Correlation Analysis on Bucharest Stock Exchange

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Bazandu-se pe conceptele de baza ale Teoriei Moderne a Portofoliului elaborate de Markowitz, articolul de fata analizeaza corelatia care exista intre preturile actiunilor a patru companii apartinand unor sectoare diferite ale economiei, toate patru listate la BVB, pentru a afla daca exista posibilitatea crearii unui portofoliu diversificat, conform Markowitz, la Bursa de Valori Bucuresti. Analiza foloseste niveluri lunare ale preturilor actiunilor in perioada decembrie 2004 - decembrie 2005 pentru companii reprezentative ale celor trei sectoare de prim-plan de la bursa de la Bucuresti: Societatea de Investitii Financiare Moldova (SIF2) pentru sectorul financiar-bancar, Antibiotice Iasi (ATB) pentru sectorul farmaceutic si Rompetrol Rafinare Constanta (RRC) pentru sectorul petrolier. In plus, s-a inclus in analiza o alta reprezentanta a sectorului financiar bancar (Societatea de Investitii Financiare Oltenia – SIF5) pentru a identifica masura in care corelatia intra-sectoriala difera de cea inter-sectoriala la BVB.

Key words: *expected return, rate of return, variance, standard deviation, covariance, correlation, portfolio, Bucharest Stock Exchange*

Before modern portfolio theory, the decision about whether to include a security in a portfolio was based principally upon fundamental analysis of the firm, its financial statements and its dividend policy. In 1952, Harry Markowitz, a University of Chicago graduate student in search of a dissertation topic, began a revolution in finance by suggesting that the value of a security to an investor might best be evaluated by its mean, its standard deviation, and its correlation to other securities in the portfolio. The investment decision is not merely which securities to own, but how to divide the investor's wealth amongst securities. This is the problem of "Portfolio Selection", the title of Markowitz's article published in the March 1952 issue of the Journal of Finance, for which he won a Nobel Prize in Economics in 1990.

Markowitz's model, as the later ones based on it, like CAPM and APT, makes the following restrictive assumptions, seldom found on financial markets:

We consider only one period of time (the model is static);

We assume that there are no restrictions concerning the fraction of an arbitrary asset in the portfolio;

All assets are infinitely divisible and marketable;

All investors have "homogeneous expectations". This implies that all investors have the same expectations about the expected returns of the assets;

Investors maximize their expected utility;

There are no taxes and no transaction costs;

All returns are normally distributed with mean μ and a standard deviation σ, that are constant over time. Asset prices are assumed to follow random walks and are thus unpredictable. This assumption states that all investors can base their portfolio decisions just on the return, standard deviation and correlation between all assets;

All investors are risk adverse. For a given level of risk, they prefer the investment which offers the higher level of return and for a given level of return, they prefer the investment associated with the lower level of risk.

We now apply Markowitz's portfolio theory and calculate the statistic indicators used by

Markowitz for the four stocks traded on Bucharest Stock Exchange: SIF2, SIF5, ATB and RRC. We try to establish in the end if BSE provides the possibility to select a Markowitz optimum portfolio. In other words, we try to find out if there are any strongly negatively correlated stocks which can be selected to form a diversified portfolio on Bucharest Stock Exchange.

1. Rates of return/ Expected rates of return

The investor return is a measure of the growth in wealth resulting from that investment. In our case, the monthly rates of return for the analyzed stocks during the one-year period can be seen in Table 1.

We calculate the Rate of Return with the formula:

$$Ri = \frac{EV - BV}{BV},$$

Where EV is ending value and BV is beginning value.

When dividends are paid, we adjust the calculation to include the intermediate dividend payment, and the equation is:

$$Ri = \frac{EV - BV + CF}{BV},$$

Where CF is the cash flow (dividend) during the period.

In our analysis, we included the dividends distributed by both SIF2 and SIF5 in March 2005, in value of 540 ROL per share for SIF2 and 585 ROL per share for SIF5.

