A Formal Model Used To Describe an Economic Process - Bank Deposits

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Formalization of an economic process is a way to find out how that process takes place into reality and which is the way the computer can implement this process. Formalization of any process allows finding all the variables that are involved and helps to improve the process by enhancing the variables. The economic process described in this paper is the accumulation account, the stages that led to the implementation of this type of account and the formalization of this process with the help formal languages. Realization of formal model is checked through an example proving the correct manner of the model.
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1 Introduction

An economic process involves the ordered enchainment of various phases and / or implementation stages of an economic operation. Economic process refers to a set of facts and specific activities for the economic life: production processes, distribution, consumption, employment, investment. In other words the whole system of activities involving and enrolling, through their duties, all economic agents represents the economic process.

For the implementation of an economic process economic means are consumed: purchase of raw materials, etc.., product manufacturing, execution of works, services, disposal (sale) of products, etc..

Economic processes can be transposed into formal languages that require a lot of strings of elements from an alphabet. These strings constitute well-formed words or sentences or grammatically correct sentences. These words in a language are not chosen at random, must comply with rules, the set of these rules forms the formal grammar.

2 Bank economic process- bank deposits

The creation and use of bank deposits represents one of the main bank functions. Preserving the customers' cash is the primary function of banks, characterized by a special relation between individuals and legal entities, on one hand, and banks, on the other [1], [2].

Deposit according to the banking law is a sum of money entrusted in the following conditions:

- to be totally repaid, with or without interest or any other facilities, on request or at a date agreed by the depositor with the depositary;
- not to relate with the transfer of ownership, provision of services or providing guarantees;

The deposit is any credit balance resulting from the remaining funds in accounts of individuals or transitional situations created by banking operations that are to be returned by the bank in applicable legal and contractual conditions, and any debt to an individual, represented by a debt instrument issued by this bank. Credit balances are not considered deposits that serve as guarantee for bank operations on behalf of the depositor; *Unavailable deposit* - deposit that can't be returned by the bank that has an insolvency process; *Common deposit* - deposit constituted of two or more individuals or deposit in which two or more persons have the right to operate against the signature of one or more persons who have constituted the deposit; *Bank deposit* - constitutes the funds entrusted to a bank for safekeeping, without specifying a term or a particularly fixed term, the depositor having the right to withdraw their funds according to the established deadline with a determined interest [1].

Banking practice currently uses various deposit accounts and their number continues to grow. This process is conditioned by the tendency of banks to meet customer demands and attract their savings in bank accounts [3].
The amount that a borrower (debtor) pays a lender (creditor) for the borrowed money over a given period. It may be attached during the whole period, or variable. Bank may have both the quality of the borrower and lender, it has to pay / to charge interest on amounts taken / lent. For the loans, the bank perceives an active interest and for deposits pays a passive interest [3].
Bank profit is given by the difference between *active interest income* and *passive interest expense*, to which are added the actual operating expenses of the bank. The net balance thus obtained by this difference is perceived as *net financial banking product* and is a *measure of financial performance* of the bank, a mark for the bank management. This must be pursued with consistency, obtained and permanently classified within the "Performance-risk" report coordinates that characterize a bank's progress with national and international banking market.
Active interest is a percentage of interest that is charged by banks for the borrowed amounts to its debtors. The name comes from the fact that is applied to an active balance sheet item, and the passive interest is the interest rate applied by the banks to the available funds that are in holder's accounts, to constituted deposits and to appealed loans. The name comes from the fact that it applies to a passive balance sheet item [3].
The economic process for depositing in a bank is given by the following diagram:

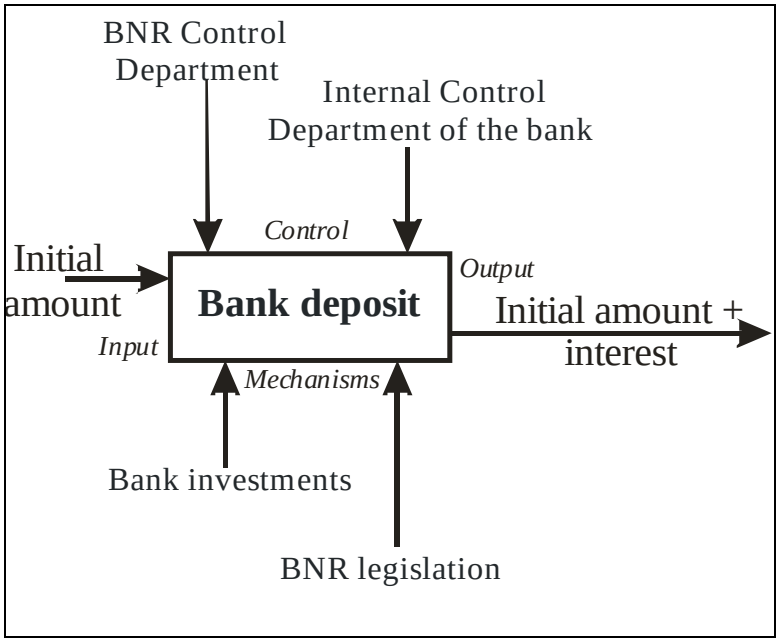

Fig. 1. Flow scheme of a bank deposit

Given the Figure 1, the input in this process is the initial amount and the outputs of the process are given by the original amount plus the interest on the depositing period.
The mechanisms that influence this economic process are given by bank investments (such investments dictate the value of interest on bank deposit) and BNR legislation that is consistent with European legislation given by the European Central Bank.

2.1 The accumulation account

Through the regulations in force (tax code) each income earned in Romania or outside the Romanian territory by the individuals is taxed. This applies to bank interest resulted from the calculation of a deposit (must be a deposit account) to which is applied the percentage of tax provided by law (that is 16%). In support of citizens and companies, the banking system came with a new product,

the accumulation account to which no longer calculates the tax on interest. Since this interest is achieved in a current account and not from an implementation of a deposit, this percentage of interest no longer applies. On BRD Bank this accumulation account was named ATUCONT and on ING Bank this account was named CONTROL, otherwise it had a generic name of saving account.

Unfortunately for the people who wanted to save without paying the tax on calculated interest (because all banks are private and try to avoid this tax to attract as many customers) the state came with new regulations that led to the disappearance of the accumulation accounts on which wasn't charged the tax on calculated interest.

Currently there is no bank to have such a bank product. The operating principle has remained the same, meaning that the amounts are deposited and withdrawn within the limits set by each bank individually. The interest that is applied depends on the fund from the accumulated account.

Products offered by commercial banks in Romania are a response to the policies that BNR implements and these products are made in such a manner as to be as attractive to customers, both individual and legal persons. The interest which is practiced by banks is closely related to the investment policy and its moment needs The more bank has greater need for financial reserves, the higher is the interest on deposits, and the reverse of this matter is when the bank has too much available money supply, in this case the interest rate for deposits is lower.

This type of saving is a flexible product through which you are rewarded with a favorable interest when saving, but when you need the savings you are not penalized for withdrawing cash. Thus, you get the interest only for the amounts that you have in account. On some banks if the account balance remains below the minimum balance, the savings account is automatically closed and all remaining money are transferred in the current account (eg. Romexterra MKB Bank). Notice that UniCredit Tiriac Bank maintains the same limits of amounts for savings accounts both in RON and foreign currency (EUR and USD).

Table 1. RON deposits in different banks with the related amount limits

Bank	**BCR**		**Piraeus Bank**		**UniCredit Țiriac Bank**	
Product name	Saving account Maxicont		Ideal account		Saving account	
Amount limits	<3.000	3,00%	<4.000	5,5%	<10.000	4,00%
	3.000-10.000	3,50%	4.001-100.000	5,75%	10.000-49.999	4,25%
	10.000-50.000	4,00%	>100.000	6,00%	50.000-99.999	4,5%
	50.000-200.000	4,10%			>100.000	5,00%
	>200.000	4,25%				

Table 2. EUR deposits in different banks with the related amount limits

Bank	**BCR**		**Raiffeisen Bank**		**UniCredit Țiriac Bank**	
Product name	Saving account Maxicont		Super Acces Plus		Saving account	
Amount limits	<4.000	1,00%	<500	0,10%	<10.000	1,70%
	4.000-12.000	1,20%	500-14.999	1,75%	10.000-49.999	1,80%
	12.000-60.000	1,50%	15.000-74.999	2,25%	50.000-99.999	1,9%
	60.000-160.000	1,75%	>75.000	2,00%	>100.000	2,00%
	>160.000	2,00%				

3 Formalization of the accumulation account

The notion of *formal* and *abstract* has received new dimensions together with the interdisciplinary researches on applied mathematics in literature, art, history, biology and of course in economics. Through a formal language it means a lot of strings of elements from an alphabet. These strings are also called well-formed words or sentences or grammatically correct sentences. These words from a language are not chosen at random, they must comply with the rule, the multitude of these rules compose the formal grammar.

