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# Determinants of the quality of financial management of insurance companies*

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**Abstract**

This study is devoted to the analysis of the statistical relationship between the efficiency of an insurance company and a number of factors characterizing the structures of its assets. Efficiency in the study is considered as a metric that evaluates the quality of an organization's management, which is the one of the most important characteristic of its financial stability.

The empirical analysis was carried out using data from the financial statements of insurance companies for the period from 2017 to 2020 of the group of leaders in terms of insurance premiums of the Expert RA rating agency based on the results of 2020. Life insurance companies, reinsurance companies and mutual insurance companies were excluded from this list due to the specifics of their business and financial statements.

For the companies included in the final sample, an assessment of overall efficiency was built. The methodology of its calculation is formulated and developed in [3, 14, 15]. It is based on Data Envelopment Analysis (DEA). The partial efficiency indicators obtained for a certain set of DEA model specifications are aggregated into several indicators using the principal component analysis method (PCA). It is important that there is a positive correlation between the overall efficiency indicator and the partial efficiency indicators.

The first principal component acts as an indicator of overall efficiency, the others allow one to identify its sources. This makes it possible to compare companies that have the same overall efficiency.

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Further, for all representatives of the final sample, a regression model of the statistical relationship of overall efficiency with the characteristics of the asset structure was built. The model specification was performed based on the MFP (Multivariable Model-Building with Fractional Polynomials) algorithm [16, 17], which allows to adapt the specification of the regression model to the properties of the data and identify nonlinear statistical relationships. The results of the evaluation of the model allow us to assert that the general and, accordingly, all partial performance indicators have a statistical relationship with the selected characteristics of the asset structure. The nature of the relationship is predominantly nonlinear. The results obtained in the work can be useful in forming a strategy for managing the financial stability of an insurance company, as well as for potential partners and investors in solving the task of benchmarking.


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*Keywords:* insurance market; efficiency of insurance companies; technical efficiency; data envelopment analysis; management quality; principal component analysis; overall efficiency; partial efficiency

## 1. Introduction. Theoretical foundations of the study

The main objective of this study is to establish the nature of the relationship between the overall efficiency of the insurance business and the asset structure. Since these indicators are available for management by financial management, the results of the study can be useful in shaping the management policy of insurance companies.

### 1.1. Efficiency in this study

The quality of management is one of the most important factors characterizing the sustainability of an organization. It's assessment is part of the CAMELS rating system for banks. However, its importance for assessing the sustainability of other organizations, in particular insurance companies, cannot be denied [19]. Since [18], the assessment of management quality in most cases is associated with the assessment of the efficiency of the implementation of processes that consume some resources (inputs) and produce some products (outputs), which generally corresponds to the definitions of the ISO 9000/2000 standard.

Efficiency is usually understood as the ratio of the observed values of certain indicators related to resources and/or products to their best (optimal) values in a certain sense for a certain set of implementations of a particular process. Both resources and products are understood here in the broadest sense. Accordingly [13], the concepts of "input efficiency" arise when output volumes are fixed and consumption volumes of resources for their production are analyzed, and "output efficiency" when resource consumption volumes are fixed and output volumes are analyzed. Regardless of the orientation ("input" or "output"), technical efficiency and scale efficiency are usually considered [4, 10]. The degree of technical inefficiency is based on an assessment of proximity to the boundary of production capabilities [9, 13, 10]. At work [12] the author gives a formal definition of full technical efficiency in contrast to the weak efficiency . The implementation of the process is technically fully efficient if an increase in the output of one of the products requires a reduction in the output of at least one other product or an increase in the consumption of at least one resource and if a reduction in the consumption of any resource requires an increase in the consumption of at least one other resource or a reduction in the output of at least one product (Pareto-Koopmans efficiency).

In this study, the authors focus on analyzing the technical efficiency of insurance companies for several reasons. Firstly, technical efficiency is a component of such practical options for evaluating efficiency as economic efficiency and income generation efficiency [10]. Secondly, as will be noted later, the use of various options for the technical efficiency indicator allows one to assess the efficiency of scale. Thirdly, the efficiency of resource allocation and revenue generation require the availability of price data, which, as a rule, are not publicly available.

