ІНФОРМАЦІЙНІ СИСТЕМИ І ТЕХНОЛОГІЇ В СИСТЕМІ ОБЛІКОВО-АНАЛІТИЧНОГО ЗАБЕЗПЕЧЕННЯ МЕНЕДЖМЕНТУ ПІДПРИЄМСТВА

УДК 658.011:330.02

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APPLICATION OF MARKOWITZ PORTFOLIOS BASED ON CURRENCY BASKETS TO COMMODITY TRADE

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Розглянуто оптимальну структуру кошика валют для мінімізації ризиків торговельних операцій. Проаналізовано принципи побудови оптимального кошика валют, розроблено засадні положення оптимального портфеля Марковіца. Надано пропозиції щодо урахування периферійних валют у структурі платіжного кошика.

The article proposes an application of currency basket payments together with Markovitz portfolio idea, to reduce a foreword transactions risk in commodity trade. It follows the line of earlier papers, where the basket payments idea was developed assuming baskets composed of national currencies and precious metals (Gold and Silver), to be used in construction of optimal Markovitz portfolio. The individual basket for each commodity was optimized by minimizations of its value prediction error variance, but the classical portfolio involving the transaction return ratios was considered. This paper is to show, that in transactions concerning similar goods, better results may be reached by using Markovitz portfolios optimized with respect to the transaction returns, i.e. operating directly on the quantities employed in construction of the optimal baskets. Results of application of the idea to selected petroleum products are shown. Variability of the baskets structure in consecutive intervals, from 2000-2004 to 2011, is discussed. Significant role of peripheral currencies, among others of Polish zloty, is exhibited.

1. Introduction. The basket payment idea has been discusses since a decade as a way to stabilize world markets against fluctuations in official currencies' exchange rates and resultant variations in commodities prices (e.g. see Ashraf [1], Branson [5], Kawai [14]). In literature it is addressed mainly to economic exchange on international level (see Drysdale [6], Frankel [10], Heller [13], Kawai [15], Kim [16], Mundel [18], Ogawa [19]-[22]). In our earlier paper (Duda and Mazur [7], Duda at al. [8]- [10]) we proposed to apply a model of basket payments to individual transactions on commodity markets. On open markets most commodities are priced and transacted in spot, futures or options contracts in terms of the US dollar. The price of an asset does not, however, have to be denominated in a particular currency but can be expressed as a weighted average of a defined number of selected assets. Such basket payments may be less risky due to mutual compensation of variability of particular basket components prices. Hence, one can reduce the forward risk of a particular transaction, by construction customized baskets minimizing instrumental price variability for the commodities under consideration. In addition to official currencies, we suggested to include precious metals (i.e. Gold and Silver) into such baskets. Promising results of application of this concept to metal commodities (shown in Duda and Mazur [7] and Duda at al. [8]), encouraged us to extend the idea by combining the basket payments method with the Markowitz portfolio theory (Markowitz [17]). In the paper [9] (Duda, Augustynek, Borszczuk) we have shown that such basket-based portfolios can significantly reduce one year forward transaction on petroleum products, especially during periods of high price volatility (2008 – 2010). Risk (standard deviation) of basket-based portfolios

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was reduced by 20-40% compared to that of to the portfolios priced in USD. The last paper (Duda at al. [10]) was focused on more detailed study of basic properties of the proposed method. Effects of the baskets and portfolios optimization interval width (6, 4 and 2 years) and price prediction horizon (1, 3 6, 9 and 12 months) on the portfolios standard deviations has been examined, and compared to that of the USD priced portfolios. It was shown that 4.year optimization interval is a good compromise between filtering properties of the optimization procedure and its adaptivity to changes in the market behavior. An inconsistency between the basket and portfolio optimization tasks was signalized, as the individual baskets minimizing their values prediction error variance were combined within the classical Markovitz portfolio involving the transaction return ratios.

In this paper we propose to eliminate the above disadvantage, by using Markovitz portfolios optimized with respect to the transaction returns, i.e. operating directly on the quantities employed in construction of the optimal baskets. It may be done when transactions concern similar goods.

Time series of seven petroleum products prices TXPropan; USGulfROil; HeatOil; LCrude1; NYGasF; WTI and Brent are taken under considerations. In the first step, the value of each of these products is expressed by a basket mix of global currencies (Euro, British Pound, SDRs, Yen, Ruble, USD) as well as of more peripheral currencies (e.g. Polish Zloty, Indian Rupees, Brazilian Real, Australian Dollar and others). Reversed prices (mass/USD) of precious metals Silver and Gold were also employed as specific currencies. Second, the performance of every basket identified in the first step is compared to an optimal basket of selected currencies based on the Markowitz efficient frontier. Variability of the baskets structure in consecutive intervals, from 2004 to 2011, is discussed. Significant role of peripheral currencies, among others of Polish zloty, is confirmed (like in the paper [10]).

2. Basket payments and portfolios – theoretical background. Let us consider a trade contract made at time n, concerning a commodity k, to be delivered at time n+p. One can take the agreement (**Rule I**) the contract amount due may be paid at time n or n+p with a package of quota $V_k=\{V_{kc}, c=1, ..., C\}$ in different currencies

$$V_{kcn} = P_{kn} b_c R_{cn} \qquad \sum_{c=1}^{C} b_c = 1 \qquad \sum_{c=1}^{C} \frac{V_{kcn}}{R_{cn}} \equiv P_{kn} \tag{1}$$

where b_c means the fraction of the original price to be paid in c-th currency, agreed at time n or before, R_{cn} is the exchange rate of c-th currency to USD at time n, P_{kn} – the price of k-th commodity expressed in USD at time n. The quota V_k are fixed at the time n according to eq.(1), so that $V_{kcn+p} = V_{kcn}$.

The transaction risk [11] could be expressed as the change $\Delta_{\mathrm{I}} P_{kp}$ of the commodity price recalculated to US dollars at the time n+p:

$$\Delta_{\mathrm{I}} P_{kp} = P_{kn+p} - \sum_{c=1}^{C} \frac{V_{kcn}}{R_{cn+p}} = P_{kn+p} - \sum_{c=1}^{C} b_c \frac{R_{cn}}{R_{cn+p}} P_{kn} \tag{2}$$

One can take also another rule (**Rule II**): at the time n we define only a currency basket $W_n=\{W_{cn}: c=1, ..., C\}$ where $W_{cn} = b_c R_{cn}$ is the quota of c-th currency to be paid for 1 USD, either at time n or n+p. The transaction risk may be expressed as the difference $\Delta_{\mathrm{II}} P_{kp}$ of the commodity price paid at n and n+p, recalculated to US dollars at the time n+p:

$$\Delta_{\mathrm{II}} P_{kp} = (P_{kn+p} - P_{kn}) \sum_{c=1}^{C} b_c \frac{R_{cn}}{R_{cn+p}} \tag{3}$$

Nevertheless, the risk measures (2) and (3) may be misleading, as they do not take into account changeable position (appreciation/depreciation) of the USD itself. Moreover the risk assessment involves the ratio of two random variables R_{cn}/R_{cn+p} that makes it more uncertain.

