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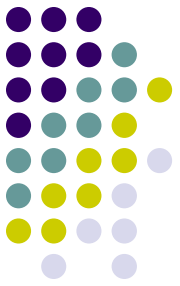
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Institute of Economics and Industrial Engineering
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Federation

Forecasting the Development of Russian Economy Using the Dynamic Input – Output Model with Fuzzy Parameters ¹⁾

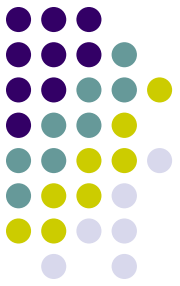
1) The project is done under the financial support of the Program of Rosobrasovaniye (Ministry of Science and

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Professor Victor Pavlov



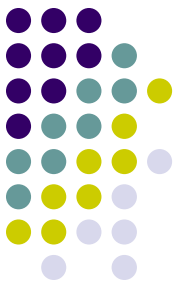
Interindustrial Analysis Department of the Institute of Economics and Industrial Engineering



The department was established by Dr. Nikolai Shatilov in the middle of 60th. In 1976-1986 Dr. Victor Ozerov was chief of the group. At present time core of the group consist of the following researchers:

- Dr. Victor Pavlov
- Dr. Tatyana Tagaeva
- Dr. Vadim Gilmundinov
- Dr. Lidia Kazantseva
- Dr. Alexander Baranov

