DYNAMICZNE MODELE EKONOMETRYCZNE
VIII Ogólnopolskie Seminarium Naukowe, 9-11 września 2003 w Toruniu
Katedra Ekonometrii i Statystyki, Uniwersytet Mikołaja Kopernika w Toruniu

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Risk on Polish Energy Market

1. Introdution

During a few last years Polish energy market began to be developed behind example of European markets. Came into existence the Polish Power Exchange. The Day Ahead Marked (DAM) was the first market, which was established on the Polish Power Exchange. This whole-day market consists of the twenty-four separate, independent markets where participants may freely buy and sell electricity. The first transaction realized on DAM the first July 2000 year and from this date Polish Power Exchange was started with physical and settlements. Advantage of Exchange is this, that all participants of market can buy and sell electric energy, independently whether is this producers or receivers of electric energy.

Many of markets not equilibrium of demand and of supply balances across wrestling. But how store the electric energy? We don't do that. The electric energy is delivered only in the moment when will appear demand on her. From September 2001 starts Balance Market (BM). This is technical market, which look after balance on polish energy market. From 31. 07. 2002 year BM introduced additional two prices: price accounting deviations of sale (PADs) and price accounting deviations of purchase (PADp). This prices should help in expectation future demand for the electric energy on whole-day and futures market.

Risk on market is this greater to them quicker and more considerable are changes of prices and demand. Comparing day's change of price for petroleum 1-3%, for gas 2-4% and with change of price for electric energy 10-50%, we can see that both producers and consumers of energy forced are to protecting oneself before losses.

At present in Poland forward energy market is developed still outside exchange. From October 2002 on Polish Power Exchange we have futures market with the futures contracts on delivery of electric energy monthly, weekly and in top - hours 19-22.

In this paper we present downside risk measures especially two quantile measures VaR and CVaR.

2. Measures of risk

When we take the financial decisions in the same time we take the risk. Notion of risk property of the future. We have many sources of risk: the changes of price, uncertainty of keeping of conditions of contract, impossibility of close of position on financial market, the changes of law and risk of strategy.

If we would like to estimate the future risk we must measure it. There are a lot of different measures of risk. We can divide them on three groups: measure of volatility, measure of sensitivity and measures of downside risk. In this paper we present quantile downside risk measure such as: VaR and CVaR and compare the results with average measure of risk standard deviation.

To the first group of risk measures we number parametric measures, which a base are parameters of probability distribution. Standard deviation of rate of return, which at foundation of normal distribution, is an efficient estimator of volatility:

$$s = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(R_t - \bar{R})^2}\ , \qquad (1)$$

where: $\bar{R}$ is an average rate of return,

$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$ is a rate of return in time t,

$R_t = \ln(\frac{P_t}{P_{t-1}})$ is a logarithmic rate of return in time t,

P_t, P_{t-1} are the prices.

Downside risk measures serve to measurement unwilling deviations from expected rate of return. One of them is VaR which is such loss of value, which couldn't exceed with the given probability $\alpha \in (0,1)$.

$$P(W \leq W_0 - VaR) = \alpha \qquad (2)$$

where

W_0 is a present value,

W is a random variable, value on the end of duration of investment.

Noticed by $Q_\alpha(W)$ α -quantile we can write:

$$Q_\alpha(W) = W_0 - VaR \quad (3)$$

Noticed by $Q_\alpha(R)$ α -quantile of rate of return we can write:

$$Q_\alpha(R)=\frac{W_\alpha - W_0}{W_0} \quad \text{or} \quad Q_\alpha(R)=\ln\left(\frac{W_\alpha}{W_0}\right) \quad (4)$$

We have now

$$VaR = -Q_\alpha(R)W_0 \quad \text{or} \quad VaR = (1 - e^{Q_\alpha(R)})W_0 \quad (5)$$

Next downside measure is CVaR. CVaR we can call Expected Shortfall – ES [2, 3]:

$$ES_\alpha(R) = E\{R \; / \; R \le Q_\alpha(R)\}, \quad (6)$$

where R means rate of return and quantile. Then we can write conditional quantile variance as:

$$D_\alpha^2(R) = D_\alpha^2(R / R \le Q_\alpha(R)) = E\{R / R \le Q_\alpha(R) - ES_\alpha(R)\}^2 \quad (7)$$

***VaR* for single contract on electric energy.**

Value of contract in moment t we can write as [7]:

$$X_t = q(U_t - K), \quad (8)$$

where U_t is running price of energy, K price of realization of contract,

$$q = N * h * W, \quad (9)$$

N is a number of days of delivery of energy, h is a number of hours of delivery every day, W is a number of energy delivered in every hour, $q > 0$ for long position, $q < 0$ for short position.

