USING INPUT-OUTPUT MODEL WITH FUZZY PARAMETERS FOR ANALYSIS OF SECTORAL STRUCTURE OF UKRAINIAN INDUSTRIAL REGION

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Using the input-output model for analysis of sectoral structure of Ukrainian industrial region is considered under conditions of lack of information about the exact values of the input-output coefficients. Coefficients are represented as fuzzy parameters in this model. For this, the classification of coefficients of Donetsk region's input-output matrixes for 2001-2003 is made using cluster analysis; each class is defined as a fuzzy variable with its membership function. Assessment of adequacy input-output model with fuzzy coefficients is implemented for the following cases: (1) analysis of the effect of changes in final demand of basic sectors onto the gross output of sectors in the Donetsk region; (2) analysis of the effect of raising wages in some sectors onto the prices in all region's sectors; (3) analysis of the effect of increasing energy prices onto prices of all other region's sectors.

INTRODUCTION

Analysis and prediction of indicators describing the economy of industrial regions, is important for the Ukrainian economy, which is characterized by a large share of industrial sectors in gross domestic product. A feature of the economic activity of the industrial region is that it includes of a number of related industries, which focus on the production of means of production. Therefore, analysis of sectoral structure and its impact on indicators of the industry is the special interest for the examine of economy of industrial region. Input-output model (I-O models) are the main tool for this analysis. In particular, using a static I-O model permits the assessment of the influence of exogenous factors (for example, market fluctuations, changes in fiscal policy, increasing the prices of products of some sectors and so on) on change of its main indicators. These assessments could be determined based on the classical and on price multipliers by Leontiev.

It is known, that the calculation of the classical multiplier effect is made by the formula:

$$\Delta X = (I - A)^{-1} \Delta Y, \qquad (1)$$

where ΔX – vector of gross output changes for region's sectors;

I – unitary matrix;

A – matrix of input-output coefficients (I-O matrix);

ΔY – vector of final demand changes for region's sectors.

Matrix $\overline{A} = (I - A)^{-1}$ is a classical multiplier by Leontiev. Each element $\overline{a_{ji}}$ of this matrix reflects the degree of gross output change for j-sector, if the final demand is changed for i-sector.

The price multiplier effect is calculated depending on factors, which cause changes in product prices for region's sectors. Thus, if these changes are related with changes of added value, the price model looks like:

$$\Delta P = [(I - A)^{-1}]' \Delta v \qquad (2)$$

where ΔP – vector of product prices changes for region's sectors;

$[(I - A)^{-1}]'$ - transposed matrix $(I - A)^{-1}$;

Δv – vector of added value changes for region's sectors.

Matrix $\overline{A'} = [(I - A)^{-1}]'$ is a price multiplier by Leontiev, each element $\overline{a_{ji}}'$ of the matrix characterizes a degree of product price change for j-sector, if added value is changed for i-sector. Per se, both the classical multiplier and the price multiplier are converters of inputs into outputs. So accuracy of modeling depends totally on the quality of assessment of input-output coefficients (I-O coefficients) as the elements of the I-O matrix.

1. ANALYSIS OF METHODS TO ASSESS THE I-O COEFFICIENTS INTO ACCOUNT THE ACCURACY OF THEIR INFORMATION REPRESENTATION

There are different approaches to define the I-O coefficients. Based on the possibilities of obtaining reliable information about their values, we distinguish three groups of such methods:

1.1. Methods of assessment under conditions of full determinacy

1.2. Methods of assessment under conditions of probabilistic determinacy

1.3. Methods of assessment under conditions of undeterminacy

Let's consider the features of each group of methods to assess the I-O coefficients for the regions of Ukraine.

1.1. Methods of assessment under conditions of full determinacy

Using the first group of methods assumes full determinacy of the studied object, in other words, the existence of complete and reliable data about its behavior. These methods are based on the need to adjust the I-O coefficients with time. Conventionally, these methods can be divided into two groups - methods of statistical prediction and analytical methods.

The methods of statistical prediction of coefficients are based on sufficient time series of their values. The easiest option is the extrapolation of I-O coefficients by trend functions. The main problem of this method is its inability to obtain statistically significant results, because the accumulation of the same type of statistical data over a long period of time is difficult due to objective and subjective reasons. Modeling I-O coefficients using multiple regression analysis is more sophisticated approach. It provides statistically significant results, but leads to a departure from the traditional I-O concept. In addition, there is not sufficient statistical information to support such analysis in Ukraine as in the case of using statistical extrapolation.

Using analytical methods do not require a long period of time to accumulate statistical data. So the problem of forecasting I-O coefficients can be solved using the linear programming method, which is based on information about total material costs and intermediate inputs of each sector. RAS method is considered more accurate for calculating the forecast values of I-O coefficients. This method is based on information about possible changes of the material capacity, but not on information about direct material costs and intermediate inputs (unlike the linear programming method).

It is considered that only the statistical correction method by Tilanus could compete with the RAS. This method is based on a single I-O table and sector's checksums for subsequent periods. Intermediate product vector is calculated using constant I-O coefficients, then it is adjusted using a correction member, which is determined from the observable error prediction. This idea was implemented in the modified RAS.

It should be noted that obtaining accurate information could be problematic for both the previously stated analytical methods of assessment of I-O coefficients as it is for using statistical prediction methods. Statistical correction method requires accurate estimation of checksums for all sectors. Obtaining this estimation is difficult due to the irregular and fluctuating dynamic of the checksums; this dynamic is result of considerable instability of Ukrainian economics. There are even more problems for implementation of the RAS method. Data, which is needed for calculation of changes of material capacity, is provided by major businesses or some I-O tables without proper integration and the lack of a systematic approach. Due to these reasons and the probabilistic nature of this model's parameters, the accuracy of results using this method is not satisfactory. All these reasons lead to the necessity of using methods which should take into account the random nature for values of I-O coefficients.

