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IDENTIFICATION COHERENT REAL ESTATE MARKET PHASE BASED ON FUZZY MODEL

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On the basis of consideration for the real estate market in Ukraine coherent market hypothesis, which assumes the market stay in one of four defined phases (random walk , unstable transition, chaotic market, coherence), a method for identifying the corresponding phase based on fuzzy model is given. To this end, the peculiarities of qualitative and quantitative phases of the real estate market are determined. The proposed method is based on the use of fuzzy model. The process of building a fuzzy model consists of four stages. The algorithm of variables of fuzzy model is given. The use with specification of economic substance is grounded. It's described the procedures and phasing of construction of fuzzy inference rules. The criterion of evaluating the accuracy of the model (such as MAPE) is used. To implement the model identification of the real estate market uses application programming package Matlab. Verification fuzzy model held a number of speakers for the data yield average property prices in Kyiv for the period from 1 January 1991 to 31 December 2012, an analysis which takes into account changes occurring in the market. Based on the comparison results of fuzzy model with the results of expert evaluation found error model, which is 5.2% and confirms its reasonable adequacy. The application of the constructed model to determine the state of the real estate market on the basis of coherent market hypothesis based on fuzzy simulation allow for a qualitative analysis of the current situation in the real estate market, to estimate the probability of transition property market in the next phase, to provide guidance on price forecasting in the presence in one or another phase. After the identification phase of the real estate market raises the question of the application of relevant tools for forecasting.

Key words: real estate market, the dynamics of prices, the hypothesis of coherent market, fuzzy modeling.

Шаповалова В.О., Максишко Н.К. ІДЕНТИФІКАЦІЯ ФАЗИ КОГЕРЕНТНОГО РИНКУ НЕРУХОМОСТІ НА БАЗІ НЕЧІТКОЇ МОДЕЛІ / *Запорізький національний університет, Україна*

На базі врахування для ринку нерухомості України гіпотези когерентного ринку, яка припускає перебування ринку в одній з чотирьох визначених фаз (випадкового блукання, нестійкого переходу, хаотичного ринку, когерентності), розроблено метод ідентифікації відповідної фази на основі нечіткої моделі. З цією метою визначено особливості якісних та кількісних характеристик фаз ринку нерухомості. Запропонований метод базується на використанні нечіткої моделі. Процес побудови нечіткої моделі складається з чотирьох етапів. Описано алгоритм визначення змінних нечіткої моделі. Обґрунтовано їх використання на основі уточнення економічного змісту. Описано процедуру фазифікації та побудову правил нечіткого виводу. Визначено критерій оцінки точності моделі (типу MAPE). Для реалізації моделі ідентифікації стану ринку нерухомості використано прикладний програмний пакет Matlab. Верифікація нечіткої моделі проведена для даних ряду динаміки дохідності середньої ціни на нерухомість у м. Києві за період з 01 січня 1991 року по 31 грудня 2012 року, аналіз якого дозволяє враховувати зміни, що відбуваються на ринку нерухомості. На основі порівняння результатів нечіткої моделі з результатами експертного оцінювання виявлено похибку моделі, що становить 5,2% та підтверджує її прийнятну адекватність. Застосування побудованої моделі з метою визначення стану ринку нерухомості з урахуванням гіпотези когерентного ринку на основі апарату нечіткого моделювання дозволить провести якісний аналіз поточної ситуації на ринку нерухомого майна, оцінити ймовірність переходу ринку нерухомості в наступні фази, надати рекомендації щодо прогнозування ціни під час знаходження в тій чи іншій фазі. Після ідентифікації фази ринку нерухомості є змога вирішення проблеми застосування релевантного інструментарію прогнозування.

Ключові слова: ринок нерухомості, динаміка ціни, гіпотеза когерентного ринку, нечітке моделювання.

