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QUALITY ESTIMATION OF STOCK INDICES IN UKRAINE

У статті досліджуються якісні характеристики фондового ринку України. Автор використовує метод латентних індексів і процедуру Якобі для того, щоб обрахувати такі якісні характеристики, як точність та адекватність. Крім того, були визначені чинники, котрі пояснюють нестабільність найбільш точного індексу – ПФТС.

Ключові слова: *фондовий ринок України, метод латентних індексів, процедура Якобі, індекс ПФТС.*

In this paper Ukrainian stock indices quality is investigated. The author has applied the method of the latent indices and Jacobi procedure in order to calculate the standard value and the estimation of such quality characteristics as accuracy and adequacy. Moreover, there were determined factors which explain the variability in the most qualified index – PFTS.

Key words: *Ukrainian stock market, the method of latent indices, Jacobi procedure, PFTS-index.*

Introduction. At the markets of capitals there are a lot of different indices with the same meaning. For investor and market participant it's still difficult to choose one index for lack of certain set of instruments to estimate the quality of stock indices. Often this chose is subconscious one without quantitative characteristics. Indices authors tell only about advantages and strong characteristics of methodology.

Moreover, stock indices errors can effect seriously on equity market, macroeconomics studies, forecasting on market participant behavior, tendencies in rates of securities. Every stock index defines certain part of world's stock market, certain group of companies at certain territory. That's why the quality requirements for stock indices are higher.

Now the sphere of using stock indices is wider than it was hundred years ago, formulas and methodologies are more difficult. For the last 10 years indices become goods. Stock indices trade is one of

the biggest segments of finance market in American and European stock exchanges.

There are some Ukrainians scientists who worked on this sphere. V. Lyawenko has profound but out-of-date research of stock indices and rates. V. Kucherenko characterizes PFTS; M. Nazarchuk defines correlation between stock indices and Ukrainian economy development. [10, 9, 11] Also some Russian scientists have done interesting researches: B. Alechin – autocorrelation analysis, M. Alekseenkova – factors of stock indices fluctuation at different sectors of the national economy, V. Borovykov – features of stock indices qualities in 1997. [2, 1, 5] For Ukraine topical question is quality analysis of stock indices made by Belarus scientist A. Belzezkyi. [3, 4] Also there researchers of foreign scientists but they are connected with all emerging markets without specifying Ukrainian features. [6, 7]

Theoretical background

In order to estimate quality of Ukrainian stock indices we use the concept of standard stock index. For the reconstruction of this index we used the method of the latent indices. The main part of this method is the calculation of eigenvalues and eigenvectors of covariance matrix. For this we used the Jacobi procedure with using MS Excel and VBA.

The result of measuring is differing from the real value. In this situation we have errors. *Stock index error* is a difference between its actual value and true value. Stock indices can have a lot of errors of different types and sources. There are four error types according to the cause of error:

1. Theoretical (defective index theory, assumption incorrectness etc.).
2. Index formula errors.
3. Input data errors.
4. Methodical errors.

Stock index quality – set of properties which determine the level of its aptitudes to use. Quality has such characteristics like accuracy and adequacy and reliability. Standard stock index is the base for its calculation.

Standard stock index – index which fairly represent certain market property. The term "standard stock index" is theoretical conception which is used to develop theoretical and practical methods of estimation stock indices quality. The method of latent indices is one of this method.

Latent index is a recondite index for market events under consideration. This index is closer to the standard stock index than others. The main idea of latent stock index is the renewal the struc-

ture of links between stock indices and on this base the reconstruction of the links between latent indices. Than we use latent index to reconstruct standard index.

The main stages of the method of latent stock indices are:

1) choice the input data of stock indices;
2) ranging of stock indices;
3) determination the links between indices;
4) latent indices calculation;
5) standard stock index reconstruction.

In Figure1 there is a scheme of reconstruction Ukrainian standard stock index.