1.2. Methods of assessment under conditions of probabilistic determinacy

Assessment of elements of I-O matrix under conditions of probabilistic determinacy is based on considering them as casual variates $A(\theta)$, which depend on state of nature θ. The probabilistic nature of matrix's elements is not only a result of the above considered economical reasons, but also a result of measurement and prediction errors, and aging information about their values. Depending on the target setting, the resulting vector of gross output will be casual, if we use this method. This variate would match gross output plans in very rare cases. As pointed out by Yermoliev, the planned vector could be selected from some criteria of minimizing discrepancy for planned and real outputs.

Conditions and methods of problem solution for finding I-O coefficients are carefully considered in the paper. However, its implementation is very difficult considering conditions of the Ukrainian economy. The poor quality of available information, frequent corrections both the technique calculation of the economic indicators and statistical reporting forms on the micro- and macrolevel do not allow for the adequate distribution law for I-O coefficients. Thus, we need other methods to make an acceptable assessment of these coefficients under conditions of indeterminacy.

1.3. Methods of assessment under conditions of indeterminacy

The baffling complexity of a regional economy as a system leads to the problem of obtaining an accurate quantitative assessment of parameters which characterize its behavior. The consequences of the complexity of regional economy are; first, the inability to accurately describe the objective value of its performance through the influence of the many different factors at any given time (true indeterminacy), and second, incomplete and inaccurate information about what these values are (information indeterminacy). Transformation processes in Ukraine's economy lead to frequent changes of fiscal and monetary policy, increasing the informational indeterminacy of regional indicators. In this regard, it makes sense to use methods which rely less on the demands for the input data, which is used for the modeling of activities for the investigated object.

One of these methods is the mathematical tool of the fuzzy set theory (FST). It should be noted that the term "fuzziness" does not mean the ambiguity of the results, which are obtained by the FST. An important feature of fuzzy models is the ability to process heterogeneous input data, increasing the overall reliability of the descriptions of an object's activities.

Using fuzzy set theory has already been examined in the case of I-O coefficients. In particular, in the paper the authors implemented the graph theory in fuzzy formulation for selecting the most important coefficients. Certainly, it is important to differentiate I-O coefficients by the degree of their importance for the realization of various investigations. In this paper the problem is posed some what differently: *how to obtain sufficiently reliable results for the analysis of the sectoral structure of the regional economy using relatively inaccurate value I-O coefficients.*

2. FUZZY ASSESSMENT OF I-O COEFFICIENT OF THE INDUSTRIAL REGION’S ECONOMY

As noted above, the I-O matrix is the basis of model calculations for the analysis of the sectoral structure of a regional economy. Let’s analyze the changing values of its elements in a definite time by the example of the Donetsk region as the major industrial region of Ukraine. Using actual statistical reporting of enterprises of Ukrainian regions, we can calculate the I-O matrix, which contains 35 sectors. These matrices are based on I-O tables which are obtained as a result of data processing of statistical reporting for 2001-2003. The economic activities, found in the I-O tables and the corresponding I-O matrices of Donetsk region, are listed in Annex 1. In Figures 1 and 2 the I-O coefficients of the material production for the two most important industrial sectors of Donetsk region: metallurgy and coal mining are given. There are taken from regional I-O matrices.

The term-set for verbal values of the linguistic variable β = “Type of intersectoral relationship” in the following way:

T(β) = {"Very Weak", "Weak, "Below Medium", "Medium", "Above Medium", "Strong", "Very Strong"}.

Definitional domain of values for this linguistic variable is obtained based on values of elements of Donetsk region’s I-O matrices for three years X = [0; 0.57]. This gives the follow definition of the linguistic variable:

$$\left\langle \text{«Type of intersectoral relationship”»}, T(\beta), [0; 0{,}57] \right\rangle$$

Each value of the linguistic variable is described by fuzzy variable, which corresponds to a certain fuzzy subset.

Formally, the fuzzy subset is defined as:

$\tilde{A}(\alpha) = \left\{ \left\langle \mu_{\tilde{A}(\alpha)}(x) / x \right\rangle \right\}, x \in X$ – fuzzy subset of the set X, which describes the restrictions on possible values of fuzzy variable α;

$\left\langle \mu_{\tilde{A}(\alpha)}(x) / x \right\rangle$, где $x \in X, \mu_A \in [0;1]$ – membership function.

For each specific value $x \in X$ the value $\mu_A(x)$ takes a specific value from a closed interval [0, 1], which is called *the degree of membership* of x to fuzzy set $\tilde{A}(\alpha)$.