Шаповалова В.А., Максишко Н.К. ИДЕНТИФИКАЦИЯ ФАЗЫ КОГЕРЕНТНОГО РЫНКА НЕДВИЖИМОСТИ НА БАЗЕ НЕЧЕТКОЙ МОДЕЛИ / *Запорожский национальный университет, Украина*

На базе гипотезы когерентного рынка для рынка недвижимости Украины, которая предполагает пребывания рынке в одной из четырех определенных фаз (случайного блуждания, неустойчивого перехода, хаотичного рынка, когерентности), разработан метод идентификации соответствующей фазы на основе нечеткой модели. С этой целью определены особенности качественных и количественных характеристик фаз рынка недвижимости. Предложенный метод основан на использовании нечеткой модели. Процесс построения нечеткой модели состоит из четырех этапов. Описан алгоритм определения переменных нечеткой модели. Обосновано их использование на основе уточнения экономического содержания. Описана процедура фаззификации и построение правил нечеткого вывода. Определен критерий оценки точности модели (типа MAPE). Для реализации модели идентификации состояния рынка недвижимости использовано прикладной программный пакет Matlab. Верификация нечеткой модели проведена для данных ряда динамики доходности средней цены на недвижимость в Киеве за период с 1 января 1991 по 31 декабря 2012 года, анализ которого позволяет учитывать изменения, происходящие на рынке недвижимости. На основе сравнения результатов нечеткой модели с результатами экспертной оценки выявлено погрешность модели, составляет 5,2% и подтверждает ее приемлемую адекватность. Применение построенной модели с целью определения состояния рынка недвижимости на основе гипотезы когерентного рынка на основе аппарата нечеткого моделирования позволит провести качественный анализ текущей ситуации на рынке недвижимого имущества, оценить вероятность перехода рынка недвижимости в последующие фази, дать рекомендации по прогнозированию цены во время нахождения в той или другой фазе. После идентификации фазы рынка недвижимости становится возможным решение проблемы применения релевантного инструментария прогнозирования.

Ключевые слова: рынок недвижимости, динамика цены, гипотеза когерентного рынка, нечеткое моделирование.

STATEMENT OF THE PROBLEM

While making management decisions in real estate, as well as within any financial market, it is necessary to bear in mind that, despite the use of existing analytical and expert techniques, the final decision is made under uncertainty. Largely decisions on real estate market based on forecasts real estate prices. Some of the real estate market factors can be determined almost exactly, but others – only with some degree of certainty. In addition, it is known [1] that coherent market hypothesis is fair for real estate market, which involves the use of complex tools for forecasting price dynamics. The system of methods and models for forecasting should be used only after phase identification (random walk, unstable transition, chaotic market, coherence). For this reason, in our opinion, for the evaluation phase of the real estate

market on the basis of the hypothesis of coherent market, it is advisable to use the tools of fuzzy modeling.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

In [2] the author of a concept for price forecasting of real property based on a hybrid approach that integrates the tools of discrete nonlinear dynamics and cognitive modeling. This concept makes it possible to increase the economic efficiency of the real estate market in the preparation and management decisions. However, the study indicated that taking any decisions on the real estate market, including the definition phase of the real estate market, is under uncertainty. Therefore, the analysis of the real estate market application of classical statistical apparatus is inefficient [3]. An alternative may be the instrument of fuzzy modeling, founded by analysis of economic systems is such scholars as Zadeh, Dubois, Prado, Kofman. Improving methods of decision-making in the economy based on the methods of fuzzy sets carry A. Matviichuk [4], A. Nedosekin [5], S. Orlovsky, S. Shtovba. Currently it's missing studies that have dealt with the use of fuzzy modeling methodology for the real estate market.

THE PURPOSE OF THIS ARTICLE

The purpose of this article is to develop a method of diagnosis (identification) real estate market based on the coherent market hypothesis using fuzzy modeling techniques. The object is market analysis of changes over time in this study are time series (TS) rates of property prices $RP = \langle rp_{t,}\, t = \overline{1,n} \rangle$ [6]. To analyze the dynamics of the real estate market we will consider it to be a system comprising a plurality of investors. However, it is well known [7], the real estate market consists of individual investors with different horizons of decision making.