In the paper (Duda at al. [8]) we have proposed to use for the trade risk assessment an instrumental price Π_{kn}, based on the currency basket composed of the currencies c=1, …, C, recalculated to USD with constant exchange ratios R_{cref}:

$$\Pi_{kn} = P_{kn} \sum_{c=1}^{C} b_c \frac{R_{cn}}{R_{cref}} \qquad \sum_{c=1}^{C} b_c = 1 \tag{4}$$

where $\{b_c$: c=1, ,$C\}$ are the factors (the basket coefficients) partitioning the transaction risk onto the currencies c.

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The contract can be made according to the rules I or II with b_c=b_c, but its risk may be evaluated as the instrumental price change:

$$\Delta_{\mathrm{I}}\Pi_{kp} = \sum_{c=1}^{C}\left(\frac{b_c}{R_{cref}}(P_{kn+p}R_{cn+p} - P_{kn}R_{cn})\right) \tag{5}$$

or weighted change of the original price (like in eq.(3):

$$\Delta_{\mathrm{II}}\Pi_{kp} = (P_{kn+p} - P_{kn})\sum_{c=1}^{C}\frac{b_c}{R_{cref}}R_{cn}(\ ) \tag{6}$$

The above measures are well legitimated when the quota V_{kcn} to be paid at time n had been acquired in a longer time interval (not bought at time n), which is rather typical case. Hence, the most suitable reference exchange rate R_{cref} seems to be the mean value R_{cNL} in a presumed time interval containing N historical samples of R_{ci} and ending at L-th sample (i=$\tilde{L}N$+1, …, L), with L taken arbitrarily (NL interval)

$$R_{cref} = R_{cNL} \overset{def}{=} \frac{1}{N}\sum_{i=1}^{N}R_{mL-i+1} \tag{7}$$

The currency basket coefficients b_c may be adjusted in such a way, to minimize the overall trade risk, expressed by the variance of $\Delta_{\mathrm{I}}\Pi_{kp}$ or $\Delta_{\mathrm{II}}\Pi_{kp}$ in NL interval, averaged over the set of the commodities to be sold/bought with the same basket. To this aim the linear quadratic optimization tools may be applied, minimizing one of the above performance measures:

$$J_{\mathrm{I}NL} = \frac{1}{K}\sum_{k=1}^{K}\left(\frac{1}{N}\sum_{i=0}^{N-1}\left(\sum_{c=1}^{C}\left(\frac{b_c}{R_{cNL}}(P_{kL-i+p}R_{cL-i+p} - P_{kL-i}R_{cL-i})\right)\right)^2 - \left(\sum_{c=1}^{C}\left(\frac{b_c}{R_{cNL}}\frac{1}{N}\sum_{i=0}^{N-1}(P_{kL-i+p}R_{cL-i+p} - P_{kL-i}R_{cL-i})\right)\right)^2\right) \tag{8}$$

$$J_{\mathrm{II}NL} = \frac{1}{K}\sum_{k=1}^{K}\left(\frac{1}{N}\sum_{i=0}^{N-1}\left(\sum_{c=1}^{C}\left(\frac{b_c}{R_{cNL}}R_{cL-i}(P_{kL-i+p} - P_{kL-i})\right)\right)^2 - \left(\sum_{c=1}^{C}\left(\frac{b_c}{R_{cNL}}\frac{1}{N}\sum_{i=0}^{N-1}R_{cL-i}(P_{kL-i+p} - P_{kL-i})\right)\right)^2\right) \tag{9}$$

The following constraints must be satisfied:

$$b_c \geq 0 \quad \text{for } c=1, \ldots, C, \quad \text{and} \qquad \sum_{c=1}^{C}b_c = 1 \tag{10}$$

On the other hand, having instrumental currencies Π_k (calculated for the individual baskets b_{ck}), one may consider the construction of a portfolio of the given commodities to be bought/sold in such a way to minimize the overall transaction risk.

The optimal portfolio idea (Markovitz [17]) is to construct a portfolio composed of a set of commodities k=1,.., K, and find an optimal set of portfolio weights a_k for each of them. The portfolio coefficients should be adjusted in such a way to satisfy a compromise between two criteria: maximize the expected transaction return and minimize a risk measure of the transaction. The optimization is based on series of historical data from a presumed time interval containing N samples, recorded at the same time instants for all the commodities.

Typically, the data are expressed as the series of return ratios w_{kn} for n=n_0, ..., N+ n_0-1, as the classical Markowitz portfolio theory focuses on relative profits, thus making the portfolio insensitive to differences in the considered prices level. However, if prices of similar goods are considered, there are no obstacles to adapt the portfolio idea directly to the commodity prices. Referring to the basket payments, the returns r_{kn} have to be calculated for the instrumental prices Π. Assuming the Rule I is taken in a contract, we may use eq.(5) to express the values for the returns r_{kn}. Let R_{kn0} denote the averaged value of k-th commodity returns in the window starting with n_0 sample, $C_{km\,m0}$ – the covariance coefficient of the k-th and m-th returns in this window. For transactions concerning the prices p samples ahead, the above quantities are calculated in the following way:

$$r_{kn} \overset{def}{=} \Pi_{kn} - \Pi_{kn-p} = \Delta_I\Pi_{knp}, \quad R_{kn0} \overset{def}{=} \frac{1}{N}\sum_{n=n0}^{N+n0-1}r_{kn}, \quad C_{km\,n0} \overset{def}{=} \frac{1}{N}\sum_{n=n0}^{N+n0-1}r_{kn}r_{mn} - R_{kn0}R_{mn0} \tag{11}$$

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The risk is measured by the variance of the portfolio return ratios, assuming that the statistics of the historical returns are representative of future transactions. The Markowitz portfolio optimization task may be expressed in the following form:

find the portfolio coefficients a_k, k=1, ..., K, minimizing the performance index:

$$J_M = -(1-l)\sum_{k=1}^{K} a_k R_{kn0} + l\sum_{k=1}^{K}\sum_{m=1}^{K} a_k a_m C_{kmn0} \qquad (12)$$

subject to the constrains:

$$\sum_{k=1}^{K} a_k = 1, \qquad a_k \geq 0 \ \text{ for } \ k = 1, ..., K \qquad (13)$$

where $l \in \langle 0,\ 1\rangle$ denotes the aversion to risk coefficient taken arbitrarily.

The above formulation involves directly the price returns r_{kn}, i.e. the same quantities which where treated in the baskets optimization Π, according to eqs.(5) and (8).

3. Data, method and results of calculations. The method proposed in the paper is applied to the pricing of basket contracts on seven petroleum products with 19 currencies as listed in Table 1.