FIGURE 1. I-O coefficients of the metallurgy sectors for Donetsk region

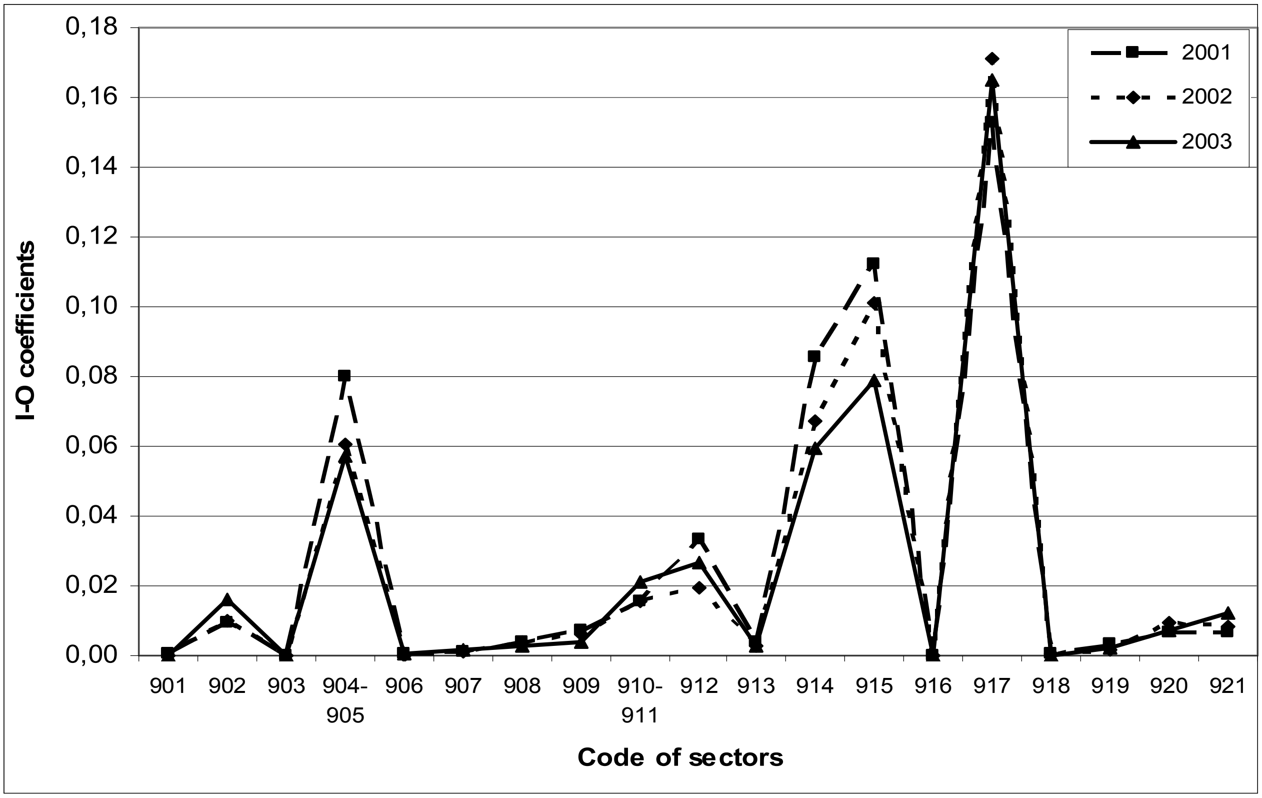
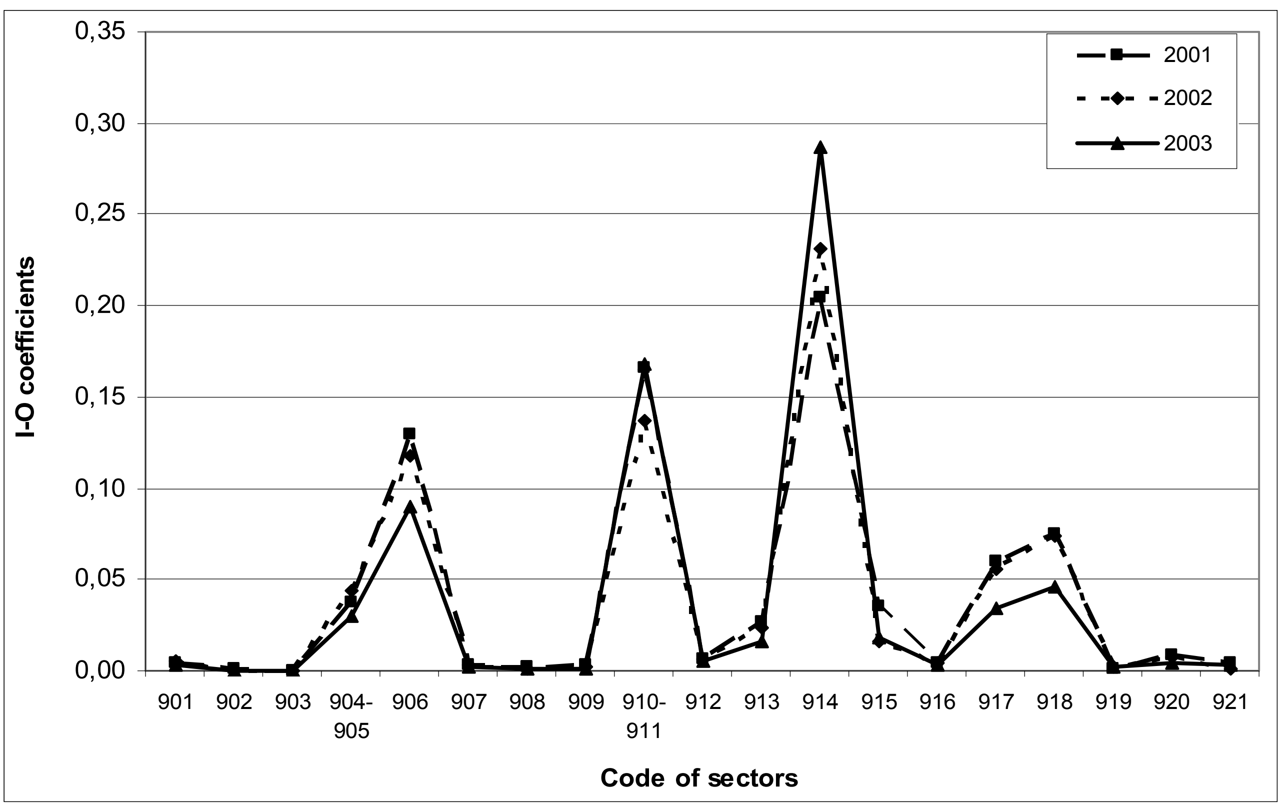
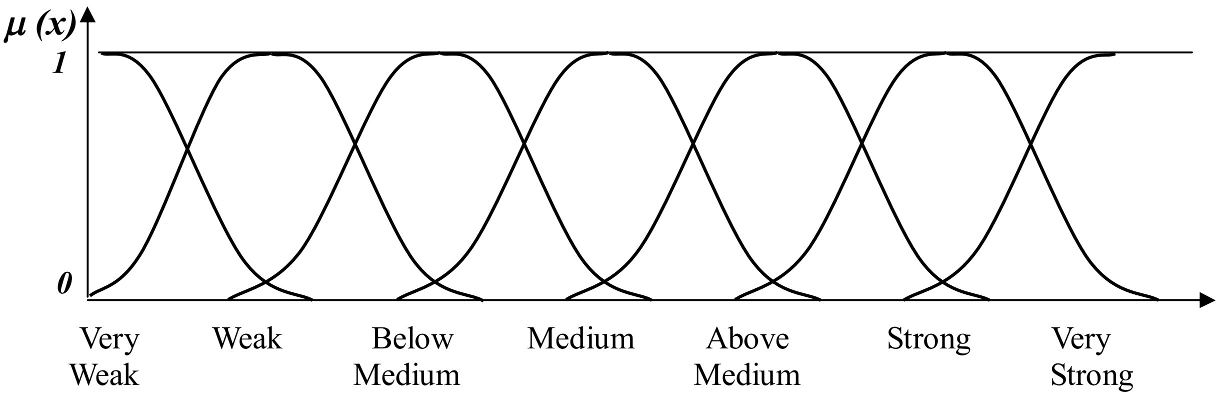


FIGURE 2. I-O coefficients of the coal mining sectors for Donetsk region



In Figure 3 there is general view of the membership function, which describe all possible types of intersectoral relationship.

