

# Regional Investment Attractiveness's Model Analysis at the Heart of Russian Investment Policy

Evgenii Mitrofanov<sup>1,\*</sup>, Alevtina Kulagina<sup>2</sup>, and Liya Panferova<sup>2</sup>

<sup>1</sup>Moscow State University of Humanities and Economics, RU-107150, Moscow, Russia

<sup>2</sup>I.N. Ulyanov Chuvash State University, RU-428015, Cheboksary, Russia

**Abstract.** The article analyzes the investment attractiveness of regions of the Volga Federal District in the Russian Federation using the principal component method. Indicators are selected characterizing investment attractiveness of Russian regions of the Volga Federal District. Functional dependence of the selected indicators are defined, based on which the estimation of level of investment appeal of regions of the Volga Federal District and their clustering. Recommendations for improving the investment policy of Russian regions are given.

## 1 Introduction

In modern economic conditions, one of the key points of Russia's investment policy is to attract investment in the competition in the global financial market and increase the level of investment attractiveness of the country's regions [1-5]. Determining the level of investment attractiveness of a country and its regions is widely used by potential investors in their activities, which helps to identify weaknesses in investment policy and investment prospects both in an individual subject and in the country as a whole, and also helps to identify factors that affect the country's investment policy and investment attractiveness of subjects, and the need to develop new and improve existing methods for assessing the investment attractiveness of regions of the country [3,5].

Many researchers agree that the investment attractiveness of a region is an integral characteristic of the investment object, which reflects the subjective relationship between the investor and the investment object, i.e. how well the investment object meets the investor's goals. Investment attractiveness includes investment potential and investment risk. In turn, they are divided into a number of indicators. Thus, investment attractiveness is determined by many factors that can be combined in meaning [1,2,4].

## 2 Results and discussion

Many existing methods of analyzing investment attractiveness are usually related to factor analysis. Therefore, in this study, we will use the principal component method to assess the level of investment attractiveness of regions.

The principal component method is used to decrease the number of variables and construct generalized

factors, i.e. principal components that are uncorrelated with each other.

At the first stage of statistical analysis, it is necessary to determine a set of initial indicators that best characterize the objects under study in terms of their investment attractiveness. We selected 15 most significant indicators (table 1).

**Table 1.** Grouping of indicators used to analyze region's investment attractiveness

Composite indicator	Group indicators
Production group of indicators	$x_1$ - GRP per capita, RUB
	$x_2$ - Industrial production index, % of the previous year
Financial and economic group of indicators	$x_3$ - The balanced financial result of activity of organizations, mln. RUB.
	$x_4$ - Share of unprofitable organizations, in % of the total number of organizations
	$x_5$ - Investment in fixed assets per capita, RUB
The employment group of indicators	$x_6$ - Employment, %
	$x_7$ - The level of labor productivity in the region (the ratio of GRP to the number of employees), %
Innovative (informational) group of indicators	$x_8$ - Innovative activity of organizations, %
	$x_9$ - Percentage of the working population engaged in research and development, people
Infrastructure group of indicators	$x_{10}$ - Retail trade turnover per capita, RUB
	$x_{11}$ - Volume of paid services per capita, RUB

\*Corresponding author: [mep79@list.ru](mailto:mep79@list.ru)

Composite indicator	Group indicators
Social group of indicators	$x_{12}$ - The share of the population with monetary incomes below the subsistence minimum, in % of the total population
	$x_{13}$ - The ratio of per capita income to the subsistence minimum, %
Consumer group of indicators	$x_{14}$ - Number of own passenger cars per 1000 people. population, PCs.
	$x_{15}$ - Total area of residential premises per inhabitant on average, sq. m.

Factor analysis is performed using the Statistica application software package. To identify the presence of hidden relationships between indicators, we will find a matrix of paired correlations (table 2). The presence of values exceeding 0,7 in absolute value indicates that there is a relationship between the initial indicators.