The research [1] found that the real estate market Ukraine satisfies the hypothesis of coherent market [8]. The basic assumption of this theory, which combines non-linear deterministic model (fractal market hypothesis) and statistical dynamic model is that the probability distribution of market changes over time based on the fundamental (or economic) environmental conditions and certain attitudes (or "group consciousness") market. Therefore, the combination of these factors turns out to change the shape of the probability density function.

According to the hypothesis of coherent market real estate market may be in one of four phases $q \in Q = \{1,2,3,4\}$, membership of which makes it possible to present it as the set of segments: RP= $\bigcup_{i=1}^{K} RP_i^q = \bigcup_{i=1}^{K} (a_i, b_i)^q$, where i – interval number, a_i – the beginning of the interval, b_i – the end of the interval, thus, K – number of intervals. Compliance (in terms of coherent market hypothesis) segments phase the real estate market means having the character of this phase. We consider the set Q phases of real estate market as a full event space $T = \{Eq\}$, where E_1 – phase random walk, E_2 – unstable phase transition, E_3 – phase chaotic market, E_4 – phase coherence. Consider them more:

1) random walk phase corresponds to the situation when individual investors make decisions under the influence of some random factors regardless of the other investors, that there is no collective decision. This may occur during recession processes, in particular after the acute recession;

2) phase transition corresponds to an unstable situation, when deciding gradually begins to form (or break down) public is expected to rational thought;

3) during the chaotic phase (or fractal) market oriented investor sentiment group found that match their preferences regarding investment horizon;

4) in the coherence phase there is a combination of group awareness and a strong manifestation of the fundamental factors causing the observed significant change of trend of price changes.

Problem identification of the real estate market at the time is set, which belongs to the segment level time series. Given the high level of uncertainty in the market price dynamics, as evidenced by its properties such as nonlinearity, nestatsionarnist and others [2] develop a method for identification of the real estate market on the basis of building a fuzzy model. The process of constructing the model has the following four stages:

Step 1. Definition of the variables of the model. A result of analysis of the dynamics of return rates (*TS RP)-based* statistical and fractal analysis of complex get a set of statistical characteristics as well as the indicator Hurst *H* and fuzzy memory depth time series [9]. Variables or as partial criteria model identification phase of the market determine the following parameters: coefficient of asymmetry of the levels distribution of TS *(A),* Hurst index *(H),* maximum depth memory TS (l_{max}) and the rate of information entropy fuzzy set memory depth of TS (H_{entrop_L}). Let's consider the contents of the selected features.

The economic meaning *of the coefficient asymmetry (A)* in this context is as follows. If the ratio has a positive value, the higher values yield property prices (the right "tail") are more likely than low. With the approach of the asymmetry zero real estate market is moving into a phase of random walk. With an increase in the absolute value of the asymmetry phenomenon of coherence increases.

Hurst index (H) – a quantitative description of the time series, on which to conclude its stability (reversal or frequent return to the mean). The closer the absolute value of the Hurst parameter to unity is the phenomenon of enhanced coherence. Approaching Hurst parameter to a value of "0.5" indicates the random walk phase. Calculation of Hurst is for time series *RP* – yields price sensitivity because this series is higher than the absolute number.

Maximum memory depth (l_{max}) of fuzzy sets memory depth is a quantitative measure that characterizes the degree of stability and predictability of the TS *RP* dynamics on real estate prices.

Index of information entropy (H_{entrop_L}) fuzzy set memory depth reflects the level of uncertainty about information concerning the direction and speed of the return.

