

# THE TIME SERIES EXTRAPOLATION MODEL BASED ON MAXIMUM LIKENESS SET

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## **Abstract**

In paper the time series extrapolation model based on maximum likeness set is described. Research of the model efficiency has been implemented on economic time series. Results of extrapolation let conclude the high efficiency of the model based on maximum likeness set for extrapolation such time series as nature gas futures prices on NYMEX (accuracy is 2.36%); day-ahead prices for the Russian Wholesale Electricity Market (accuracy is 7.00%); currency pair GBP/USD on FOREX (accuracy is 0.64%).

## **1. Introduction**

A time series forecast task is the basis for 1) planning in economics and trading, 2) manufacturing planning, 3) storehouse control, 4) control and optimization of industrial processes etc. Information system progress brings considerable development of extrapolation models. In the paper a new time series extrapolation model based on maximum likeness set (EMMLS) is offered.

## **2. The extrapolation model description**

In the research we deal with discrete time series values which are obtained in moments  $t_1, t_2, t_3, \dots, t_N$ . The time moments can be non-equidistant. Denote the time series  $Z = z(t_1), z(t_2), z(t_3), \dots, z(t_N)$  with  $Z_1^N = z_1, z_2, z_3, \dots, z_N$ . The

collection of consecutive values  $Z_t^M = z_t, z_{t+1}, z_{t+2}, \dots, z_{t+M-1}$  which is located inside time series  $Z_1^N$  we name *set* length  $M$  and start time  $t$ ,  $M \in [1, N-1]$ ,  $t \in [1, N-M]$ . The time difference between start time  $Z_t^M$  and  $Z_{t-k}^M$  is named *delay*  $k$ ,  $k \in [1, t-1]$ .

Based on literature [1] we introduce *likeness measure* for sets  $Z_t^M$  and  $Z_{t-k}^M$

$$\rho_k^M = \frac{|\text{cov}(Z_t^M, Z_{t-k}^M)|}{\sqrt{D[Z_t^M]} \cdot \sqrt{D[Z_{t-k}^M]}} \in [0,1]. \quad (1)$$

Value  $\rho_k^M$  depends on the set length  $M$  and the delay between  $Z_t^M$  and  $Z_{t-k}^M$ . The likeness measure  $\rho_k^M$  reflects the level of a linear dependence: the closer  $\rho_k^M$  to 1 the higher the linear dependence is.

Calculate for set  $Z_t^M$  values  $\rho_1^M, \rho_2^M, \dots, \rho_{t-1}^M$  and find maximum  $\rho_{k \max}^M = \max(\rho_1^M, \rho_2^M, \dots, \rho_{t-1}^M)$ . The set which corresponds to delay  $k_{\max}$  we denote  $Z_{t-k \max}^M$  and name *maximum likeness set* for  $Z_t^M$ .

*Likeness hypothesis.* If sets  $Z_t^M$  and  $Z_{t-k \max}^M$  have  $\rho_{k \max}^M$  value close to 1, then for some  $P$  and sets  $Z_t^{M+P}$  and  $Z_{t-k \max}^{M+P}$  value  $\rho_{k \max}^{M+P}$  will be also close to 1.

Switch to vector designation and denote set  $\mathbf{Z}_t^M = (z_t, z_{t+1}, \dots, z_{t+M-1})^T$ . Set  $\mathbf{Z}_t^M$  can be approximated using set  $\mathbf{Z}_{t-k \max}^M$  as follows:

$$\check{\mathbf{Z}}_t^M = a_1 \cdot \check{\mathbf{Z}}_{t-k \max}^M + a_0. \quad (2)$$

Here  $\check{Z}_t^M$  are the model values for  $Z_t^M$ . Then set  $Z_{N+1}^P$  which we have to forecast can be expressed using some set  $Z_\tau^P$ , which is located inside the original time series  $Z_1^N$  as follows

$$\check{Z}_{N+1}^P = a_1 \cdot Z_\tau^P + a_0. \quad (4)$$

The algorithm for defining set  $Z_\tau^P$  is described in article [2].

### 3. Results

The model validation has been obtained using mean absolute percentage error (MAPE).

Time series	Extrapolation period		Resolution	Forecast time, P	MAPE
	From	To			
Nature gas futures prices on NYMEX (www.nymex.com)	01.10.2008	01.05.2009	Hourly	24	2.36%
Electricity prices on the Russian Wholesale Electricity Market (www.atsenergo.ru)	01.03.2009	30.09.2009	Hourly	24	7.00%
Currency pair GBP/USD on FOREX (www.forex.com)	03.11.2008	06.11.2009	Hourly	24	0.64%

### References

1. *Draper N. R., Smith H.* Applied regression analysis. – New York: Wiley, In press, 1981.
2. *Чуцужева И.* Модель экстраполяции по максимуму подобия для временных рядов цен и объемов на рынке на сутки вперед оптового рынка электроэнергии и мощности. – М: Наука и образование, 2010, (<http://technomag.edu.ru/doc/135870.html>).