KAMIN system has been developing since the end of 70th

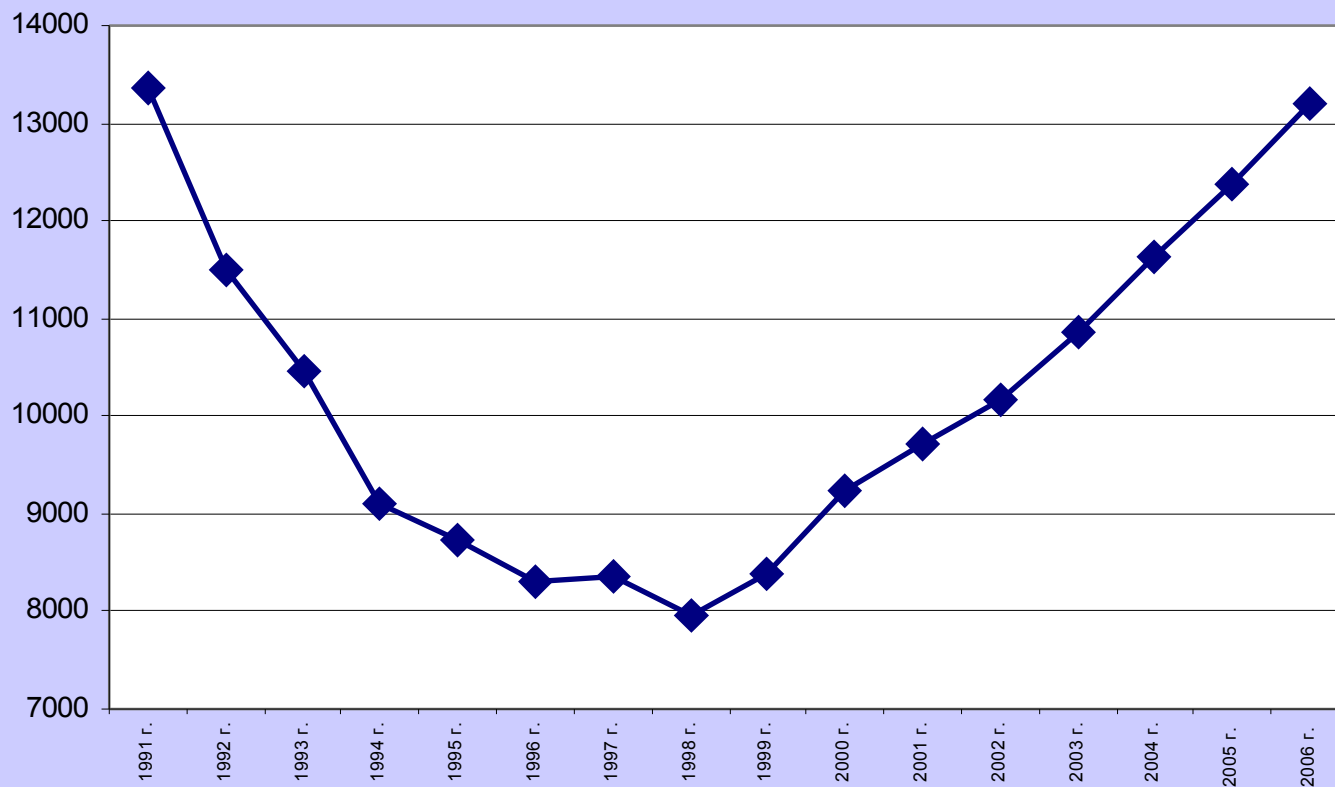


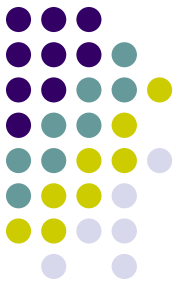
The system consists of the following blocks:

2. Dynamic Input-Output Model taking account of the investment lag (DIOML).
3. DIOML with fuzzy parameters.
4. Monetary block of the DIOML.
5. Financial block of the DIOML.
6. Environment protection block.



Russian economy GDP in 1991 - 2006, 4th quarter 2001 constant prices, bln rubl.

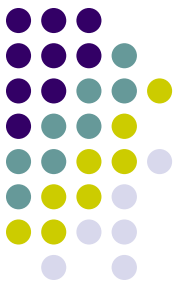




Estimates for forecasting the development of the Russian economy for the period 2008-2012 were carried out in two stages.

1. A forecast was carried out with the help of a Deterministic Dynamic Input-Output Model.

2. Calculations based on the Dynamic Input - Output Model with fuzzy parameters were made that took into account the results of forecasting the development of the Russian economy using the Deterministic Dynamic Input-Output Model.



▪1. Forecasting the development of the Russian economy using the Deterministic Dynamic Input-Output Model

- *The main goal of the forecasting estimates* was to investigate whether it would be possible for Russia to reach the level of per capita GDP output close to that of the least developed countries of Western Europe - Greece and Portugal in the course of the next decade (2008-2018). In 2002, taking into account the parity of the purchasing power of national currency, GDP per capita in Russia was approximately two times lower than in these countries.
- As in the course of ten years GDP at least doubles, its average annual growth rate should account for not less than 7.2%. In the period 2008 - 2012, due to this average annual growth rate, GDP should grow at least 41%.

Table 1. Major macroeconomic indices growth rates in the economy of Russia in 1999 - 2006, %.

Index	Growth rates in 1999 - 2006
Gross Domestic Product	165,8
Expenditures for Final Consumption	170,0
Employment in the Economy	107,9
Fixed Assets	105,5
Labour Productivity with respect to GDP	153,7
Capital Productivity	157,1
Fixed Capital Investments	217,5
Fixed Assets Put in Service	211,5
Average annual growth of GDP per 1% of investments into fixed assets, %	0,56
Average annual growth of labour productivity per 1% of fixed capital investments, %	0,46
Average annual growth of final consumption per 1% of fixed capital investments, %	0,6





Table 2. Dynamics of indices characterizing the state of fixed assets in Russia in 1998 – 2005, %.

Indices	1998	1999	2000	2001	2002	2003	2004	2005	Percentage changes in 2005 compared to 1998
Fixed assets depreciation rate in the country's economy as a whole	42,2	41,9	42,4	45,8	47,9	49,5	42,8	44,3	2,1
Fixed assets renewal ratio in the country's economy as a whole	1,1	1,2	1,4	1,5	1,6	1,9	2,1	2,2	1,1
Fixed assets retirement ratio in the country's economy as a whole	1,1	0,9	1,0	1,0	1,0	1,1	1,1	1,1	0
Fixed assets renewal ratio in industry	0,9	1	1,3	1,5	1,5	1,7	1,8	1,9	1
Fixed assets retirement ratio in industry	1,3	1	1,2	1,1	1	1,0	1,0	1,0	-0,3
Fixed assets depreciation rate in industry	52,9	55,1	51,6	52,3	51	52,9	51,4	49,7	-3,2
Share of equipment less than 10 years old in industry	24,2	19,3	15,3	13,3	12,5	12,7	No data	No data	-11,50 ¹⁾



The following scenarios of the development of the Russian economy were studied.

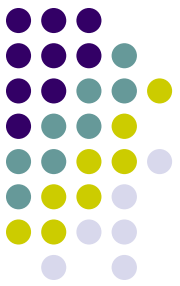
The assumptions in the **first (optimistic) scenario**

1. On the basis of the hypothesis that GDP in Russia will double in ten years and the living standard of the population will grow correspondingly it was concluded that the growth rate of expenditure on final consumption in 2008 – 2012 should be equal to at least 41%.