Table 1: Computation of Monthly Rates of Return: 2005

Date	Closing price SIF2 (ROL)	Rate of return SIF2 (Ri) %1	Closing price SIF5 (ROL)	Rate of return SIF5 (Rj) %	Closing price ATB (ROL)	Rate of return ATB (Rk) %	Closing price RRC (ROL)	Rate of return RRC (Rl) %
ec.04	**7250**		**8700**		**4820**		**921**	
an.05	**9750**	**34,48**	**13400**	**54,02**	**7600**	**57,67**	**1190**	**29,20**
eb.05	**13600**	**39,48**	**15800**	**17,91**	**7350**	**-3,28**	**1140**	**-4,20**
ar.05	**9500**	**-26,17***	**11300**	**-24,77***	**6400**	**-12,92**	**903**	**-20,78**
pr.05	**10500**	**10,52**	**12500**	**10,61**	**6000**	**-6,25**	**853**	**-5,53**
ay.05	**10100**	**-3,80**	**12300**	**-1,6**	**6750**	**12,5**	**746**	**-12,54**
un.05	**10900**	**7,92**	**13200**	**7,31**	**6100**	**-9,62**	**760**	**1,87**
ul.05	**12900**	**18,34**	**14900**	**12,87**	**7350**	**20,49**	**956**	**25,78**
ug.05	**13700**	**6,20**	**16300**	**9,39**	**7350**	**0**	**978**	**2,30**
ep.05	**15700**	**14,59**	**18700**	**14,72**	**8450**	**14,96**	**1170**	**19,63**
ct.05	**18500**	**17,83**	**21500**	**14,97**	**9350**	**10,65**	**1180**	**0,85**
ov.05	**21900**	**18,37**	**25000**	**16,27**	**9700**	**3,74**	**1120**	**-5,08**
ec.05	**22500**	**2,73**	**25700**	**2,8**	**9650**	**-0,51**	**1090**	**-2,67**
		E(RSIF2)= 11,71		**E(RSIF5)=11,21**		**E(RATB)=7,28**		**E(RRRC)=2,40**

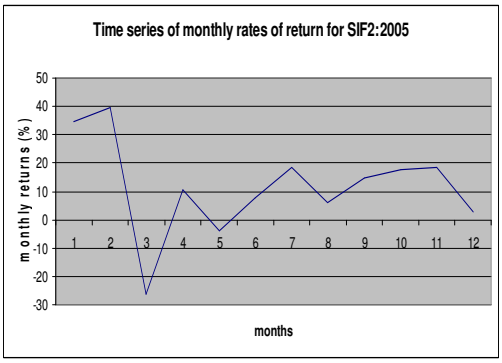
The expected return [E(R)] is the average return and is calculated in many statistical models, and in this article, as the arithmetic mean. We found that the SIFs offer higher levels of monthly returns (over 11%) than the other two companies (7,28%

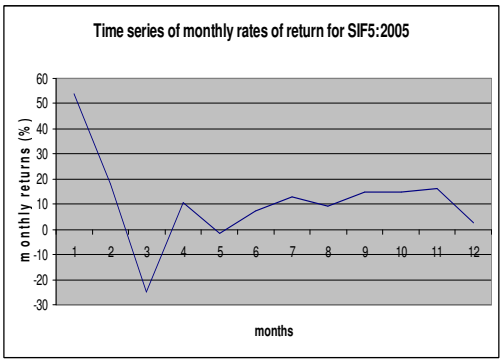
[1] The figures from this article are written with only two decimals, but the calculations have used the whole decimals.

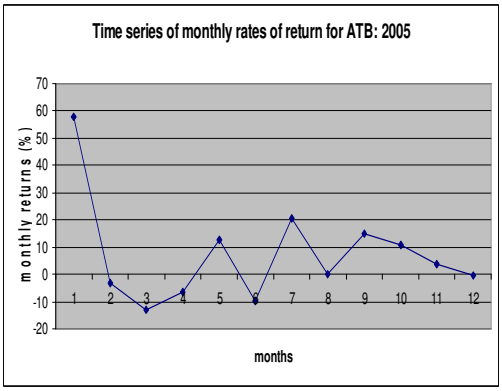
and 2,40%). It remains to be seen if higher returns are associated with higher levels of risk, as one may expect.

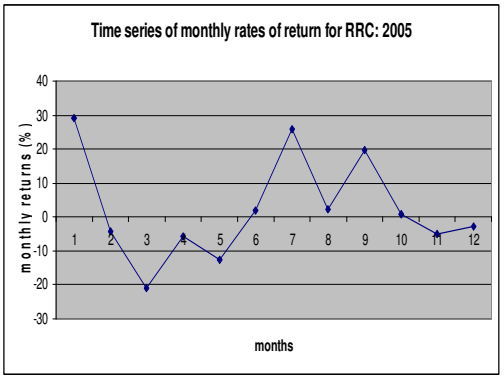
2. Covariance of returns

Covariance is a measure of the degree to which two variables "move together" relative to their individual mean value over time. We analyze here the covariance of rates of return of the considered stocks. A positive covariance means that the rates of return for two stocks tend to move in the same direction relative to their individual mean during the same period. In contrast, a negative covariance indicates that the rates of return for two investments tend to move in opposite directions relative to their mean for the specified period of time. The magnitude of the covariance depends on the variances of the individual return series, as well as on the return between the series. (CFA Program Curriculum, Vol IV, 2006)









For two assets I and j, the covariance of rates of return is defined as:

$$Cov_{ij} = \frac{1}{n}\sum_{i,j=1}^{n}[R_i - E(R_i)]\times[R_j - E(R_j)]$$

Table 2: Computation of Covariance of Returns between each pair of the considered stocks: 2005