To reflect changes in the market situation, these indicators will be determined by analyzing the so-called "pre-window", which has a width and ends on TS level (similar to the principles of [10]), choose one that is 30 (*k* = 30). This term is two and a half years, that is a time period within which might occur structural changes of price changes. In figure 1 shows a graphical representation of the TS of average real estate prices in Kyiv, Hurst and asimmetry TS with previous window (for the period from 01.1991 to 12.2012) in accordance with the allocation phase coherent market hypothesis by an expert [11].

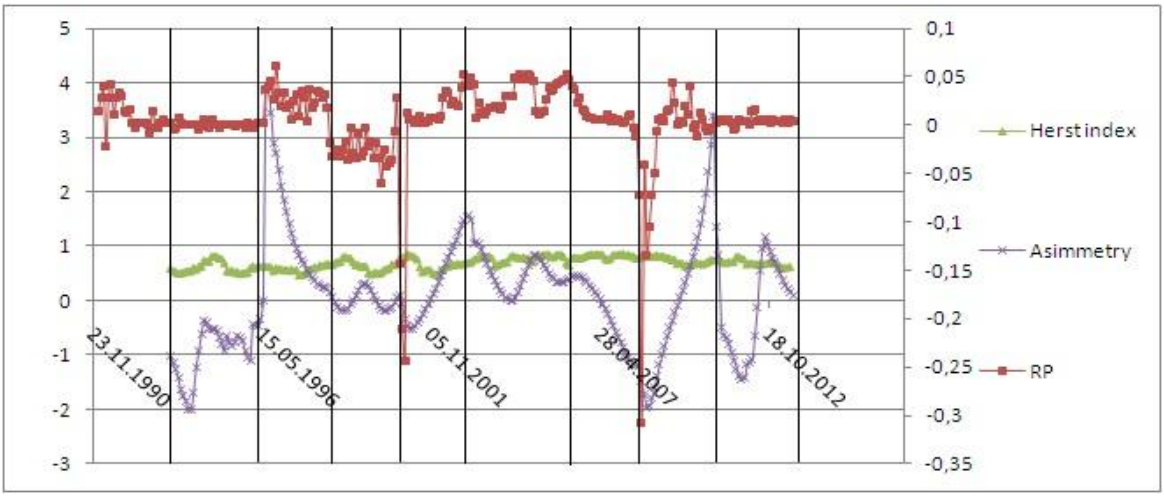


Fig. 1. Graphical representation of the original TS of average real estate prices in Kyiv, Hurst and asymmetry TS with previous window *k* = 30 for the period from 01.1991 to 12.2012 in accordance with the allocation phase coherent market hypothesis

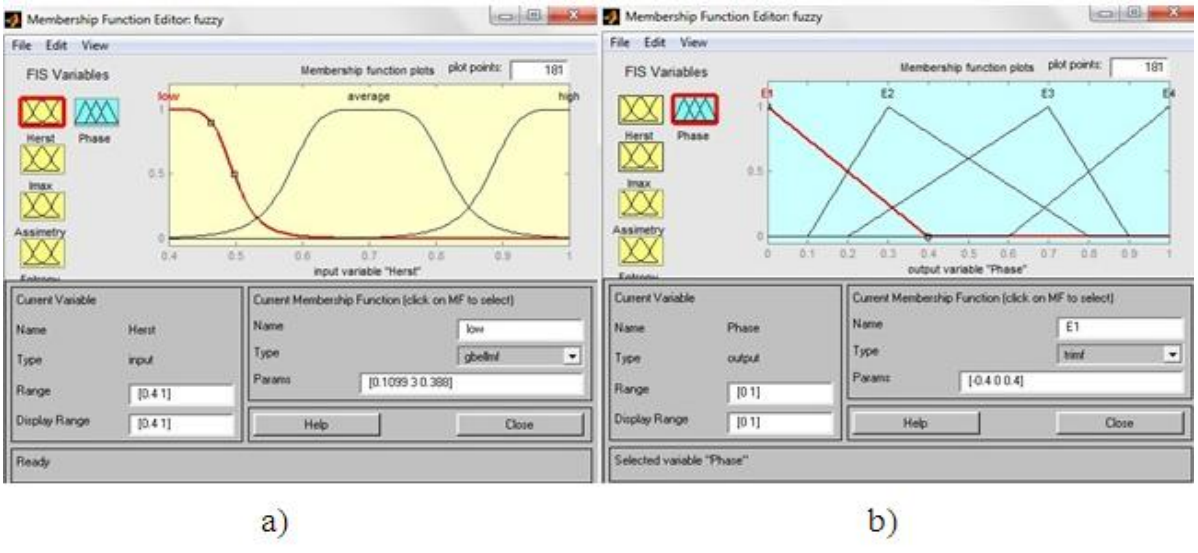
Step 2. Definition of linguistic variables (partial criteria) based on histogram segments time series {(a_i, b_i)} and expert analysis.