In this scenario it is assumed that the economy of Russia follows the innovational way of development, which makes it possible to provide a considerable growth of the living standard of the population, make it possible to diversify export (get rid of dependence on world market prices on energy carriers) and to provide a more stable economic growth.

2. During the whole projected period the fixed assets put in service will grow at least 90%. The rate of investments into fixed assets will at least double.

3. During the whole forecasting period replacement rates for the active (equipment) and passive (structures) parts of fixed assets in the Russian economy as a whole will grow 3 and 1.5 times accordingly. The scenario of a considerable renewal of the production mechanism makes it possible to accelerate the introduction of new technologies into production processes and raise the efficiency of production.



The second (pessimistic) scenario is based on the following assumptions.

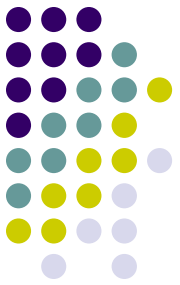
1. The GDP and gross output of the Russian economy in 2008 – 2012 will grow at the rate of approximately 30% that corresponds to the average annual growth of 5.2%. This rate conforms to the inertial scenario of the development of the economy of the Russian Federation included into the forecast of the Ministry of Economic Development and Trade of Russia for the period 2008 – 2012.

2. The scenario assumes a slower replacement of machines and equipment. The replacement rate for the active part of fixed assets will grow gradually from 1.6% in 2007 to 3.2% in 2012; for the passive part of fixed assets it will increase from 1% to 1.2% correspondingly (see table 4). Fixed capital investments will grow approximately 38% (97% in the optimistic scenario), while investments into the active part of fixed assets will increase by 48% (214% in the optimistic scenario).

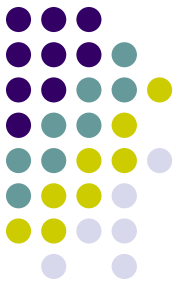


Table 3. Projected growth rates of certain major indices of the Russian economy in 2008 - 2012, %.

Index	2008	2009	2010	2011	2012	2012/2007
Total Gross Output and GDP						
Optimistic Scenario	107,5	107,5	107,5	107,5	107,5	143,6
Pessimistic Scenario	105,4	105,4	105,4	105,4	105,4	130,1
Gross output of the 1 st subdivision						
Optimistic Scenario	109,2	106,9	107,0	107,4	107,6	144,4
Pessimistic Scenario	106,8	104,6	104,6	104,9	105,0	128,7
Gross output of the 2nd subdivision						
Optimistic Scenario	104,4	108,6	108,5	107,7	107,2	142,0
Pessimistic Scenario	102,8	106,8	107,0	106,4	106,1	132,7
Total Fixed Assets						
Optimistic Scenario	101,6	101,8	102,0	102,3	102,7	110,8
Pessimistic Scenario	101,5	101,6	101,6	101,7	101,8	108,6
Including						
Active Part of Fixed Assets (machines and equipment)						
Optimistic Scenario	102,0	102,0	102,1	102,4	102,7	111,8



Continuation of Table 3						
Index	2008	2009	2010	2011	2012	2012/2007
Pessimistic Scenario	102,0	102,0	102,0	102,0	102,0	110,3
Passive Part of Fixed Assets (structures)						
Optimistic Scenario	101,4	101,6	101,9	102,3	102,6	110,3
Pessimistic Scenario	101,3	101,4	101,5	101,6	101,7	107,6
Total Fixed Capital Investments						
Optimistic Scenario	114,6	113,9	114,4	114,7	115,0	196,9
Pessimistic Scenario	106,7	106,5	106,6	106,8	106,9	138,3
Including						
Investments into the Machines and Equipment						
Optimistic Scenario	117,5	115,9	116,2	116,3	116,2	213,7
Pessimistic Scenario	109,1	108,0	108,1	108,0	107,9	148,4
Investments into the Structures						
Optimistic Scenario	112,3	112,3	112,8	113,4	113,9	183,8
Pessimistic Scenario	104,9	105,3	105,4	105,7	106,0	130,4



