Mass appraisal of real estate and fuzzy numbers in Belarus

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Mass appraisal in Belarus used mostly for taxes

Purpose of the research is with a help of existing examples (Belarusian experience of mass valuation) to find a disadvantages of traditional approaches in mass appraisal and consider a possibilities to use fuzzy system in mass appraisal. We come to the conclusion on the existing stage of development fuzzy system that we should combine traditional statistic approaches (for example multyregression techniques) with fuzzy logic and neural system. We can use fuzzy in individual valuation or in mass appraisal if the valuation of factors is making at time, when their future estimation is labored (has not a sufficient probabilistic bases). We also should develop fuzzy approaches and methods and first of all computers fuzzy technologies. It is necessary to develop big the program "of fuzzy researches directed on achievement by valuation and real estate economy sphere of a qualitatively new level of self-consciousness". These questions can be solved, if it is created and within 2-3 years minimally financed working group of the researchers in area Fuzzy Sets and Control.

It was completed cadastral valuation of the lands of 208 cities and towns, 24,000 villages, 5,000 garden companies, and industry, transport.
• The Main methodological principle of the methods cadastral valuation of the town lands - an approximation of market value.
Briefly technology cadastral estimations of the lands of the

- The Stage 1. Shaping the thematic layers to source information in format ArcView GIS.
- The Stage 2. Merit zoning.
- The Stage 3. The Determination of market value test land area.
- The Stage 4. The Determination of the base cost of the lands.
- The Stage 5. The Determination cadastr cost of the merit zones and land area.
- The Stage 6. The Registration to merit documentation. Expert operation and statement to merit documentation
Conclusions of 1st part

• Technology of cadastral valuation of the town lands in Republic Belarus provides broad using GIS-technology, facilities of the statistical analysis data and mathematical device that allows:
Research purpose of flat mass appraisal
Jointly with Sergio Coppiello (Italy)

- Purpose of the research was to provide the first attempt of mass appraisal of housing prices in emerging market of transition economies.
Analysis model

- Mass appraisal
  - Exploration
    - Factor analysis
  - Cluster analysis
  - Explanation
    - Regression models
Mass appraisal models

- The models for mass appraisal are the two following:

  \[ P = \alpha + \beta_j \cdot X_j + \varepsilon \]  
  \[ P' = \alpha + \beta_j \cdot X_j + \varepsilon \]

- where \( P \) represent total house prices, \( P' \) house prices per square meter, \( X_j \) the vector of housing characteristics, and \( \varepsilon \) a residual process.
Mass appraisal models

- In statistical terms [4] and [5] are linear models, which can be handled with standard regression techniques, namely least squares estimators and test of significance based on t-statistics.
- Models are tested both on original variables and on normalized variables [6], in order to highlight their relative importance:
  
  \[ X_{ij} = 2 \cdot \frac{(X_{ij} - X'_j)}{(X_{\text{max}j} - X_{\text{min}j})} \]  
  \[ X'_i = \frac{(X_{\text{max}j} + X_{\text{min}j})}{2} \]
Empirical evidences:
total price model

- The model results for total price of house are:
  
  \[
P = -13.583 + 665 \times X_3 + 1.056 \times X_5 + 1.764 \times X_8 + 31 \times X_9 + 3.239 \times X_{11} + \\
  (16,06) \quad (79,87) \quad (13,83) \quad (6,96) \quad (2,89) \quad (11,30)
\]

  \[
  + 2.228 \times X_{14} - 1.272 \times X_{16} + 10.365 \times X_{17} - 983 \times X_{23} + 4.522 \times X_{24} + \\
  (4,42) \quad (3,40) \quad (8,12) \quad (3,02) \quad (12,66)
\]