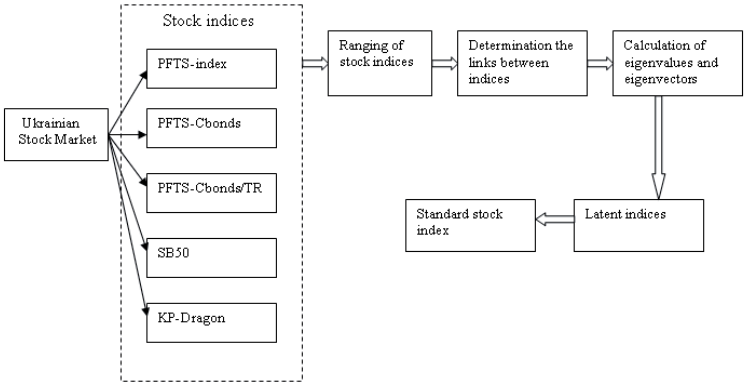


Figure 1: The scheme of reconstruction Ukrainian standard stock index

Methodology

Step 1. Organization the input set of stock indices

In Ukraine there are five stock indices: PFTS-index, PFTS-Cbonds, PFTS-Cbonds/TR, SB50 and KP-Dragon. Three indices from the PFTS-family define 96.4% of the whole formal securities market in Ukraine. [1, c.58] For the analysis stock indices values from 01.01.2008 to 01.04.008 were used.

Step 2. Ranging of stock indices

Then we convert absolute values of stock indices to relative values:

$$\varepsilon_{It} = 100\%(I_t - I_{t-1}) / I_{t-1} \qquad (1.1)$$

where ε_{It} is a relative change of stock index, I_t, I_{t-1} – current value and previous value of stock index.

Step 3. Centering of ranged stock indices values

$$u_{tj} = x_{tj} - \overline{X}_j, \quad (1.2)$$

where u_{tj} – centered j stock index value at moment, t, x_{tj}– ranged stock index value at moment, t, $\overline{X}_j$ – average stock index value.

Step 4. Calculation of covariance matrix of stock indices

$$C = \frac{1}{n} U^T U, \quad (1.3)$$

where C – covariance matrix of stock indices, U– matrix of centered stock indices values.

In Table 1 there are the results of covariance matrix calculation.

Table 1

Covariance matrix of relative changes in stock indices values, 01.01.2008-01.04.008

Stock index	Stock index				
	KP-Dragon	**PFTS-index**	**PFTS-Cbonds**	**PFTS-Cbonds/TR**	**SB50**
KP-Dragon	*0,21240*	0,09680	0,04640	0,05537	0,06909
PFTS-index	0,09680	*0,11952*	0,03529	0,03956	0,04784
PFTS-Cbonds	0,04640	0,03529	*0,03892*	0,03807	0,03418
PFTS-Cbonds/TR	0,05537	0,03956	0,03807	*0,03852*	0,03826
SB50	0,06909	0,04784	0,03418	0,03826	*0,00002*

Step 5. Calculation of eigenvalues and eigenvectors

$$CQ = \Lambda Q, \quad (1.4)$$

where $Q = \{q_1, q_2, ..., q_m\}$ – eigenvectors matrix, $\Lambda = diag\{\lambda_1, \lambda_2, ..., \lambda_m\}$ – diagonal matrix of eigenvalues.

The best method to calculate eigenvectors and eigenvalues of the matrix is Jacobi method. This method uses elementary orthogonal matrix transformation. As a result of the cycle of this transformation the input matrix changes in such way:

$$A \to D = V^T A V, \quad (1.5)$$

where D – diagonal matrix of eigenvalues, V – orthogonal matrix of eigenvectors.

Procedure Jacobi seeks for the maximum modulo value in the right top angle of the input matrix. In order to complete this pro-

cedure there should be 6...10 cycles or $3n^2 ... 5n^2$ transformations of Jacobi.

The result of Jacobi procedure is eigenvectors matrix Q and diagonal matrix of eigenvalues Λ. In the matrix Λ there is also the process of assorting eigenvalues in the order of decreasing takes place.

Step 6. Determination a degree p of basis of the eigenvectors which are used to form latent values

In this operation we use all eigenvalues sorted in the order of decreasing and find the minimum of possible integer $p<<m$ which approach to the condition:

$$\sum_{l=1}^{p} \lambda_l \Big/ \sum_{i=1}^{m} \lambda_i \geq 0.85 \quad (1.6)$$

In our case degree p is 2, because 97.04% of the whole variability of stock indices is concentrated in the first and second latent index.