Continuation of Table 3						
Index	2008	2009	2010	2011	2012	2012/2007
Total Fixed Assets Retirement Compensation Rate, %						Retirement Compensation Rate in 2007, %
Optimistic Scenario	1,5	1,8	2,2	2,5	2,8	1,2
Pessimistic Scenario	1,4	1,5	1,7	1,8	2,0	1,2
Including						
Replacement Rate of the Machines and Equipment, %						
Optimistic Scenario	2,3	2,9	3,6	4,2	4,9	1,6
Pessimistic Scenario	1,9	2,3	2,6	2,9	3,3	1,6
Replacement Rate of the Structures, %						
Optimistic Scenario	1,1	1,2	1,3	1,4	1,5	1,0
Pessimistic Scenario	1,0	1,1	1,1	1,2	1,2	1,0
Capital /Gross Output Ratio						
Optimistic Scenario	94,5	94,7	94,9	95,2	95,5	77,2
Pessimistic Scenario	96,3	96,4	96,4	96,5	96,6	83,5
Materials / Gross Output Ratio						
Optimistic Scenario	98,0	98,0	98,3	98,3	98,4	91,4
Pessimistic Scenario	98,8	98,9	99,3	99,4	99,6	96,1



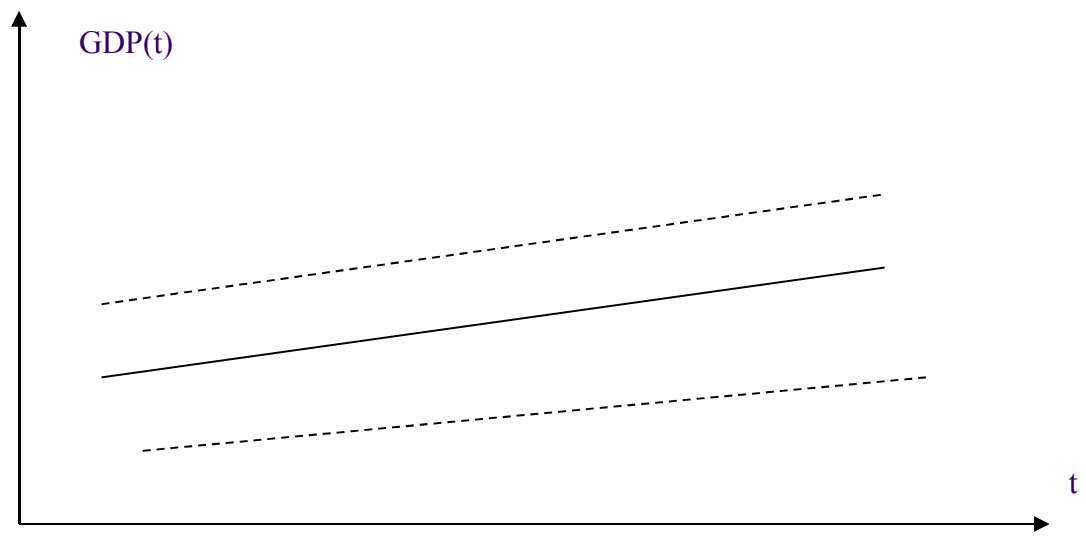
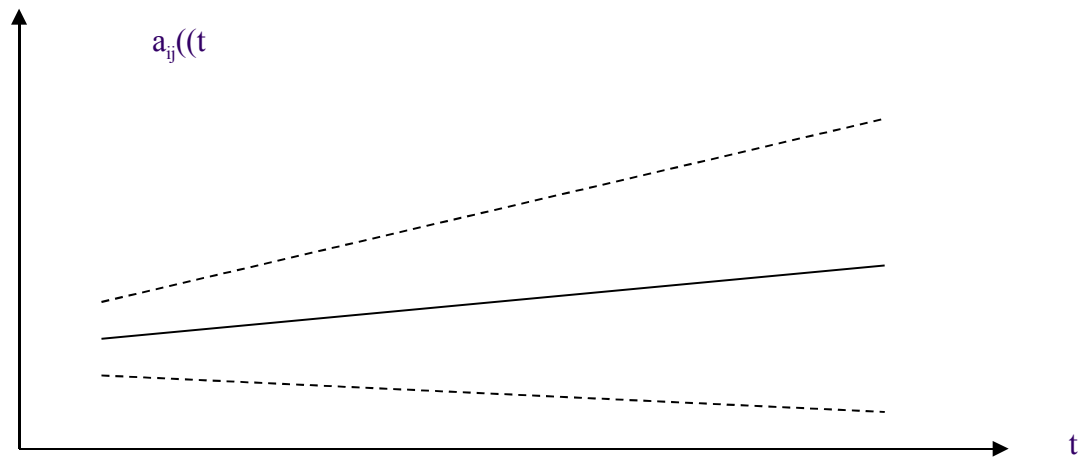
2. Forecasting the development of the Russian economy using the Dynamic Input-Output Model with fuzzy parameters