When we analysis changing of price of contract during(t-1, t) we have:

$$\Delta X = q\Delta U, \qquad D^2(\Delta X) = q^2 D^2(\Delta U). \quad (10)$$

We can estimate variance of contract on base historical data by:

$$D^2(\Delta X) = q^2 U^2 D^2\left(\frac{\Delta U}{U}\right), \qquad \left(D^2\left(\frac{\Delta U}{U}\right) \approx \frac{D^2(\Delta U)}{U^2} \right) \quad (11)$$

Standard deviation for values of contract we can write as:

$$\sigma_K = qU\sigma, \tag{12}$$

where σ is a variability of price of energy estimated by equation (1).

$$VaR = -\,\mathrm{Q}_{\alpha}(\mathrm{R})\mathrm{W}_0 \qquad VaR = (1 - \mathrm{e}^{\mathrm{Q}_{\alpha}(\mathrm{R})})\mathrm{W}_0 \tag{13}$$

Let U means running value of energy and R is a rate of return then we have:

***VaR and CVaR* for prices of electric energy:**

$$VaR_{99\%} = -Q_{0,01}(R) * U \quad \text{or} \quad VaR_{99\%} = (1 - \mathrm{e}^{\mathrm{Q}_{0,01}(\mathrm{R})}) * U \tag{14}$$

$$CVaR_{99\%} = ES_{0,01} \tag{15}$$

$$VaR_{95\%} = -Q_{0,05}(R) * U \quad \text{or} \quad VaR_{95\%} = (1 - \mathrm{e}^{\mathrm{Q}_{0,05}(\mathrm{R})}) * U \tag{16}$$

$$CVaR_{95\%} = ES_{0,05} \tag{17}$$

VaR and CVaR* for contract on electric energy*:

$$VaR_{99\%} = -Q_{0,01}(R) * q * U = -\,Q_{0,01}(R) * N * h * W * U \tag{18}$$

or

$$VaR_{99\%} = (1 - \mathrm{e}^{\mathrm{Q}_{0,01}(\mathrm{R})}) * q * U = (1 - \mathrm{e}^{\mathrm{Q}_{0,01}(\mathrm{R})}) * N * h * W * U \tag{19}$$

$$CVaR_{99\%} = ES_{0,01} N * h * W * U \tag{20}$$

$$VaR_{95\%} = -Q_{0,05}(R) * q * u = -Q_{0,05}(R) * N * h * W * U \tag{21}$$

or

$$VaR_{95\%} = (1 - \mathrm{e}^{\mathrm{Q}_{0,05}(\mathrm{R})}) * q * u = (1 - \mathrm{e}^{\mathrm{Q}_{0,05}(\mathrm{R})}) * N * h * W * U \tag{22}$$

$$CVaR_{95\%} = ES_{0,05} N * h * W * U \tag{23}$$

3. Risk on Polish Energy Market

For estimation of risk on Polish Energy Market we took under attention of price of contracts on electric energy, price of electric energy DAM and BM noted from 01. 10. 2002 to 20. 12. 2002. In table 1 we presented parameters for each values. Prices and rates of return each values behave to 1 MWH of electric energy.