  where in parenthesis are t statistics, \( R^2 0,79 \).
### Variables of analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th></th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P$</td>
<td>supply price ($)</td>
<td>$X_{13}$</td>
</tr>
<tr>
<td>$P'$</td>
<td>supply price ($ per square meter)</td>
<td>$X_{14}$</td>
</tr>
<tr>
<td>$X_1$</td>
<td>number of rooms</td>
<td>$X_{15}$</td>
</tr>
<tr>
<td>$X_2$</td>
<td>Neighborhood</td>
<td>$X_{16}$</td>
</tr>
<tr>
<td>$X_3$</td>
<td>total square meters of flat</td>
<td>$X_{17}$</td>
</tr>
<tr>
<td>$X_4$</td>
<td>square meters of the living part</td>
<td>$X_{18}$</td>
</tr>
<tr>
<td>$X_5$</td>
<td>square meters of kitchen</td>
<td>$X_{19}$</td>
</tr>
<tr>
<td>$X_6$</td>
<td>number of floor of flat</td>
<td>$X_{20}$</td>
</tr>
<tr>
<td>$X_7$</td>
<td>number of floors of building</td>
<td>$X_{21}$</td>
</tr>
<tr>
<td>$X_8$</td>
<td>flat not at first or last floor</td>
<td>$X_{22}$</td>
</tr>
<tr>
<td>$X_9$</td>
<td>age of the building in year</td>
<td>$X_{23}$</td>
</tr>
<tr>
<td>$X_{10}$</td>
<td>prefabricated building</td>
<td>$X_{24}$</td>
</tr>
<tr>
<td>$X_{11}$</td>
<td>brick building</td>
<td>$X_{25}$</td>
</tr>
<tr>
<td>$X_{12}$</td>
<td>cement building</td>
<td>$X_{26}$</td>
</tr>
</tbody>
</table>
Correctness of valuation

- the model can not be ideal, since it is based not on 100% market information: incorrect deals, bad database brings about that in 9 events model gives close to ideal results, but in tenth - surge. Particularly this often occurs on unique object.
Reasons of inaccuracy of the valuation

• 1. Analysis market and collection of data is conducted on the first stage.
• The problem - correctness of the price for each transaction
• Database is formed on the second stage.
• At this stage, inaccuracy appears at a rate of formalizations. For example, the factor wall building is assigned as panel, block, brick, wood and multifunction wall.
• But types of wall can be combined and type of brick can differ between itself.
• The Third stage - a choice of the type of models, making the corrections for importances of factors, forming additional variable and, finally, creation the models. Inaccuracy here appears in consequence of any inexact step. The Main type to inaccuracy here remains inaccuracy of the process of modeling, connected with inadequate reflection of the real situation by structure to models mortgaged in it internal relationship factor.
• In the step of calibrations appears the last type of inaccuracy connected with choice of the vector of initial importances for iterative methods, with number by cast-off filter data, finally, with number of iterations.

• In the course of mass valuation of flats it was found out inaccuracy about 4 %. From the words of mass valuation specialists inaccuracy is available up 5-10 %.

• Lets look the result of such mistake (inaccuracy) on example of the following valuation
Cadastral value can be defined: normative method; expert method

- \( VL = PV + (I - E) : R \) (*)
- \( PV \) - payments for granting the right of the rent land area; \( I \) - annual income from rent of land area; \( E \) - annual expenses connected with rent of the area; \( R \) – rate of capitalization for land.
<table>
<thead>
<tr>
<th>Parameters of calculation per year</th>
<th>5 year</th>
<th>4 year</th>
<th>3 year</th>
<th>2 year</th>
<th>1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>rate of the discounts- Kd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17.0%</td>
</tr>
<tr>
<td>Real rate of growth of the income on years- G</td>
<td>39.7%</td>
<td>16.6%</td>
<td>10.1%</td>
<td>7.1%</td>
<td></td>
</tr>
<tr>
<td>Difference between rate of the discounts and rate of growth on year - (Kd - G)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.9%</td>
</tr>
<tr>
<td>Capitalized income- D₀ (млн.руб.)</td>
<td>4.8</td>
<td>6.7</td>
<td>7.8</td>
<td>8.6</td>
<td>9.2</td>
</tr>
<tr>
<td>Total value Ск = D₀ / (Kd - G) (млн.руб.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93.5</td>
</tr>
</tbody>
</table>
On the graph you can see that change the rate of the discounts or rate of growth on 1% changes importance of the cost of the valued object on 8-20%. Thereby, mistake in value of the rate of the discounts in amount more than two percents brings about appearance of the mistake in the price of the estimation in 16-40%.
Not good statistical explanation

Average price of 1 sq.m. dwelling of Minsk ($)

\[ y = -0.0113x^6 + 0.5029x^5 - 8.5284x^4 + 70.938x^3 - 314.44x^2 + 749.15x - 401.32 \]

\[ R^2 = 0.9923 \]
Tendency of growth

USD per square meters

Euro per square meters


Minsk (constant price) Milan (constant prices)
• For "Management of uncertainty is an intrinsically important issue in the design of ... systems because much of the information in the knowledge base ... is imprecise, incomplete or not totally reliable" (Zadeh, 1983).
Literature research. What kind of fuzzy is available?

• From "Fuzzy Sets" in 1965 to Perception-Based Theory... " (Zadeh, 2000).


