Analysis of Bank Accounts Using Multi-Criteria Decision-Making and a Custom Web Application

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Abstract: The topic of multi-criteria decision-making and evaluation of alternatives is currently very popular, and many authors use these methods in various economic areas including banking. The aim of the article is the application of multi-criteria decision-making methods to bank account analysis. The first part will describe the theory of banking and bank accounts, methods of multi-criteria decision-making, and methods for determining the weights of criteria, their principle, and method of application. The bank accounts of those banking entities with the highest balance sheet for the year 2021 will be analyzed. Based on this decision, eleven banking entities were selected. Another goal is the analysis of the evaluation of student bank accounts and regular bank accounts with the help of selected methods of multi-criteria decision-making with the use of our own web application. This will allow the user to choose a bank account that will be optimal given the user's set preferences.

1. Introduction

The banking industry in Europe is being changed by the emergence of new technologies, new players, and favorable regulatory frameworks such as the European Commission's Payment Service Directive 2, which came into force in 2018 (Omarini, 2022).

Decision-making is a process that a person encounters daily. However, these are usually not very important decisions, which is why most people think instinctively and without thinking. Whatever decision is made in these situations; it can be expected that the choice will not have a significant impact on the individual's future. However, in the case of important decisions, such as a strategic decision of the company, a choice of employment, or for example, a certain investment, it is advisable to think about the consequences of choosing a particular choice and possibly use a certain tool that is suitable for making a decision and choosing the option that is the most advantageous. Choosing the right option is all the more important in cases involving personal finances. Most people care about their finances, they want to take care of them in the right way, protect them and use them appropriately. That's why choosing the optimal bank account seems like an important decision, especially in times of the current economic crisis.

The topic of multi-criteria decision-making and evaluation of variants is currently very popular and many authors use these methods in various economic areas, for example (Kandakoglu et al., 2022) or (Macháč et al., 2021). Especially in banking, multi-criteria decision-making methods are used by (García et al., 2010) and (Doumpos & Zopounidis, 2010).

1.1. Banking Products and Bank Accounts

Banking products are services that banks can offer and usually perform for a fee. These products are usually of an intangible nature, i.e., they are not visible and cannot be stored or patented. They can be connected to each other or mutually conditioned. Banks can use the conditionality of individual products when setting prices for these products, especially if the link is very tight (when using one product, it is more or less automatically required to use another product), when the price of a certain product is very low (or the service is free), with the aim of attracting clients.

The systematization of banking products is not very unambiguous due to their large number and great diversity. Probably the most widespread breakdown of bank products is according to their reflection in the bank's balance sheet. They are therefore divided into active, passive, and neutral banking products. Active banking products are those reflected in the bank's balance sheet assets. For these products, the bank acts as a creditor and receives claims (e.g. when granting a loan) or ownership rights. Passive banking products, on the other hand, are reflected in liabilities. These are mainly products where the bank acquires foreign capital on a loan basis, and a classic passive banking transaction is the receipt of a deposit.

A bank account is a banking product that reflects the relationship between the bank and its clients. The client's bank account can be characterized as an account of the bank's receivables and liabilities resulting from its relations with the client. If the bank is in the role of the debtor, it records its debts and obligations towards a specific client through a bank account.

There are several types of bank accounts based on the purpose of their use. The breakdown of these bank accounts may not be completely uniform. Individual banks can modify or combine these accounts in a certain way, for example, to increase the attractiveness of these banking products for their clients.

When a client decides to purchase a current account with a particular bank, the revenues, and costs that the account will bring to the client play a significant role. In the case of income, this is so-called interest, and the costs of a current account most often include fees associated with the use of account services, such as ATM withdrawals, account statements, or fees for outgoing foreign payments.

The study (Fernandes & Pinto, 2019) states that owing to the intangibility, long-term delivery, and complexity of financial services, also characterized by considerable uncertainty (Ponsignon et al., 2015), cultivating high-quality relationships with customers is of paramount importance (O'Loughlin et al., 2004; Oly Ndubisi, 2007), particularly in an age of increased depersonalization, homogenization, and automation in the industry (Barari & Furrer, 2018; Hedvicakova, 2017; Mačí, 2022).