In Figure 1 there is a spectrum of eigenvalues of covariance matrix of relative changes in stock indices. Eigenvalues are in the order of decreasing. In the Figure 3 also there is an accumulation curve K_p which is corresponded to the eigenvalues spectrum. Here is you can see that 82.04% of the whole variability is corresponded to the first eigenvector, 6.14% – to the second. We can exclude other eigenvectors from analysis because they are corresponded only to the 2.96% of the whole stock indices variability.

Also it's possible to determine the part of total variance which is corresponded to the main components. The elements on the main diagonal of covariance matrix (Table 1) are the dispersions of the input values of relative changes of Ukrainian stock indices. The dispersion of KP-Dragon is 0.2124, PFTS-index – 0.11952, PFTS-Cbonds – 0.03892, PFTS-Cbonds/TR – 0.03852 and SB50 – 0.00002. Total variance as the sum of input indices variances is 0.4094. Eigenvalues of covariance matrix equals to variances of the corresponding main components. Total variance is 0.4094 and concentrated in the first two components. For these components the sum of variance is 0.3973 that is 97.04% of the total variability. Other 2.96% of the total variability is connected with the specific properties of the stock indices.

Step 7. Calculation of latent indices

$$Z = UQ', \quad (1.7)$$

where Z – the matrix of latent indices, $Q' = \{q_1, q_2, ..., q_p\}$ – truncated matrix of the first p eigenvectors..

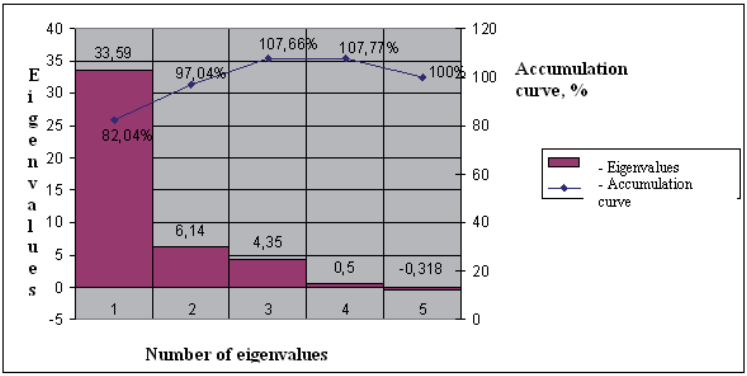


Figure 1: Spectrum of the eigenvalues of the covariance matrix of the relative changes in stock indices.

Step 8. Calculation standard stock indices values

$$A_e = ZQ^T, \qquad (1.8)$$

where *Ae*– matrix of the standard centered values of the stock indices.

$$E_j = A_{ej} + \overline{X}_j, \qquad (1.9)$$

where *Ej* – vector of the standard value of the stock index, *Aej* – vector or column of the matrix *Ae* (matrix of the standard centered values of stock indices).

Now we can convert back the matrix of relative values to the matrix of absolute values of stock indices and get matrix *Ae*. In this matrix column 1 is KP-Dragon, 2 – PFTS-index, 3 – PFTS-Cbonds, 4 – PFTS-Cbonds/TR and 5 – SB50.

Results: estimation the quality of Ukrainian stock indices

We can use the standard values of Ukrainian stock indices to estimate its quality.

The first equality characteristic is accuracy. *Accuracy of stock indices* is the difference between its actual and true value and measured with the series of errors *et*. Generalized index of accuracy is *average relative error*:

$$\varepsilon_I = e_{cp} / E_{cp} \qquad (2.1)$$

where ε_I – average relative error of the index for the period of time *T, Ecp*– average value of standard index for the period of time T.

$$E_{cp} = \sum_{t=1}^{T} E_t \Big/ T, \quad (2.2)$$

where *Et* – standard value of index in the period of time t.

The results of estimation accuracy of Ukrainian stock indices are in Table 2. According to these calculations the highest level of accuracy has index KP-Dragon. It's average relative error is 1.11%. Also high levels of accuracy have PFTS-Cbons/TR (1.19%) and PFTS-index (1.64%). The biggest average relative error has index SB50.