Two definitions and one idea

1. The *degree of plausibility* of a particular statement was understood in the following way. Namely, fuzzy set A in space X is understood as a geometrical object having the following property: for each $x \in X$, number is determined $\chi_A(x)$: $0 \leq \chi_A(x) \leq 1$, that is interpreted as the degree of plausibility of the statement that $x \in A$. If $\chi_A(x) = 0$, statement is absolutely implausible; if $\chi_A(x) = 1$, then statement is absolutely plausible.

2. Function $\chi_A: X \rightarrow I$ is called the *function of membership of a (fuzzy) set A*. Here $I = [0; 1]$, I^X - is the domain of measurable images $f: X \rightarrow I$.

Fuzzy assignment of parameters in the Dynamic Input-Output Model and the computation of fuzzy values of economic indices give new possibility to research the problem of macroeconomic stability: namely, to make assessment of stability of computed fuzzy indices with respect to a fuzzy description of model parameters.



Some results of experimental estimates.



First experiment

- It was determined whether an event was plausible, that is whether the growth rate of gross output of the Russian economy would be equal to 143.6% (the most probable index value in the optimistic scenario) in the conditions when the most important parameters of the Dynamic Input-Output Model are presented fuzzily.
- The following parameters were set in a fuzzy way: 1) the growth rates of employment in the economy during five years; 2) the value of fixed assets put into service in each year of the projected period; 3) the growth rate of net export during five years; 4) the growth rate of each element of materials output ratio matrix during five years; 5) the sectoral structure of fixed assets put into service; 6) labour productivity growth rate (the rate of growth of each element of the vector was specified in a fuzzy way).



Table 4. Dependence of the gross output stability level of the Russian economy on the degree of variation of 6 groups of parameters

Index	10%	15%	20%	25%
Stability level for gross output as a whole	95,6	79,1	69,0	50,5
Stability level for gross output of the 1 st subdivision	94,8	77,0	63,1	49,2
Stability level for gross output of the 2 nd subdivision	93,9	74,1	61,6	47,4

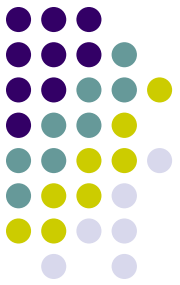
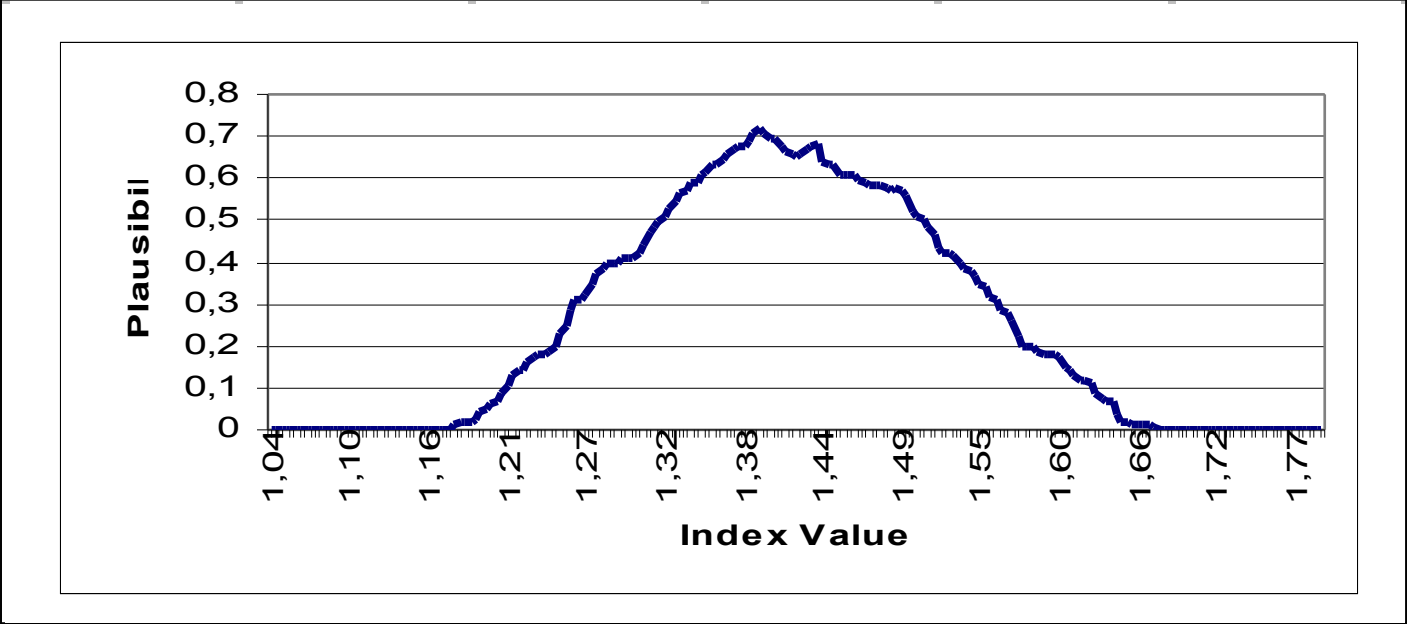