### 1.2. Efficiency and DEA

Traditionally, entities that provide various implementations of the selected process are called Decision Making Units (DMUs). They get the same sets of m types of resources (x, inputs) and produce the same sets of s types of products (y, outputs).

There are two main approaches to evaluating the effectiveness of implementation. The Stochastic Frontier Analysis (SFA) method is a variant of regression analysis [1, 11]. One of the problems with this approach is the need to

specify a production function. Another problem is the difficulty of extending this approach to the case when DMUs produce several products, i.e. have a vector output [11]. The second approach is based on linear programming and is called – Data Envelopment Analysis, DEA [6, 8]. It is devoid of these disadvantages and was used in this study.
The central concept of measuring efficiency is the set of production capabilities [8] — P, the production capability set, satisfying four conditions:

1. All observed DMUs belong to P;
2. If $DMU = (x, y) \in P$, then for any positive scalar t it is fulfilled $(tx, ty) \in P$ (the assumption of constant returns to scale);
3. if $DMU = (x, y) \in P$, then $\forall\ DMU = (\tilde{x}, \tilde{y}) : \tilde{x} \geq x, \tilde{y} \leq y\ DMU \in P$
4. if $DMU_1, DMU_2 \in P$, then $\forall a, b \geq 0\ DMU = (ax_1 + bx_2, ay_1 + by_2) \in P$

According to the proposal formulated in the seminal work [9], the efficiency of each DMU should be defined as the distance to the boundary of a given set.
In [5, 6, 7, 8], a solution to this problem using linear programming was proposed. The corresponding assessment was called CCR. The choice of the CCR orientation for evaluating weak efficiency is determined solely by the applied context of the task. At work [8] it is shown that the indicator of weak efficiency at the input is always inversely proportional to the same indicator at the output.
An important development of the above assessment was the assessment of weak efficiency formulated in [Banker et al, 1984] and called BCC. Its technical difference from the CCR assessment is the presence of an additional constraint in the corresponding linear programming problem, which ensures the convexity of set of production capabilities.
In this study, estimates of weak efficiency were used. This type of assessment is the basis for evaluating other types of efficiency. In addition, the result obtained with its help is the starting point for further analysis, which allows one to identify opportunities for additional optimization of resource consumption and the creation of products, i.e. the possibility of further productivity growth. When choosing the typology of efficiency assessment, the authors were guided by the fact that the external economic environment in which the insurance companies involved in the study operate is very heterogeneous, which determines the different returns on scale. Thus, the most appropriate assessment option would be the BCC assessment. Choosing the orientation of efficiency assessment, the authors proceeded from the assumption that the specifics of the insurance business largely determine the orientation to maximize the result while preserving available resources.

### 1.3. Identification of non-linear relationships.

Since the main task of the study is to analyze the statistical relationship between efficiency and asset structure, an important issue is the choice of a model characterizing this relationship. The study is based on financial statements for several years. Thus, its empirical basis is panel data. At the same time, the experience of the authors and their colleagues shows that linear regression models are very rarely informative enough when solving problems of this kind. At the same time, the specification of nonlinear regression models is generally a difficult and poorly formalized task.
There is an approach that allows partially automating the specification of the nonlinear form of occurrence of explanatory variables in the regression model. It is designed in the form of the concept of fractional polynomials proposed in [16]. The initial indicators are replaced here by some of their nonlinear transformations. Parameterization of these transformations makes it possible to take into account a wide class of nonlinearities such as saturation and changes in the direction of influence. The choice of parameter values is carried out solely on the basis of data properties, taking into account the specifics of the subject area.
The fractional polynomial is defined based on the concept of the generalized degree of the factor ‘x’

$$x^{(p)} = \begin{cases} x^p, \ p \neq 0 \\ \ln(x), \ p = 0 \end{cases} \tag{1}$$

A fractional polynomial from ‘x’ of the second order (relevant for this study) is a function of the form:

$$H\left(x;(a_1,a_2),(p_1,p_2)\right)=\begin{cases} a_1x^{(p_1)}+a_2x^{(p_2)},\ p_1\neq p_2 \\ a_1x^{(p)}+a_2x^{(p)}\ln(x),\ p_1=p_2=p \end{cases} \quad (2)$$

For several explanatory variables, the regression model takes the form:

$$y_t=\sum_k H_k\left(x_{k,t};(a_{1,k},a_{2,k}),(p_{1,k},p_{2,k})\right)+v_t \quad (3)$$

The formal solution to the problem of specification of a multidimensional model was obtained within the framework of the MFP (Multivariable Model-Building with Fractional Polynomials) algorithm described in the work [17].