Table 2

Accuracy and adequacy of Ukrainian stock indices, 25th August 2007 to 4th September 2007

Quality indices	Stock indices				
	KP-Dragon	**PFTS-index**	**PFTS-Cbonds**	**PFTS-Cbonds/TR**	**SB50**
Accuracy, average relative error	1,11%	1,64%	2,75%	1,19%	2,90%
Adequacy index	0,000016	0,001485	0,337367	0,87887	0,002538

Adequacy of stock index – the level of accordance the values of stock indexes to the character of the market events. We determine adequacy with using such index:

$$A = 1 - \sum_{t=1}^{T} e_t^2 \Big/ \sum_{t=1}^{T} (E_t - \overline{E})^2, \quad (2.3)$$

where A – adequacy index, e_t – index error in a period of time t, Et– standard index value in a period of time t, $\overline{E}$ – average value of standard index for the period of time T.

The low value of this index means the low adequacy of stock index. If $A<0,75$ there is no practical use of this index.

Adequacy index for the PFTS-Cbonds/TR is 0.87887. It means PFTS-Cbonds/TR shows 87.887% of the total variability of standard stock index. In operation on stock market you can use this index. All of others Ukrainian stock indices have the adequacy index lower than 0.75 and don't correspond to this characteristic of quality. The base of calculation KP-Dragon index and SB50 is the value of PFTS-index which is also has low level of adequacy. This is one of the reason of its low quality.

We need further analysis to determine the reasons of low PFTS-index quality. This is very important question because PFTS-index is only one index which has acknowledgement abroad.

Factors of PFTS dynamic

In our model there are 8 independent variables which may influence PFTS.

1. DAX index. DAX is calculated on the trends of such industries development as consumer, insurance, automobile, chemicals, banks, financial services, transportation & logistics, telecommunication, utilities, pharma&healthcare, technology, industrial, retail, software.

In fact, the main parts of Ukrainian industries which are included in PFTS are also included in DAX. Moreover, the variance of DAX can be as example of PFTS future. Ukraine has a perspective to develop its automobile, consumer, chemicals and transportation industries to be presented at the listing of companies which are included in PFTS.

One more reason for causality is the strict pro-European vector of Ukrainian policy. In fact, stock market relations are determined by the fact that our country has border with the EU, exports and imports flows, investor objects.

According to Ukrainian statistics the second place after Cyprus (22,8%) in the volumes of direct investments to Ukraine comes from Germany (18,5%). [3] These investments flows are connected our economies and stock markets. And worse condition of doing business in Germany will also negatively effect conditions of doing business in Ukraine. As for the future this effect should be more precise, because more and more Ukrainian companies will "enter" stock market.

Also the causality exists because German stock market is the most popular among foreign stock markets for Ukrainian companies. In fact, some our companies have claimed about IPO after financial crisis at such well-known German stock exchanges as Frankfurt, Düsseldorf and Stuttgart.

According to the sign index PFTS it should be positive.

2. USD. This variable we decided to include because of the last events on the currency market in Ukraine. Actually the situation is very difficult. Ukrainians save their money in dollars and have rally great unsatisfied demand on American currency. Some specialists estimate that the volume of this unsatisfied demand only from population is 300 mln. dol.

By our hypothesis before the model estimation as the rate of 100 USD rises PFTS should decrease. There are several reasons. At

first, Ukrainians think about dollars as the way to save their money and they buy them for temporary "free" hryvnyas. These hryvnyas could be invested in stock market but they are accumulated in dollar assets. Second reason is that the level of confidence to the dollar is much higher as the culture of investment at stock market. Also the reason for causality is not good level of Ukrainian stock market development. Furthermore, the last but not the least reason is high start-up costs to become a player at stock market.

3. Euro. The question with euro is also very important. Now this currency becomes more popular in Ukraine. First reason is European vector of Ukrainian foreign policy. Time is going on and most of people are starting to divide their currency assets among euro ad dollar, sometime they begin use only euro. As for the character of relations the sign near the coefficient should be negative.

4. Cross-course. This variable is very interesting for analyze. First, reason is that there is may a possibility to use only this value instead of the USD and Euro. Cross-course USD/Euro also explains the alternative way to allocate resources. Actually, the relations should be negative. As cross-course becomes high people begin to save more in euro than in dollars, they don't allocate their currency assets on the stock market. The question is in fact about psychology. As people will want to have more profit, to try the role of risk-taker they will play more on stock market. Also as they become more familiar with the process on stock market they will think more about the profitable use of their knowledge.

The use of cross-course analysis gives more weight to our analysis because now this cross-course is rather unstable and may show some implicit, internal relations. The main reason is that this index is unstable now. The strength of dollar goes down with after election in the USA results, high unemployment, and mass bankruptcy of the major American corporations.