	SIF2	SIF5	ATB	RRC
Date	Ri-E(Ri)	Rj-E(Rj)	Rk-E(Rk)	Rl-E(Rl)
	A	B	C	D
jan.05	22,77	42,81	50,39	26,8
feb.05	27,77	6,7	-10,56	-6,6
mar.05	-37,88	-35,98	-20,2	-23,18
apr.05	-1,18	-0,59	-13,53	-7,93
may.05	-15,51	-12,81	5,22	-14,94
jun.05	-3,78	-3,89	-16,9	-0,52
jul.05	6,63	1,66	13,21	23,38
aug.05	-5,5	-1,81	-7,28	-0,09
sep.05	2,88	3,51	7,68	17,23
oct.05	6,12	3,76	3,37	-1,54
nov.05	6,66	5,06	-3,53	-7,48
dec.05	-8,97	-8,41	-7,79	-5,07

A*B	A*C	B*C	A*D	B*D	C*D
974,78	1147,38	2157,19	610,23	1147,30	1350,45
186,05	-293,25	-70,75	-183,28	-44,22	69,69
1362,92	765,17	726,79	878,058	834,01	468,23
0,69	15,96	7,98	9,35	4,67	107,29
198,68	-80,96	-66,86	231,71	191,38	-77,98
14,70	63,88	65,74	1,96	2,02	8,78
11,00	87,58	21,92	155,00	38,81	308,84
9,95	40,04	13,17	0,49	0,16	0,65
10,10	22,11	26,95	49,62	60,47	132,32
23,01	20,62	12,67	-9,42	-5,79	-5,18
33,69	-23,50	-17,86	-49,81	-37,84	26,40
75,43	69,87	65,51	45,47	42,63	39,49
Sum=2901,06	Sum=1834,92	Sum=2942,48	Sum=1739,41	Sum=2233,63	Sum=2429,01

In our case, we found that:

CovSIF2,SIF5 = 2901,06/12 = 241,75

CovSIF2,ATB = 1834,92/12 = 152,91

CovSIF2,RRC = 1739,41/12 = 144,95

CovSIF5,ATB= 2942,48/12 = 245,20

CovSIf5,RRC = 2233,63/12 = 186,13

CovATB,RRC = 2429,01/12 = 202,41

3. Correlation

As Markowitz stated, the answer to the investment problem is not the selection of one asset above all others, but the construction of a portfolio of assets, or diversification across a number of different securities. The key to diversification is the correlation across securities. The correlation coefficient is a value between -1 and 1, and measures the degree of co-movement between two random variables, in this case stock returns. A value of +1 would indicate a perfect positive linear relationship between returns of two securities. This means that their returns move together in a completely linear manner. A value of -1 indicates a perfect negative relationship between the two return series such that when one stock's rate of return is above the mean, the other stock's rate of return will be below its mean by the comparable amount. (CFA Program Curriculum, Vol IV, 2006)

The correlation coefficient is calculated as:

$$\rho_{ij} = \frac{Cov_{ij}}{\sigma_i \sigma_j}$$

where:

ρ_{ij} = the correlation coefficient of returns

σ_i = the standard deviation of Ri in period t

σ_j = the standard deviation of Rj in period t

In order to calculate the correlation coefficient we need to compute the standard deviation for each of the return series. Standard deviation (σ) is a summary measure about the average spread of observations and is the measure of risk used in Modern Portfolio Theory. It is the square root of the variance, which is calculated as:

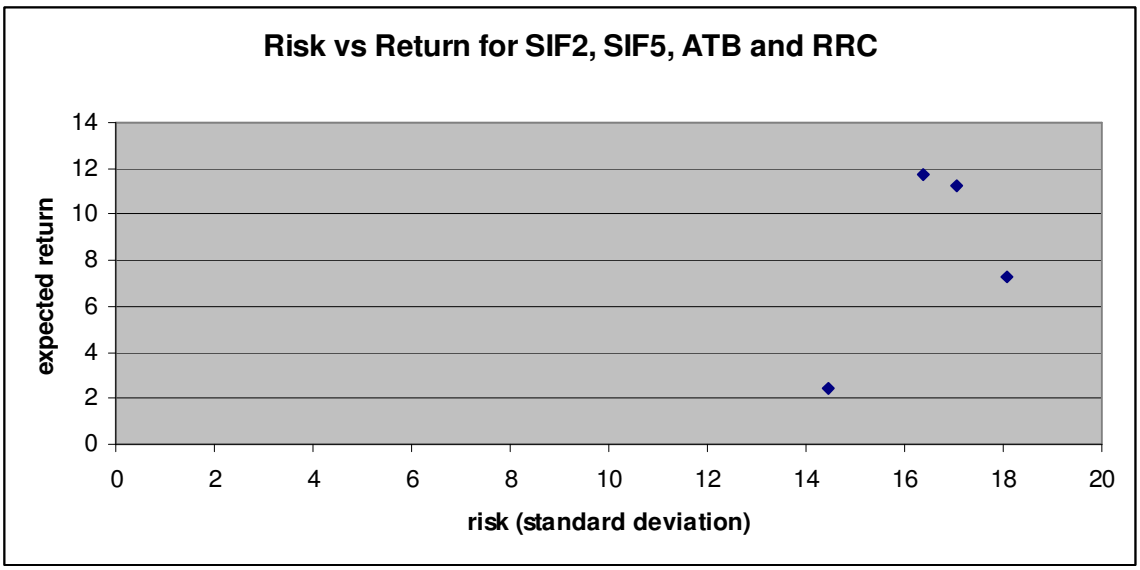
$$\text{Variance}=\frac{1}{n-1}\sum_{i=1}^{n}[R_i - E(R_i)]^2$$