All data used in calculations were recorded as daily close USD prices in the time interval from 01.01.1998 to 28.02.2011, taken from various Internet sources [23]. The data deficiencies (e.g. weekends, holidays or other interruptions) were removed by neglecting the weekends and linear interpolation of asynchronous deficiencies (holidays or global incidents such as terrorist attack on WTC or U.S. intervention in Iraq).

Table 1

List of raw commodities and exchange rates used in calculations.

Commodity prices used in calculations	
TXPropan	Mont Belvieu, TX Propane Spot Price FOB (Cents/Gallon)
USGulfROil	U.S. Gulf Coast Kerosene-Type Jet Fuel Spot Price FOB (Cents per Gallon)
HeatOil	New York Harbor No. 2 Heating Oil Spot Price FOB (Cents per Gallon)
LCrude1	NYMEX Light Sweet Crude, Contract 1
NYGasF	NY Harbor Conventional Gasoline Regular Spot Price FOB (Cents per Gallon)
WTI	Cushing, OK WTI Spot Price FOB (Dollars per Barrel)
Brent	Europe Brent Spot Price FOB (Dollars per Barrel)
Exchange rates employed in the study	
EUR/USD	Euro/U.S. Dollar
GBP/USD	British Pound/U.S. Dollar
SDR/USD	Special Drawing Right/ U.S. Dollar
JPY/USD	Japanese Yen/U.S. Dollar
RUB/USD	Russian Rouble/US Dollar
PLN/USD	Polish Zloty/U.S. Dollar
INR/USD	Indian Rupee/U.S. Dollar
BRL/USD	Brazilian Real/ U.S. Dollar
AUD/USD	Australian Dollar/U.S. Dollar
CAD/USD	Canadian Dollar/U.S. Dollar
MXN/USD	Mexican Peso/ U.S. Dollar
SGD/USD	Singapore Dollar/ U.S. Dollar
NZD/USD	New Zealand Dollar/ U.S. Dollar
CHF/USD	Swiss Francs/ U.S. Dollar
CLP/USD	Chilean Peso/ U.S. Dollar
ZAR/USD	South African Rand/ U.S. Dollar
EGP/USD	Egyptian Pounds/ U.S. Dollar
NOK/USD	Norwegian Kroner/ U.S. Dollar
USD	United States Dollar
Reversed Silver price	London Bullion Market Association, held each working day at 12.00 PM in the City of London, **Troy Ounce per Dollars**
Reversed Gold price	London Bullion Market Association, Gold prices Day 3:00 PM, **Troy Ounce per Dollars**

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Time series of the examined raw material prices and exchange rates are presented in Figures 1, 2. They show all studied series are non-stationary and highly varying in the last four years (during the crisis of 2008-2011). This made any medium term forward transactions very risky.

Forward transactions for p=1, 6 and 9 months ahead are considered and optimized with the discussed method in the interval of 4 years: first by constructing the optimal currency basket related to the instrumental price increments defined in eq.(5), then by optimizing the commodity portfolio by following the steps described in eqs.(11-13).

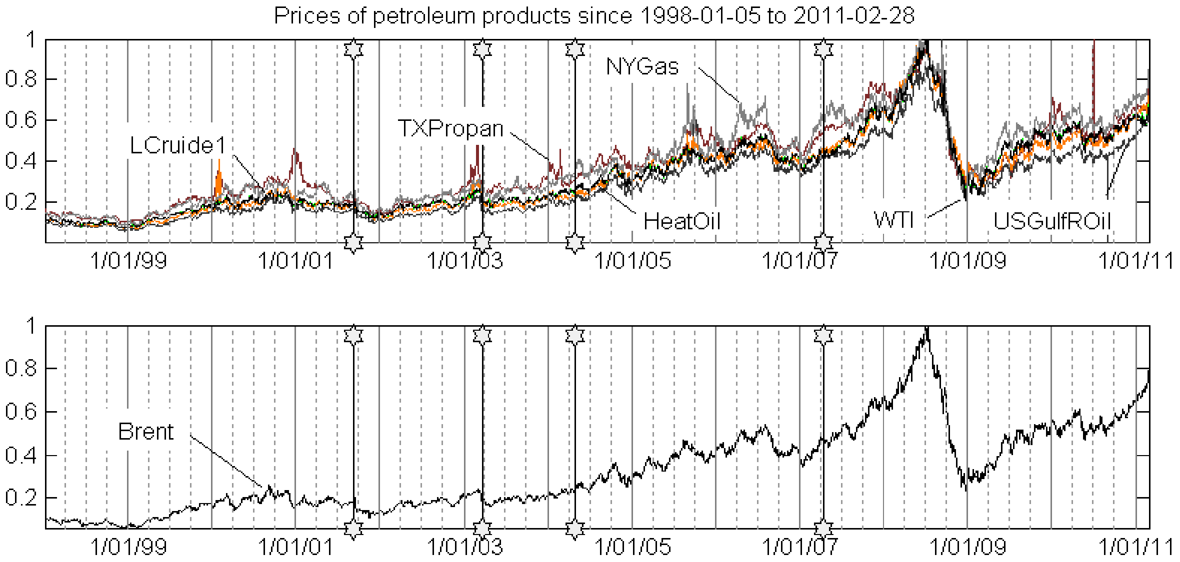

Fig. 1. *Time series of petroleum products prices (in USD).*
The values in each series are proportional to their maximal value. Vertical dotted lines – 3 months and 1-year (bold) intervals. Vertical solid lines show global events: from left – attack on WTC (11/09/2001), start of war in Iraq (22/03/2003), and European Union enlargement (01/05/2004)