**Table 2.** Correlation coefficient

	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	$x_6$
$x_1$	1					
$x_2$	-0,15	1				
$x_3$	0,87	0,06	1			
$x_4$	0,19	-0,18	-0,08	1		
$x_5$	0,99	-0,18	0,83	0,09	1	
$x_6$	0,97	-0,01	0,90	0,06	0,96	1
$x_7$	0,93	0,21	0,87	0,13	0,91	0,96
$x_8$	-0,71	0,05	-0,73	-0,47	-0,63	-0,70
$x_9$	-0,91	0,25	-0,73	-0,13	-0,90	-0,83
$x_{10}$	0,99	-0,19	0,80	0,20	0,99	0,95
$x_{11}$	0,99	-0,20	0,81	0,23	0,98	0,93
$x_{12}$	-0,74	0,14	-0,62	0,35	-0,81	-0,73
$x_{13}$	0,35	-0,10	0,20	-0,26	0,45	0,40
$x_{14}$	0,99	-0,19	0,81	0,24	0,98	0,95
$x_{15}$	0,99	-0,17	0,85	0,26	0,96	0,94

**Table 2.** Correlation coefficient (continuation)

	$x_7$	$x_8$	$x_9$	$x_{10}$	$x_{11}$
$x_1$					
$x_2$					
$x_3$					
$x_4$					
$x_5$					
$x_6$					
$x_7$	1				
$x_8$	-0,72	1			
$x_9$	-0,76	0,49	1		
$x_{10}$	0,90	-0,65	-0,93	1	
$x_{11}$	0,89	-0,66	-0,94	1,00	1
$x_{12}$	-0,64	0,13	0,81	-0,78	-0,77
$x_{13}$	0,29	0,21	-0,34	0,42	0,39
$x_{14}$	0,90	-0,71	-0,92	0,99	0,99
$x_{15}$	0,90	-0,73	-0,93	0,98	0,99

**Table 2.** Correlation coefficient (continuation)

	$x_{12}$	$x_{13}$	$x_{14}$	$x_{15}$
$x_1$				
$x_2$				
$x_3$				
$x_4$				
$x_5$				
$x_6$				
$x_7$				
$x_8$				
$x_9$				
$x_{10}$				
$x_{11}$				
$x_{12}$	1			
$x_{13}$	-0,66	1		
$x_{14}$	-0,73	0,35	1	
$x_{15}$	-0,71	0,31	0,99	1

We will check the validity of the principal component method and the significance of the correlation matrix using Wilkes test. Let's formulate hypotheses:

- $H_0$  – the correlation matrix is insignificant;
- $H_1$  – the correlation matrix is significant.

Calculate the observed value of the criterion using the formula:

$$X_{obs}^2 = - \left( n - \frac{1}{6}(2m + 5) \right) \ln(\det R) = - \left( 11 - \frac{1}{6}(2 \cdot 15 + 5) \right) \ln(1,73 \cdot 10^{-8}) = 92,33 \quad (1)$$

The critical value is found in the Pearson distribution table  $X_{obs}^2 = X_{0,05;105}^2 = 82,35$ , with significance level 0,05 and the value of the degree of freedom equal to  $\frac{1}{2} m(m - 1) = \frac{1}{2} \cdot 15 \cdot (15 - 1) = 105$ .

Thus  $X_{obs}^2 = X_{crit}^2$ , therefore the main hypothesis is rejected in favor of the competing one  $H_1$ . The found matrix of paired correlations is significant at the significance level of 0,05, i.e. there are hidden connections between the initial features and the use of the principal component method is justified.

The next stage of analysis involves decreasing the dimension of factors. We need to understand how many main components we need to allocate. This can be determined using the Kaiser and scree criteria. The Kaiser criterion selects factors with eigenvalues equal to or greater than 1. According to this criterion, in our case, it is necessary to select 3 factors. According to scree criterion, after the fourth main component, the eigenvalues slow down, so it is worth selecting 4 main components.

