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RISK AND RETURNS ON POLISH POWER EXCHANGE AND EUROPEAN ENERGY EXCHANGE

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Abstract: The aim of this paper is a comparative analysis of contracts on electric energy at Polish Power Exchange (POLPX) and European Energy Exchange (EEX) spot markets. The approach considered in this article is based on minimization of the Conditional Value at Risk and maximization of portfolio rates of return. The analyzed portfolios were constructed with contracts noted on POLEX and EEX from 1st January 2011 to 31st December 2012.

Keywords: risk, portfolio, electric energy market,

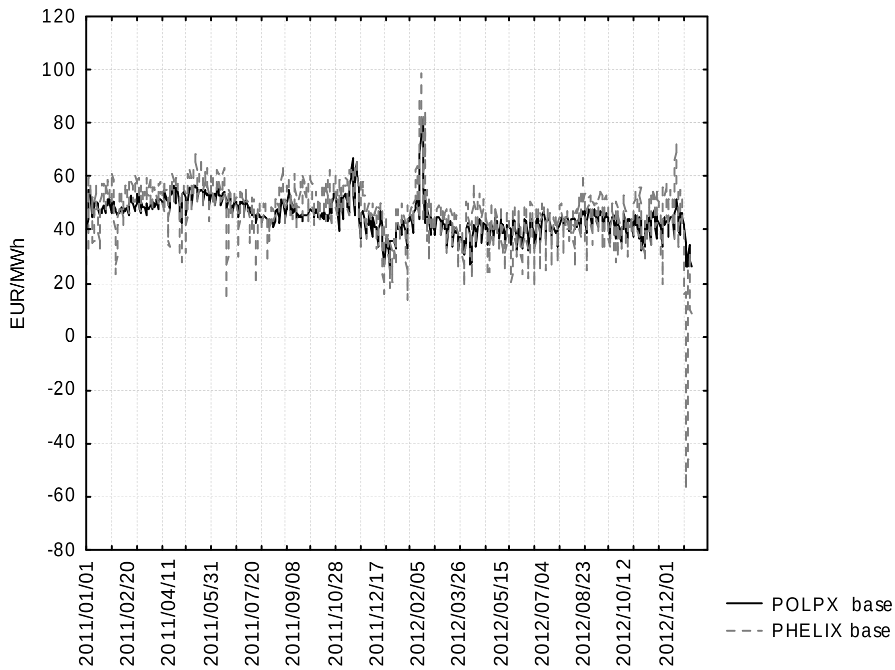
INTRODUCTION

The Polish Power Exchange (POLPX) was started in July 2000. Investors on POLPX may participate in the Day Ahead Market (DAM, spot market), the Commodity Derivatives Market (CDM, future market), the Electricity Auctions, the Property Right Market, the Emission Allowances Market (CO2 spot) and the Intraday Market. All these markets differ with respect to an investment horizon length and the traded commodity.

The result of the merger of the two German power exchanges in Leipzig and Frankfurt was the establishment in 2002 the European Energy Exchange AG (EEX) in Leipzig. This is one of the European trading and clearing platforms for energy and energy-related products, such as natural gas, CO2 emission allowances and coal. The EEX consists of three sub-markets (EEX Spot Markets, EEX Power Derivatives and EEX Derivatives Markets) and one Joint Venture (EPEX Spot Market). Moreover, EEX is trying to become the leader among European Energy Exchanges assuming an active role in the development and integration process of the European market.

Indices POLPX base and POLPX peak in EUR/MWh were noted on POLPX from 2011, calculated in the same way as indices on EEX. Figure 1 shows indices POLPX base noted on POLPX and PHELIX base noted on EEX, which represent average prices of electric energy during a day. The indices exhibit similar behavior, but on EEX greater changes of the index and negative prices are observed.