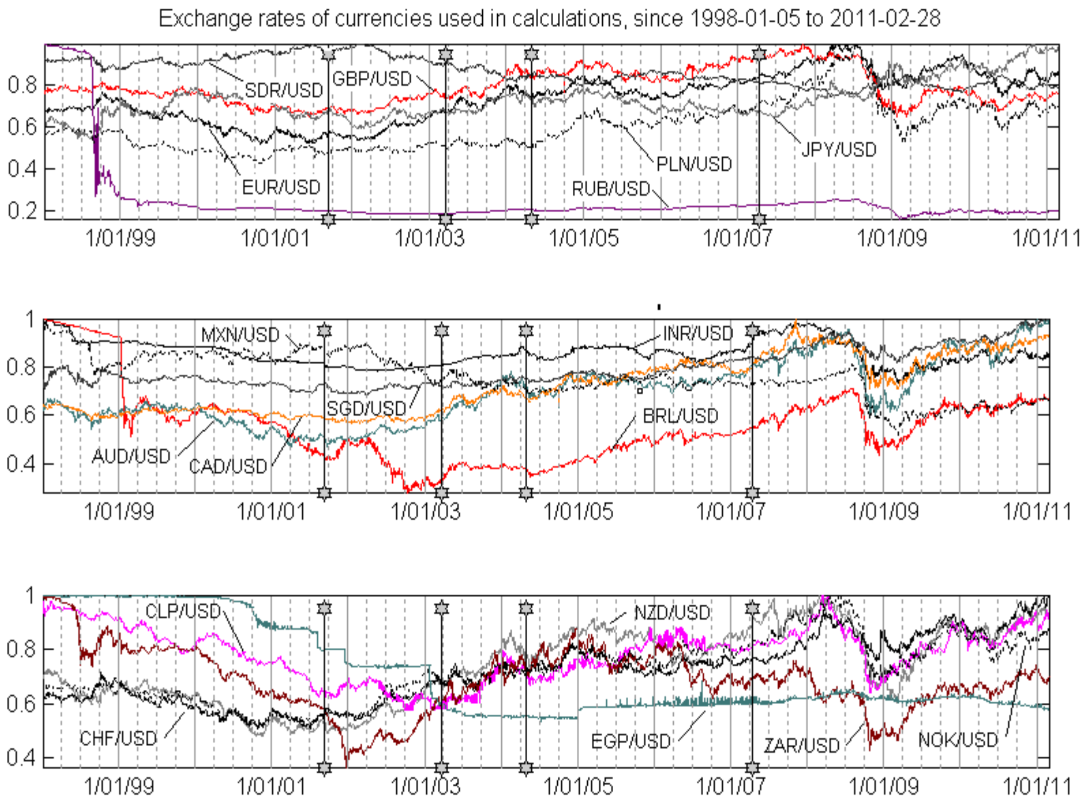

Fig. 2. *Time series of exchange rates used in calculations. The values in each series are proportional to their maximal value. Vertical dotted lines – see Figure 1*

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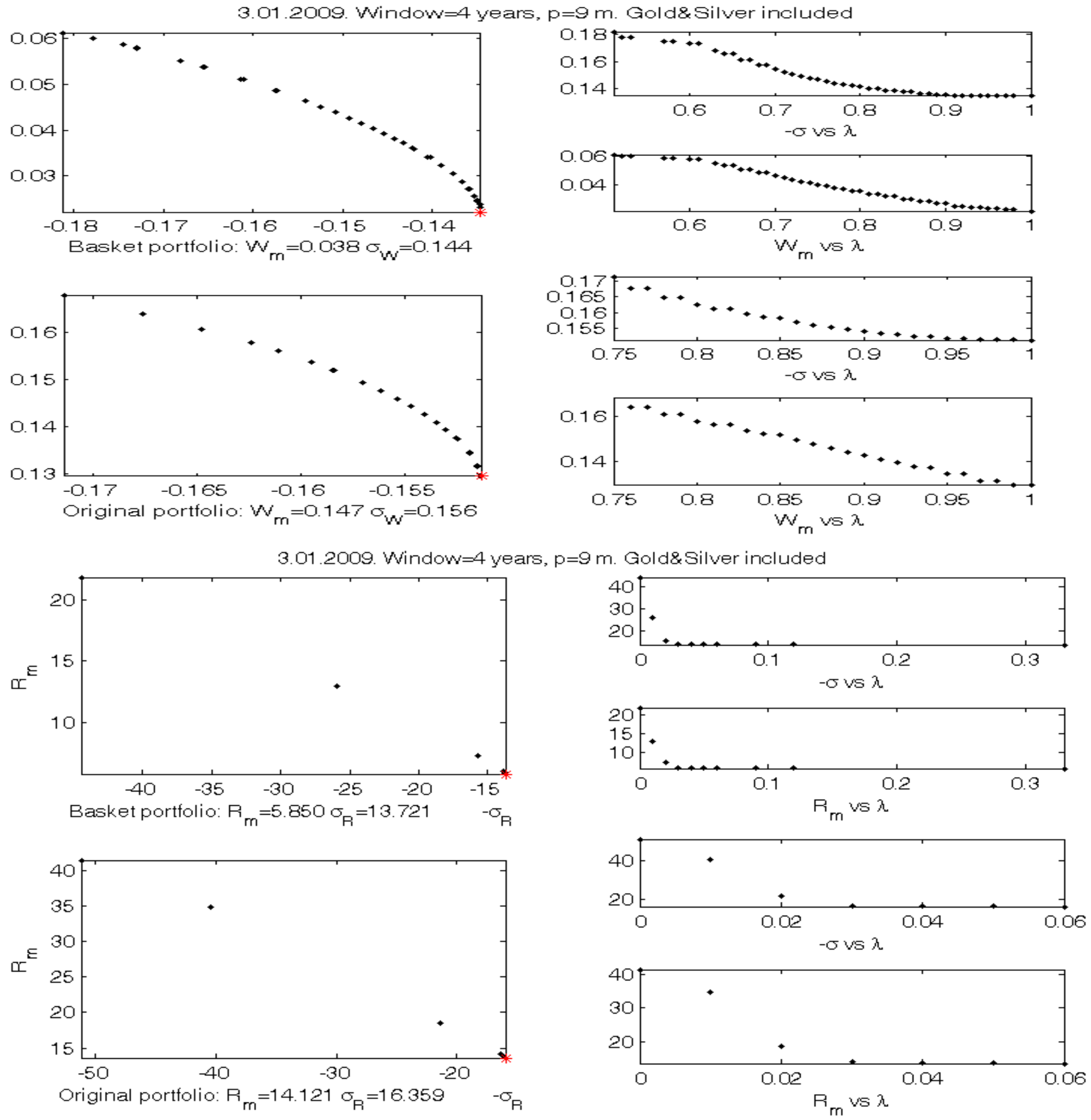

***Fig.3.** An example of Pareto curves for the portfolio related to return ratios $W_m(s_m)$ – upper figures (see [10]), and for the portfolio operating on returns $R_m(s_m)$ (consistent with the baskets optimisation) – lower figures. The dependencies $W_m(l)$, $R_m(l)$ and $s_m(l)$ are shown in right subfigures, p – prediction horizon, Window – optimization interval*

The proposed basket elements are the world's principal currencies (Euro, British Pound, SDRs, Yen, Rouble and US Dollar itself) as well as more peripheral ones (listed in Table 1). Reversed prices (exchange rates mass/USD) of Gold and Silver are proposed alternatively as components of the baskets. For each petroleum commodity an individual currency basket is constructed using these elements. The performance of the basket and Markowitz portfolio method is then confronted with the Markowitz portfolio computed with original market prices (in USD) of the commodities by comparing the risk of transacting in the basket (standard deviation of the basket returns) against transacting in the US dollar. The confrontation is being made, first at the optimization interval, then in the one year validation interval.The calculations were performed in custom-written software running on the MATLAB platform, employing MATLAB *fmincon*() as the solver for the optimization tasks (8-10) and (11-13). The coefficient l has been chosen in a way to produce non-dominated compromise solutions (Pareto curves – see Figure 3), and finally its mean value in this interval has been accepted as the best compromise solution.