In the case of accumulation account the first step to formalization is to create the graph for this process. This type of accumulation can be represented as a directed graph Figure 2.

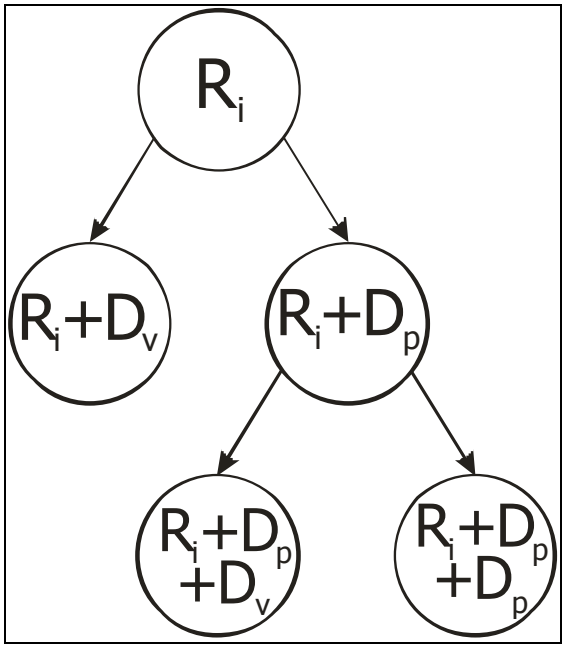

Fig. 2. Graph representation for the deposit process

where: - R_i is the initial resource
- D_p passive interest
- D_v interest on demand

Restrictions are the following:

- the initial resource R_i (the amount deposited by the individuals) to be the minimum amount for the constitution of this type of accumulation account R_{min};
- even if $R_i > R_{min}$ the resource owner must have constituted this type of accumulation account;
- $R_i + D_p$ can be calculated only if R_i has respected the duration of the deposit.

Consider a finite oriented graph, $\Gamma = (X, U)$ cu $x = \{a_0, a_1, ..., a_n\}$ where node a_0 is the initial amount which is to form in a bank account and the points $a_1, a_2, ..., a_n$ the deposits that were formed. The *U* arcs will describe the direct routes between points $a_0, a_1, ..., a_n$. Several parameters must be naturally considered in such a situation [4]:

- *the duration of each arc* (a_i, a_j) of U. We denote by t_{ij} this duration and assume that it is expressed in days or months (that is 30 days);
- *frequency of returning at each point.* Each point has a certain amount of accumulation. Also, depending on the length of disposal and the type of interest, can again return to the starting point. For each point a_i is defined a variable $k_{i,1}$ in the relation $0 < k_{i,1}$ with the mean that between two consecutive passes through the point a_i must pass at least $k_{i,1}$ days;
- *interest to be taken from every point.* We suppose that, in case of the compliance of imposed periodicity of parameter $k_{i,1}$ on each pass through a_i, $i \geq 1$ the person will have taken a calculated interest d_i (to the concerned interest we do not predict the unit of measurement that is expressed % or the value). The fact that from a_i it rises the amount d_i after $k_{i,1}$ days. We can consider that d_i is the capacity produced in point a_i in one day (or even a month) so that the interest to be taken from a_i to depend on the period since the previous passage through a_i;
- *deposit capacity. Given* q_1 and q_2 two constant, real numbers in the relation $0 \leq q_1 \leq q_2$, with the following meaning: on the returning to point $a_0(R_i)$, the deposit must have a certain amount

between the limits q_1 and q_2 (q_2 is the optimal maximum amount of the deposit and q_1 is the minimum limit of the account);

- *duration of the deposit.* Depending on the organization of each bank a duration of the deposit (measured in days) is specified as a constant Z, $0 \le Z \le 31$. The duration of activities of a deposit shouldn't exceed the duration Z but neither should be less.

The problem includes many options and features being thus very close to reality (is even reality). Although very complex, it will lead, however to a regular language.

It can be actually constructed a grammar G that generates correct accumulation accounts (interest) in relation to all previous conditions. Planning the interest is therefore done with a regular grammar and tracking its activity can be done using a finite state automaton. The activity dispatcher described by accumulation accounts problem can be done with the most simple (restrictive) generative and recognition devices in relation to Chomsky's hierarchy.