Figure 1. Time series of POLPX base and PHELIX base

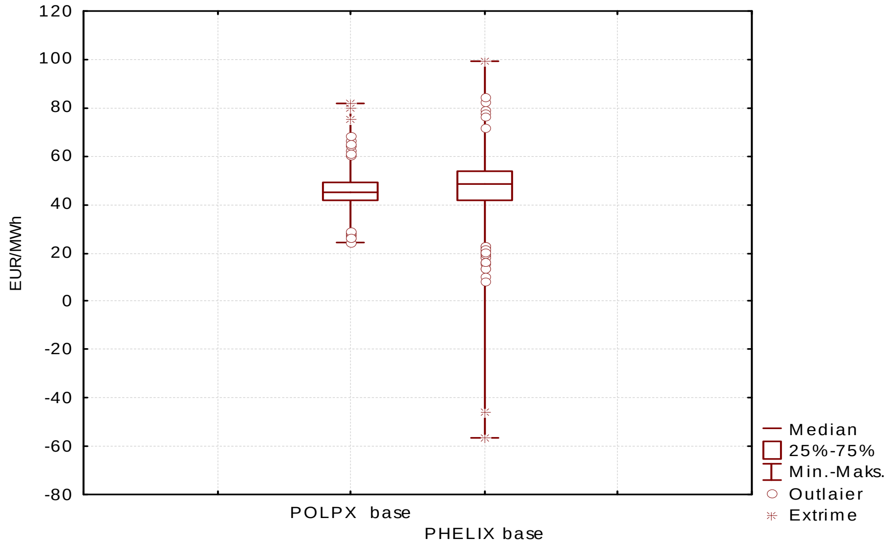


Source: own calculations

On box plot of indexes (Figure 2) one can observe asymmetry, high volatility, outliers and extreme value in average electric energy prices. Negative value of PHELIX base were registered on Christmas Eve 25 and 26 December

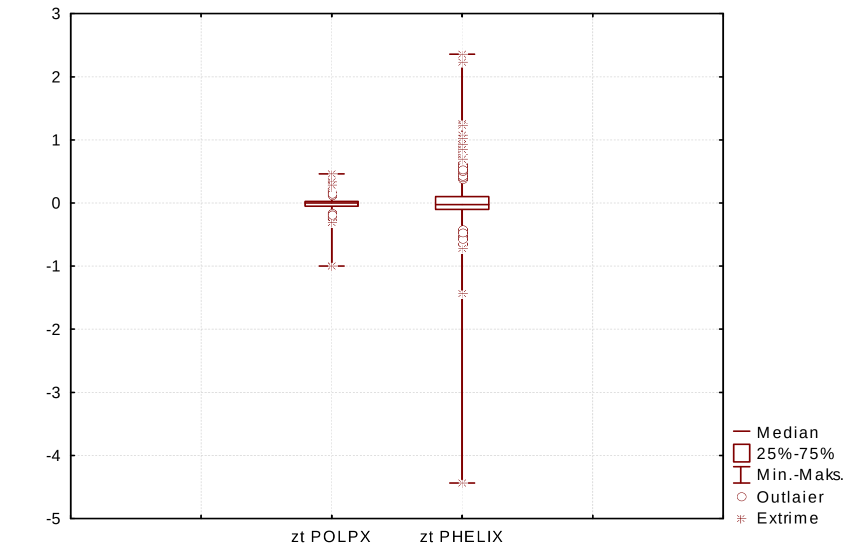
2012 year. Prices observed on POLPX were quite stable. In the night hours on EEX prices were negative: investors had to pay for selling electric energy.

Figure 2. Box plot of POLPX base and PHELIX base



Source: own calculations

Figure 3. Box plot of POLPX base and PHELIX base linear rates of return



Source: own calculations

METHODOLOGY

The portfolio selection model considered in this paper is based on two criteria "mean-variance" portfolio problem analyzed by Steuer et al. (2006):

$$\begin{cases} \min\{x^T \Sigma x\} \\ \max \mu^T x \\ x \in S \end{cases} \tag{1}$$

which regarding CVaR – downside risk measure, is given as follows:

$$\begin{cases} \min \boldsymbol{CVaR_\alpha} \\ \max \mu^T x \\ x \in S \end{cases} \tag{2}$$

where:

***CVaR*α**- *Conditional Value-at-Risk* for portfolio,
x - vector of portfolio weights, μ - vector of contract return rate means,
S - set of acceptable results, α - order of CVaR.

Using results of Steuer et al. (2011) the problem (2) may be expressed in the form:

$$\begin{cases} \min(\boldsymbol{CVaR_\alpha} - \mu^T x) \\ x_{\min} \le x_i \le x_{\max} \\ \sum_{i=1}^{m} x_i = 1 \end{cases} \tag{3}$$

EMPIRICAL ANALYSIS

Investors from spot energy markets make trading decision with one day horizon of investment. So, to build portfolios from POLPX and EEX we consider daily linear rates of return of prices from 01. JAN 2011 to 31. DEC 2012. Based on results of Trzpiot et al. (2013) to estimate VaR and CVaR α=0.01, 0.05, 0.95, 0.99 and historical simulation method were used. Parameters of distribution of contract linear return rates from spot markets were presented in Table 1 and Table 2. Distribution of contracts is characterized by a very high volatility. Furthermore, observed values of percentiles and standard deviation of contracts from spot markets suggest, much lower volatility of prices on POLPX (Table 1) than on EEX

(Table 2). Additionally the highest volatility on EEX was observed for contracts of night hour and in 16th hour.