FIGURE 3. General view of the membership functions, which describe all types of intersectoral relationship



The subset $\widetilde{A}(\alpha)$ be simplified as $\widetilde{A}$, and a set $T(\beta)$ as T. To create fuzzy subsets for fuzzy variables, which correspond to elements of the therm-set T, it is first necessary to select the numerical intervals, which characterize the definitional domain of each fuzzy variable using cluster analysis procedure by module Claster Analysis package *STATISTICA 6.0*. In order to get stable cluster structure of intersectoral relationships, let's clusterize elements of I-O matrix with data for Donetsk region in 2001-2003 years. Next, based on calculated numeric intervals, determine the corresponded fuzzy subsets (Table 1) for each type of intersectoral relationship. Transformation of elements of I-O matrix to fuzzy representation is done using this table.

TABLE 1. Fuzzy definition of intersectoral relationships for economic system of region

Cluster	**Terms , which characterize the type of intersectoral relationships**	**Range of changes for Input-Output coefficients**		**Fuzzy sets corresponding types of intersectoral relationships**
1	«Very Strong»	0,2978	0,5700	<0/0,2978; 0,25/0,3659; 0,5/0,4339; 0,75/0,5020; 1/0,5700>
2	«Strong»	0,2313	0,3630	<0/0,2313; 0,25/0,2478; 0,5/0,2642; 0,75/0,2807; 1/0,2972; 0,75/0,3136; 0,5/0,3301; 0,25/0,3465; 0/0,3630>
3	«Below Medium»	0,0950	0,2563	<0/0,095; 0,25/0,1152; 0,5/0,1353; 0,75/0,1555; 1/0,1757; 0,75/0,1958; 0,5/0,2160; 0,25/0,2361; 0/0,2563>
4	«Medium»	0,0550	0,1188	<0/0,055; 0,25/0,0630; 0,5/0,0710; 0,75/0,0789; 1/0,0869; 0,75/0,0949; 0,5/0,1029; 0,25/0,1108; 0/0,1188>
5	«Above Medium»	0,0184	0,0650	<0/0,0184; 0,25/0,0242; 0,5/0,0301; 0,75/0,0359; 1/0,0417; 0,75/0,0475; 0,5/0,0534; 0,25/0,0592; 0/0,0650>
6	«Weak»	0,0056	0,0250	<0/0,0056; 0,25/0,0080; 0,5/0,0105; 0,75/0,0129; 1/0,0153; 0,75/0,0177; 0,5/0,0202; 0,25/0,0226; 0/0,0250>
7	«Very Weak»	0,0000	0,0090	<0/0,0090; 0,25/0,0068; 0,5/0,0045; 0,75/0,0023; 1/0,0000>

3. THE ASSESSMENT OF MULTIPIER IN THE ECONOMY OF AN INDUSTRIAL REGION USING THE FUZZY I-O MATRIX

The fuzzy I-O matrix can be used for solving different problems of structural analysis of industrial region economy, particularly for assessment of multiplier effect based on the static I-O model (ref. (1) - (2)). Notice that changes of assessed parameters are of more interest than their absolute value when calculating this effect. Using fuzzy I-O model, we examine the exogenous factors influence on the key economical indicators changes in Donetsk region and compare the results obtained with their non-fuzzy analogues.

It is known that generation of any fuzzy model consists of three stages:

2.1. *Fuzzyfication*, input information is transformed into fuzzy form by means of one or more linguistic variables;

2.2. *Work experiments with model,* fuzzy model is being investigated, the response values are being analyzed;

2.3. *Defuzzification,* response values are transformed into non-fuzzy form.

Consider the realization of these stages regarding static I-O model of Donetsk region.

3.1. Fuzzification.

For fuzzification of I-O matrix elements use Table 1. Demonstrate the transformation of real values to fuzzy ones by using the example of Manufacture of gas. This column of I-O matrix for the sector given is as follows:

$$a_{i,16} = \begin{bmatrix} 0{,}0481 \\ 0{,}0221 \\ \vdots \\ 0{,}0012 \end{bmatrix}, \quad i = 1,\dots,35$$

After transformation into fuzzy type, this column takes on the form:

$$a_{i,16} = \begin{bmatrix} "\,Above\ Medium\," \\ "\,Weak\," \\ \vdots \\ "\,Very\ Weak\," \end{bmatrix}, \quad i = 1,\ldots,35$$

After replacing the verbal form of every I-O connection to the fuzzy one, we get:

$$a_{i,16} = \begin{bmatrix} < 0/0{,}0184;\ 0{,}25/0{,}0242;\ 0{,}5/0{,}0301;\ 0{,}75/0{,}0359;\ 1/0{,}0417;\ 0{,}75/0{,}0475;\ 0{,}5/0{,}0534;\ 0{,}25/0{,}0592;\ 0/0{,}0650 > \\ < 0/0{,}0056;\ 0{,}25/0{,}0080;\ 0{,}5/0{,}0105;\ 0{,}75/0{,}0129;\ 1/0{,}0153;\ 0{,}75/0{,}0177;\ 0{,}5/0{,}0202;\ 0{,}25/0{,}0226;\ 0/0{,}0250 > \\ \vdots \\ < 0/0{,}0090;\ 0{,}25/0{,}0068;\ 0{,}5/0{,}0045;\ 0{,}75/0{,}0023;\ 1/0{,}0000 > \end{bmatrix}$$

In this way we can fuzzificate all the elements of I-O matrix.