1.2. Multi-Criteria Decision-Making and Evaluation of Options

Multi-criteria decision-making problems are described by a set of n variants $X = \{x_1, x_2, \dots x_n\}$, which are assessed based on m criteria from the set $K = \{K_1, K_2, \dots K_m\}$. From this information, a multi-criteria decision-making model can be formulated (which, according to the characteristics of the set of variants, is either discrete, when the variants are evaluated according to criteria, or continuous, which has a set of variants expressed by a system of limiting conditions), in which it is additionally necessary to include additional information about subjective preferences decision makers. It follows that other important information is also related to the criteria, such as their weight, importance, or relationship to other criteria.

The variant that would simultaneously achieve the best rating in all criteria is referred to as ideal. However, this variant usually does not exist in the set of variants, and it is necessary to look for an alternative non-dominated variant, for which there is no other variant in the set of variants, which is better evaluated according to at least one criterion, and not worse according to the other criteria, while the selection of these variants usually requires the decision maker's preferred information. The opposite of the ideal variant is the so-called basal variant, and it is the variant that has the lowest evaluation of each criterion from the entire set of variants.

2. Methodology

2.1. Methods for Determining Criteria Weights

Criteria preference can be expressed in several ways. Can be set as
- aspirational levels of criteria (nominal information),
- order of criteria (ordinal information),
- criteria weights (cardinal information),
- or they may not be set at all.

Criteria weights are non-negative real numbers that express the different importance of the selected criteria with respect to the target evaluation of the variants. Most work is done with standardized weights, which applies

$$\sum_{j=1}^{m} v_j = 1. \tag{1}$$

In the issue of multi-criteria decision-making, one can also encounter cases where information about preferences is completely missing in the set of criteria or is given through a preference relation on the set of criteria.

2.2. Fuller's Method

This method of determining the weights of criteria uses a pairwise comparison of criteria, where the number of comparisons in the case of n criteria is equal to the number $\binom{n}{2}$ in the case of using this method, and its principle is based on the comparison of two criteria each time, with the more significant being selected from this pair criterion, and the weights are thus derived from a preference relation on the set of criteria.

It is called Fuller's method because the application of this method uses the so-called Fuller's triangle - it is a preference matrix P that represents the more significant criterion from each possible pair, while only the upper triangle of the matrix is defined, and the rest of the matrix can subsequently be derived. For the element $p_{j,k}$ of this matrix it holds that

$$p_{j,k} = \begin{cases} 1 \text{ if the j-th criterion is more important that k-th criterion,} \\ 0 \text{ in other cases.} \end{cases} \tag{2}$$

The unstandardized weight of the j-th criterion w_j, which determines its significance, is derived from the number of criteria over which this criterion is preferred, and this weight can be calculated according to the formula (Fiala et al., 2008).

$$w_j = \sum_{k=1}^{n} p_{j,k} + 1 \tag{3}$$

where the added one prevents the least significant criterion from having zero weight.

2.3. Saaty's Method

Saaty's method differs from the pairwise comparison method in that, instead of the preference matrix P, an intensity matrix S is entered, the elements of which represent the relative importance of the j-th criterion to the k-th criterion (Fiala et al., 2008). When entering the values of this matrix, a five-point scale of preference intensities is usually used

$$s_{j,k} = \begin{cases} 1 \text{ if the criteria are equally important,} \\ 3 \text{ weak preference of the } j - \text{th criterion over the } k - \text{th criterion,} \\ 5 \text{ strong preference of the } j - \text{th criterion over the } k - \text{th criterion,} \\ 7 \text{ very strong preference of the } j - \text{th criterion over the } k - \text{th criterion,} \\ 9 \text{ absolute preference of the } j - \text{th criterion over the } k - \text{th criterion.} \end{cases} \tag{4}$$

If the j-th criterion is less significant than the k-th, then the value of the element $s_{j,k}$ corresponds to the value

$$s_{j,k} = \frac{1}{s_{k,j}}. \tag{5}$$

2.4. Methods based on minimizing the distance from the ideal variant

The TOPSIS method is based on the principle of the distance of the variant from the ideal and basal variant. For its application, a cardinal evaluation of the variants according to the criteria and determination of the weights of the considered criteria is required.