Table 1. Distribution parameters of rates of return of contracts on POLPX

Contracts	Mean	Stand. dev.	Median	Min	Percentile 1%	Percentile 5%	Percentile 95%	Percentile 99%	Max
1	0.001	0.07	0.001	-0.29	-0.18	-0.10	0.11	0.17	0.33
2	0.002	0.08	0.002	-0.33	-0.23	-0.11	0.12	0.22	0.37
3	0.002	0.08	0.001	-0.31	-0.23	-0.13	0.15	0.25	0.35
4	0.003	0.09	0.004	-0.33	-0.25	-0.15	0.15	0.27	0.37
5	0.003	0.09	0.003	-0.33	-0.24	-0.15	0.17	0.32	0.42
6	0.006	0.12	-0.003	-0.35	-0.27	-0.18	0.24	0.41	0.66
7	0.017	0.20	-0.007	-0.50	-0.32	-0.23	0.45	0.76	1.24
8	0.014	0.18	-0.006	-0.51	-0.33	-0.21	0.43	0.66	1.31
9	0.012	0.17	-0.008	-0.55	-0.26	-0.20	0.35	0.50	1.53
10	0.009	0.15	-0.007	-0.56	-0.27	-0.19	0.31	0.46	1.48
11	0.007	0.12	-0.004	-0.48	-0.24	-0.18	0.25	0.37	0.94
12	0.006	0.12	-0.005	-0.45	-0.23	-0.16	0.25	0.37	0.88
13	0.006	0.11	-0.006	-0.39	-0.22	-0.16	0.25	0.33	0.65
14	0.006	0.11	-0.005	-0.39	-0.23	-0.16	0.23	0.36	0.65
15	0.005	0.11	-0.008	-0.34	-0.21	-0.15	0.23	0.33	0.63
16	0.005	0.11	-0.008	-0.32	-0.21	-0.14	0.23	0.35	0.68
17	0.006	0.12	-0.006	-0.33	-0.28	-0.15	0.24	0.44	0.65
18	0.006	0.12	-0.005	-0.52	-0.28	-0.14	0.21	0.41	0.66
19	0.005	0.11	-0.001	-0.47	-0.25	-0.13	0.20	0.30	0.71
20	0.004	0.09	-0.002	-0.45	-0.25	-0.12	0.17	0.28	0.69
21	0.003	0.08	-0.001	-0.33	-0.18	-0.11	0.13	0.23	0.56
22	0.001	0.06	0.000	-0.28	-0.15	-0.09	0.09	0.14	0.65
23	0.001	0.05	-0.001	-0.32	-0.13	-0.08	0.11	0.17	0.23
24	0.001	0.06	-0.003	-0.20	-0.15	-0.09	0.11	0.21	0.33

Source: own calculations

Table 2. Distribution parameters of rates of return of contracts on EEX

Contracts	Mean	Stand. dev.	Median	Min	Percentile 1%	Percentile 5%	Percentile 95%	Percentile 99%	Max
1	-0.620	17.67	0.005	-477.3	-0.83	-0.42	0.58	1.80	6.04
2	-5.871	113.6	0.002	-2555	-1.76	-0.53	0.69	2.42	228.1
3	2.771	127.9	-0.002	-1063	-1.58	-0.58	0.82	2.43	3273
4	-6.178	100.6	-0.001	-2467	-1.31	-0.58	0.91	2.12	41.48
5	-0.831	41.64	-0.001	-1004	-1.11	-0.54	0.87	2.11	477.5
6	-0.571	12.11	-0.005	-274.1	-1.30	-0.61	0.84	2.75	13.93
7	-3.582	125.5	-0.030	-2795	-1.79	-0.62	1.25	3.60	1577
8	-0.274	20.28	-0.033	-479.9	-1.08	-0.55	1.74	5.14	198.6
9	-0.602	55.23	-0.030	-1283	-0.83	-0.47	1.27	3.01	761.5
10	-1.852	55.24	-0.021	-1491	-0.71	-0.39	0.91	2.31	88.42
11	0.060	0.44	-0.018	-0.84	-0.60	-0.38	0.77	1.93	4.88
12	0.047	0.39	-0.015	-0.83	-0.54	-0.36	0.68	1.54	5.18
13	0.052	0.41	-0.009	-0.82	-0.57	-0.38	0.65	1.67	5.07
14	0.074	0.51	-0.020	-0.81	-0.64	-0.41	0.85	2.30	5.36
15	0.128	1.33	-0.030	-0.96	-0.67	-0.43	0.99	2.34	32.19
16	-4.941	115.5	-0.036	-3067	-0.69	-0.44	0.94	2.38	4.67
17	-0.083	3.78	-0.028	-101.5	-0.60	-0.39	0.85	1.93	4.53
18	0.056	0.67	-0.024	-0.93	-0.49	-0.33	0.59	1.46	16.01
19	0.028	0.31	-0.015	-0.80	-0.40	-0.28	0.48	1.01	5.18
20	0.018	0.21	-0.011	-0.61	-0.39	-0.24	0.38	0.87	1.83
21	0.015	0.20	-0.001	-0.58	-0.38	-0.23	0.32	0.80	1.56
22	0.012	0.18	-0.002	-0.60	-0.35	-0.23	0.28	0.59	1.56
23	0.012	0.17	0.000	-0.58	-0.37	-0.22	0.28	0.49	1.76
24	1.581	42.03	0.000	-1.80	-0.62	-0.28	0.31	1.43	1136