We will build in turn the languages associated with each of the considered conditions. All parameters that are related to the time are expressed on the same unit that is by day.

a) We will consider first the following right-linear grammar:

$$G(\Gamma) = (\{S\} \cup U, V(\Sigma), S, P),$$

where:

$$P = \{S \to b^{t_{0i}} a_i (a_i, a_j) \mid (a_0, a_i), (a_i, a_j) \in U\} \cup$$

$$\cup \{(a_i, a_j) \to b^{t_{ij}} a_j \quad (a_j, a_k) \quad | \quad (a_i, a_j), \quad (a_j, a_k) \in U\}$$

The language $L(G(\Gamma))$ contains all the correct paths in graph Γ with the proper movement duration, but the length of time equal to one unit. Given the following finite substitution $s: V(\Sigma)^* \to P(V(\Sigma)^*)$ defined by

$$s(b) = \{b\},$$

Then the language $L(U,t) = s(L(G(\Gamma)))$ that contains all the correct paths in relation to *U* and with the movement duration on arcs.

b) Given the following language

$$Q = \{a_{i_1} ... a_{i_k} a_0 \quad | \quad k \ge 1, \quad i \ne i_{j+1}, \quad i_j \ge 1$$

$$\text{for any j and } \sum_{j=1}^{k} c_{i_j} \quad \in [q_1, \quad q_2]\}.$$

Also, we consider the substitution $s \quad X^* \to P(V(\Sigma)^*)$ defined by

$$s(a_i) = \{a_i^{si}\}\{b,c\}^*, \; i=0, 1, \ldots, n.$$

Then, the language

$$L(q_1, q_2, c) = \Pr ef\,(s(Q)^*)$$

contains all deposits that satisfy the condition imposed by the account capacity and the saving of his return to point a_0 ignoring all other conditions (except the duration of the deposit).

c) We now consider the conditions expressed by the parameter $k_{i,1}$ related to the frequency of return at each point. For each $a_i \in X$ we build the finite language

$$L(a_i, k_{i,1}) = \{\alpha\alpha' \quad | \quad \alpha, \alpha' \in V(\Sigma) - \{a_i\}\} \cup \{a_i x, \quad x a_i \mid \quad x \in (V(\Sigma)) - \{a_i\})^*, \quad |x| = k_{i,1}\} \cup$$

$$\cup \{a_i a_i, \quad a_i a_i b, \quad a_i a_i c, \quad b a_i a_i, \quad c a_i a_i, \quad b a_i b, \quad c a_i b, \quad b a_i c\}.$$

The $C(L(a_i, k_{i,1}), L(a_i, k_{i,1}))$ language contains all paths that meet the periodicity condition imposed by the parameter $k_{i,1}$. The pairs $\alpha\alpha'$, $\alpha, \quad \alpha' \in V(\Sigma) - \{a_i\}$ allow the extension of terminal strings with other symbols than a_i, while strings $a_i x$ and $a x_i$ allow the introduction of a symbol a_i only after at least $k_{i,1}$ different symbols of a_i because $|x| = k_{i,1}$ in both cases. Once a symbol a_i has been introduced, using the string $a_i a_i$ we can arbitrary increase the number of appearances of a_i or we can introduce a symbol *b* or *c* with the strings $a_i a_i b, \quad a_i a_i c, \quad b a_i a_i, \quad c a_i a_i$. Then, the language

$$L(K_1) = \bigcap_{i=0}^{n} C(L(a_i, k_{i,1}), \; L(a_i, k_{i,1}))$$

contains all the strings that meet this condition for all points of X.

All languages $L(U,t)$, $L(q_1,q_2,c)$, $L(K_1)$ are regular languages and their grammars can be effectively constructed.

$L(\Sigma)$ language obtained as the intersection of the above languages is regular and its grammar can be built effectively because there is an algorithm that receives as input the parameters describing the problem and will provide on output the grammar that generates the language to all solutions of the problem. Using this grammar one can decide if the language $L(\Sigma)$ is null, finite or infinite, so for any problem like the one before it can be said whether there are or aren't solutions and whether their multitude is or isn't infinite. In the case that the problem has no solutions, the imposed conditions by parameters $k_{i,1}$, q_1, q_2 need to relax..

