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A CONCEPT FOR CONSTRUCTION NEW CURRENCY BASKETS BASED ON STATISTICAL CRITERIA

Two approaches to construction new currency baskets are proposed. The first one is based on the Karhunen-Loeve transformation (PCA) of time series of more important currencies exchange rates, and employs the least variance component of the transformed series as the most stable currency. The second one uses formal optimization techniques to find a currency basket minimizing variability of prices of representative raw materials (non-iron metals and fuels).

Introduction.

The present position of the American dollar as the world currency in last recession time is criticized. This is the result of the fact that United States are being blamed for rising the global crisis. A large deficit, unbalance, funding the economy of USA by the rest of the world makes the dollar unstable and little reliable. Countries that have trade surplus (China, Japan, Arabian countries) and invest the majority of surplus in dollars nominated assets are the most dissatisfied with the present position of the dollar. In this connection a lot it is said about the necessity to create a new system of financial world that would also include new world currency allowing to stabilize the world markets. Discussions concerning this problem are lead in the groups G8 and G20 ect. Various conceptions are proposed. One of the concepts has many followers. It says that Special Drawing Rights (SDR) – the currency created by International Monetary Fund - should be the new world currency. Thus the important issue is to check if the SDR currency is really the best alternative for the weak dollar. The value of SDR is calculated on the basis of the currency basket which consists currently of the following currencies: euro, U.S. dollar, yen and pound sterling. The weight of the currencies in the basket is being actualized (calculated) in every five years and is being established on the basis of the sales level and the reserves level of individual countries which are the part of the basket composition [1].

This paper concentrates on proposing new possibilities to form the currency baskets, which create currencies that would allow to stabilize the selected markets (we selected energetic and non-iron raw material markets) and would be of a low variation level.

Data characterization and formal tools

In the study we have used the daily close exchange quotations for raw material prices and also daily interbank quotation of exchange rates. All data include the period from 01.01.1998 to 28.02.2009. Both exchange rates and raw material prices were stated in U.S. dollar (currency per USD, USD per given raw material unit of measure).

Regarding the main goal of the analyses being carried out to construct an alternative basket towards the current SDR basket, there was also SDR exchange rate (founded on the mentioned basket) expressed by USD (SDR/USD) in the gathered data. This exchange rate allows to evaluate the SDR currency variation and also what follows the qualities of the SDR basket. It also gives the possibility to check in what degree the current SDR basket is fitted to the current situation in the world economy.

World economy situation is reflected by time profiles of crude oils (Brent and WTI), petroleum products and some non-ferrous metal prices like copper, gold (look table 1). Gold was also used in the study as an additional currency being an interesting alternative for others. Other exchange rates representing currencies of the most important countries (Great Britain, Japan, Canada, Australia etc.) allowed to propose a new baskets by using mathematical tools. The mentioned basket could create the value of the SDR currency in the future [2].

All the examined raw material prices and exchange rates take the form of time series i.e. time ranked information sequences which measurement is proceed at regular intervals.

The following table presents the list of time series used in calculations.

Table.1. *Names of raw material prices quotations and exchange rates quotations used in calculations.*

Raw Materials Prices	
Brent	Europe Brent Spot Price FOB (Dollars per Barrel)
WTI	Cushing, OK WTI Spot Price FOB (Dollars per Barrel)
SingReOil	Singapore Residual Fuel Oil 180 Spot Price FOB (Cents per Gallon)
GasOilARA	Rotterdam (ARA) Gasoil Spot Price FOB (Cents per Gallon)
LosAng	Los Angeles, CA Residual Fuel Oil 180 Spot Price FOB (Cents per Gallon)
USGulfHOil	U.S. Gulf Coast No. 2 Heating Oil Spot Price FOB (Cents per Gallon)
NYGasF	New York Harbor Gasoline Regular Future Contract 3 (Cents per Gallon)
LMEsetl	Copper (Dollars per Ton) settlement in London Metal Exchange
Alumin	Aluminium (Dollars per Ton)
Zinc	Zinc (Dollars per Ton)
Silver	Silver (Dollars per Ounce)
Gold	Gold (Dollars per Ounce)
Exchange rates	
AUD/USD	Australian dollar/U.S. dollar
GBP/USD	British pound/U.S. dollar
CAD/USD	Canadian dollar/U.S. dollar
EUR/USD	Euro/U.S. dollar
JPY/USD	Japanese yen/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 franc/U.S. dollar
CLP/USD	Chilean peso/U.S. dollar
INR/USD	Indonesian rupiah/U.S. dollar
PLN/USD	Polish zloty/U.S. dollar
ZAR/USD	RPA rand/U.S. dollar
EGP/USD	Egyptian pound/U.S. dollar
NOR/USD	Norwegian kroner/ U.S. dollar
SDR/USD	Special Drawing Right/ U.S. dollar
Gold/USD	Gold/ U.S. dollar