The application procedure of the TOPSIS method consists of several steps, while first, it is necessary to construct a normalized matrix according to the formula

$$r_{ij} = \frac{y_{ij}}{\sqrt{\Sigma_{j=1}^{p} y_{ij}^2}}. \tag{6}$$

The columns of the resulting matrix specify vectors of unit length. In the next step, the normalized weighted criterion matrix is calculated by the relation

$$w_{ij} = v_j r_{ij}. \tag{7}$$

Subsequently, the basal variant D and the ideal variant H are determined based on the values of the matrix W, which was compiled in the previous step. Further, the distances of the variants from the ideal variant are calculated using the formula

$$d_i^+ = \sqrt{\sum_{j=1}^{k}(w_{ij} - h_j)^2} \tag{8}$$

and, from the basal variant

$$d_i^- = \sqrt{\sum_{j=1}^{k}(w_{ij} - d_j)^2}. \tag{9}$$

Finally, the relative distance indicators of the variants from the basal variant are calculated

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-}, \tag{10}$$

while the values of these indicators are in the interval $\langle 0,1 \rangle$, where the value 0 is taken by the basal variant and the value 1 by the ideal variant (Talašová, 2003).

2.5. Other Used Methods

Other methods used include the ranking method and the scoring method, which are described for example in (Brožová et al., 2003) or (Šubrt, 2011).

3. Analysis and Results

3.1. Data Description

The first step of the analysis itself was obtaining information about bank accounts. It was decided that the bank accounts of those banking entities with the highest balance sheet amount (i.e., the largest amount of managed money) for the year 2021 will be analyzed, to reduce the number of bank products analyzed. Based on this decision, eleven banking entities with the largest balance sheet total for 2021 were selected (see Table 1).

The resulting data sample of bank accounts to be analyzed contains data on 28 bank accounts offered, including both regular and student bank accounts. The selected attributes of these bank accounts are the type of bank account – student or current, internet banking, interest rate p.a., a one-time fee for opening an account, monthly account management fee, ATM withdrawal fee in the Czech Republic, fee for withdrawal from an ATM of another bank

Table 1. Selected banks in 2021

Bank	Balance sheet in bn. CZK	Number of clients	Net profit in bn. CZK	Operating since	Number of ATMs in Czech Republic
ČSOB	1,805.0	4.225 mil.	16.200	1964	837
Česká spořitelna	1,642.0	4.493 mil.	14.200	1825	1,414
Komerční banka	1,244.4	2.251 mil.	12.700	1990	807
UniCredit Bank	693.5	0.850 mil.	6.980	1996	190
Raiffeisenbank	511.0	1.200 mil.	4.690	1993	135
Moneta	340.2	1.400 mil.	3.980	1998	545
Fio banka	215.0	1.162 mil.	2.300	2010	215
Air Bank	151.0	0.986 mil.	1.472	2011	261
Equa bank	73.7	0.519 mil.	0.553	1993	16
Banka Creditas	67.0	0.150 mil.	0.115	1996	0

in the Czech Republic, fee for withdrawing from an ATM abroad, fee for withdrawal from a foreign bank's ATM abroad, fee for balance inquiry via ATM, a fee for a balance inquiry via a foreign bank's ATM, fee for withdrawal at a bank branch, fee for account statement sent electronically, fee for account statement sent by post, fee for sending an information SMS, a fee for a one-time payment via the Internet, fee for one-time payment at the branch, fee for setting up/executing a standing order at a branch, a fee for setting up/executing a standing order via the Internet.

From the list of criteria, it can be seen that criteria were chosen that relate to the possibilities of modern times (for example, the use of Internet banking, the possibility of payment via the Internet), but also in today's not-so-used possibilities of using bank accounts, such as the possibility of payment at a bank branch. The choice of diverse criteria was made due to the possibility of using the bank calculator by different age generations, which have different preferences.

3.2. Results of the Analysis

Bank accounts were analyzed by almost all implemented multi-criteria decision-making methods. The method of basal variants cannot be used for analysis due to incompatible data. An error condition occurs during the calculation, as the data contains zero values, and when substituted into the formula for calculation, division by zero occurs. For that reason, an analysis of bank accounts will be carried out using the weighted sum method, the TOPSIS method, the Lexicographic method, and the ranking method, for all the mentioned models - i.e., the student, adult, and senior models.