To illustrate we took data from UniCredit Bank because the limits of amounts are identical for both RON and EUR. In this case the problem has the following development:

$$\Gamma = (\{a_0, a_1, a_2\},$$

$$\{(a_0, a_1), (a_0, a_2), (a_1, a_0), (a_2, a_0)\},$$

$$t_{01} = t_{12} = 30 \ \ zile,$$

$$s_0 = s_1 = s_2 = 1 \ \ zi,$$

$$c_1 = d_v \quad c_2 = d_c$$

$$q_1 = 1 \quad q_2 = 10.000,$$

$$k_{0,2} = k_{1,2} = 30, \quad k_{0,1} = 30, \quad k_{2,1} = 0,$$

where:

$$a_0 = R_i, \quad a_1 = R_i + D_v, \quad a_2 = R_i + D_p$$

In this case the graph would have the following model as in Figure 3., where the person may deposit money in the bank and account accumulation to constitute it after several days (in this case is followed the arc T_1 and after T_2), or may deposit money and constitute the accumulation account on the same day and after the maturity account to raise the interest and return to baseline (in this case is followed the arc T_3 and after T_4):

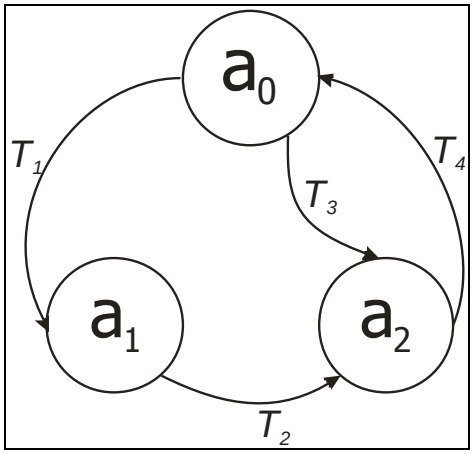

Fig. 3. Graph example for the deposit process

All circuits connecting the three points are defined by:

$$T_1 = (a_0, t_1, a_1, v_1)$$
$$T_2 = (a_1, t_2, a_2, v_2)$$
$$T_3 = (a_0, t_3, a_2, v_3)$$
$$T_4 = (a_2, t_4, a_0, v_4)$$

where t_i represents the start date (start date of the accumulation account) and v_i is the completion date (the date on which accumulation account was completed).

Suppose we want to know all the options that begin with a departure from the accumulation account a_0 and ends, also in point a_0, because we are interested only on arcs starting from the point a_0 (that may be the arc T_1 or arc T_3) and ends a_0 (that is T_4).

The problem is straightforward meaning that the graph is complete. However the language $L(\Sigma)$ is infinite, so there are infinite possibilities to meet the formal restrictions.

$L(\Sigma)$ language associated with this problem may be represented by the following solutions:

$$b^{30}a_1c_1^{31}b^{30}a_2c_2^{31}b^{30}a_0$$
$$b^{30}a_2c_2^{31}b^{30}a_0b^{30}a_2c_2^{31}b^{30}a_0$$

for the solutions

$$a_0a_1a_2a_0$$
$$a_0a_2a_0$$

4 Conclusions

Similar with any economic process, the level

and profitability of these activities depends on many factors. Therefore any decision making process is a challenge, which now we find a rather difficult disposal, turning to IT solutions. Finding a solution of automation can be a real gain. This paper focuses on formulating and solving a formal model that can be a support solution of decision-making process for the economic segment represented by bank deposits.

We have presented the manner in which can be saved with the help of accumulation account and we also have presented the interests that various commercial banks in Romania are practicing. On this mode of saving we made a formal model respecting the various restrictions that may encounter a person or entity when opening an accumulation account. The model was developed following the functioning of this type of deposit, namely, the accumulation account. For achievement the formal model we developed the graph that corresponds to this type of accumulation deposit and we imposed the parameters for achieving this model. For each parameter we defined a formal language and finally, we gathered all formal languages in one.

In the case of this model of economic processes can be observed that there is a periodicity and cyclicity of events. Thus for the accumulation account we used data collected from UniCredit Tiriac Bank because this bank has the same limits of amounts in RON and foreign currency. I developed the appropriate graph of analyzed process that is given by the conditions imposed by the bank. For the economic process we made the appropriate flow scheme, identifying each element of the scheme (input, output, control and mechanism).

The economic process can be repeated for infinity of time all depending on the person who concludes the bank deposit contract.

The proposed methodology allows its extension for modeling and generating a decisional support, in the case of numerous types of economic processes, which gives it a significant degree of generality.

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