Essential problem in this kind of study is adaptation of mathematical apparatus to the specification of stock exchange data. Mentioned specification has two basis. The first one is incoherency of data

registration period (companies come into the stock exchange and then sometimes leave it suddenly), the second one is deficiency of data (for example weekends, holidays). Weekends are synchronical interruptions and that's the reason why we can erase them and regard as continuous period. Asynchronical deficiencies (holidays or global incidents such as terrorist attack on WTC or U.S. intervention in Iraq) cause mainly interruption which lasts couple days or more and effects the work of stock exchange. This kind of deficiencies can't be eliminated in the same way as synchronical. Nevertheless we can eliminate them in two different ways. The classic one which rests upon interpolation of shortages and helps to gain compact set of data. The second one is based on ignoring data insufficiencies [3,4].

The problem concerning incoherency of the data was solved in the article through erasing weekend days and deficiencies resulted from different causes were removed through linear interpolation.

The time profiles of studied series are shown in figures 1a and 1b. As it is presented all studied series are nonstationary. Qualitatively similar shape of the time profiles of the raw materials prices quotation (Fig. 1b) is characteristic what perhaps could show their correlation.

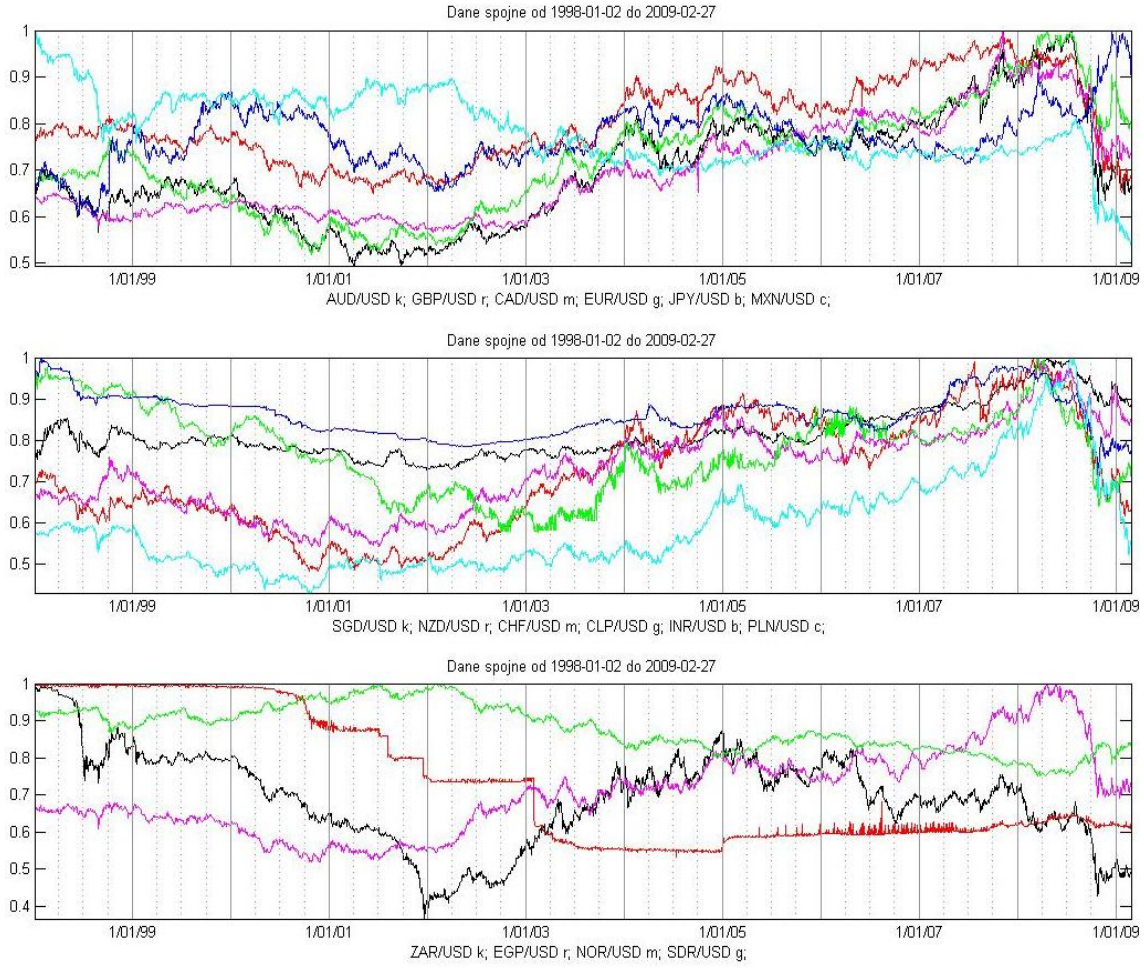

Fig.1a. *Time series of exchange rates used in calculations. The values in each series are related to their maximal value. Vertical dotted lines – three months and 1-year (bold) intervals*

There are many mathematical tools which allow to create optimal baskets concerning different criteria. Two of them were used in this study.