## 2. The empirical part of the study

### 2.1. Description of the data

The sample was based on the rating of the agency "Expert RA" of insurance companies in terms of insurance premiums at the end of 2020. 151 companies were initially selected. Life insurance companies, reinsurance companies and mutual insurance companies were excluded from this list due to the specifics of their business and financial statements. Also, after a preliminary analysis of the data, several companies were deleted, since some indicators of their financial statements for all years were identified as outliers. As a result, 97 companies were included in the sample. It should be noted that later, during the efficiency assessment, the list of companies was reduced to preserve the convexity of the boundary of the production set. For some insurance companies, it was impossible to evaluate the effectiveness of certain specifications of the DEA model. The final sample included the reporting of 64 insurance companies for 2018 – 2020.

### 2.2. Assessment of the overall efficiency.

In accordance with the technology for evaluating the overall effectiveness described in the works of the authors [14, 15], many potential inputs of DEA models were formed. When choosing the resources consumed, the authors were guided by the experience of evaluating the efficiency of banks.

Potential inputs are listed below. The list contains the numbers of the reporting forms and, if possible, the reporting lines used. It should be noted that by 2020, some insurance companies were accounting in accordance with Russian accounting rules, and some companies used IFRS. The list contains the lines of Russian reporting (in the numerator) and the dates of international reporting (in the denominator).

- «stuff» — payment of wages and other remuneration to employees (F0420128 line 24/ line 24)
- «fixas» — intangible assets and fixed assets (F0420125 line 17 + line 18/ line 23 + line 24)
- «fin» — profitable financial resources (F0420125 Cash, Financial assets, Investments and so on)

Profit (loss) before taxation (F0420126, p. 33 / p. 68) was considered as an output — "profit".

The selected sets of inputs and outputs allow one to generate 7 different specifications of DEA models — {(staff; profit), ..., ([staff, fixas]; profit), ..., ([staff, fixas, fin]; profit)}. Note that, firstly, all specifications, in authors opinion, make practical sense. For example, the specification (staff; profit) allows one to evaluate the efficiency of investments in personnel in the context of profit. It is based on the amount of profit per one monetary unit invested in personnel for each insurance company.

Partial technical efficiency estimates for 2019 and 2020 were obtained for all specifications. The analysis of the results showed that the partial technical efficiency of insurance companies depends very much on the specification of the DEA model. No one company is partially efficient in every sense. Insurance companies that are efficient in one context often turn out to be very far from ideal in another. Thus, no partial efficiency can claim to be a universal indicator of the quality of a company's management.

In accordance with the above methodology, based on the principal component analysis procedure (PCA), an assessment of the value of the overall efficiency indicator for all participants in the sample was built. It turned out that the main contribution to data variability is made by the first three principal components. The first component plays the role of an indicator of overall efficiency. All factor loads are positive for it. Thus, an increase in the values of any variant of partial efficiency is associated with an increase in the values of overall efficiency.

The second principal — PC2 —component allows one to separate companies that efficiently convert fixed assets, intangible assets and personnel into profit (PC2 > 0) and companies that efficiently convert financial resources into profit (PC2 < 0). Thus, for each participant in the sample, you can specify the source of achieving its level of overall efficiency. The results are shown in Figure 1.

Similar reasoning can be carried out for other main components, but this is beyond the scope of this study.


Picture 1. The higher the overall efficiency, the more noticeable the sources of its achievement

### 2.3. Analysis of the determinants of overall efficiency

As noted above, in order to determine the statistical relationship of overall efficiency with the asset structure, a regression model for panel data was built in combination with the MFP algorithm. The dependent variable was the overall performance in the year following the year of the financial statements. Financial results were considered as resources to achieve future efficiency. From a technical point of view, this approach avoided the need to analyze the presence of simultaneity in variables and, consequently, the presence of endogeneity in the model.