On the basis of these criteria, it was decided to limit ourselves to three main components, which account for 92.1% of the total variance (table 3).

**Table 3.** Eigenvalues and relative contribution to the total variance

№	Eigenvalue	% of the total variance	Cumulative eigenvalue	Total %
1	10,5623	70,4153	10,5623	70,4153
2	1,9426	12,9505	12,5049	83,3658
3	1,3160	8,7732	13,8209	92,1391

№	Eigenvalue	% of the total variance	Cumulative eigenvalue	Total %
4	0,6496	4,3307	14,4705	96,4697
5	0,3444	2,2957	14,8148	98,7654
6	0,1007	0,6710	14,9155	99,4364
7	0,0492	0,3281	14,9647	99,7644
8	0,0259	0,1724	14,9905	99,9368
9	0,0050	0,0331	14,9955	99,9699
10	0,0045	0,0301	15,0000	100,0000

The first main component took the load of 12 indicators. Among them are GRP per capita; the level of employment of the population aged 15-72 years; the volume of paid services per capita; the number of own cars per 1000 people population; the total area of residential premises, on average per inhabitant and others. The first main component can be interpreted as «Coefficients that characterize the standard of living in the region». The second component is defined by two indicators. This is the share of unprofitable organizations and the ratio of average per capita income to the subsistence minimum. We interpret it as «Coefficients of financial capabilities of the region». The third main component contains only one indicator - the industrial production index. Let's call it the «Regional industry coefficient».

Next we calculate the integral assessment of investment attractiveness of the Volga Federal District of Russian Federation according to the weight coefficients:

$$IA = \beta_1 F_1 + \beta_2 F_2 + \beta_3 F_3 \quad (2)$$

$$F_1 = 0,095x_1 + 0,053x_2 + 0,107x_3 + 0,026x_4 + 0,086x_5 + 0,102x_6 + 0,115x_7 - 0,106x_8 - 0,069x_9 + 0,086x_{10} + 0,086x_{11} - 0,04x_{12} - 0,011x_{13} + 0,09x_{14} + 0,094x_{15} \quad (3)$$

$$F_2 = -0,017x_1 + 0,08x_2 - 0,008x_3 - 0,404x_4 + 0,048x_5 + 0,02x_6 - 0,032x_7 + 0,321x_8 - 0,047x_9 + 0,013x_{10} - 0,004x_{11} - 0,309x_{12} + 0,374x_{13} - 0,027x_{14} - 0,047x_{15} \quad (4)$$

$$F_3 = 0,018x_1 - 0,691x_2 - 0,235x_3 + 0,273x_4 + 0,044x_5 - 0,11x_6 - 0,24x_7 + 0,104x_8 - 0,146x_9 + 0,079x_{10} + 0,089x_{11} - 0,051x_{12} + 0,134x_{13} + 0,071x_{14} + 0,047x_{15} \quad (5)$$

$\beta_i$  – share of the total variance of the i-th factor.

The final assessment of investment attractiveness of the Volga Federal District regions based on the indicators of 2018 is shown in table.4. The subjects are arranged in order of decreasing values of the level of investment attractiveness.

**Table 4.** Integrated assessment of investment attractiveness of Russian Volga Federal District regions

	F <sub>1</sub>	F <sub>2</sub>	F <sub>3</sub>	IA
Republic of Tatarstan	0,69065	0,61295	-0,58509	<b>0,55826</b>