Following results are for TOPSIS method. For all implemented methods similar tables were done and evaluated.

4. Discussion

In our work, the results of the following methods were implemented and evaluated: the lexicographic method, the order method, the TOPSIS method, and the weighted sum method.

The Table 2 above shows the results obtained by the TOPSIS method.

Table 2. Results for TOPSIS method, Source: own processing

Bank	Account	Model Adult		Model Student		Model Senior	
		Order	Value	Order	Value	Order	Value
Air Bank	Current account	10	0.79765	10	0.81550	1	0.94197
Banka CREDITAS	Current account	4	0.91868	4	0.94098	8	0.71444
Česká spořitelna	Student account			12	0.79420		
	Standard account	11	0.77536	13	0.78983	4	0.77583
	Plus account	13	0.75741	16	0.76920	5	0.74904
ČSOB	Plus konto			18	0.64426		
	Basic account	17	0.48628	20	0.62520	15	0.60437
Equa bank	Current account	2	0.93893	2	0.95763	3	0.86330
Fio banka	Student account			1	0.96257		
	Personal account	1	0.94138	8	0.89653	2	0.89267
Komerční banka	My account Gold	8	0.85266	9	0.84025	9	0.71002
	Student account			11	0.79603		
	My account Plus	12	0.77076	14	0.78923	10	0.70481
	My account	14	0.56084	17	0.70531	14	0.65638
MONETA Money Bank	Tom account Plus	3	0.92167	3	0.94325	6	0.74541
	Tom account	7	0.86010	7	0.90388	7	0.74504
	Genius Student			22	0.60276		
	Genius Gold	16	0.55831	25	0.42118	17	0.54211
Raiffeisenbank	Exclusive account	15	0.56066	24	0.49731	19	0.45949
	Premium account	9	0.80206	15	0.77719	13	0.68611
	Clever account	5	0.91607	5	0.93855	11	0.70266
	Active account	15	0.90697	6	0.92338	12	0.69206
UniCredit Bank	Start konto	18	0.48151	19	0.63320	16	0.58799
	Account Open	19	0.45204	21	0.60782	18	0.53047
	Account TOP	20	0.36556	23	0.51840	20	0.42144

In contrast to the evaluation of the variants using the order methods and the Lexicographic method, we found that some bank accounts have a relatively different final order. For example, Tom Account Plus, which was determined by the Lexicographic method as an ideal account for students and adults, was evaluated by the TOPSIS method as the third most advantageous bank account, while the current (or student) account from Fio Bank was determined as the most advantageous option.

Like the case of the TOPSIS method, the weighted sum method also evaluated bank accounts from Fio Bank as the optimal option for students and adults, which was mainly contributed to low fees for making payments via the Internet and low withdrawals from ATMs. For seniors, as with the previous method, the Air Bank current account has the highest utility value, mainly due to the low fees for bank operations performed at the branch.

5. Conclusions

The aim of the article was the application of multi-criteria decision-making methods to bank accounts. The lexicographic method, the order method, the TOPSIS method, and the

weighted sum method were implemented, evaluated, and compared on data from 28 bank accounts.

The current (or student) account from Fio Bank was determined as the most advantageous option using TOPSIS method and the weighted sum method. Also, Tom Account Plus, which was determined by the Lexicographic method as an ideal account for students and adults, was evaluated by the TOPSIS method as the third most advantageous bank account, so it is a very good result.

Of course, the results of the analysis depend on the chosen method of determining the weights of the criteria and on the chosen evaluation method. All parameters can be changed in the web application and decision-making tailored to the future client. Considering the current economic development of the Czech Republic, when the inflation rate is around 15 percent, banks will have to actively respond to this development and adapt their offer. Thus, clients will have to constantly monitor developments in the banking market and the economic situation and evaluate how best to manage their financial assets. It is necessary to take into account that the real interest rate is negative for retail accounts.

The challenge in retail banking is not only to attract new customers but to retain them and enhance relationships with existing ones, it is important to know the factors necessary to build solid relationships with customers (Sayil et al., 2019). The role of relationship marketing in establishing long-term relationships and building customer loyalty in the banking industry has been strongly emphasized in the literature (Sayil et al., 2019; van Esterik-Plasmeijer & van Raaij, 2017).

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