3.2. Work experiments with model.

Demonstrate the realization of the stage by calculating classical multiplier effect (ref. (1)) in fuzzy interpretation:

$$\Delta\widetilde{X} = (I - \widetilde{A})^{-1}\,\Delta Y, \qquad (3)$$

where $\widetilde{A}$ – fuzzy I-O matrix;

I – unity matrix;

$\Delta\widetilde{X}$ – fuzzy vector of gross output changes for region's sectors;

ΔY – normalized vector of final demand changes for region's sectors.

Using formula (3) examine the fuzzy multiplier effect from the 10% increase of the final demand for the production of the main sector of Donetsk region - metallurgy industry. Notice that matrix A used for calculations consists of sectors with positive value of final product $Y_j > 0$, and others are given as the one element “Other Sectors”. The calculation results are given in the Appendix 2.

Compare the obtained fuzzy values of gross output changes with the corresponding values obtained when using the classical model. Given in a diagram for convenience (Figure 4).

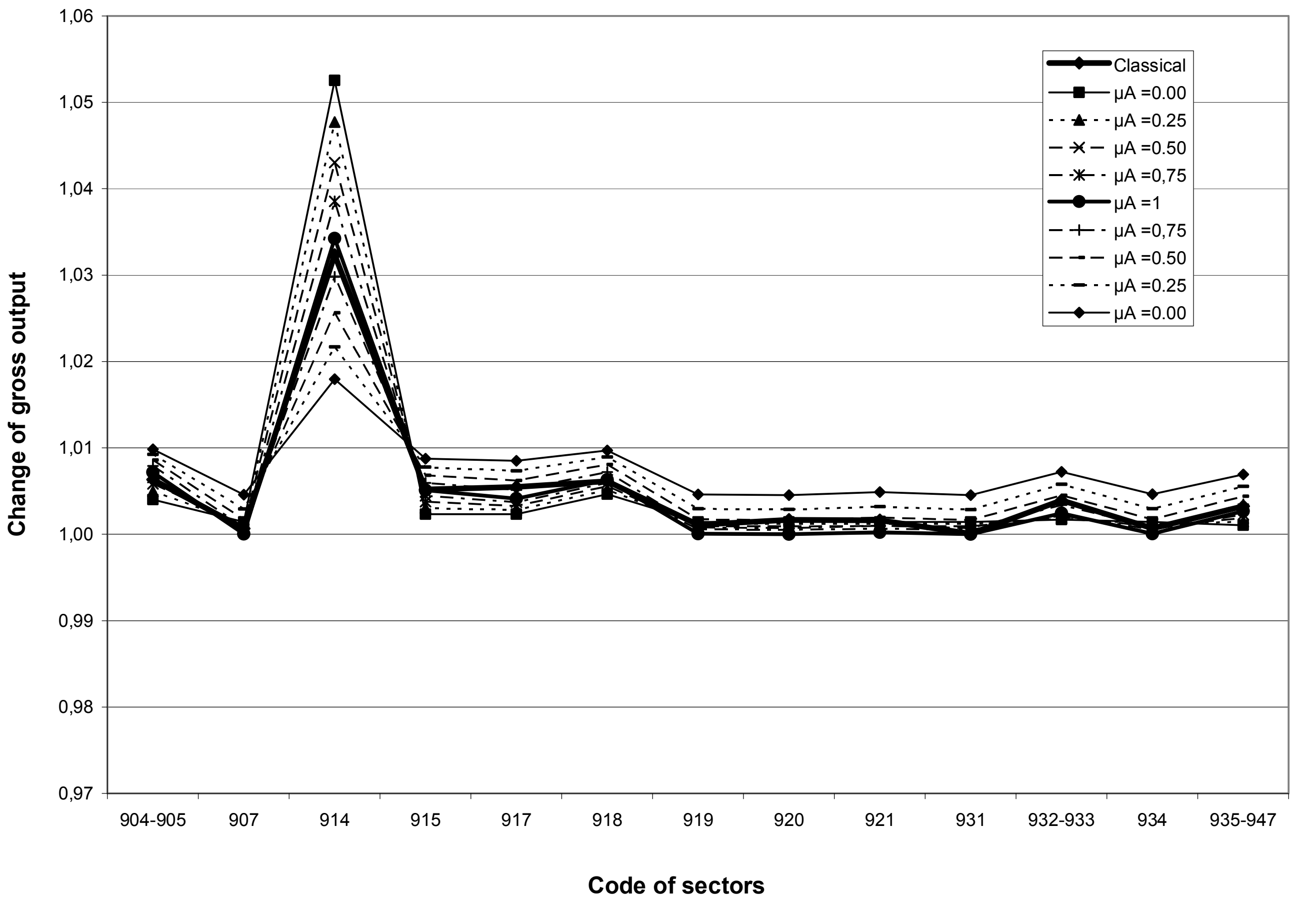


FIGURE 4. Comparison of fuzzy and non-fuzzy gross output changes

The family of graphs in Figure 4 indicates that gross output changes in the regional sectors, which was calculated by using the I-O fuzzy model, correspond to that one which was obtained on the base of classical model. Particularly, it is clear that both the models reflect high energy intensity of metallurgy as a result of *substantial consumption of coal, gas and electricity in this sector*.

3.3. Defuzzification.

For the quantitative assessment of the adequacy of the fuzzy model, it is necessary to defuzzificate the fuzzy vector of gross output changes ΔX and, comparing its values with the non-fuzzy vector, to calculate any possible error.

Interpreting in this case the result of fuzzy model as an average value in fuzzy discrete subset, we use the method of gravity center as a method of defuzzification. Defuzzificated values of gross output changes and their relative deviations from the fuzzy values are in the Appendix 3. The absolute value of deviations which characterize error of assess are not more than 1%, and therefore, it confirms the adequacy of the I-O model. The calculation of the classical multiplier effect for other sectors of Donetsk region prove the adequacy of the fuzzy model.