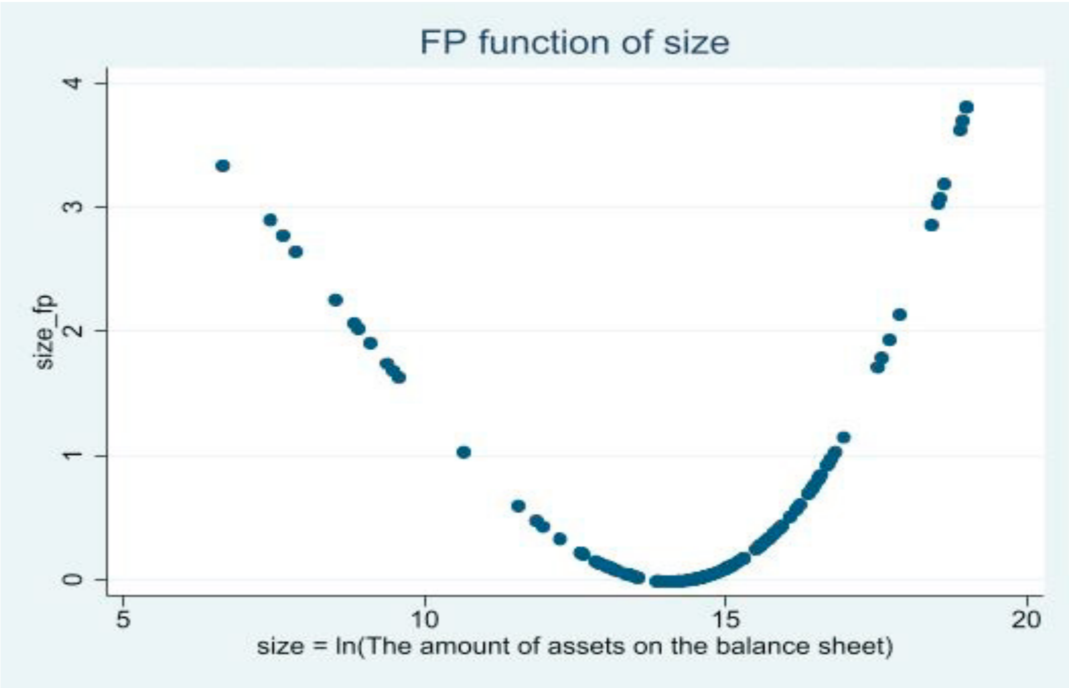
Fractional second-order polynomials were used to reflect the nonlinear influence of financial relations characterizing the structure of assets on overall efficiency. In this case, each regressor was included in the model as the sum of two nonlinear components, which is named FP functions of regressors. The parameters of the components — generalized degrees and coefficients in the model were determined during the operation of the algorithm.

As a result of the algorithm, only those regressors that had a significant statistical relationship with the overall efficiency remained in the model. Below is a list of them in Table 1.

Table 1. Characteristics of the asset structure that are significant for overall efficiency.

| determinants | description |
|---|---|
| size | Ln(The amount of assets on the balance sheet) |
| C00 | The share of insurance premiums transferred to reinsurance in the total amount of premiums |
| C04 | Current liquidity ratio |
| C10 | Loss ratio (net) |
| C15 | The coefficient of coverage of insurance reserves by investment assets |
| C16 | The share of reinsurers in insurance reserves |