The currency basket has been optimized over four year interval. It was stated in our paper (Duda at al. [10]) that such an interval width is an acceptable compromise between necessity of data randomness

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reduction (wide interval preferred), and on the other hand side – prediction flexibility by exploring mainly more recent data to find recent tendencies (short intervals preferred). The four years intervals correspond to cyclic properties of the World economy. Cycles of 4 year periods in financial time are often suggested in the literature (Baxter [3], [4]). In our earlier papers (Augustynek&Duda-Kękuś [2], Duda&Augustynek [11]) we have shown that such cycles are present in leading Stock Market indexes and metal prices. Thus the interval covering four years data makes possible elimination of disturbing effects of periodical oscillations on the covariance estimates calculated in eq.(8) and eq.(12).

In this interval we have calculated two Markowitz portfolios (like in the paper [10]): the first one is based on the optimized basket currency (Basket Portfolio), and the second is constructed for the USD prices (USD Portfolio). Both portfolios (with constant basket and portfolio coefficients) were then tested in a one year validation interval. The procedure was repeated for the years since 2004 to 2011, in the intervals shifted ahead by one year. Typical Pareto curves found for the both portfolios are shown in Figure 3.

The expected (average) portfolio return of the basket portfolio R_{mB} and the standard deviation s_{rB} of the returns, related to the same quantities, R_{mP} and s_{rP}, reached with the portfolio based on original prices (USD), were used as the efficiency measures of the basket-Markowitz portfolios in the optimization intervals (R_{mBopt}/R_{mPopt}, $\sigma_{rBopt}/\sigma_{rPopt}$) and in the validation intervals (R_{mBval}/R_{mPval}, $\sigma_{rBval}/\sigma_{rPval}$). Two basket types were employed: containing only official currencies and currencies plus Gold and Silver (mass/USD).

The results of calculations are summarized in Table 2 and confronted with those obtained in (Duda at al. [10]) with Markowitz portfolios optimized for return ratios (represented by the expected return ratios W_{mBopt}/W_{mPopt}, W_{mBval}/W_{mPval} and their standard deviations $\sigma_{wBopt}/\sigma_{wPopt}$, $\sigma_{wBval}/\sigma_{wPval}$). The ratios R_{mBopt}/R_{mPopt}, W_{mBopt}/W_{mPopt} and R_{mBval}/R_{mPval}, W_{mBval}/W_{mPval} are presented only for 1 months predictions, to avoid excessive tables. The basket-portfolios risk reduction measures $\sigma_{wBopt}/\sigma_{wPopt}$ and $\sigma_{rBval}/\sigma_{rPval}$ (more important for the basket payment concept assessment) are listed for each prediction horizon (1, 6, and 9 months). The results reached with baskets based only on official currencies are confronted with those obtained with baskets containing Gold and Silver treated as additional currencies.

Table 2

Efficiency assessment of the basket based Markowitz portfolios found for the prices returns (consistent with the baskets optimization), confronted with the efficiency of portfolios optimized for the prices return ratios (as proposed in the paper [10]), applied to forward transactions of 1, 6 and 9 months ahead for seven petroleum products: TXPropan, USGulfROil, HeatOil, LCrude1, NYGasF, WTI and Brent (see Table 1)

Gold&Silver excluded. Optimisation interwal = 4 years

Valid.start time	3.01.03	3.01.04	3.01.05	3.01.06	3.01.07	3.01.08	3.01.09	3.01.10	3.01.11
Prediction horizon = 1 month. Markovitz portfolio based on return ratios [10]									
W_{mBopt}/W_{mPopt}%	65.29	115.62	129.01	-126.46	60.78	55.83	64.73	59.02	89.93
$W_{mBval}/ _{mPval}$%	84.68	195.98	79.86	177.61	152.22	66.89	66.58	52.55	77.47
$\sigma_{wBopt}/\sigma_{wPopt}$%	97.90	98.74	97.37	98.63	101.03	96.59	91.99	79.44	77.13
$\sigma_{wBval}/\sigma_{wPval}$%	105.46	100.49	111.06	97.61	99.23	79.14	81.33	91.06	94.38
Prediction horizon = 1 months. Markovitz portfolio consistent with the baskets optimization									
R_{mBopt}/R_{mPopt}%	170.21	111.58	108.88	15.83	94.43	72.07	74.12	92.48	27.35
R_{mBval}/R_{mPval}%	79.51	150.08	84.91	173.54	155.25	68.81	64.78	56.33	92.69
$\sigma_{rBopt}/\sigma_{rPopt}$%	109.55	107.64	116.19	139.56	130.08	111.09	98.31	77.25	77.63
$\sigma_{rBval}/\sigma_{rPval}$%	106.14	**98.30**	111.93	111.17	**98.37**	86.51	83.31	91.48	**77.99**
Prediction horizon = 6 months. Markovitz portfolio based on return ratios [10]									
$\sigma_{wBopt}/\sigma_{wPopt}$%	97.07	81.63	82.18	94.09	126.99	103.43	98.94	53.96	52.95
$\sigma_{wBval}/\sigma_{wPval}$%	100.66	136.88	131.78	119.20	86.91	67.65	51.92	73.82	73.82
Prediction horizon = 6 months. Markovitz portfolio consistent with the baskets optimization									
$\sigma_{rBopt}/\sigma_{rPopt}$%	108.81	67.21	97.64	75.79	89.81	110.00	91.89	63.19	62.01
$\sigma_{rBval}/\sigma_{rPval}$%	126.57	138.76	133.08	**113.85**	94.13	73.52	53.58	**73.60**	96.51
Prediction horizon = 9 months. Markovitz portfolio based on return ratios [10]									
$\sigma_{wBopt}/\sigma_{wPopt}$%	92.71	82.83	85.35	101.96	137.91	113.18	90.97	50.54	51.43
$\sigma_{wBval}/\sigma_{wPval}$%	112.83	100.67	106.76	133.43	74.73	61.40	73.50	65.11	60.73
Prediction horizon = 9 months. Markovitz portfolio consistent with the baskets optimization									
$\sigma_{rBopt}/\sigma_{rPopt}$%	86.63	86.20	92.18	76.20	149.33	100.97	98.68	57.97	58.41
$\sigma_{rBval}/\sigma_{rPval}$%	119.67	116.86	118.40	**115.00**	86.84	68.96	**57.35**	**58.68**	76.67

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Bold letters show the basket portfolio found for returns being less risky than that for return ratios