Table 1. Parameters of price, rates of return and logarithmic rates of return

Contracts on electric energy	Parameters of price					Parameters of rates of return		Parameters of logarithmic rates of return	
	mean	min	max	s	V	mean	s	mean	S
FFM01-03	125,43	122,00	127,23	1,63	0,01	-0,0001	0,0055	-0,0001	0,0055
FFM02-03	126,23	122,75	127,23	1,53	0,01	-0,0254	0,1603	0,0010	0,0051
FFW01-03	122,89	116,50	126,47	3,82	0,03	-0,0024	0,0241	-0,0027	0,0247
FFW02-03	126,69	118,00	135,00	5,89	0,05	-0,0045	0,0309	-0,0050	0,0313
FFW03-03	124,95	121,90	126,47	2,15	0,02	-0,0026	0,0093	-0,0026	0,0095
FFW04-03	124,98	122,00	126,47	2,11	0,02	-0,0025	0,0091	-0,0026	0,0093
FFM13-02	124,11	110,00	138,05	4,80	0,04	0,0015	0,0514	0,0002	0,0511
FFW45-02	127,79	123,50	132,25	2,73	0,02	0,0005	0,0238	0,0002	0,0238
FFW46-02	125,59	107,74	134,15	5,34	0,04	0,0000	0,0405	-0,0009	0,0413
FFW47-02	128,22	111,15	135,04	5,48	0,04	-0,0033	0,0313	-0,0039	0,0335
FFW48-02	125,77	102,59	135,54	9,03	0,07	-0,0062	0,0389	-0,0070	0,0400
FFW49-02	124,94	118,00	134,04	3,60	0,03	0,0045	0,0368	0,0038	0,0365
FFW50-02	122,73	114,00	134,04	4,91	0,04	-0,0019	0,0447	-0,0030	0,0449
FFW51-02	122,93	115,00	131,39	4,44	0,04	0,0019	0,0403	0,0011	0,0402
FFW52-02	116,35	111,00	126,50	3,24	0,03	-0,0012	0,0331	-0,0017	0,0331
PW43-02	144,46	140,30	153,65	3,08	0,02	0,0026	0,0229	0,0023	0,0231
PW44-02	149,38	143,09	161,50	6,51	0,04	0,0057	0,0293	0,0052	0,0289
CRO RB	107,09	71,09	375,09	37,86	0,35	0,0087	0,1418	-0,0004	0,1344
CROs RB	236,67	120,00	632,69	61,08	0,26	0,0086	0,1379	-0,0002	0,1322
CROz RB	82,12	70,00	120,00	9,70	0,12	0,0018	0,0625	-0,0001	0,0616
RDN	108,44	4,00	174,25	24,36	0,22	0,1889	2,0467	0,0001	0,4274

Already in initial analysis in table 1 we see, that on BM and DAM is higher changing of price than on futures market. The prices of contracts are more stable, standard deviation determines 7% of level of average price for the most diverse contract FFW48-02. On BM and DAM variation coefficients of prices are between 11% and 35%. This analysis show that we should look at changes of prices in distribution tails. We can say, that on the average thing taking in investigated period of price of energy on whole-day market had increasing tendency and we can't say the same about prices on futures market.

In table 2 we introduced values of 0, 01- quantiles and 0, 05- quantiles for prices and rates of return. In contrast to average measures in bottom distribution tail we obtained for futures contracts much higher rate of return than for price and rates on DAM and BM.

Table 2. Quantiles of price, rates of return and logarithmic rates of return

Contracts on electric energy	Price		Parameters of rates of return		Parameters of logarithmic rates of return	
	$Q_{0,01}(U)$	$Q_{0,05}(U)$	$Q_{0,01}(R)$	$Q_{0,05}(R)$	$Q_{0,01}(R)$	$Q_{0,05}(R)$
FFM01-03	122,00	122,00	-0,0254	-0,0254	-0,0257	-0,0257
FFM02-03	122,75	122,90	-0,0080	0,0000	-0,0080	-0,0080
FFW01-03	116,50	116,50	-0,0788	0,0000	-0,0821	0,0000
FFW02-03	118,00	118,00	-0,0830	-0,0468	-0,0866	-0,0480
FFW03-03	121,90	121,90	-0,0361	0,0000	-0,0368	0,0000
FFW04-03	122,00	122,00	-0,0353	0,0000	-0,0360	0,0000
FFM13-02	110,00	114,50	-0,1129	-0,0854	-0,1198	-0,0893
FFW45-02	123,50	123,50	-0,0519	-0,0448	-0,0533	-0,0458
FFW46-02	107,74	116,75	-0,1180	-0,0894	-0,1256	-0,0936
FFW47-02	111,15	124,34	-0,1580	-0,0225	-0,1719	-0,0228
FFW48-02	102,59	102,59	-0,1347	-0,0973	-0,1447	-0,1024
FFW49-02	118,00	118,00	-0,0574	-0,0574	-0,0591	-0,0591
FFW50-02	114,00	115,50	-0,1097	-0,0611	-0,1162	-0,0630
FFW51-02	115,00	115,50	-0,1097	-0,0492	-0,1162	-0,0504
FFW52-02	111,00	111,50	-0,1024	-0,0510	-0,1080	-0,0523
PW43-02	140,30	140,30	-0,0586	-0,0586	-0,0604	-0,0604
PW44-02	143,09	143,09	-0,0700	-0,0700	-0,0726	-0,0726
CRO RB	72,27	73,81	-0,3758	-0,1799	-0,4713	-0,1984
CROs RB	124,32	158,42	-0,3432	-0,2046	-0,4204	-0,2289
CROz RB	70,41	71,25	-0,1789	-0,0928	-0,1971	-0,0974
RDN	75,00	79,00	-0,3760	-0,1675	-0,4716	-0,1833