For each parameter defined range of possible values and sub-ranges for which it can be divided. We set parameters as fuzzy variables defined name and domain of definition (description of restrictions is presented in Table 1).

Table 1 – Definition of linguistic variables model

Indicator	Time-series dynamics of real estate prices	The range of values	Linguistic value of the index
Asymmetry coefficient *A*	local variability that characterizes the tendency of the time series of significant changes to the values in a small neighborhood of the time	(- 2, 2)	Is low
		(-3, 2] ∪ [2, 3)	Average
		(- ∞; 3] ∪ [3; ∞)	The high is
Hurst index *H*	inertia that characterizes the dynamics of a tendency to move in the direction of the trend	[0.45, 0.6)	Low
		[0.6, 0.85)	Average
		[0.85, 1]	High
Maximum depth memory time series l_{max}	local resistance that characterizes the ability to preserve the values of the time series with limited neighborhood for some (limited) time intervals	[0, 4)	Low
		[4, 7)	Average
		[7, 10]	High
Index of information entropy fuzzy set memory depth H_{entrop_L}	uncertainty that characterizes the dynamics on the predictability	[0, 2.5)	Low
		[2,5, 4)	Average
		[4, 5]	High

Another difficult task is to determine the type of membership functions for each variable. The four input variables (asymmetry coefficient *A*, Hurst parameter *H*, the maximum memory depth time series l_{max}, entropy of TS H_{entrop_L}) was chosen hauss membership functions that represent smoothed term – the scale of values {Low, Medium, High}. For the scale of output variable belonging to one of the four coherent market phases on the basis of expert assessments interval was chosen function of triangular form [12]. The results of determining the normal membership function for Hurst parameter and interface real estate market shown in Fig. 2 as a visualization obtained by application software package Matlab.



a) b)

Fig. 2. Visual representation of fuzzy membership functions a) input variable – Hurst parameter *H;* b) output variable – phase of the real estate market E_q

Step 3. Constructing fuzzy model identification of the real estate market by Mamdani type.

We consider the set of phases estate market as a full event space}, where E_1 – random walk phase, E_2 – unstable transition phase, E_3 –chaotic market phase, E_4 – coherence phase. To define specific phases we will use linguistic variable *"degree of belonging to phase"*, for which we introduce the notation:

$$ADV(rp_t) = \left\{ \quad (E_q,\ \mu_q(rp_t)), \quad q = \overline{1,4} \quad \right\} \tag{1}$$

where E_q – linguistic variable;

T – term-set, *T = {random walk, unstable transition, chaotic market, coherence}.*

For values of linguistic variable that should be the basis for determining the phase of the real estate market, we apply compositional rule proposed L. Zade which formalizes fuzzy output on unclear assumptions (values of parameters: the asymmetry coefficient *A*, Hurst coefficient *H*, maximum depth memory time series l_{max}, index information entropy fuzzy set memory depth H_{entrop_L}) and opinion $ADV(rp_t)$. For its application develop the knowledge base in the form of inference rules for future use, in particular, in our case Mamdani algorithm. Rules of the values of the linguistic variable "degree of belonging to phase E_q" are presented in Table 2.