It was proposed an original method of setting the currency basket as a linear combination of the original currencies in a chosen time window, which gives the smallest variation of the outcome currency. To this aim one of the multidimensional analysis methods called the Principal Component Analysis (PCA) or Karhunen-Loeve transformation was used.

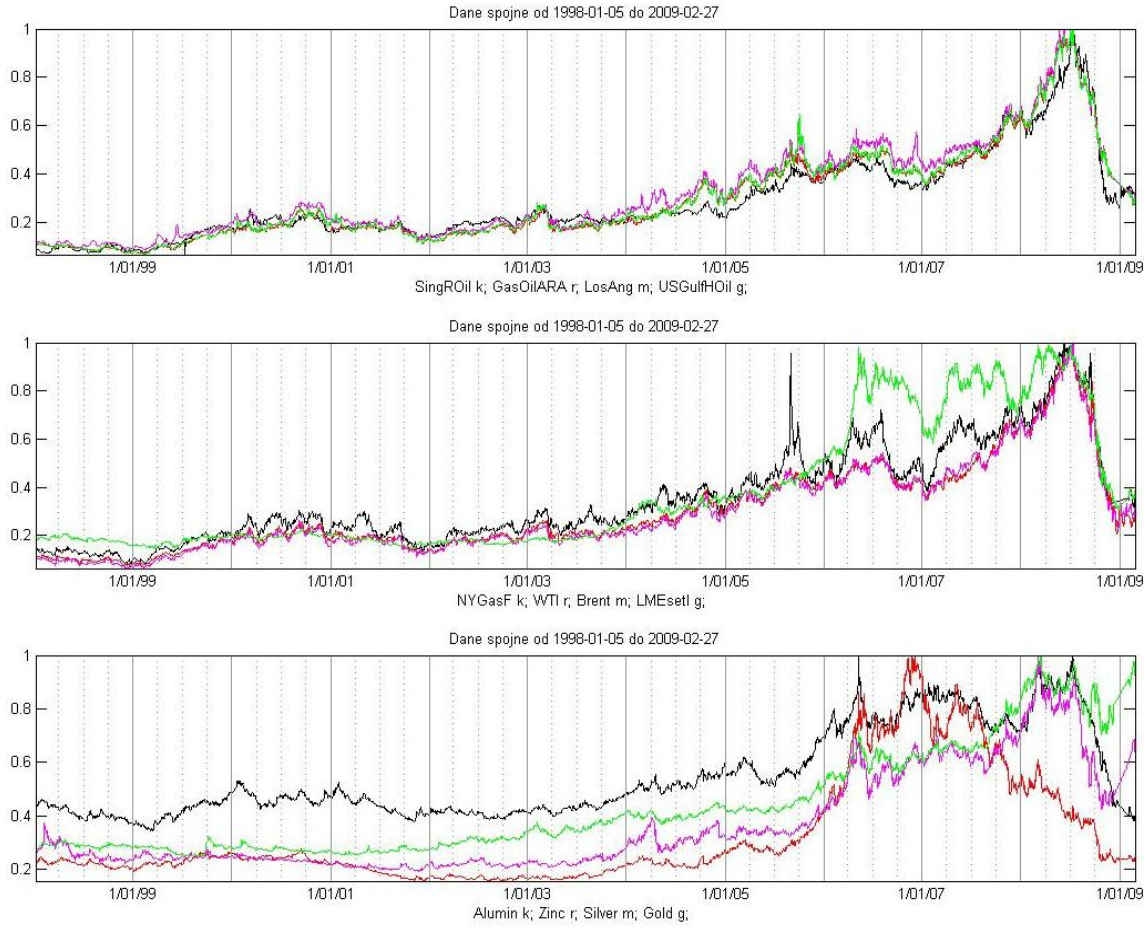

Fig.1b. *Time series of raw material prices used in calculations. The values in each series are related to their maximal value. Vertical dotted lines – three months and 1-year (bold) intervals*

Principal Component Analysis is a mathematical method, which allow to reduce the dimension of the data vector entrance. A smaller dimension vector obtainment is proceed through the transformation of correlated vectors of entrance data to the new data vectors mutually orthogonal.

Let X means the matrix of M columns that represent M variables characterizing the studied object (M features). We have N registered values for every variables (rows of the matrix X). Every row represents one point in the M dimension space of the object features. KL transforma is calculated with formula:

$$U = P \cdot X, \text{ and } X = P^{-1} \cdot U \qquad (1)$$

where P is the square matrix of normalised eigenvectors of covariance matrix $X^T X$, and the matrix U columns are orthogonal, i.e. for all $k \neq j$ we have $R_{UkUj} = 0$ and UU^T is the diagonal matrix. KL procedures rank variables U_k in descending variation order, what facilitates the analysis of their influence on another series *Y* (PCA). Typically variation of the next row of U_k vectors decreases very quickly what allows to take that several first of them (named Principal Components, PC) provides reliable information on expected value of Y.