Check the possibility of using the fuzzy I-O matrix for the assessment of price multiplier effect. If the change of prices in sectors is not the result of an element of added value change, for example, the wage increase in some sector, the formula (2) is as follows:

$$\Delta\widetilde{P} = [(I - \widetilde{A})^{-1}]'[r + \Delta z + s + d + q], \quad (4)$$

where $\Delta\widetilde{P}$ - fuzzy vector of price change in sectors;

r, z, s, d and *q* – normalized vectors of depreciation charges, wage, social insurance payment and other expenses and the profit accordingly.

The formula (4) assesses the influence of wage growth to 10% in metallurgy industry to price changes in the material production sectors of Donetsk region. We defuzzificate fuzzy values obtained by the method of gravity center and compare with the results found with the help of the classical price model. As shown in the Figure 5, their values are very close (relative deviations is a little more than 0,1%). The maximum deviation (0,10282 %) seen in the sector "Other Production" which influence on the regional development among all the industrial sectors is the least substantial. Therefore, this given fuzzy price I-O model is adequate.

The assessment of the influence of elements of added value in other sectors of Donetsk region on the variation of sectoral prices by using the fuzzy I-O model also proved its adequacy.

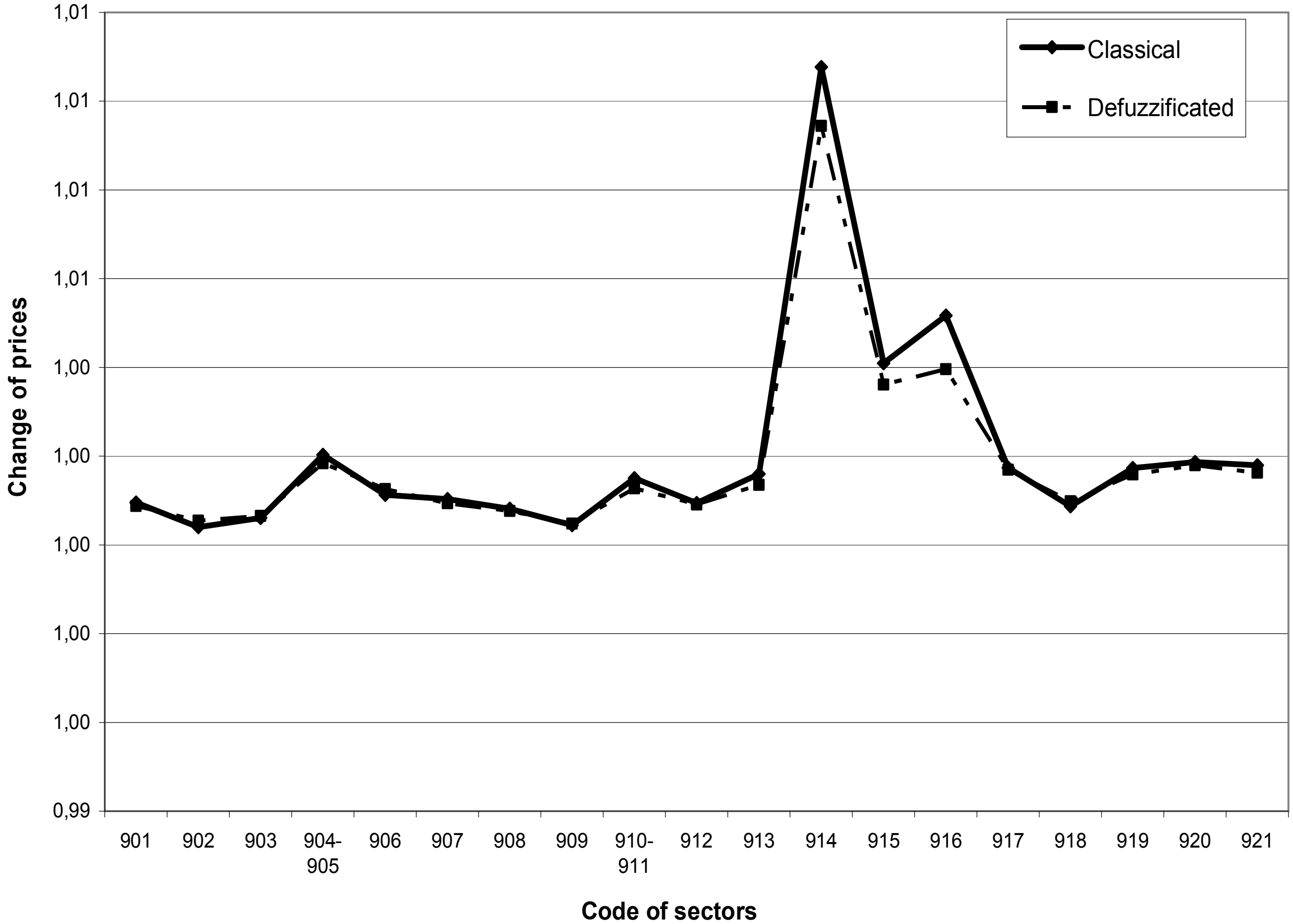


FIGURE 5. Comparison of the defuzzificated and non-fuzzy changes of prices

Price multiplier effect can also characterize the variation of prices in different sectors as a result of price changes in some sectors. In this case, fuzzy assessment is done in the following way:

$$\widetilde{P}_{n-1} = (I - \widetilde{A}'_{-1} - q_{-1})^{-1} P_{\Sigma}, \tag{5}$$

where $P_{\Sigma} = p_n \widetilde{A}'_n + r_{-1} + z_{-1} + s_{-1} + d_{-1}$.

Defuzzificated values of prices change in the material production sectors when assessing the influence of a 10% growth of natural gas price is shown in the Figure 6. As in previous cases we can see the substantial closeness of values being compared (results of fuzzy and non-fuzzy models). The absolute deviation is not more than 1%.