• Deep roots of 'fuzzy' logic can be found in R.Hodges(2000)
• Fuzzy mathematics, cognitive and decision process were being developed by Kaufmann (1975), Zadeh, Fu, Tanaka, Shimura (1975), Neogita and Ralescu, (1975).
• D. Dubois and H. Prade, 1980
Very simple to use

valuation cost =

\[(9,2,10,11)/(0,14;0,15;0,16).\]

*With a help of \(\alpha\)-cuts*

\[D = \frac{[9,2+0,8a,11-1a]}{[0,14+0,01a,0,16-0,01a]} = \frac{[(9,2+0,8a)/(0,16-0,01a),(11-1a)/(0,14+0,01a)]}.\]
It is evident that the property cost is not lower $57500 and not above $78571.

With 100% certainty, we can state that the cost of the estimated property is $66 666.

<table>
<thead>
<tr>
<th>A</th>
<th>9,2+0,8a</th>
<th>11-1a</th>
<th>0,14+0,01a</th>
<th>0,16-0,01a</th>
<th>14+2a/130-14a</th>
<th>20-4a/100+16a</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>9,2</td>
<td>11</td>
<td>0,14</td>
<td>0,16</td>
<td>57,5</td>
<td>78,5714</td>
</tr>
<tr>
<td>0,1</td>
<td>9,28</td>
<td>10,9</td>
<td>0,141</td>
<td>0,159</td>
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<tr>
<td>0,2</td>
<td>9,36</td>
<td>10,8</td>
<td>0,142</td>
<td>0,158</td>
<td>59,24051</td>
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<td>0,3</td>
<td>9,44</td>
<td>10,7</td>
<td>0,143</td>
<td>0,157</td>
<td>60,12739</td>
<td>74,8252</td>
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<tr>
<td>0,4</td>
<td>9,52</td>
<td>10,6</td>
<td>0,144</td>
<td>0,156</td>
<td>61,02564</td>
<td>73,6111</td>
</tr>
<tr>
<td>0,5</td>
<td>9,6</td>
<td>10,5</td>
<td>0,145</td>
<td>0,155</td>
<td>61,93548</td>
<td>72,4138</td>
</tr>
<tr>
<td>0,6</td>
<td>9,68</td>
<td>10,4</td>
<td>0,146</td>
<td>0,154</td>
<td>62,85714</td>
<td>71,2329</td>
</tr>
<tr>
<td>0,7</td>
<td>9,76</td>
<td>10,3</td>
<td>0,147</td>
<td>0,153</td>
<td>63,79085</td>
<td>70,068</td>
</tr>
<tr>
<td>0,8</td>
<td>9,84</td>
<td>10,2</td>
<td>0,148</td>
<td>0,152</td>
<td>64,73684</td>
<td>68,9189</td>
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<tr>
<td>0,9</td>
<td>9,92</td>
<td>10,1</td>
<td>0,149</td>
<td>0,151</td>
<td>65,69536</td>
<td>67,7852</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>0,15</td>
<td>0,15</td>
<td>66,66667</td>
<td>66,6667</td>
</tr>
</tbody>
</table>
Disadvantages of fuzzy system:

• 1. Absence of understanding in mass appraisal specialists.
• 2. Absence of special computer programs available like Excel. The best way out is to integrate fuzzy system in Microsoft Office and Excel.

  • In spite of Zadeh observes "... in its traditional sense, computing involves ...manipulation of numbers and symbols. By contrast, humans employ mostly words in computing and reasoning, arriving at conclusions expressed in words from premises expressed in a natural language or having the form of mental perceptions" (Zadeh, 1996).
For mass appraisal

• On the existing stage of development fuzzy system that we should combine traditional statistic approaches (for example multyregrerssion techniques) with fuzzy logic and neural system.

• Creation of fuzzy expert system is the best way out. (We found understanding such approaches from mass appraisal specialists in Belarus). But we must use fuzzy in individual valuation or in mass appraisal if the valuation of factors is making at time, when their future estimation is labored (has not a sufficient probabilistic bases).