5. S&P500. This world-renowned index includes 500 leading companies in leading industries of the U.S. economy. Index constituents exhibit the following characteristics:

1) Market Coverage – Approximately 75% of the U.S. equities market;

2) Weighting – Market capitalization;

3) Market Capitalization – Minimum of US$ 4 billion;

4) Public Float – At least 50%;

5) Reconstitution – As needed basis.

With more than US$ 1.53 trillion in indexed assets, the S&P U.S. indices have earned a reputation for being not only leading market indicators, but also investable portfolios designed for cost

efficient replication or the creation of index-linked products. The history of the S&P 500 dates back to 1923, with an expansion to include 500 companies in 1957.

For sure this index can play the role of indicator of the world stock market development. This is the main reason of including this index to our multiply regression model. The coefficient of elasticity near this index should be positive.

6. Volume, PFTS. This is PFTS in its value term. It shows how much money was converted at Ukrainian stock market. In any case this variables has positive impact on PFTS-index dynamics.

7. Rate of deposits in national currency.

This variable should be taking into account as a measure of alternative investment decision. In this case, the sign near coefficient elasticity of this variable should be negative: the high the amount which an individual can gain from deposit the less the amount of money he is ready to invest in stock market.

8. *Rate of deposits in foreign currency.*

This rate should be also taken into account because of the high level of economy dolarization in Ukraine. Theoretically, the nature of this indicator is the same as the rate on deposits in national currency – negative.

To construct multiply regression model we used data in the period from 19.08.2008 to 18.11.2008. As a result we got 59 values.

The best among received models is model with 2 variables:

$$Y = -68{,}172X_1 - 27{,}8X_2 + 1129{,}8, \qquad (2.4)$$

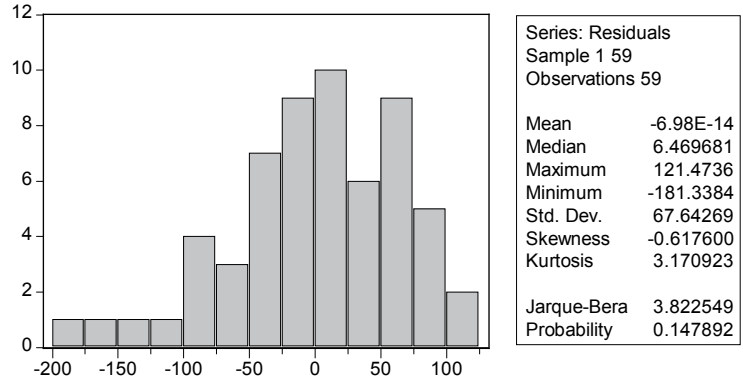
where *Y = PFTS, X1* – rate of deposits in national currency, *X2* – rate of deposits in foreign currency

This model has significant values of parameters b_1 and b_2, the coefficient of determination is quite high (0,66). The p-value in the Jarque-bera test of normality is reasonably high that we don't reject the normality assumption (Fig.1). The satisfactory value of White Heteroskedasticity test (2.779704), we can estimate that there is no multicollinearity.

But we have positive autocorrelation, Durbin-Watson test – 1.052624. The more expected reason in this case is a specification error. We tried to get out autocorrelation: add to the model the third variable and used other functional forms. By these manipulations we could not solve the problem with the autocorrelation, in all models the values of Durbin-Watson test are low.

The model should be transformed. According to the theory we can determine two possible reasons of autocorrelation – incorrect model specification or inertia. In fact, we try to use different func-

tional forms of the model that's why it's higher possibility that the problem is with inertia. In any case this topic is now much more interesting for further research.



Picture 2: Residuals of the regression

Conclusions

With using the method of latent indices and Jacobi procedure the standard stock indices were calculated. This was a base for the calculation such characteristics of quality as accuracy and adequacy. All indices have sufficient level of accuracy but actually only one Ukrainian stock index (PFTS-Cbond/TR) has the appropriate level of adequacy. Further directions of studying this topic are estimation the third characteristic of quality – reliability, determination the influence on the stock indices quality such factors as input data, market capitalization, branches set for the calculation the index base, index formula, foreign issuers, representativeness of sample, volatility and liquidity.

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