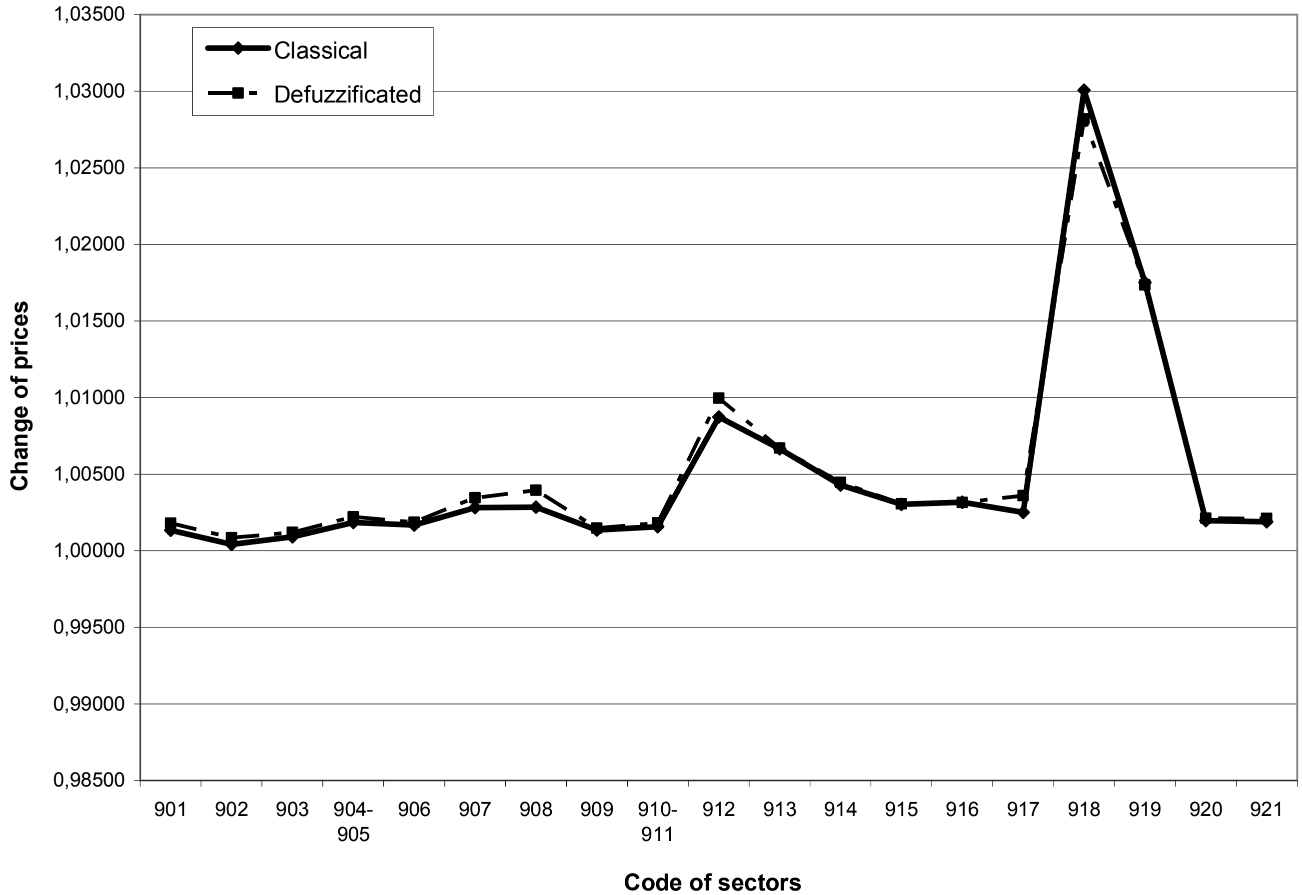


FIGURE 6. Comparison of the defuzzificated and non-fuzzy price change when increasing the gas price

Comparing the price effects of raising wage in the metallurgy industry as the largest sector of Donetsk region and the increasing price of natural gas as one of the important regional energy resources, it should be noted that the impact of latter in increasing the sectoral prices in regional material production is much greater. Due to the increasing price of natural gas, prices change of some sectors such as steam and hot water supply (919), chemical industry (912), manufacture of other non-metallic mineral products (913), manufacture of basic metals and fabricated metal products (914) can lead to cost inflation in industrial region. Natural gas is an imported energy resource to Ukraine, so it is important to apply new technologies for reducing consumption of natural gas primarily in these sectors of Donetsk region. The adequacy of the price model (5) has been demonstrated for different cases of prices change in sectors of the investigated region.

SUMMARY

Due to the inaccuracy and lack of information about I-O coefficients of Ukrainian regions, it is suggested to use the fuzzy sets theory for their assessment. In this paper the fuzzy assessment of the element of I-O matrix is shown. They have been calculated for one of the biggest industrial regions of Ukraine. Fuzzy I-O matrix is used for the structural analysis of the economy of industrial region, for the assessment of the classical and price multiplier effects. Any coefficient can be given verbally as a characteristic of the strength of intersectoral connection. A rather wide fuzzy range of value of I-O coefficients corresponds to the verbal characteristic, but at the same time the dispersion of resulting variable (for this paper, it is the changes of the gross output or prices in regional sectors) stays within acceptable limits of calculations error. Thus, fuzzy assessment of I-O coefficients makes it possible to obtain the adequate results when investigating the impact of exogenous factors on the economy of industrial region and it can be used for structural analysis and forecasting the economical development of Ukrainian regions.

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Appendix 1

TABLE 2. The economic activities, found in the I-O tables of Donetsk region

#	The Classification of Economic Activities in Ukraine (Section, Subsection, Division)	Line Code of Appendix in Statistical Reporting Form #1 Enterprise (Annual)	The Name of Economic Activity according to the Classification of Economic Activities in Ukraine
	Section A		***Agriculture, hunting and forestry***
1.	Division 01	901	Agriculture, hunting and related service activities
2.	Division 02	902	Forestry, logging and related service activities
3.	***Section B***	***903***	***Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing***
	Section C		***Mining and quarrying***
4.	Subsection CA	904 - 905	Mining and quarrying of energy producing materials
5.	Subsection CB	906	Mining and quarrying, except of energy producing materials
	Section D		***Manufacturing***
6.	Subsection DA	907	Manufacture of food products, beverages and tobacco
7.	Subsection DB, Subsection DC	908	Manufacture of textiles and textile products Manufacture of leather and leather products
8.	Subsection DD, Subsection DE	909	Manufacture of wood and wood products Manufacture of pulp, paper and paper products; publishing and printing
9.	Subsection DF	910 - 911	Manufacture of coke, refined petroleum products and nuclear fuel
10.	Subsection DG, Subsection DH	912	Manufacture of chemicals, chemical products and man-made fibres; Manufacture of rubber and plastic products
11.	Subsection DI	913	Manufacture of other non-metallic mineral products
12.	Subsection DJ	914	Manufacture of basic metals and fabricated metal products
13.	Subsection DK, Subsection DL, Subsection DM	915	Manufacture of machinery and equipment n.e.c. Manufacture of electrical and optical equipment Manufacture of transport equipment
14.	Subsection DN	916	Manufacturing n.e.c.
	Section E		***Manufacture of electrical and optical equipment***
15.	Division 40.1	917	Production and distribution of electricity
16.	Division 40.2	918	Manufacture of gas; distribution of gaseous fuels through mains
17.	Division 40.3	919	Steam and hot water supply
18.	Division 41	920	Collection, purification and distribution of water