Source: own calculations

Values of CVaR for contracts with α=0.01, 0.05, 0.95, 0.99 (Table 3) confirm the initial assessment. Moreover on EEX one can observe much greater risk for investors which can sell electric energy on POLPX and little greater risk for investors who can buy electric energy, but the risk is much lower than the risk on EEX.

Table 3. CVaR on POLPX and EEX

Contracts	POLPX				EEX			
	α =0.01	α =0.05	α =0.95	α =0.99	α =0.01	α =0.05	α =0.95	α =0.99
1	-0.23	-0.15	0.16	0.22	-62.40	-13.90	1.52	3.67
2	-0.27	-0.17	0.18	0.28	-575.47	-125.00	8.90	36.96
3	-0.28	-0.20	0.22	0.31	-162.98	-35.86	90.16	412.48
4	-0.29	-0.21	0.22	0.32	-576.99	-125.36	3.11	9.89
5	-0.29	-0.21	0.25	0.36	-150.16	-33.02	16.34	70.93
6	-0.31	-0.24	0.35	0.49	-60.70	-13.70	2.28	6.07
7	-0.38	-0.29	0.64	0.91	-537.53	-116.95	46.17	205.76
8	-0.37	-0.27	0.57	0.80	-78.61	-17.56	11.65	44.72
9	-0.33	-0.25	0.49	0.75	-161.89	-35.46	23.21	100.99
10	-0.33	-0.24	0.41	0.60	-187.07	-40.83	3.99	13.75
11	-0.31	-0.23	0.34	0.49	-0.70	-0.51	1.49	2.77
12	-0.30	-0.22	0.33	0.49	-0.63	-0.48	1.28	2.35
13	-0.29	-0.21	0.32	0.44	-0.65	-0.50	1.35	2.43
14	-0.29	-0.21	0.32	0.45	-0.68	-0.56	1.81	2.97
15	-0.27	-0.18	0.31	0.41	-0.74	-0.58	2.86	7.41
16	-0.25	-0.18	0.31	0.42	-458.45	-99.54	1.80	3.20
17	-0.31	-0.21	0.35	0.54	-13.30	-3.24	1.49	2.64
18	-0.36	-0.23	0.33	0.51	-0.59	-0.43	1.48	3.71
19	-0.35	-0.22	0.29	0.46	-0.49	-0.36	0.87	1.75
20	-0.33	-0.20	0.25	0.40	-0.47	-0.33	0.66	1.20
21	-0.27	-0.16	0.20	0.31	-0.46	-0.32	0.59	1.08
22	-0.19	-0.12	0.14	0.23	-0.44	-0.31	0.50	0.89
23	-0.18	-0.12	0.15	0.20	-0.46	-0.31	0.47	0.88
24	-0.18	-0.12	0.17	0.26	-1.02	-0.53	31.68	144.56

Source: own calculations

In Table 4 we present portfolios for investors who take up position on POLPX and EEX. Based on problem (3) we built four different portfolios dependent on α=0.01, 0.05, 0.95, 0.99. We used restriction for portfolio weights which represents daily demand for electric energy.