Gold&Silver included. Optimisation interval=4 years

Valid.start time	3.01.03	3.01.04	3.01.05	3.01.06	3.01.07	3.01.08	3.01.09	3.01.10	3.01.11
Prediction horizon = 1 month. Markovitz portfolio based on return ratios [10]									
$W_{m\mathrm{Bopt}}/W_{m\mathrm{Popt}}$%	42.74	104.94	242.80	-135.40	44.00	-23.29	45.22	111.88	128.56
$W_{m\mathrm{Bval}}$/ $_{m\mathrm{Pval}}$%	70.63	214.31	73.08	103.73	248.57	54.95	72.22	53.67	57.11
$\sigma_{\mathrm{wBopt}}/\sigma_{\mathrm{wPopt}}$%	109.59	99.40	95.84	97.97	100.18	95.64	92.72	79.68	76.59
$\sigma_{\mathrm{wBval}}/\sigma_{\mathrm{wPval}}$%	105.79	**98.32**	113.75	**94.66**	**88.53**	80.50	83.02	**89.26**	**86.50**
Prediction horizon = 1 month. Markovitz portfolio consistent with the baskets optimization									
$R_{m\mathrm{Bopt}}/R_{m\mathrm{Popt}}$%	165.65	124.56	74.97	16.78	88.08	24.66	63.71	495.10	99.51
$R_{m\mathrm{Bval}}/R_{m\mathrm{Pval}}$%	78.70	188.13	93.31	125.93	223.96	55.83	75.98	59.16	24.11
$\sigma_{\mathrm{rBopt}}/\sigma_{\mathrm{rPopt}}$%	109.80	131.12	126.51	153.12	150.98	144.07	115.02	86.81	101.15
$\sigma_{\mathrm{rBval}}/\sigma_{\mathrm{rPval}}$%	106.12	**97.65**	135.52	**110.30**	94.59	89.24	87.64	**88.63**	127.63
Prediction horizon = 6 month. Markovitz portfolio based on return ratios [10]									
$\sigma_{\mathrm{wBopt}}/\sigma_{\mathrm{wPopt}}$%	93.81	93.21	91.67	101.64	105.84	100.43	97.10	63.19	60.93
$\sigma_{\mathrm{wBval}}/\sigma_{\mathrm{wPval}}$%	101.74	**121.29**	**109.58**	141.75	94.23	103.82	65.71	85.74	128.64
Prediction horizon = 6 month. Markovitz portfolio consistent with the baskets optimization									
$\sigma_{\mathrm{rBopt}}/\sigma_{\mathrm{rPopt}}$%	108.8	85.02	130.9	100.3	123.6	112.9	111.6	67.91	62.76
$\sigma_{\mathrm{rBval}}/\sigma_{\mathrm{rPval}}$%	126.6	139.0	133.5	**95.89**	96.25	**72.26**	74.82	**84.42**	**91.01**
Prediction horizon = 9 month. Markovitz portfolio based on return ratios [10]									
$\sigma_{\mathrm{wBopt}}/\sigma_{\mathrm{wPopt}}$%	92.71	82.69	84.23	99.94	144.47	115.95	92.51	49.90	50.83
$\sigma_{\mathrm{wBval}}/\sigma_{\mathrm{wPval}}$%	112.83	101.04	213.66	**89.55**	**72.81**	**59.56**	94.39	**60.91**	100.00
Prediction horizon = 9 month. Markovitz portfolio consistent with the baskets optimization									
$\sigma_{\mathrm{rBopt}}/\sigma_{\mathrm{rPopt}}$%	86.63	86.20	156.5	114.2	146.6	104.2	83.87	57.80	57.33
$\sigma_{\mathrm{rBval}}/\sigma_{\mathrm{rPval}}$%	119.67	116.86	237.79	**91.73**	**81.23**	69.72	**83.12**	**55.92**	**55.93**

Bold letters - basket portfolios with Gold&Silver being less risky than these excluding Gold&Silver

From practical viewpoint the most interesting index is the ratio $\sigma_{\mathrm{rBval}}/\sigma_{\mathrm{rPval}}$, i.e. the risk of the basket payment measured during the validation interval (reachable in real life), related to that of USD pracing. The relation $\sigma_{\mathrm{rBval}}/\sigma_{\mathrm{rPval}} < 1$ points advantage of basket payments and vice versa. It may be seen in Table 2 that, in general, the basket payments are less risky than USD pracing during large fluctuations in the commodity prices, i.e. during the crisis 2008-2010. In this period the risk reduction by the basket payments exceeded 40%. In the hossa time (up to 2007) the USD based portfolios are often advantageous.

The data gathered in Table 2 show that Markovitz portfolios involving the baskets based only on official currencies, and constructed with basket price returns (i.e. in the way consistent with the basket optimization) do not have significant advantages versus the portfolios optimized for return ratios (as in [10]). Nevertheless, when Gold and Silver are admitted in the baskets, the portfolios proposed in this paper, i.e. optimized for the basket price returns, are often less risky than these employing return ratios. Their real efficiency (in validation intervals) is also better predictable based on the efficiency calculated in the optimization intervals. It is especially profitable during the crisis times, and speaks for using the portfolios proposed in this paper, i.e. employing the same risk measures, which were minimized at the basket optimisation stage.

Apart from the portfolio efficiency improvement problem, very interesting information may be gained by analysis of the optimal basket structures, and their influence on the portfolio efficiency. An example of such a study is presented in Table 3. It shows the structures of USD and Basket portfolios, together with the currencies contributing into the baskets (optimized for individual commodities) in consecutive intervals for nine months forward transactions. The portfolio coefficients a_k for the considered commodities (k=1, …., 7), and the currency weights b_c in the baskets are presented. In each subtable (corresponding to the given validation interval) sum of b_c for each commodity (in each column) equals to 1 (see eq.4). Portfolios based in baskets of official currencies, as well as including Gold and Silver, are shown.

It can be seen that the basket structures do not change significantly in consecutive years. Changes in the portfolio coefficients are larger. Often, especially in the crisis time, the portfolio includes only one commodity (Brent). When looking at baskets admitting Gold and Silver one may observe that inclusion of Silver is more profitable (and so more frequent) than of Gold. The only basket including Gold was profitable in 2008, i.e. at the start of the crisis.