The last column of the matrix *U* is interesting from the point of view of this article aim. That is the least varying component of the structure. **This component could be the basis of the currencies basket composition with the smallest variation**. The last column of the matrix *P*, i.e. vector P_M divided by the range of the currency D_w variations (established in the standardization procedure) can be defined as coefficients of the basket (hereinafter called **the PCA basket**).

The principles of calculation the basket can not be changed too often (the SDR basket is calculated for the period of 5 years at present). That is why it was accepted that the PCA basket would be calculated in the settled interval of the time (once in the year) and on the basis of data including a suitably long interval of the row till the moment of the currency calculation. The window of the analysis should be

sufficiently long to average local fluctuations of the exchange rates. In the study we took four years width of window. Such mode of the basket actualization was chosen arbitrarily to illustrate characteristic of here proposed method.

The possibility of appearing negative weights in the PCA basket is the defect which can bring on the negative currency value. The sum of the basket coefficients will not be also unitary. In this connection, the currency W_{Pn} value (hereinafter called **the PCA currency**) for the moment *n*, on the basis of the original currencies $V_{n,}$ value was calculated with the formula:

$$W_{Pn} = \left| \sum_{i=1}^{M} \frac{P_{iM}}{D_i} V_{n,i} \right| + W_{P0} \tag{2}$$

where W_{P0} means uniform value which regulates the level of the calculated currency, so it would be equal to SDR for the first period of analysis and for the rest – the same as the last value calculated for the previous period. Uniform W_{P0} is being added to assure the comparability of the W_P currency with SDR and its continuity it in next periods.

As another tool to construct the currency basket one can use formal techniques of optimization, which minimize the average variation of selected goods prices in a given time interval. This approach realizes directly the real aim of the basket, which is a stabilization of world markets. The result will depend on the selection of goods. In this paper we took a representative set of energetic raw material prices and non-iron metals prices, what seems to be rational because of the meaning of these goods for the world economy.

In this order one of the optimization function from the MATLAB software package was proposed - ***fmincon***. The decision variables are the coefficients of the considered *K* currencies in the basket. All coefficients of the k_i basket have to be positive, what imposes M inequality bounds. Moreover the equality constraint says that sum of the basket coefficients k_i has to be equal one:

$$\sum_{i=1}^{M} k_i = 1 \tag{3}$$

$k_i \geq 0$ for i=1,2,…,M

As the optimization performance index (objective function) we have used the sum of the average squared deviations of the selected raw material prices (expressed in the demanded currency) from their average in the window with combined width (for the combined period of study). This index was formulated in the matrix form:

$$J = K^T (A_1 - A_2) K \tag{4}$$

where:

A_1- matrix aggregating the calculation of the average square prices

A_2- matrix aggregating the calculation of the average price squares

For the *K* basket, gained through this function, the currency W_{On} value was calculated (hereinafter called **the OPT currency)** for the moment *n*, on the basis of the original currencies $V_{n,}$ value with the formula:

$$W_{On} = \sum_{i=1}^{M} k_i V_{n,i} + W_{O0} \tag{5}$$

where W_{O0} means uniform value which regulates the level of the calculated currency like in the formula (2). Also in case of the W_{On} currency it was decided that the basket *K* will be calculated for one year interval in four years window.

Hereinafter presented results were gained with using a dedicated package of software, working in the MATLAB environment.

Computation results

Four different sets of data containing the exchange rates were used in the study. Table 2 presents these sets.

Table.2. Data sets

Set	Data
I	15 exchange rates
II	15 exchange rates + Gold/USD
III	15 exchange rates + SDR/USD
IV	15 exchange rates + Gold/USD+ SDR/USD

The new currency baskets were calculated for these data sets with the two described tools (the PCA analysis and the optimization procedure). The additional basket founded only on one currency- gold (Gold / USD) was also proposed.

All exchange rates received in the result of calculations for the various data sets and also for the SDR and gold rate are presented in figures 2-5. It may be seen that the smallest variation hais reached with the OPT currencies (set I and II), but SDR is also comparatively stable. Gold has decreasing tendency what allows to minimize inflation. The PCA (set I and III) and OPT (set III and IV) currencies have the biggest variations.

Figures 6-9 present the raw materials prices received in the result of the recalculation on individual currencies. Every figure suits the next data set.

The curves in figure 2-9 show that the currency which in the best way to minimize the fluctuation of raw material prices is gold. SDR also allows quite good price stabilization. Decidedly the worst currencies are PCA and OPT. They give minimum improvement and in some cases almost imperceptible. This follows from the accepted principle of basket adaptation in the peculiarity of upholding the value during next adaptation periods (every year). The interesting think is that optimum basket from the set IV is in principle the gold exchange rate so it should give the similar stabilization effect as gold. Decidedly higher exchange rate value level of this basket is the result of upholding value.