Table 2 – Rules of the values of linguistic variable $ADV(rp_t)$ – "The level of belonging to phase E_q"

Number	Linguistic values of				Linguistic variable "The level of belonging to phase E_q"
	Asymmetry coefficient *A*	Hurst index *H*	Maximum depth memory time series l_{max}	Index of information entropy fuzzy set memory depth H_{entrop_L}	
1	High	High	High	High	Coherence
2	Low	Low	Low	Low	Random walk
3	Average	Average	Average	Average	Chaotic Market
4	High	Average	High	High	Coherence
5	High	High	Average	High	Coherence
6	High	High	High	Average	Coherence
7	Average	High	High	High	Coherence
8	Average	Low	Average	Average	Chaotic Market
9	Average	Average	Low	Average	Chaotic Market
10	Average	Average	Average	Low	Chaotic Market
11	Low	Average	Average	Average	Chaotic Market
12	Average	High	Average	Average	Chaotic Market
13	Average	Average	High	Average	Chaotic Market
14	Average	Average	Average	High	Chaotic Market
15	High	Average	Average	Average	Chaotic Market
16	High	Average	High	High	Coherence
17	High	High	Average	High	Coherence
18	High	High	High	Average	Coherence
19	Average	High	High	High	Coherence
20	Low	Average	Low	Average	Unstable transition
21	Average	Low	Average	Low	Unstable transition
22	Low	Low	Average	Average	Unstable transition
23	Average	Average	Low	Low	Unstable transition
24	Low	High	Low	High	Unstable transition
25	High	Low	High	Low	Unstable transition
26	Low	Low	High	High	Unstable transition
27	High	High	Low	Low	Unstable transition

The visual representation of the surface of linguistic variables – "The level of belonging to phase E_q" obtained by application software package Matlab (Fig. 3).