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Table 3

Portfolios based on basket price return and optimal basket structures found in consecutive intervals for nine months forward transactions. Data in the 1.st and 2.nd rows of each subtable – portfolio coefficients, italic letters - the USD portfolio. Data in columns of other rows - basket weights b_c (see eq.4), bold letters emerge used currencies and commodities

Gold&Silver excluded, Optimisation interval=4 years, prediction horizon=9 months

Commod.:	TXPropan	USGulfROil	HeatOil	LCrude1	NYGas	WTI	Brent
Validation interval start time: 03.01.02 $\sigma_{mBval}/\sigma_{mPval}$ = 119.67 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
JPY/USD	0.877	0.759	0.656	0.760	0.757	0.777	**0.742**
ZAR/USD	0.123	0.241	0.344	0.240	0.243	0.223	**0.258**
Validation interval start time: 03.01.03 $\sigma_{mBval}/\sigma_{mPval}$ =116.86 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.442*	*0.000*	*0.000*	*0.558*
Bask.Portf	0.000	0.000	0.000	**0.792**	0.000	0.000	**0.208**
JPY/USD	0.000	0.582	0.538	**0.722**	0.613	0.732	**0.842**
ZAR/USD	0.973	0.351	0.462	**0.249**	0.387	0.246	**0.145**
EGP/USD	0.027	0.067	0.000	**0.029**	0.000	0.022	**0.012**
Validation interval start time: 03.01.04 $\sigma_{wBval}/\sigma_{wPval}$ = 118.40 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.778*	*0.000*	*0.000*	*0.222*
Bask.Portf	0.000	0.000	0.000	**0.370**	0.000	0.000	**0.630**
GBP/USD	0.000	0.454	0.429	**0.611**	0.461	0.612	**0.682**
CHF/USD	0.000	0.000	0.005	0.000	0.000	0.000	0.000
ZAR/USD	1.000	0.546	0.566	**0.389**	0.539	0.388	**0.318**
Validation interval start time: 03.01.05 $\sigma_{wBval}/\sigma_{wPval}$ = 115.00 %							
USD Portf	*0.000*	*0.000*	*0.174*	*0.616*	*0.000*	*0.000*	*0.210*
Bask.Portf	0.000	0.000	0.000	0.000	0.000	**0.117**	**0.883**
PLN/USD	0.113	0.558	0.858	0.449	0.000	**0.424**	**0.542**
NZD/USD	0.681	0.427	0.000	0.190	0.736	**0.204**	**0.085**
CHF/USD	0.197	0.000	0.000	0.000	0.000	0.000	0.000
CLP/USD	0.000	0.000	0.000	0.000	0.097	0.000	0.000
EGP/USD	0.009	0.015	0.142	0.362	0.167	**0.372**	**0.373**
Validation interval start time: 03.01.06 $\sigma_{wBval}/\sigma_{wPval}$ = 86.84 %							
USD Portf	*0.119*	*0.000*	*0.000*	*0.881*	*0.000*	*0.000*	*0.000*
Bask.Portf	0.000	0.000	**0.219**	0.000	0.000	**0.781**	0.000
SDR/USD	0.429	0.000	0.000	0.000	0.000	0.000	0.000
PLN/USD	0.353	0.336	**0.557**	0.424	0.000	**0.408**	0.447
BRL/USD	0.000	0.547	**0.066**	0.081	0.334	**0.079**	0.159
NZD/USD	0.000	0.031	0.000	0.000	0.000	0.000	0.000
CLP/USD	0.155	0.000	0.000	0.000	0.466	0.000	0.000
EGP/USD	0.063	0.086	**0.378**	0.495	0.200	**0.513**	0.394
Validation interval start time: 03.01.07 $\sigma_{wBval}/\sigma_{wPval}$ = 68.96 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	**0.110**	0.000	0.000	**0.890**
BRL/USD	0.108	0.707	0.515	**0.226**	0.915	0.230	**0.375**
CAD/USD	0.759	0.000	0.042	**0.626**	0.000	0.628	**0.401**
ZAR/USD	0.134	0.293	0.443	**0.148**	0.085	0.142	**0.224**
Validation interval start time: 03.01.08 $\sigma_{wBval}/\sigma_{wPval}$ = 57.35 %							
USD Portf	***0.186***	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	***0.814***
Bask.Portf	0.000	0.000	**0.188**	0.000	0.000	0.000	**0.812**
PLN/USD	0.008	0.276	**0.527**	0.479	0.000	0.474	**0.425**
BRL/USD	**0.992**	0.724	**0.473**	0.521	1.000	0.526	**0.575**
Validation interval start time: 03.01.09 $\sigma_{wBval}/\sigma_{wPval}$ = 58.68 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
PLN/USD	1.000	1.000	1.000	1.000	0.994	1.000	**1.000**
BRL/USD	0.000	0.000	0.000	0.000	0.006	0.000	0.000
Validation interval start time: 03.01.10 $\sigma_{RBval}/\sigma_{RPval}$ = 58.68 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
PLN/USD	0.954	1.000	1.000	1.000	0.987	1.000	**1.000**
BRL/USD	0.046	0.000	0.000	0.000	0.013	0.000	0.000

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Gold&Silver included, optimisation interval=4 years, prediction horizon