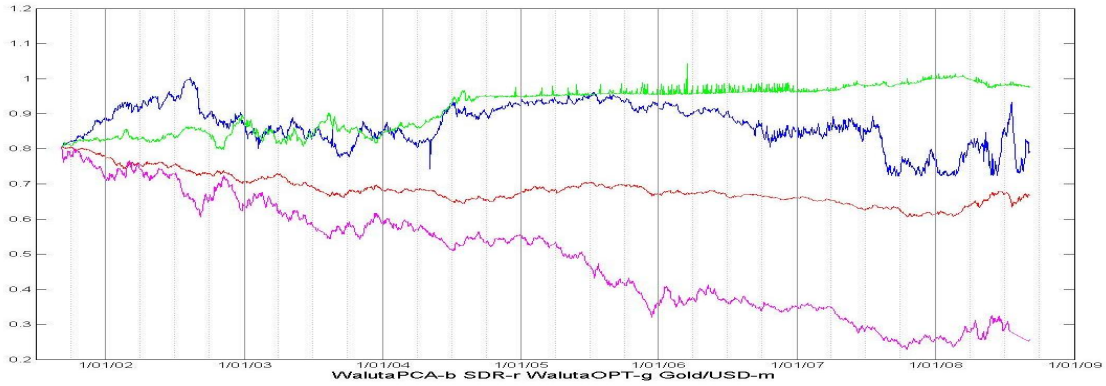

Fig.2. *Time profiles of PCA, OPT, SDR, Gold exchange rates. (set I)*

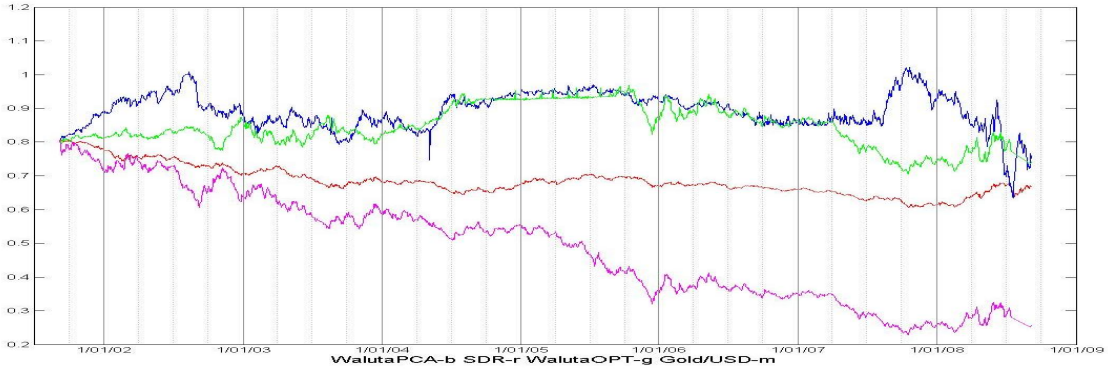

Fig.3. *Time profiles of PCA, OPT, SDR, Gold exchange rates. (set II)*

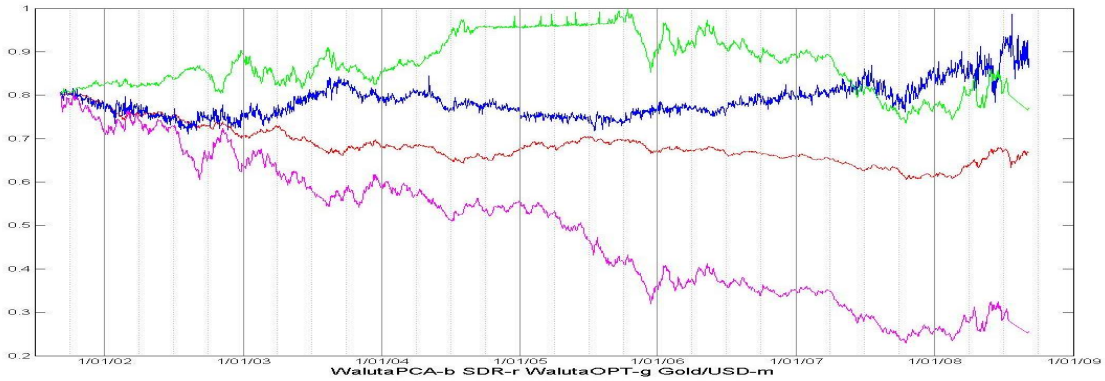

Fig.4. *Time profiles of PCA, OPT, SDR, Gold exchange rates. (set III)*

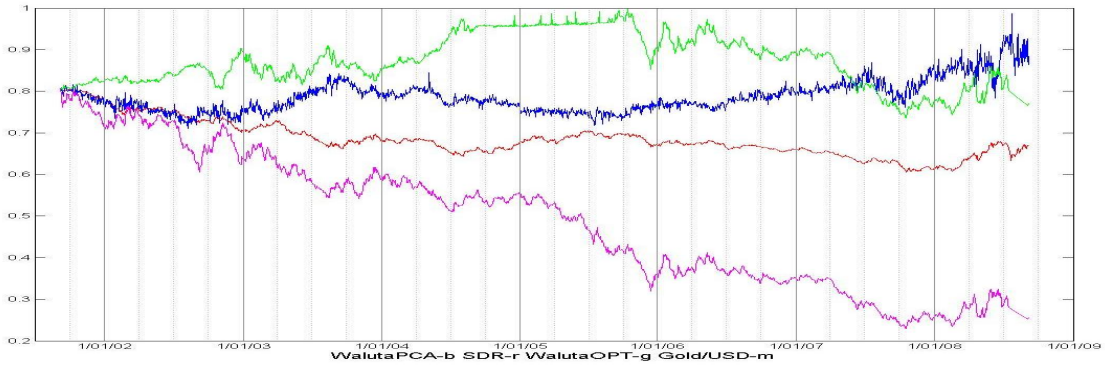

Fig.5. *Time profiles of PCA, OPT, SDR, Gold exchange rates. (set IV)*

