INVESTIGATION OF DISTRIBUTION OF CURRENCY PAIRS USING METHODS OF FACTOR ANALYSIS

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ИССЛЕДОВАНИЕ РАПРЕДЕЛЕНИЯ СОВОКУПНОСТИ ВАЛЮТНЫХ ПАР МЕТОДАМИ ФАКТОРНОГО АНАЛИЗА

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Аннотация. *Рассматривается возможность оценки совместного распределения совокупности приращений котировок валютных пар, используя представление всей совокупности в виде канонической факторной модели. Показана принципиальная возможность построения такой модели для выбранной совокупности признаков, сделана оценка распределений обобщенных и характерных факторов и на ее основе смоделировано многомерное распределение всей совокупности исходных признаков.*

A significant role in the construction of econometric models plays a choice of the multidimensional distribution of asset returns. For example, from the theory point of view of constructing optimal portfolios, the investor may require knowledge of the joint distribution of returns available on the assets market. That is why the assessment of the joint distribution of returns is an urgent practical problem for the financial markets [1].

In this paper we consider the possibility of estimating the joint distribution of the aggregate currency pairs, using techniques of factor analysis. It is obvious that the direct evaluation of multi-dimensional distribution of currency pairs together is a very difficult task, if we take into account the complicated relationship between the variables, and can not be reduced to the evaluation of one-dimensional distributions of the individual components (currency pairs). Using factor analysis, we can try to represent each source component in the form of a linear combination of generic and specific factors uncorrelated with each other [2]. The links between the original components are completely determined by the generalized factors, the variation of each component is defined as a generalized and relevant characteristic factor. If anyone knows the laws of the distribution of generic and specific factors, the last independent force can get the law of each original component distribution, finding joint component distribution. At the same time, this approach allows to estimate the distribution of values that depend on the data, for example, the cost of distribution of a portfolio consisting of currency pairs and depending on the distribution of multidimensional data currency pairs.

Seven currency pairs (BYR / RUB, CNY / RUB, EUR / RUB, GBP / RUB, KZT / RUB, UAH / RUB, USD / RUB) were chosen as the subject of analysis for the periods from January 12, 2015 till October 13, 2015.

In accordance with the canonical model of factor analysis, we have studied the possibility presentation of each of the original features ξ_j, $j=\overline{1,k}$ in the form of: $\xi_j = \alpha_{1j} f_1 + \alpha_{2j} f_2 + \ldots + \alpha_{mj} f_m + \varepsilon_j$, $j=\overline{1,k}$ or in the vector form : $\vec{\xi} = \vec{\alpha}_1 f_1 + \vec{\alpha}_2 f_2 + \ldots + \vec{\alpha}_m f_m + \vec{\varepsilon} = \alpha \vec{f} + \vec{\varepsilon}$,where $\vec{\xi} = (\xi_1, \xi_2, \ldots, \xi_k)$ - the vector of initial (factors); $\vec{f} = (f_1, f_2, \ldots, f_m)$ - a vector of latent factors, $m < k = 7$; $\alpha_1, \alpha_2, \ldots, \alpha_m$ - vectors of factor loadings; $\alpha = (\alpha_1, \alpha_2, \ldots, \alpha_m)$ - a matrix of factor loadings; $\vec{\varepsilon} = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_k)$ - a vector specific factors. We have assumed, that the following relations are valid for the covariance and variance of the initial factors:

$$\begin{cases} \operatorname{cov}(\xi_i, \xi_j) = \sum_{s=1}^{m} \alpha_{si} \alpha_{sj}, \quad i=\overline{1,k}, \quad j=\overline{1,k}, \quad i \neq j \\ D(\xi_i) = \sum_{s=1}^{m} (\alpha_{si})^2 + D(\varepsilon_i), \quad i=\overline{1,k} \end{cases}.$$

The maximum likelihood method have been used as a method of factor analysis. In the factor analysis it is necessary to estimate the number of generalized factors that allow the representation of the original data in the form of the model described above, as well as to determine the vectors of factor loadings and factor values for each of the original observations. Table 1 shows the achieved significance levels, as well as the proportion of the total variance explained by the factors for the generalized constructed one and two- factor models.

