# Symbolic CTQ-analysis – a new method for studying of financial indicators

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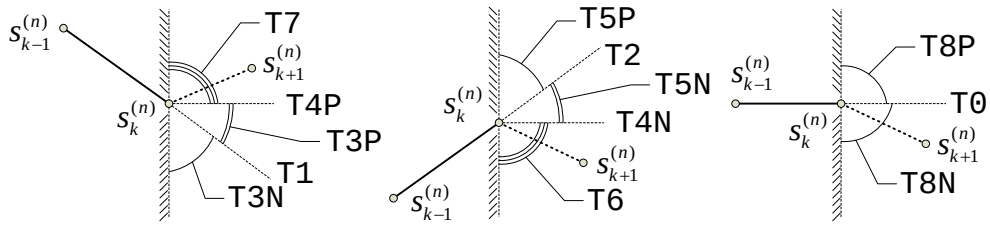
Modern financial and economic system extremely complex, and the creation of accurate adequate models from first principles is very difficult. One of the approaches to the study of these systems is based on the analysis of financial and economic time series of the form:

$$\{\mathbf{s}_k\}_{k=1}^{K}, \quad \mathbf{s} \in \mathrm{S} \subset \mathbb{R}^N, \quad n = \overline{1,\, N}, \quad k \in \mathrm{K} \subset \mathbb{N}, \quad k = \overline{1,\, K}. \tag{1}$$

Every $k$-th countdown can be associated with moment of time $t_k$, at that $t_{k+1} > t_k$, $t \in \mathrm{T} \subset \mathbb{R}$. Variable $s_k^{(n)}$ – may be interpreted as value of some financial indicator on moment of time $t_k$.

In recent times, in financial mathematics for the analysis of these time series are increasingly using methods of statistical physics, nonlinear dynamics and chaos theory. One of the most effective tools - this a symbolic dynamics, which allows you to explore a variety of complex phenomena in dynamical systems: chaos, strange attractors, hyperbolic, structural stability, controllability, etc. In the author article [1] introduced by the finite T-alphabet for encoding shape of trajectories of $\{\mathbf{s}_k\}_{k=1}^{K}$ in the space $\mathrm{S} \times \mathrm{K}$ through the matching: $\{s_k^{(n)}\}_{k=0}^{K+1} \Rightarrow \{T_k^{\alpha\varphi}|_n\}_{k=1}^{K}$, $T_k^{\alpha\varphi} = \left[T_k^{\alpha\varphi}|_1 \ldots T_k^{\alpha\varphi}|_N\right]$. The scheme of terms $T^{\alpha\varphi}|_n$ is shown in the figure.




In addition, the approach allows us to analyze the level of synchronization and its temporal structure for complex ensembles of highly non-stationary and non-identical chaotic oscillators large dimensions with arbitrary shape and topology of the network (lattice) [2, 3].

This report illustrates the basic features of the symbolic CTQ-analysis applied to the study of the dynamics of financial indicators. As an example, we study the structure and parameters of the synchronization rates of world currencies (the U.S. Dollar [USD], Euro [EUR], Japanese Yen [JPH], Swiss Franc [CHF], and the British Pound [GBP]) against the ruble of the Russian Federation [RUB] for period from 01.01.1999 on 31.03.2013. The initial data are taken from the official web-site

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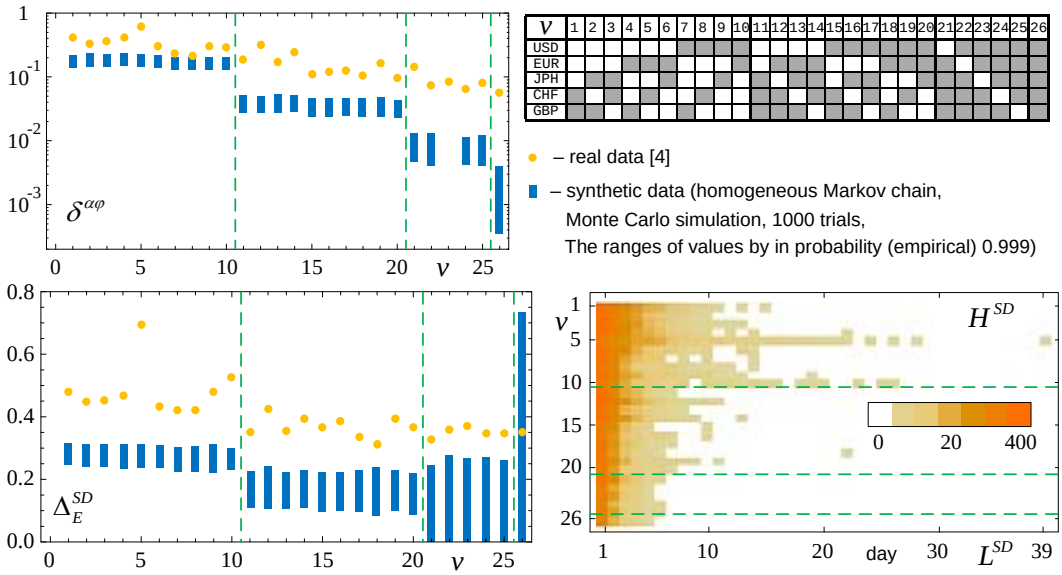
Central Bank of Russia [4]. The sample size of $K = 3\ 545$ counts. Data extraction and processing was carried out in the program Wolfram Mathematica 9.

Among the results obtained. For specified 5-financial indicators are constructed and analyzed their of symbolic TQ-images [1, 3]. The analysis revealed a difference between the structure of the time series for the exchange rate USD/RUB and the rest currency pairs. Over all possible combinations (v) the specified 5-currency pairs, the analysis of T-synchronization [2, 3]. For some combinations found non-random higher values of integral level of synchronicity $\delta^{\alpha\varphi}$ and the entropy of the structure of synchronous domains $\Delta_E^{SD}$. In the $H^{SD}$ spectra of synchronous domains, detected long periods $L^{SD}$ of synchronized exchange rate fluctuations. For all relevant periods obtained their real date (for linking the to external events).




It is further planned multiscale CTQ-analysis of these financial indicators for investigation of their temporal structure in order to study the mechanism and causes of synchronicity.

## References

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