in Turkmenistan in 2023
Source: Author's analysis based on data from the database of Central Bank of Turkmenistan

As can be seen from the graph in Figure 2, following an accelerated growth in the 2016-2019, the total number of ATMs installed in the country decreases after 2020. There are two main reasons for this. Firstly, the number of ATMs installed in the country prevails, and secondly, it is a question of placing ATMs in the corresponding optimal locations. Therefore, it is important to carry out the calculations and their analysis in order to place the ATMs in the corresponding optimal locations. In this work, the problem of increasing the profitability of ATMs depends on many factors. Taking into account the number of customers who will use ATMs, the cases that will bring the most profit are determined by making appropriate calculations.

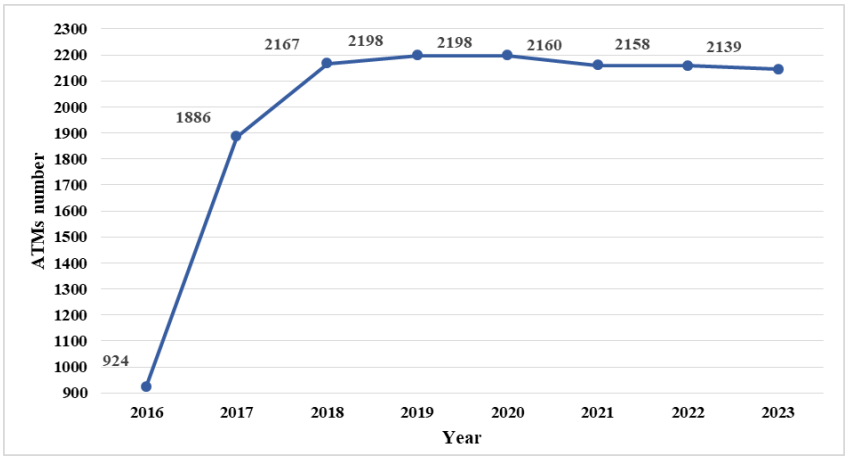

Figure 2: Annual growth dynamics of the number of ATMs in Turkmenistan in the 2016-2022 time period
Source: Author's analysis based on data from the database of Central Bank of Turkmenistan

It follows from the above literature review that the parameters used in the proposed models to solve the problem of determining the optimal point of placing ATMs depend on the area in which the ATM is to be installed. In this article, a regression analysis method is proposed and appropriate calculations are made to solve the problem of placing ATMs at the optimal points throughout Turkmenistan. The article shows the necessity of placing ATMs at efficient points by means of special calculations and determines the efficiency coefficient of ATMs for optimal and non-optimal points.

5. Methodology

Every bank tries to locate its ATMs in the best possible locations to maximize the return on its investment. This phenomenon depends on the popularity of the location to be installed, the location in a densely populated area, the number and types of operations that can be performed at the ATM, the security conditions, the economic status of the location, and several other factors.

If the ATMs are placed in non-optimal locations, then its nailing down will also be low, in which case it is necessary for the bank to be active. In a scientific study of the positions of ATMs, it can be seen that the location of the ATM is the main criterion for its income. If ATMs are placed in sub-optimal locations, it can be assumed that revenues will fall sharply. This raises the problem of finding and placing ATMs in more active locations in order to obtain a large amount of income from ATMs. This problem can be solved using the mathematical method of regularization analysis (Tsyganov, 2018).

Below is the calculation sequence of the methodology for the effective placement of ATMs. In the calculation, the commission/fee for services provided by ATMs operating throughout the country is the same, as is the amount of cash withdrawn, which is assumed to be 0.86%. The maximum profit from the use of ATMs has been taken into account and the data used in the calculations are self-selected prices.

Let us consider two situations, during the same period of time:

a. a high volume of customers served;
b. a situation in which significantly fewer customers are served than in situation a.

In this study, the calculations were carried out separately for each of the above two cases and compared with each other. The ATMs considered in both cases are technically sound and sophisticated. Let us move forward with the analysis by assuming that these ATMs are in two different locations with different frequencies of customer visits. The calculations take into account the monthly income from the ATMs (Tsyganov, 2018).

6. Results and discussions

To simplify the calculations, we have assumed that ATMs are only used to withdraw cash from plastic cards. Assume that 13190 customers use a heavily loaded ATM and 4450 customers use an unloaded ATM in one month. Suppose that for the service of withdrawing the largest amount of cash from an ATM, a deduction of 6.88 Turkmen manats is made from the customer's personal account. The total income to be received for using the ATM service during the month can be calculated using the following formula:

$$J_i = P_i \cdot Q_i$$

Where J_i is the total income from the ith ATM for one month (in manats- Turkmen currency), P_i is the average commission for the service of withdrawing the largest amount of cash from an ATM (in Turkmen manats), Q_i is the total number of customers served at the ith ATM during the month. For loaded ATMs with a large number of customers and unloaded ATMs with a small number of customers, formula (1), previously presented, takes the following form:

$$J_k = P_k \cdot Q_k \quad (2)$$

$$J_a = P_a \cdot Q_a \quad (3)$$

Where J_k, J_a are the total income (in Turkmen manats) of an ATM with a high and low number of customers, respectively, P_k, P_a are the average cost of the service (in Turkmen manats), Q_k, Q_a are the total number of customers served at ATMs with more and less customers, respectively.
For formula's (2) and (3), together with their corresponding calculations, are presented in Table 1.