Table 1

Results of the factor analysis

Number of factors	1	2
Dedicated dispersion	18.90%	25.50%
Significance level	$1.094 \cdot 10^{-6}$	0.327

We see that the source data in the form of two-factor model idea is acceptable, but we note that the generalized factors explain only a quarter of the total variance. Table 2 shows the distribution of dispersions f generalized and typical factors for the resulting two-factor model.

Table 2

Distribution of the share dispersions initial signs of generalized and characteristic factors

Currency pairs	Generalized factors			Characteristic factor
	F1	F2	F1+F2	
BYR/RUB	0.215	0.090	0.305	0.695
CNY/ RUB	0.426	0.260	0.686	0.314
EUR/RUB	0.877	0.015	0.892	0.108
GBP/RUB	0.230	0.001	0.231	0.769
KZT/ RUB	0.022	0.081	0.103	0.897
UAH/ RUB	0.036	0.002	0.038	0.962
USD/RUB	0.670	0.012	0.682	0.318

Maximum likelihood method assumes a normal distribution of the original data, so in the case of an arbitrary allocation does not guarantee the independence of the found generalized and specific factors. Therefore, the check has been carried out on the independence of the factors, using the Pearson's test.

Thus, it have been shown that it is possible presentation of the initial factors as a linear combination of independent variables (two generalized and one characteristic factor). Thereby, the multi-dimensional distribution of the original features will be completely determined by the distribution of these values , and the problem of estimating the multivariate distribution can be reduced to the evaluation of the distributions received by the generalized and specific factors.

The statistical analysis of distributions of random and specific factors has shown that both the generic and specific factors can be considered as a random variables distributed according to the Laplace law with density: $f(x) = 0{,}5ae^{-a|x|}$, where $a > 0$ - the distribution parameter. Table 3 shows the results of hypothesis testing of the distribution of each factor by the Laplace law (as estimates of the unknown parameters of the maximum likelihood estimation method have been used: $a^* = 1/\overline{X}$ - the corresponding sample average).

Table 3

Testing hypotheses of the distribution of the factors on the Laplace law

Factor	F1	F2	X1	X2	X3	X4	X5	X6	X7
Parameter distribution	1.302	1.211	94.19	311.828	464.38	86.876	71.057	50.692	165.113
Statistical Significance	1.076	1.370	4.372	17.513	7.630	8.552	12.106	9.918	8.981
Significance level	0.982	0.967	0.626	0.007	0.266	0.200	0.059	0.128	0.174

If we know the distribution of generic and specific factors, we can get an estimate of the distribution of any underlying asset as well as a multi-dimensional distribution of all the factors. In this paper, the evaluation has been made numerically using the Monte Carlo method. Figure 1 shows an example of the resulting two-dimensional simulation for the distribution of currency pairs EUR / RUB and USD / RUB.

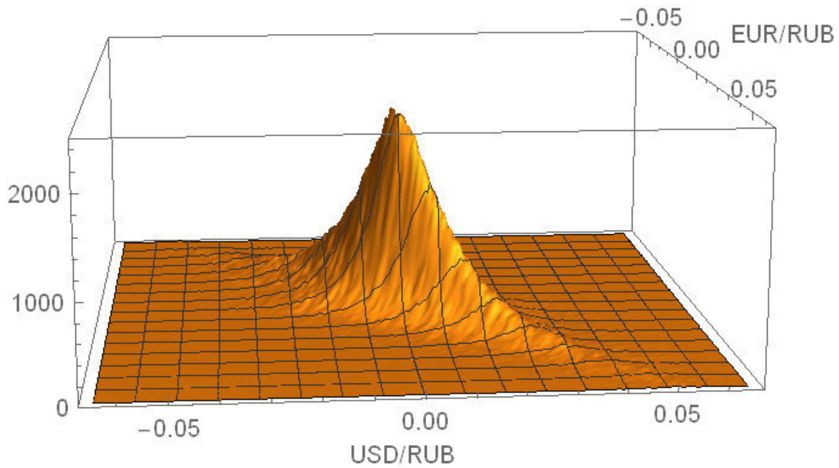

Fig. 1. Assessment of the distribution density increments of quotations of currency pairs

So, this paper shows the fundamental possibility of constructing factor model for the relative increments of quotations of currency pairs together.

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