Continuation of TABLE 2

#	The Classification of Economic Activities in Ukraine (Section, Subsection, Division)	Line Code of Appendix in Statistical Reporting Form #1 Enterprise (Annual)	The Name of Economic Activity according to the Classification of Economic Activities in Ukraine
19.	***Section F***	***921***	***Construction***
20.	***Section G***	***930***	***Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods***
21.	***Section H***	***931***	***Hotels and restaurants***
	Section I		***Transport, storage and communication***
22.	Divisions 60-63	932 - 933	Transport
23.	Division 64	934	Post and telecommunications
24.	***Section J***	***935***	***Financial intermediation***
	Section K		***Real estate, renting and business activities***
25.	Division 70	936	Real estate activities
26.	Division 71	937	Renting of machinery and equipment without operator and of personal and household goods
27.	Division 72	938	Computer and related activities
28.	Division 73	939	Research and development
29.	Division 74	940	Other business activities
30.	***Section L***	***941***	Public administration and defence; compulsory social security
31.	***Section M***	***942***	***Education***
32.	***Section N***	***943***	***Health and social work***
	Section O		***Other community, social and personal service activities***
33.	Divisions 90-91	944 - 945	Sewage and refuse disposal, sanitation and similar activities; Activities of membership organizations n.e.c.
34.	Division 92	946	Recreational, cultural and sporting activities
35.	Division 93	947	Other service activities

Appendix 2

TABLE 3. Fuzzy calculation of impact of increasing final demand in metallurgy sector onto the gross output changes in sectors of Donetsk region

The Cod of Economic Activities	Base Gross Output, X_0	New Gross Output, X_1	Increment of Gross Output, ΔX	Fuzzy Increment of Gross Output, $\Delta\widetilde{X}$								
				$\mu_A = 0.00$	$\mu_A = 0.25$	$\mu_A = 0.50$	$\mu_A = 0,75$	$\mu_A = 1$	$\mu_A = 0,75$	$\mu_A = 0.50$	$\mu_A = 0.25$	$\mu_A = 0.00$
904-905	4,55607	4,58500	1,00633	1,00353	1,00423	1,00483	1,00533	1,00572	1,00668	1,00761	1,00851	1,00934
907	3,53604	3,53800	1,00067	1,00143	1,00121	1,00094	1,00057	1,00005	1,00083	1,00184	1,00317	1,00501
914	4,50617	4,65200	1,03233	1,05123	1,04589	1,04068	1,03564	1,03079	1,02672	1,02294	1,01941	1,01608
915	2,63654	2,65000	1,00518	1,00231	1,00303	1,00373	1,00439	1,00497	1,00583	1,00674	1,00769	1,00870
917	3,32497	3,34300	1,00548	1,00232	1,00282	1,00328	1,00372	1,00413	1,00513	1,00621	1,00734	1,00850
918	3,14513	3,16400	1,00613	1,00463	1,00510	1,00552	1,00589	1,00620	1,00706	1,00792	1,00875	1,00952
919	1,21069	1,21200	1,00110	1,00143	1,00121	1,00094	1,00058	1,00008	1,00086	1,00186	1,00320	1,00503
920	1,34219	1,34400	1,00167	1,00142	1,00121	1,00093	1,00056	1,00001	1,00078	1,00178	1,00311	1,00495
921	1,57227	1,57500	1,00161	1,00142	1,00122	1,00097	1,00067	1,00026	1,00107	1,00211	1,00346	1,00529
931	1,00940	1,00900	1,00006	1,00142	1,00121	1,00093	1,00055	1,00000	1,00077	1,00177	1,00310	1,00494
932-933	2,13418	2,14300	1,00393	1,00170	1,00182	1,00201	1,00226	1,00256	1,00356	1,00469	1,00598	1,00745
934	1,28594	1,28700	1,00069	1,00142	1,00121	1,00094	1,00058	1,00007	1,00085	1,00187	1,00321	1,00505
935-947	2,03401	2,04100	1,00324	1,00106	1,00147	1,00190	1,00234	1,00279	1,00362	1,00460	1,00578	1,00721
Other Activities	7,58419	7,66800	1,01103	1,01122	1,01084	1,01042	1,00997	1,00948	1,00970	1,00991	1,01011	1,01030

Appendix 3

TABLE 4. The assessment of deviations of defuzzificated incremented value of gross output from classical incremented value

The Cod of Economic Activities	Increment of Gross Output by Classical I-O Model (Classical Values)	Increment of Gross Output by Fuzzy I-O Model (Defuzzificated Values)	Deviations
904–905	1,00633	1,00603	0,02968%
907	1,00067	1,00090	-0,02246%
914	1,03233	1,03142	0,08779%
915	1,00518	1,00514	0,00460%
917	1,00548	1,00451	0,09686%
918	1,00613	1,00652	-0,03870%
919	1,00110	1,00092	0,01860%
920	1,00167	1,00086	0,08074%
921	1,00161	1,00107	0,05384%
931	1,00006	1,00086	-0,07944%
932–933	1,00393	1,00305	0,08738%
934	1,00069	1,00091	-0,02202%
935–947	1,00324	1,00308	0,01623%
Other Activities	1,01103	1,00991	0,11081%