Commod	TXPropan	USGulfROil	HeatOil	LCrude1	NYGas	WTI	Brent
Validation interval start time: 03.01.02 $\sigma_{wBval}/\sigma_{wPval}$ = 119.67 %							
USD Portf	*-0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	-0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
JPY/USD	0.877	0.759	0.656	0.760	0.757	0.777	**0.742**
ZAR/USD	0.123	0.241	0.344	0.240	0.243	0.223	**0.258**
Validation interval start time: 03.01.03 $\sigma_{wBval}/\sigma_{wPval}$ = 116.86 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.442*	*0.000*	*0.000*	*0.558*
Bask.Portf	0.000	0.000	0.000	**0.793**	0.000	0.000	**0.207**
JPY/USD	0.000	0.582	0.538	**0.722**	0.613	0.732	**0.842**
ZAR/USD	0.973	0.351	0.462	**0.249**	0.387	0.246	**0.145**
EGP/USD	0.027	0.067	0.000	**0.029**	0.000	0.022	**0.012**
Validation interval start time: 03.01.04 $\sigma_{wBval}/\sigma_{wPval}$ = 237.79 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.778*	*0.000*	*0.000*	*0.222*
Bask.Portf	0.000	0.000	0.000	**0.362**	0.000	0.000	**0.638**
CHF/USD	0.000	0.000	0.215	**0.117**	0.000	0.117	**0.092**
ZAR/USD	0.970	0.522	0.555	**0.397**	0.520	0.397	**0.334**
EGP/USD	0.000	0.000	0.000	**0.052**	0.028	0.057	**0.076**
Validation interval start time: 03.01.05 $\sigma_{wBval}/\sigma_{wPval}$ = 91.73 %							
USD Portf	*0.000*	*0.000*	*0.174*	*0.616*	*0.000*	*0.000*	*0.210*
Bask.Portf	0.000	0.000	**0.028**	**0.455**	0.000	0.000	**0.517**
PLN/USD	0.068	0.052	**0.720**	**0.350**	0.000	0.333	**0.340**
NZD/USD	0.106	0.000	0.000	0.000	0.000	0.000	0.000
CHF/USD	0.182	0.000	0.000	0.000	0.000	0.000	0.000
EGP/USD	0.000	0.000	**0.096**	**0.284**	0.000	0.295	**0.276**
Silver/USD	0.000	0.464	**0.120**	**0.349**	0.326	0.340	**0.384**
Validation interval start time: 03.01.06 $\sigma_{wBval}/\sigma_{wPval}$ = 81.23 %							
USD Portf	*0.119*	*0.000*	*0.000*	*0.881*	*0.000*	*0.000*	*0.000*
Bask.Portf	0.000	0.000	**0.134**	**0.535**	0.000	**0.331**	0.000
SDR/USD	0.339	0.000	0.000	0.000	0.000	0.000	0.000
PLN/USD	0.166	0.263	**0.557**	**0.342**	0.000	**0.325**	0.359
BRL/USD	0.000	0.510	**0.066**	**0.038**	0.373	**0.036**	0.109
NZD/USD	0.139	0.089	0.000	0.000	0.000	0.000	0.000
CLP/USD	0.000	0.000	0.000	0.000	0.211	0.000	0.000
EGP/USD	0.138	0.063	**0.378**	**0.461**	0.203	**0.478**	0.370
Silver/USD	0.217	0.076	0.000	**0.160**	0.214	**0.161**	0.162
Validation interval start time: 03.01.07 $\sigma_{wBval}/\sigma_{wPval}$ = 69.72 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	**0.349**	0.000	0.000	**0.651**
BRL/USD	0.108	0.707	0.515	**0.238**	0.882	0.242	**0.392**
CAD/USD	0.759	0.000	0.042	**0.565**	0.000	0.571	**0.295**
ZAR/USD	0.134	0.293	0.443	**0.161**	0.074	0.155	**0.249**
Silver/USD	0.000	0.000	0.000	**0.035**	0.044	0.032	**0.064**
Validation interval start time: 03.01.08 $\sigma_{wBval}/\sigma_{wPval}$ = 83.12 %							
USD Portf	*0.186*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.814*
Bask.Portf	**0.079**	0.000	0.000	0.000	0.000	0.000	**0.921**
PLN/USD	0.000	0.212	0.302	0.116	0.000	0.111	**0.114**
BRL/USD	**0.807**	0.704	0.384	0.349	0.988	0.354	**0.422**
Gold/USD	**0.193**	0.084	0.314	0.536	0.012	0.536	**0.464**
Validation interval start time: 03.01.09 $\sigma_{wBval}/\sigma_{wPval}$ = 55.92 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
PLN/USD	0.857	1.000	0.948	0.720	0.704	0.720	**0.628**
Silver/USD	0.143	0.000	0.052	0.280	0.296	0.280	**0.372**
Validation interval start time: 03.01.10 $\sigma_{wBval}/\sigma_{wPval}$ = 55.93 %							
USD Portf	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*1.000*
Bask.Portf	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
PLN/USD	0.746	1.000	0.996	0.821	0.782	0.823	**0.732**
Silver/USD	0.254	0.000	0.004	0.179	0.218	0.177	**0.268**

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It is noteworthy that the more efficient baskets are composed mainly of peripheral currencies. In particular USD itself and EURO were never found as appropriate to be used in basket payments. Other strong currencies, GBP, CHF and JPY appear incidentally in rather poor portfolios. Interestingly, Polish zloty seems to be the most profitable currency for the transactions on petroleum products. It is often the key currency in baskets producing very effective portfolios. In 2009 and 2010 it was the only currency in the basket or dominant currency completed with Silver.

Conclusions. The article shows that the proposed payment method, based on optimized currency baskets, is a promising way to reduce forward transaction riskiness in commodity markets. The baskets found for individual commodities (to express their price instead of USD) may be then employed to construct Markovitz portfolios. The portfolio may be optimized with respect to price return ratio, or alternatively – for commodities of comparable prices – with respect to the price return. The second way is consistent with the basket optimization method, which is to minimize the price prediction error, i.e. price return at a given prediction (forward transaction) horizon.

The paper examines the performance of such baskets (involving 19 currencies and possibly Gold and Silver) with respect to their ability to reduce the riskiness of forward transactions for selected petroleum commodities (TXPropan, USGulfROil, HeatOil, LCrude1, NYGasF, WTI and Brent). The performance is then evaluated for three prediction intervals: 1, 6 and 9 months over the period from 2002 to 2010.

The calculations show that such portfolios are mostly less risky then portfolios based on USD prices, although in same cases may be worse. In general, the alternative portfolios (optimizing the basket return) are comparable with the classical ones in the risk reduction ability, but their efficiency - reachable in validation intervals - is closer to that calculated in optimization intervals (hence it is better predictable). Such portfolios efficiency may be raised by including precious metals (Silver and Gold) reversed prices into the currency baskets. The risk reduction may reach 20-40%, especially during large changes of USD prices (in the crisis period 2008-2010).

The most efficient baskets are composed mainly of peripheral currencies (e.g. PLN) that reflect regional tendency, to compensation of changes in commodity USD prices by appreciation/depreciation of national currencies. Usually, strong currencies (USD, GBP, Euro) do not contribute to optimal baskets, thus they seem to be not suitable to forward transactions.

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УДК 328.47

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МОДЕЛЬ ОРГАНІЗАЦІЇ ІНФОРМАЦІЙНОГО ЗАБЕЗПЕЧЕННЯ УПРАВЛІННЯ РОЗВИТКОМ ЕКОНОМІЧНИХ СУБ'ЄКТІВ РЕГІОНУ

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Розглянуто роль інформаційного забезпечення у розвитку підприємств регіонів. Запропоновано модель організації регіонального інформаційного забезпечення для вирішення проблем надання економічним суб'єктам достовірної, оперативної інформації.

The information support role in development of the regional enterprises is considered. The model of the organization of regional information support for the decision of problems of granting for the economic subjects of the authentic and operative information is offered.

Постановка проблеми. Зважаючи на ситуацію, що склалася в соціально-економічному розвитку країни, та з урахуванням світових тенденцій важливою проблемою є суттєве вдосконалення інформаційного забезпечення управлінням регіональним розвитком. Як свідчить практика, інформаційно-комунікаційні технології відкривають для всіх великі можливості доступу до інформації, задовольняючи потреби в знаннях. Економіка, основана на знаннях, – це певний етап розвитку суспільства, коли відбувалося усвідомлення надзвичайної важливості інформації та знань як стратегічних ресурсів, необхідних для економічного зростання, і значення яких підвищується внаслідок їхнього активного використання в усіх сферах суспільного життя [1, с. 25]. Знання – єдиний вид ресурсів, який суттєво відрізняє одне підприємство від іншого, ресурс, який не можуть швидко відтворювати конкуренти, ресурс, завдяки якому підприємство має унікальні, стійкі переваги. Оскільки знання – це багатство підприємств та організацій, а вміння управляти ними створює конкурентні переваги, то виникає потреба в ефективному управлінні знаннями.

Аналіз останніх досліджень і публікацій. Питання обґрунтування сутності, особливостей, місця і ролі інформаційних ресурсів у становленні інформаційної економіки розглянуті в працях В.В. Іванової, В.М. Глушкова, О.Г. Пенькової, О. Сосніна, Л.І. Федулової, С.І. Яковенко. В деяких

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