Fig 1. Membership function of a fuzzy gross output growth rate of the Russian economy according to the optimistic development scenario, with a fuzzy assignment of 6 major parameters under the variations range of 10%

The level of stability is equal to 95,6% (plausibility degree of coincidence of sample and standard indices).



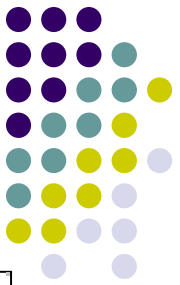
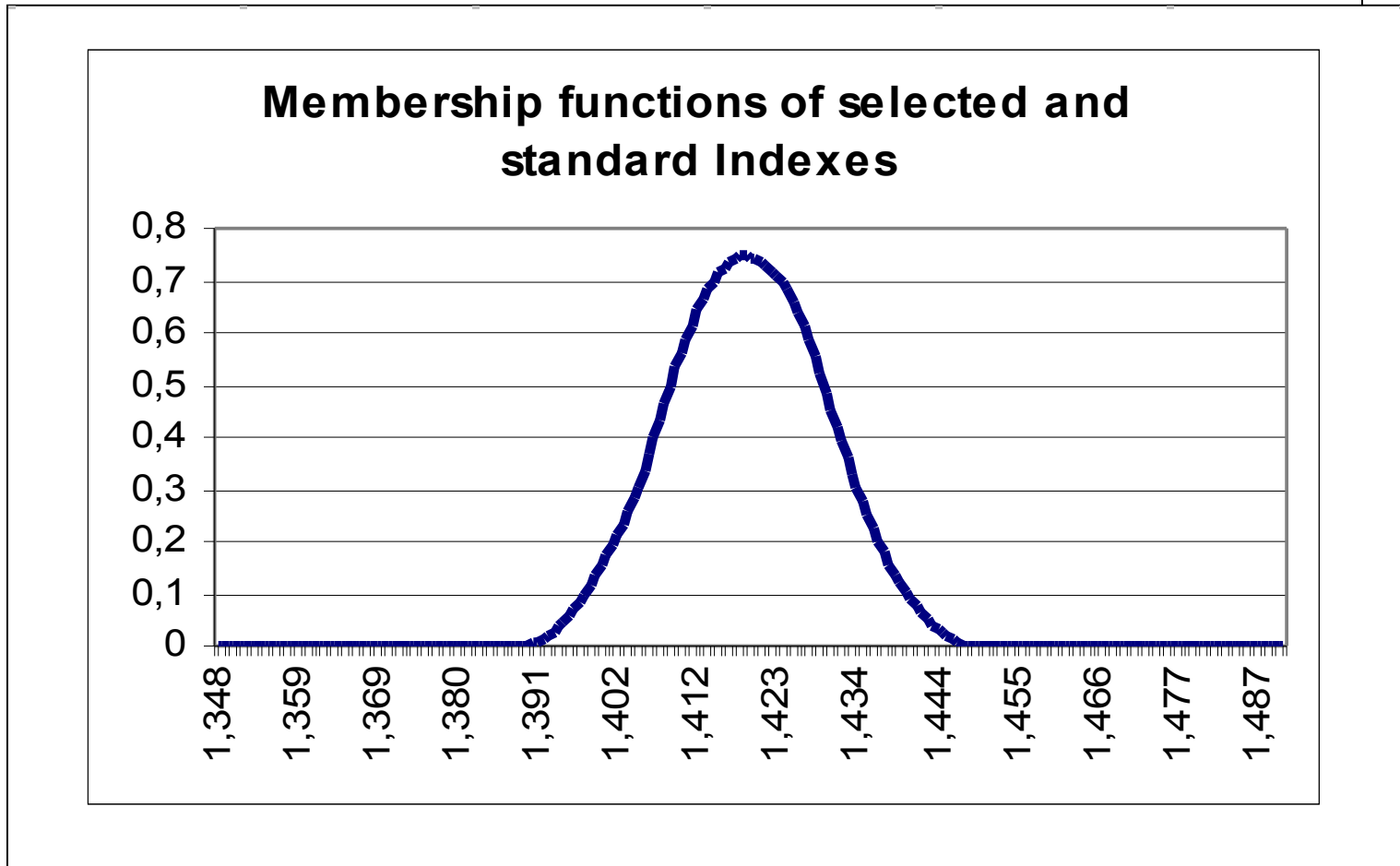