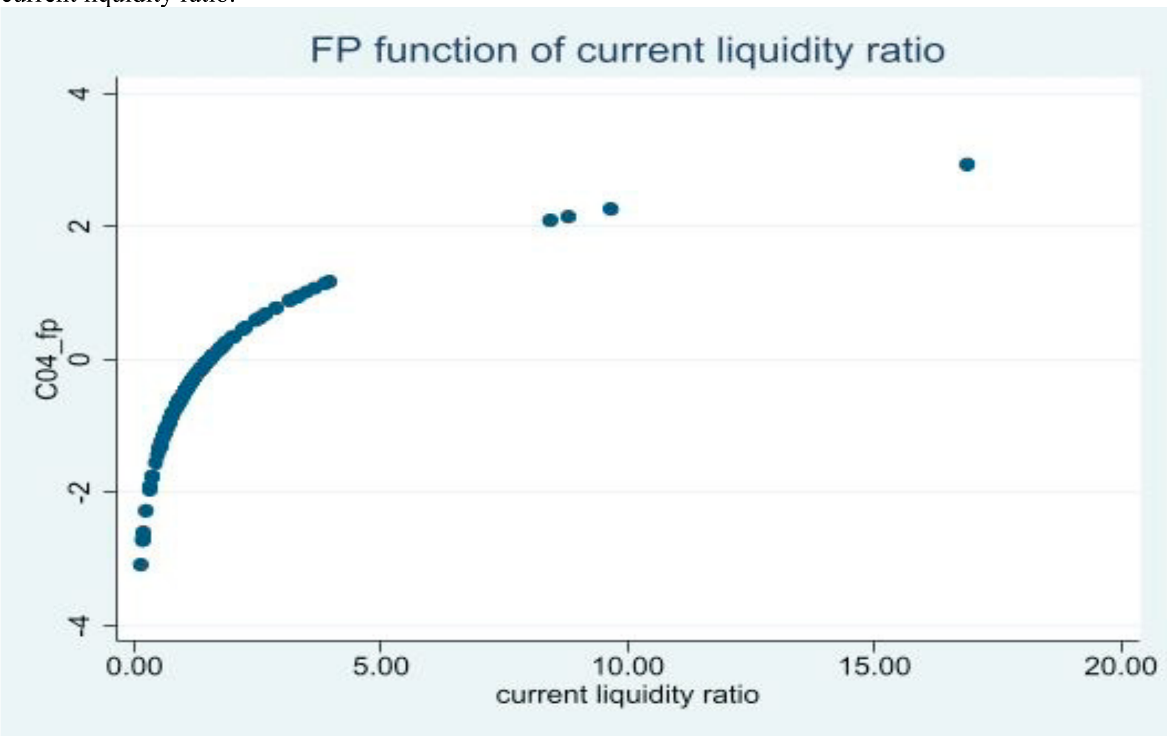
The functional form of generalized polynomials is quite difficult to analyze. In this regard, it is more convenient to analyze the nature of the influence of regressors on the overall efficiency using graphs of FP functions of regressors. Let's look at some of them.




Picture 2. The impact of company size on overall efficiency.

From this graph, it can be seen that the initial growth in the size of the company is associated with an increase in non-profitable assets. The resulting profit is spent on increasing them. Only after gaining a "critical mass", the company begins to generate profit efficiently.

Interesting conclusions can also be drawn as a result of analyzing the graph of the impact on the effectiveness of the current liquidity ratio.




Picture 3. The nature of the impact on the overall effectiveness of the current liquidity ratio.

It can be seen that up to a certain amount, the build-up of highly liquid (and possibly low-profit) assets leads to a decrease in profits, which is quite consistent with the previous schedule. In the future, the growth of highly liquid assets is associated with an increase in profits, but the growth rate is gradually decreasing.

It should be noted that in order to prevent excessive adaptation of the model to the properties of the sample (overfitting), the authors analyzed the stability of the results obtained using bootstrap technology. The results showed the high reliability of the estimates obtained.

## 3. Brief conclusions

The results of the study have once again proved the practical importance of evaluating the overall efficiency. For the selected market segment, results were obtained that allow not only to compare the quality of management in different contexts for its participants, but also to analyze how each specific insurance company achieves the current level of efficiency. This allows them to be compared based on criteria relevant to the analyst. In particular, the management of a particular company should assess its position against the background of competitors.

The analysis of the relationship between overall efficiency and asset structure allows the financial management of each company to make more adequate decisions on managing its effectiveness, to form a more correct financial management strategy.

From a technical point of view, the results of the study confirm the importance of taking into account the nonlinear nature of the relationship between targets and regressors when solving problems related to the management of commercial organizations.

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