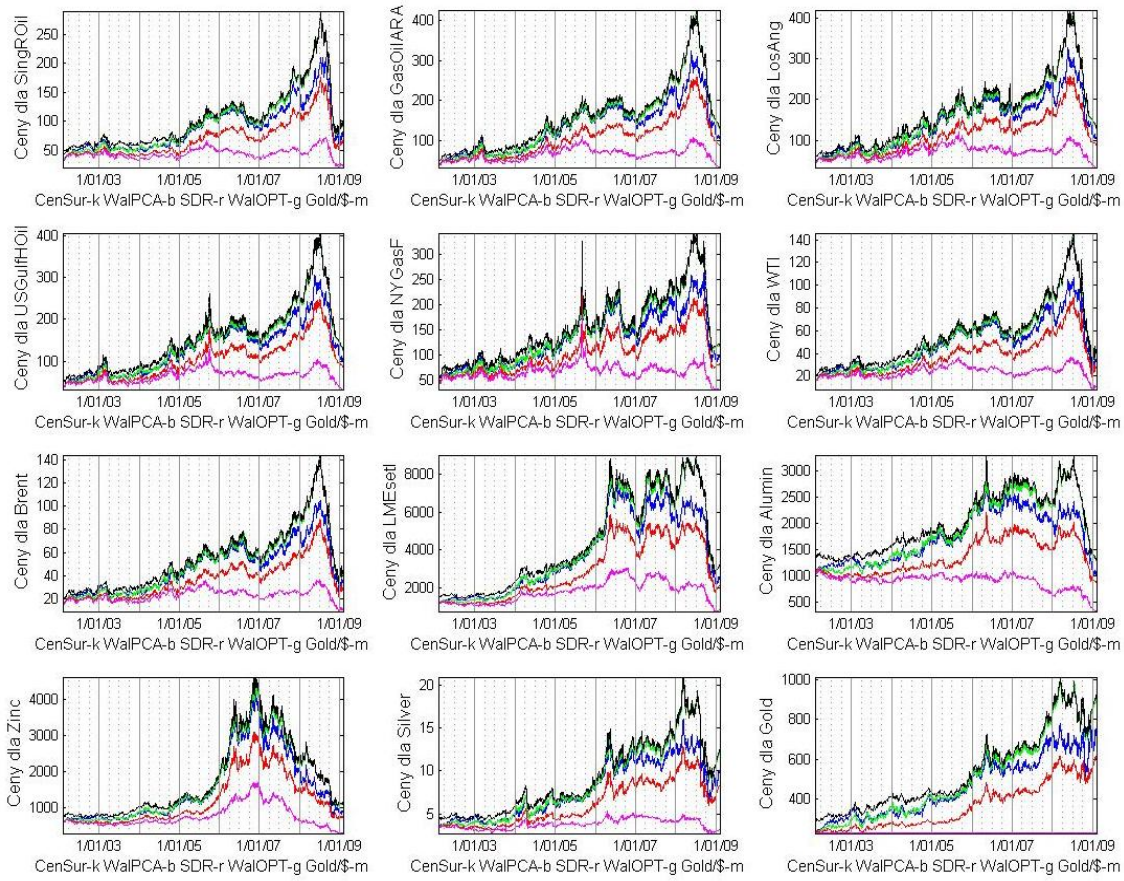

Fig.6. *Time profiles of raw material prices for the I set*

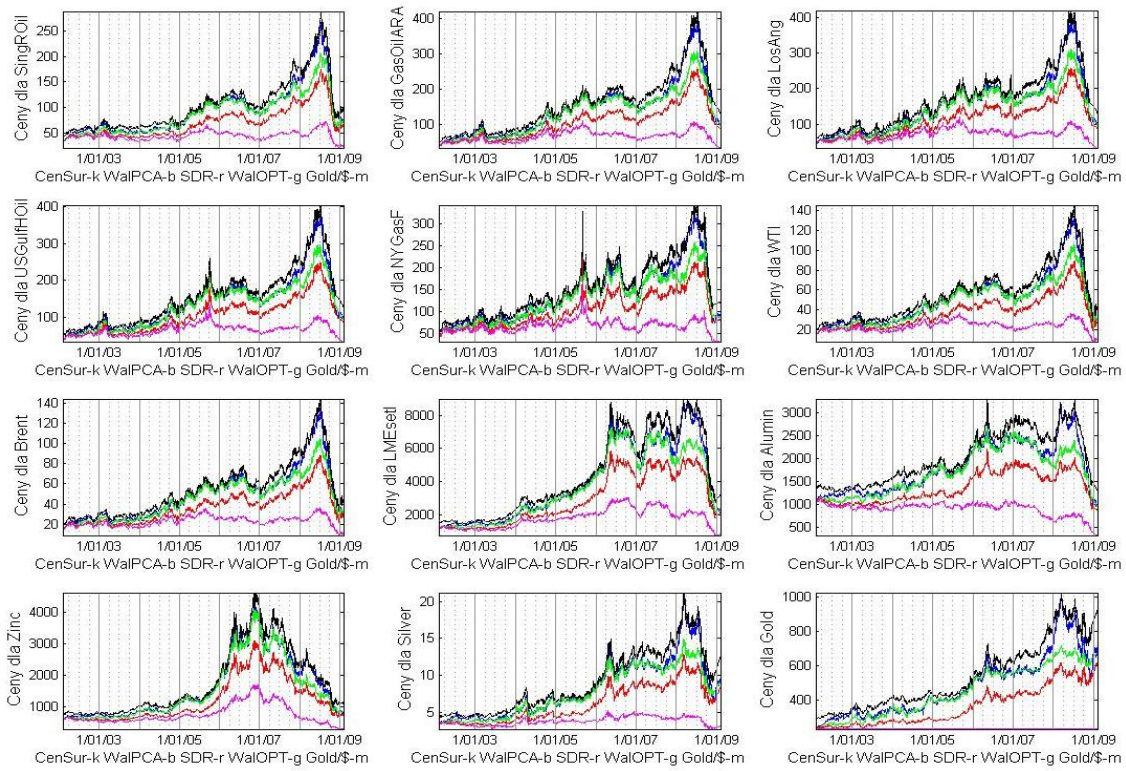

Fig.7. *Time profiles of raw material prices for the II set*

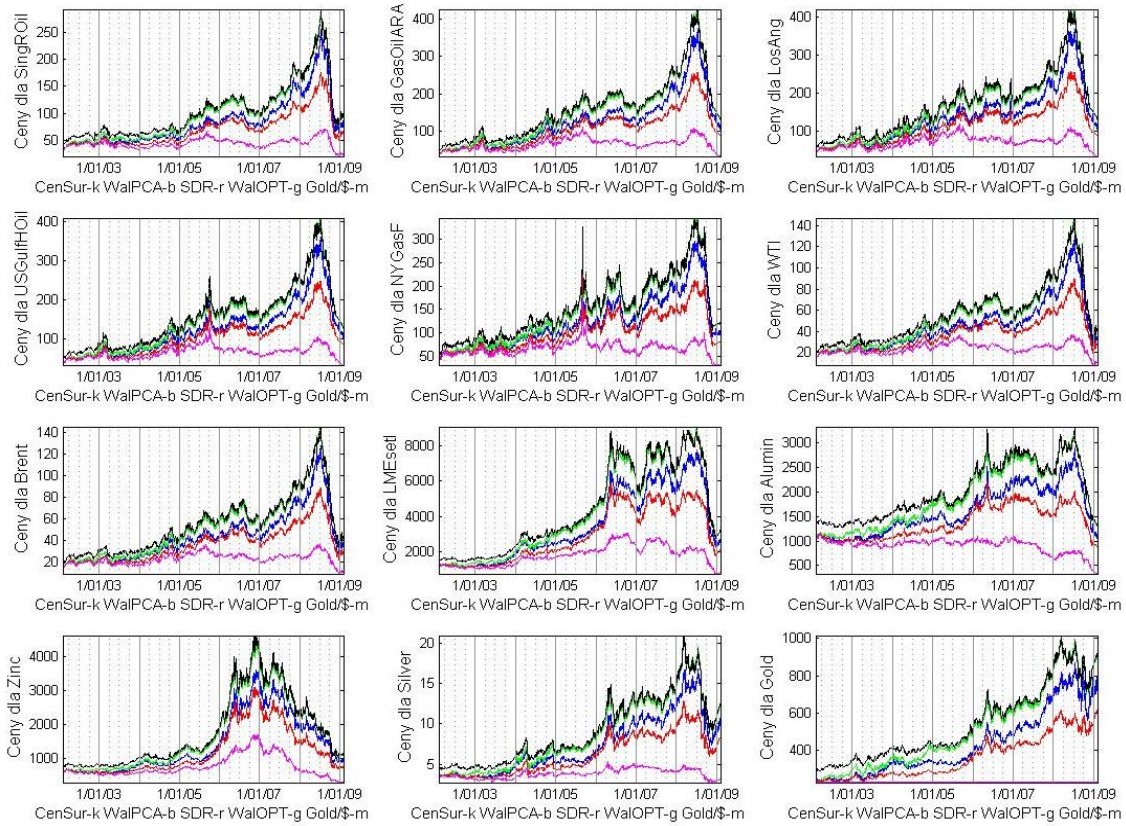

Fig.8. *Time profiles of raw material prices for the III set*

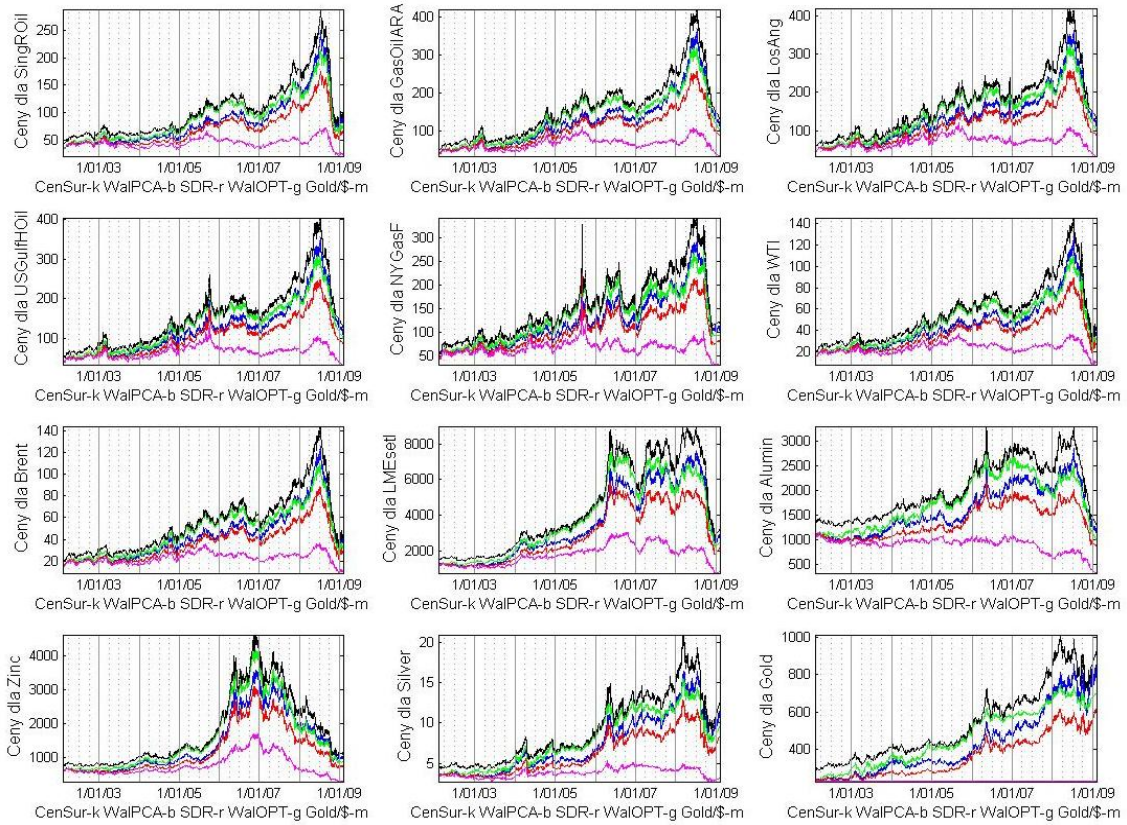

Fig.9. *Time profiles of raw material prices for the IV set*

Conclusions

On the basis of the presented studies it was established that the most profitable currency in view of the smallest fluctuation of raw material prices is gold. However gold exchange rate is also the most unpredictable what relates with the plurality of the factors determines his price as the raw material i.e. political, social events or natural threats. This is why we can not establish ideal prognosis model for such currency exchange rate.

Including only a variability level of the individual exchange rate the most stable is currency based on the optimized basket, received for sets including 15 exchange rates and SDR.

Taking under consideration the gathered data, received baskets and earlier accepted principles i.e. the minimization of the raw material prices variation and the variability of the exchange rate, baskets received through the PCA analysis are characterized by the weakest results. However the best is the basket creating the SDR currency.

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