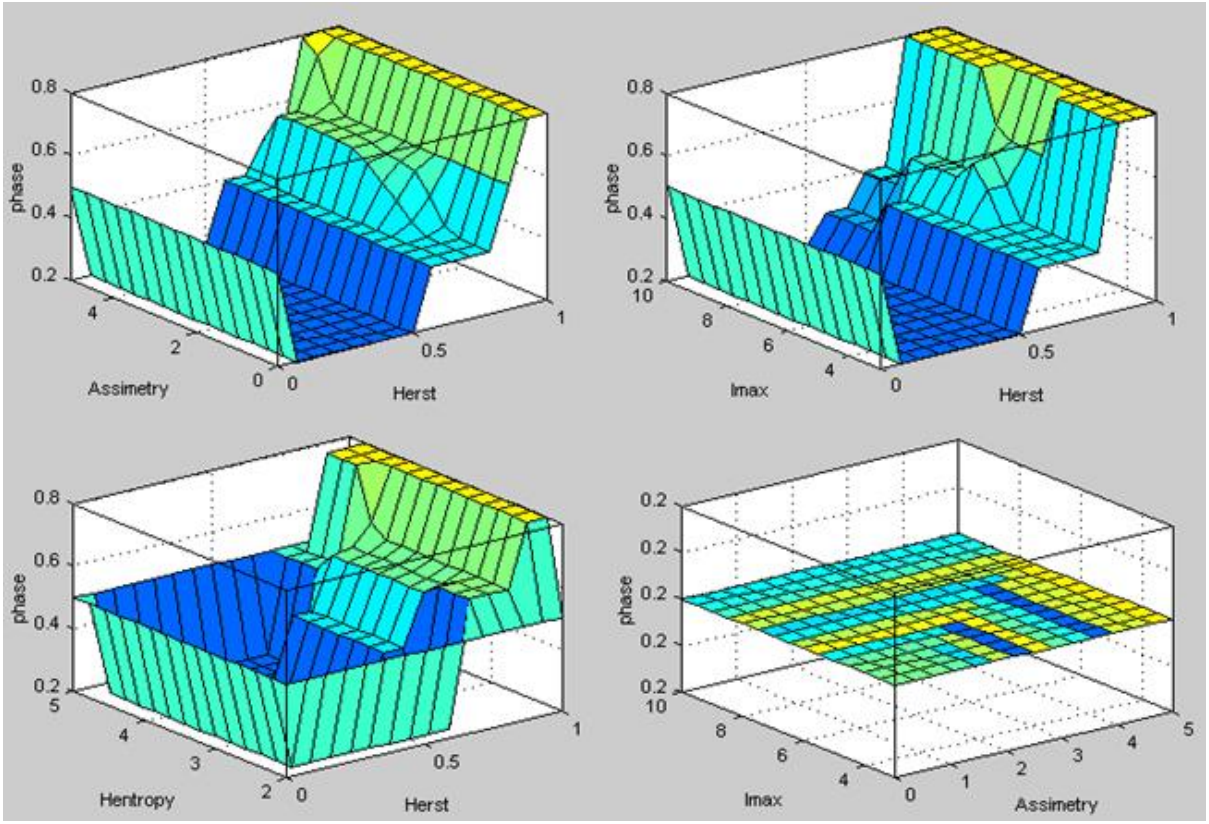


Fig. 3. The visual representation of the surface values of linguistic variable "level belonging to phase $E_{q»}$ where the coordinates are: a) Hurst index, the coefficient of asymmetry, phase market; b) Hurst index, the maximum memory the TS phase market; c) information entropy index, Hurst parameter, phase market; d) the asymmetry factor, the maximum memory the TS phase of the market

Step 4. Evaluation of a model.

We introduce criteria for evaluating the quality of the model. For this we consider the cases that may occur as a result of construction of the model:

1) the length of the interval phase derived from expert evaluation, is less than the result of building a fuzzy model.

Thus $a_i > a_i^{'}$ *and* $b_i < b_i^{'}$, where a_i – the lower limit of the interval derived from peer reviews; $a_i^{'}$ – the lower limit of the interval derived from the construction of the fuzzy model; b_i – the upper limit of the interval derived from peer reviews; $b_i^{'}$ – the upper limit of the interval derived from building a fuzzy model.

2) the length of the interval phase derived from expert assessment is greater than the result of model building. Thus $a_i < a_i^{'}$ *and* $b_i < b_i^{'}$.

3) the length of the interval phase derived from expert evaluation, is approximately equal to the length of the interval that results from model building. Thus $a_i > a_i^{'}$ *and* $b_i > b_i^{'}$.

4) the length of the interval phase derived from expert evaluation, is approximately equal to the length of the interval that results from model building. Thus $a_i < a_i^{'}$ *and* $b_i > b_i^{'}$.

The error of the constructed fuzzy model, we estimate the following formula:

$$\text{MAPE} = \frac{100}{K} \left(\sum_{i=1}^{K} \frac{a_i - a_i^{'}}{a_i} + \sum_{i=1}^{K} \frac{b_i - b_i^{'}}{b_i}\right)$$

As a result of the proposed model to the real estate price TS in Kyiv for the period from 01.1991 to 12.2012 returned error value MAPE = 5,2%.

CONCLUSIONS

Thus, a study was based fuzzy diagnostic model (identification) real estate market based on the hypothesis of coherent market, which revealed verification of sufficient adequacy compared with the results of expert evaluation. The application of the constructed model to determine the state of the real estate market on the basis of coherent market hypothesis based on fuzzy simulation allow for a qualitative analysis of the current situation in the real estate market, to estimate the probability of transition property market in the next phase, to provide guidance on price forecasting in the presence in one or another phase. Upon identification phase of the real estate market question the use of relevant tools prediction [11]. Thus, for phase random walk and an unstable transition it's suitable to use statistical techniques short-term forecasting, including extrapolation, for phase coherence and chaotic market we must use prediction methodology based on discrete models and methods of nonlinear dynamics.

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