• “Decisions on operational, financial, healthcare, and environmental systems, etc., are complex and data we have to rely on are often imprecise or appear to be unrelated even though we have access to large data bases. We may have access to terabytes or more data stored in data warehouses, but to analyse them efficiently and effectively, we need to use fuzzy data mining and fuzzy system modeling techniques.”. Zadeh, 1996
## Expert’s opinions

<table>
<thead>
<tr>
<th>Experts</th>
<th>Income (V)</th>
<th>Costs (C)</th>
<th>Net income (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(650, 660, 700)</td>
<td>(650, 670, 675)</td>
<td>(-25, -10, 50)</td>
</tr>
<tr>
<td>2</td>
<td>(660, 690, 720)</td>
<td>(640, 660, 670)</td>
<td>(-10, -30, 80)</td>
</tr>
<tr>
<td>3</td>
<td>(600, 640, 660)</td>
<td>(620, 630, 655)</td>
<td>(-55, 10, 40)</td>
</tr>
<tr>
<td>4</td>
<td>(630, 640, 680)</td>
<td>(580, 600, 620)</td>
<td>(10, 40, 100)</td>
</tr>
<tr>
<td>5</td>
<td>(640, 650, 710)</td>
<td>(600, 620, 630)</td>
<td>(10, 30, 110)</td>
</tr>
<tr>
<td>6</td>
<td>(590, 660, 690)</td>
<td>(540, 570, 590)</td>
<td>(0, 90, 150)</td>
</tr>
<tr>
<td>7</td>
<td>(610, 650, 670)</td>
<td>(560, 580, 620)</td>
<td>(-10, 70, 110)</td>
</tr>
<tr>
<td>8</td>
<td>(670, 690, 720)</td>
<td>(600, 640, 650)</td>
<td>(20, 50, 120)</td>
</tr>
<tr>
<td>9</td>
<td>(620, 640, 680)</td>
<td>(570, 600, 620)</td>
<td>(0, 40, 110)</td>
</tr>
<tr>
<td>10</td>
<td>(640, 670, 690)</td>
<td>(600, 620, 630)</td>
<td>(10, 50, 90)</td>
</tr>
</tbody>
</table>
We a help of average fuzzy numbers

• Valuation of I expert

\[ V = \frac{1}{n} \sum_{i=1}^{n} (a_i, b_i, c_i) \]

• With a help of \( \alpha \)-cuts

\[ a_i(\alpha) = \frac{1}{n} \sum_{i=1}^{n} a_i(\alpha) \]

\[ V = \frac{1}{10} \cdot \sum_{i=1}^{n} (6310,6590,6920) = (631,659,692) \]
The most probable income is 40. Than we put the figure in formula * and get exact result. Than we use traditional approaches. Thus we can combine fuzzy and traditional statistic.
Conclusions

Professor Zadeh

In humanistic systems, human reasoning and decision making is not just "measurement" based, as we are taught throughout our academic education, rather "perception" based. "Fuzzy Sets" in 1965 and came to surface toward the beginning of this Millennium in "Toward a Perception-Based Theory... " (Zadeh, 2000).

Conclusion: from the above analysis we can state that the application of fuzzy numbers in the process of property evaluation enables to determine property value with much higher probability (100%) in comparison with the traditional approaches of evaluation according to which the cost valuation precision is up to 10%.

Thus the fuzzy logic applications in valuation area were fewer in comparison to many successes in fuzzy control.
We need to work on further developments of fuzzy theory in particular on fuzzy knowledge representation and reasoning in real estate field. This is more acutely needed in the development of humanistic decision making domains which Professor Zadeh have been urging us to direct our attention over the last thirty five years or so.

We need to create of an fuzzy economy, valuation and management of real estate organization. It is aimed to establish an institute, which accepts fuzzy valuation and economy as a profession, to control and manage the applications in respect of education, rules and standards. It is also aimed to standardize fuzzy valuation, approaches, rules and factors which must be taken care during the fuzzy valuation and management. We also need to provide by methodology and standards valuers and mass appraisal issues and define the role fuzzy valuation in investment decision-making process.

To take off all doubts in efficiency and correctness of use of fuzzy economic and valuation models, it is necessary to develop the big program "of fuzzy researches directed on achievement by valuation and real estate economy sphere of a qualitatively new level of self-consciousness. All these questions can be solved, if it is created and within 2-3 years minimally financed working group of the researchers in area Fuzzy Sets and Control.
• On the base of developed methodologies we can create the intellectual information systems, producing analysis data and production mass and individual valuation and make optimum economic decisions.
Welcome to Belarus

Conferences:

1. International real estate conference
15-17 November 2006, Minsk
For more detail: www.expozona.lt

2. The 2-d International Conference
ECONOMY, VALUATION AND MANAGEMENT OF THE REAL ESTATE AND NATURAL RESOURCES
For more detail: www.bstu.unibel.by
inform@bstu.unibel.by or siniakn@mail.ru

➢ You will have a chance to see some from Belarusian architecture and hospitality of Belarusian people.
Thank you for your attention!


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