Table 1: Comparison of ATMs with high and low customer base

Multi-client (loaded) ATM	**Low-client (unloaded) ATM**
Q - total number of clients	
13190	4450
P is the maximum income from a customer using an ATM (Turkmen manat)	
6.88	6.88
J, gross profit (Turkmen manat)	
90747.2	30616

Source: own calculations

Moving forward with our analysis, we have compared the efficiency of ATMs located at the first point with a large number of customers and at the second point with a small number of customers. The efficiency formula (4) can be written as follows:

$$I = \frac{P \cdot Q}{P_0 \cdot Q_0} \tag{4}$$

Here is the efficiency factor I is variable size, P, P_0 are the ratio is taken to serve an ATM with a high and low number of customers, respectively (Turkmen manat) Q, Q_0 are variable sizes and represent the total number of customers served at ATMs with high and low number of customers, respectively.
There are mutual efficiency coefficients for 3 different situations of location of ATMs in the first and second points.
The efficiency coefficient of changing the capacity of the ATM and the number of customers is presented below:

$$I_{PQ} = \frac{P_k \cdot Q_k}{P_a \cdot Q_a} = \frac{6{,}88 \cdot 13190}{6{,}88 \cdot 4450} = \frac{90747{,}2}{30616} \approx 2{,}96$$

The efficiency factor for changing the throughput of an ATM is given below:

$$I_P = \frac{P_k \cdot Q_k}{P_a \cdot Q_k} = \frac{6.88}{6.88} = 1$$

The efficiency ratio as a function of the number of customers is given below.

$$I_Q = \frac{P_a \cdot Q_k}{P_a \cdot Q_a} = \frac{13190}{4450} \approx 2{,}96$$

As can be seen from the mutual efficiency coefficient of ATMs located in the first and second points, the efficiency coefficient increases by about 2.96 times when ATMs are located in an effective active point. As can be seen from the efficiency coefficient of ATMs by changing the capacity standard and the efficiency coefficient by changing the number of customers, it increases by a factor of 1 only when the capacity standard is changed and by a factor of 2.96 when only the number of customers is changed.
The percentage of "lost revenue" that an ATM owner can lose by placing ATMs in the wrong, i.e. non-optimal, location can be calculated using formula the following formula (5):

$$X_J = \frac{J_k - J_a}{J_k} \cdot 100\ \% \tag{5}$$

Here, X_J is the lost profit ratio (cashing account), J_k is the total income from an ATM with a large number of customers (Turkmen manat), J_a is the total income from an ATM with a small number of customers (Turkmen manat).
The following result is obtained when the calculations are performed by substituting their numerical values into magnitudes:

$$X_J = \frac{J_k - J_a}{J_k} \cdot 100\% = \frac{90747{,}2 - 30616}{90747{,}2} \cdot 100\% = 66{,}26\ \%$$

As can be seen from the calculations, if an ATM is placed in the wrong location, the amount of the bank's losses from ATM expenses is 66.26% of its monthly income.
If ATMs are placed in non-optimal locations with a low number of customers, the percentage of customer volume loss as the total number of customers decreases can be determined from formula (6) below:

$$X_Q = \frac{Q_k - Q_a}{Q_k} \cdot 100\ \% \tag{6}$$

Where X_Q is the customer loss coefficient, Q_k is the total number of customers served in a multi-user ATM and Q_a is the total number of customers served in a small-client ATM.
If the calculations are carried out by replacing their numerical values with magnitudes, the following result is obtained.

$$X_Q = \frac{Q_k - Q_a}{Q_k} \cdot 100\% = \frac{13190 - 4450}{13190} \cdot 100\% = 66{,}26\ \%$$

If the number of customers that use the services of ATMs is reduced from 13190 to 4450, as can be seen from the results of our calculation, the bank's loss from ATMs will be 66.26 % of the total income for the month.
What can be taken from the results of the above calculations is that by placing an ATM in the wrong place can lead to a decrease in the deposit income of the corresponding bank. In this case, the problem of placing ATMs in efficient locations arises.

6. Conclusion

The aim of this study is to propose an integrated decision support system for ATM management which will aid management team in banking services and make decision making easier with a scientific methodology in a trustworthy way. Based on the regulatory analysis conducted in the article regarding the optimal placement of ATMs within local conditions, it has been determined that such placement holds the potential to generate significant revenue for the banking system. The findings of our calculations reveal that the efficiency ratio, resulting from regression analysis, when altering the throughput ratio of ATMs, is approximately 1.02. This implies that optimizing the placement of ATMs can yield a considerable increase in their overall efficiency.
Furthermore, our analysis demonstrates that an ATM situated in an optimal location can generate a monthly income roughly 2.96 times higher than that of an ATM located in a non-optimal location. Conversely, the financial loss incurred by an ATM in a non-optimal location is estimated to be approximately 66.26% of its total monthly income. These conclusions underscore the critical importance of strategic placement for ATMs to enhance their financial performance within the local banking context. As mentioned earlier, there is a

scarcity of studies and researches about ATM management. The cash flow of ATMs depends on their efficient location. Therefore, we need a two-step solution for ATMs. The first step is to effectively locate ATMs. The second step should be a cash flow problem. Because these issues are deeply interconnected. As a result, the location of ATMs at an active location reveals the problem of cash flow in ATMs. Solving this problem will be one of our next goals.

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