Fig. 2.



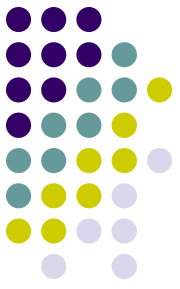
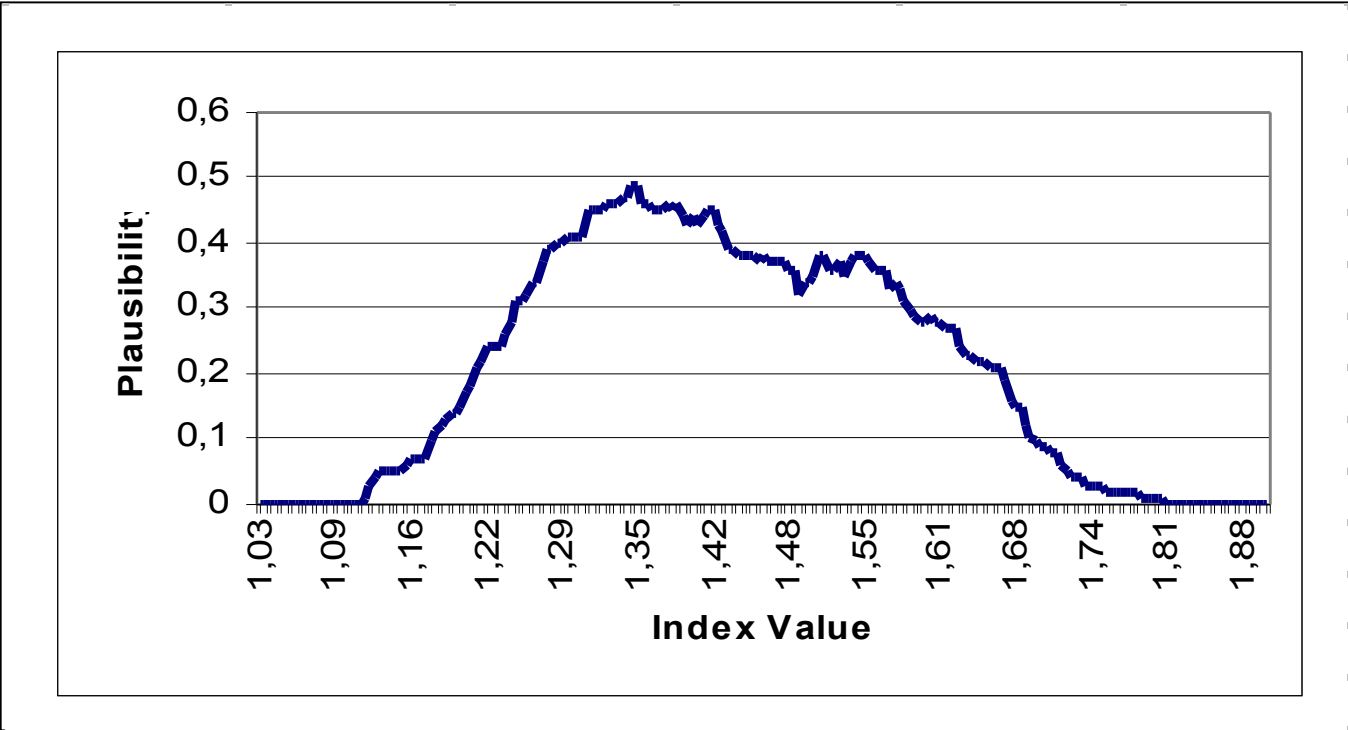


Fig 3. Membership function of a fuzzy gross output growth rate of the Russian economy according to the optimistic development scenario, with a fuzzy assignment of 6 major parameters with the variations range of 15%.