Results obtained for $CVaR_{99\%}$ inform on which one average level was shaped 1% of lowest prices. On futures market among these 1% average lowest price is 107,74 zł/MWh and on whole-day market only 14,14 zł/MWh. 5% of lowest prices on futures market hesitates from 111,25 zł/MWh to 143,09 zł/MWh, and on whole-day market from 64,75 zł/MWh to 138,10 zł/MWh.

When we look at Value at Risk we can say, that with probability 0,99 on contract FFM01-03 we will not lose more than 3,18 zł/ MWh. On contracts FFM02-03, FFW01-03, FFW02-03, FFW03-03 and FFW04-03 with probability 0,95 we will not lose nothing. We can take the biggest losing on contract FFW47-02, but with probability 0,99 this loss will not cross 20,25 zł/MWh. In analogous period on whole-day market our losses with probability 0, 99 will not cross value from 14, 69 to 81, 24 zł/MWh, and from 7, 62 to 48, 43 zł/MWh with probability 0, 95.

Table 3. Quantile downside risk measures of price, rates of return and logarithmic rates of return

Contracts on electric energy	Price		Parameters of rates of return		Parameters of logarithmic rates of return	
	$CVaR_{99\%}$	$CVaR_{95\%}$	$VaR_{99\%}$	$VaR_{95\%}$	$VaR_{99\%}$	$VaR_{95\%}$
FFM01-03	122,00	122,00	3,18	3,18	3,18	3,18
FFM02-03	122,75	122,83	1,01	0,00	1,01	0,00
FFW01-03	116,50	116,50	9,69	0,00	9,69	0,00
FFW02-03	118,00	118,00	10,51	5,94	10,51	5,94
FFW03-03	121,90	121,90	4,51	0,00	4,51	0,00
FFW04-03	122,00	122,00	4,42	0,00	4,42	0,00
FFM13-02	110,00	112,25	14,01	10,60	14,01	10,60
FFW45-02	123,50	123,50	6,63	5,72	6,63	5,72
FFW46-02	107,74	112,25	14,82	11,22	14,82	11,22
FFW47-02	111,15	117,75	20,25	2,89	20,25	2,89
FFW48-02	102,59	102,59	16,95	12,24	16,95	12,24
FFW49-02	118,00	118,00	7,17	7,17	7,17	7,17
FFW50-02	114,00	114,75	13,46	7,50	13,46	7,50
FFW51-02	115,00	115,00	13,48	6,04	13,48	6,04
FFW52-02	111,00	111,25	11,91	5,93	11,91	5,93
PW43-02	140,30	140,30	8,46	8,46	8,46	8,46
PW44-02	143,09	143,09	10,46	10,46	10,46	10,46
CRO RB	71,85	72,81	40,25	19,27	40,25	19,27
CROs RB	120,71	138,10	81,23	48,43	81,24	48,43
CROz RB	70,10	70,76	14,69	7,62	14,69	7,62
RDN	14,14	64,75	40,77	18,16	40,77	18,16

Taking under attention quantile downside risk measures for participant of market interesting short position, more profitable is investing on futures market. Values of prices and rate of return for lower distribution tail are higher on futures market and also the values of conditional downside risk measures. This market we can characterize as a moment with greater stability.

The quantile values for upper distribution tail were not presented in this work. For VaR this will be analogous, we can interpret they not as fall but as height of price and rate of return values. Also average conditional values will be similar for upper tail of prices they will by closer to maximum values. From this we have conclusion, that for participant of market interesting long position more safely is to invest on futures market.

Summing up one should claim, that quantile measures have superiority over average measures. Participants of market, not only of market of energy, want to draw advantages from one's own possibilities and with expectations. In this of chance quantile measures of risk give to them more precise answer than average measures. Mark extreme and not only average positions of values can be also signal of buying or of sale.

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