	F <sub>1</sub>	F <sub>2</sub>	F <sub>3</sub>	IA
Samara region	0,51758	0,01487	-0,31870	<b>0,36729</b>
Nizhny Novgorod region	0,45323	0,24763	-0,47211	<b>0,33622</b>
Bashkortostan	0,46803	0,07059	-0,37830	<b>0,33158</b>
Perm region	0,41439	-0,05557	-0,29482	<b>0,28081</b>
Orenburg region	0,37997	-0,24316	0,05532	<b>0,26147</b>
Republic of Udmurtia	0,33549	-0,06923	-0,75793	<b>0,17450</b>
Penza region	0,24123	-0,19816	-0,22530	<b>0,13505</b>
Saratov region	0,27225	-0,25538	-0,41258	<b>0,13288</b>
Ulyanovsk region	0,26850	-0,50392	-0,08130	<b>0,12663</b>
Kirov region	0,20308	-0,12959	-0,34929	<b>0,10372</b>
Republic of Mordovia	0,18072	-0,23440	-0,24222	<b>0,08210</b>
Chuvash Republic	0,07956	-0,03722	-0,54337	<b>0,00383</b>
Republic of Mari El	0,08835	-0,49745	0,04453	<b>0,00184</b>

In order to identify common features and similarities of regions in terms of investment attractiveness, we will conduct a cluster analysis. The purpose of cluster analysis is to group objects with similar characteristics into clusters.

Since in our case there is no information that any factor is more important for classification than others, we want to take into account the differences in each feature equally, so we will choose the usual Euclidean distance, formula (1), and Ward's method, which often gives fairly compact and well-separated clusters as a distance measure:

$$d_{ij} = \sqrt{\sum_{k=1}^m (x_{ik} - x_{jk})^2} \quad (6)$$

The final composition of clusters is shown in table 5.

**Table 5.** Cluster composition

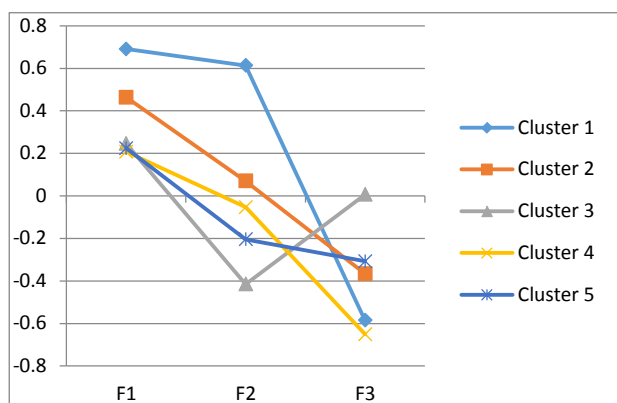
Cluster number	Number of objects in the cluster	Cluster composition
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Cluster number	Number of objects in the cluster	Cluster composition
1	1	Republic of Tatarstan
2	4	Samara region, Nizhny Novgorod region, Bashkortostan, Perm region
3	3	Orenburg region, Ulyanovsk region, Republic of Mari El
4	2	Republic of Udmurtia, Chuvash Republic
5	4	Penza region, Saratov region, Kirov region, Republic of Mordovia

## References

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To interpret the clusters, we plot the average values of the factors (Fig. 1).



**Fig. 1.** Graph of average values of factors

## 3 Conclusion

The leader in terms of living standards and financial opportunities in the region is the first cluster, which includes the Republic of Tatarstan.

The second cluster has a fairly high standard of living in the regions, but the third factor has a negative value, which shows a low index of industrial production in the four regions included in the cluster.

The third cluster was the leader in the industrial production index among other clusters. But at the same time, it has the worst position on the second factor.

The fourth cluster is characterized by the standard of living in the region, but has the last position in almost all factors. Two of the three factor values are negative.

The fifth cluster does not stand out from the others. This cluster has average positions for all factors.

Hence, we can conclude that the regions included in clusters 1, 2 need to improve the level of industrial development in the region in order to increase investment attractiveness.

Regions included in 3, 4, 5 clusters have a large share of unprofitable organizations, as well as a low standard of living. It is possible that decreasing unprofitable organizations and improving the standard of living will lead to an increase in investment attractiveness in these regions.