Table 4. Portfolios on POLPX and EEX

Contracts	PORTFOLIO 1 $\alpha = 0.01$		PORTFOLIO 2 $\alpha = 0.05$		PORTFOLIO 3 $\alpha = 0.95$		PORTFOLIO 4 $\alpha = 0.99$	
	POLPX	EEX	POLPX	EEX	POLPX	EEX	POLPX	EEX
1	0.0583	0.0004	0.0585	0.0003	0.0553	0.0002	0.0556	0.0002
2	0.0567	0.0001	0.0567	0.0000	0.0567	0.0004	0.0567	0.0003
3	0.0566	0.0000	0.0566	0.0000	0.0566	0.0002	0.0566	0.0002
4	0.0568	0.0000	0.0568	0.0001	0.0568	0.0077	0.0568	0.0076
5	0.0574	0.0001	0.0574	0.0000	0.0574	0.0004	0.0574	0.0003
6	0.0585	0.0000	0.0585	0.0000	0.0585	0.0000	0.0585	0.0000
7	0.0319	0.0000	0.0319	0.0000	0.0318	0.0002	0.0318	0.0001
8	0.0208	0.0005	0.0208	0.0005	0.0207	0.0000	0.0207	0.0000
9	0.0208	0.0000	0.0208	0.0000	0.0207	0.0000	0.0207	0.0000
10	0.0208	0.0000	0.0208	0.0000	0.0208	0.0002	0.0208	0.0002
11	0.0208	0.0206	0.0208	0.0206	0.0208	0.0204	0.0208	0.0204
12	0.0209	0.0206	0.0209	0.0206	0.0208	0.0205	0.0208	0.0205
13	0.0209	0.0206	0.0209	0.0206	0.0208	0.0205	0.0208	0.0205
14	0.0209	0.0205	0.0209	0.0205	0.0208	0.0203	0.0208	0.0203
15	0.0209	0.0212	0.0209	0.0212	0.0208	0.0210	0.0208	0.0210
16	0.0209	0.0000	0.0209	0.0000	0.0208	0.0005	0.0208	0.0005
17	0.0209	0.0182	0.0209	0.0181	0.0208	0.0180	0.0208	0.0179
18	0.0209	0.0209	0.0209	0.0209	0.0208	0.0208	0.0208	0.0208
19	0.0209	0.0208	0.0209	0.0208	0.0209	0.0207	0.0208	0.0207
20	0.0209	0.0208	0.0209	0.0208	0.0209	0.0208	0.0209	0.0208
21	0.0210	0.0209	0.0210	0.0209	0.0210	0.0209	0.0210	0.0209
22	0.0210	0.0209	0.0210	0.0209	0.0210	0.0209	0.0210	0.0209
23	0.0210	0.0209	0.0210	0.0209	0.0210	0.0209	0.0210	0.0209
24	0.0210	0.0208	0.0210	0.0207	0.0210	0.0171	0.0210	0.0171
Objective (3)		0.2892		0.2280		0.3630		0.4864
Mean		0.0445		0.0440		-0.0137		-0.0125
Stand. dev.		0.8756		0.8667		0.3607		0.3584
α	VaR	CVaR	VaR	CVaR	VaR	CVaR	VaR	CVaR
0.01	-0.2156	-0.2447	-0.2153	-0.2447	-0.3156	-2.4569	-0.2789	-2.4172
0.05	-0.1402	-0.1885	-0.1358	-0.1840	-0.1467	-0.6794	-0.1465	-0.6708
0.95	0.2721	0.9944	0.2639	0.9843	0.2565	0.3493	0.2598	0.3571
0.99	0.4499	3.3853	0.4441	3.3545	0.4127	0.4744	0.4159	0.4738

Source: own calculations

For every value of α we obtained portfolios consisting only of contract from POPLPX for night hour and in 16 hour. Portfolio weights of daily contracts are very close on two exchanges (see Table 4). This result is specific for the electric energy as particular commodity. The demand is greater during a day than in the night irrespective of prices. The negative value of portfolio returns for α=0.95, 0.99 (see Table 4) as well as for EEX may result from negative electricity prices observed on EEX.

4. CONCLUSION

In conclusion one can say. that despite similar price levels the risk of price changes on EEX is much greater than risk on POLPX, but based on problem (3) to build the portfolio, the investor should buy and sell electricity on EEX too. Contracts in night and early morning hour on POLPX are more attractive than on EEX, but for odd hours contracts on two spot markets give very similar distance between risk and profit. independently on level of α. Very similar results was obtained for from 01 JAN 2009 to 24 OCT 2012 [Trzpiot et al. 2014].

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