Table 3: Computation of standard deviation of returns for SIF2, SIF5, ATB and RRC: 2005

	SIF2	SIF5	ATB	RRC
Date	[Ri-E(Ri)]2	[Rj-E(Rj)]2	[Rk-E(Rk)]2	[Rl-E(Rl)]2
dec.04	518,5985352	1832,952	2539,79195	718,635798
jan.05	771,5717003	44,896	111,713774	43,5821877
feb.05	1435,384654	1295,171	408,248897	537,75169
mar.05	1,40110831	0,348727	183,0609	62,9975336
apr.05	240,8556193	164,0961	27,2484	223,322015
may.05	14,35809667	15,15488	285,935574	0,27386842
jun.05	44,07132666	2,784853	174,551746	547,067479
jul.05	30,34301713	3,290693	52,9984	0,00975053
aug.05	8,343664175	12,34768	59,0743869	296,938441
sep.05	37,50821295	14,16214	11,362883	2,38794945
oct.05	44,4672702	25,69547	12,5081372	56,0214191
nov.05	80,46581514	70,7281	60,7692577	25,7918878
dec.05	518,5985352	1832,952	2539,79195	718,635798
	Sum=3227,36	Sum=3481,62	Sum=3927,26	Sum=2514,78
Variance= $\frac{1}{n-1}\sum_{i=1}^{n}[R_i - E(R_i)]^2$	268,94	290,13	327,27	209,56
Std Deviation= $\sqrt{Variance}$	16,39	17,03	18,09	14,47

We find that the four stocks have similar levels of risk (standard deviation) for very different levels of expected return. As we have seen, the two SIF stocks are the

ones that offer a higher return (11,21% and 11,71%) for similar risk. It is said in this case that securities SIF2 and SIF5 dominate the other two. But if we have to chose between securities ATB and RRC, we must consider our attitude towards risk. ATB offers o higher return (7,28% opposite to 2,40%), but is at the same time riskier (a standard deviation of 18,09 for ATB and of only 14,47 for RRC). (See chart below) In this situation, an investor with a preference towards risk would chose ATB, and one with aversion towards risk would invest in RRC stocks. That would be the case if the SIFs stocks were not on the market. Because they actually are on the market, all investors will prefer these two stocks, independent on ther attitude towards risk.



Notice that the two SIF stocks provide the highest return, and are not associated with the highest level of risk, as would be expected, and as it is the case on the developed stock markets. BSE is an immature market which presents the strange situation that blue-chip stocks, associated with lower level of risk, provide nevertheless the highest levels of return.

Based on the covariance of returns between each two of the considered stocks, which we calculated before, and the individual standard deviation that we just found, we can now calculate the correlation coefficient between returns for each pair of stocks.

In our case, the correlation matrix between the returns of the four stock would be:

	SIF2	SIF5	ATB	RRC
SIF2		0,865	0,51	0,61

SIF5	0,865		0,79	0,75
ATB	0,51	0,79		0,77
RRC	0,61	0,75	0,77	

We can observe that the returns of the four stocks listed on Bucharest Stock Exchange are quite strong correlated, the correlation coefficient having a minimum value of 0,51, even between stocks from diverse industries. Actually, it is quite surprising that the level of correlation is not very different between stocks within the same industry, comparing to stocks from fundamental different sectors of the economy. We found that the lower level of correlation is between returns of SIF2 Moldova and ATB (0,51) and, as we expected, the strongest correlated are returns of the two SIFs, with a correlation coefficient of 0,865.

We must underline that the difference is smaller than expected, which is not an encouraging thing. Stocks listed on Bucharest Stock Exchange are strong and positive correlated, making it harder for investors to have a well diversified portfolio on BSE, and in this way to minimize the risk.

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