The level of stability is equal to 79,1% (plausibility degree of coincidence of sample and standard indices).





Second experiment

It was determined whether an event was plausible, that is whether the growth rate of gross output of the Russian economy would be equal to 143.6% (the most probable index value in the optimistic scenario) in the conditions when the size of fixed assets put into operation and labour productivity in the Dynamic Input-Output Model are presented fuzzily within the limits specified earlier. “The excitation” of the parameters grew from year to year as in the first experiment. Cases of a fuzzy fixed assets put in service and labour productivity were studied when these parameters deviated from the standard value by 10% and 20%. Similarly, the plausibility degree of achieving the growth rates of gross output of the first (144,4%) and second (142,0%) subdivisions was determined.

Table 5. Dependence of the gross output stability level of the Russian economy on the degree of variation in the description of fixed assets put in service and labour productivity

Index	10%	20%
Stability level for total gross output	93,9	56,0
Stability level for gross output of the 1 st subdivision	95,0	68,1
Stability level for gross output of the 2 nd subdivision	97,2	38,2



Third experiment

The next experiment consisted in the “excitation” of the rates of growth of materials output ratio. During five years, the growth rate of each element of materials output ratio matrix varied within the range of +/- 10% and +/- 20%.

Fig 4. Membership function of a fuzzy growth rate of gross output of the first subdivision of the Russian economy, according to the optimistic scenario of its development, with an fuzzy assignment of the dynamics of materials output ratio under the variations range of +/-10%.

The level of stability is equal to 88,7 % (plausibility degree of coincidence of sample and standard indices).

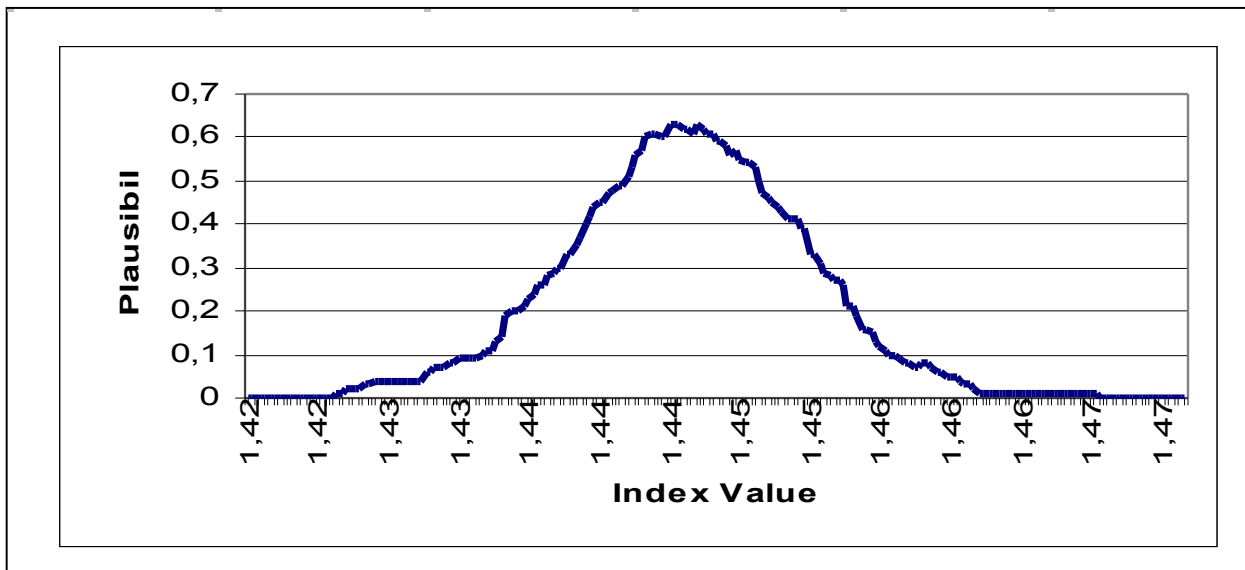
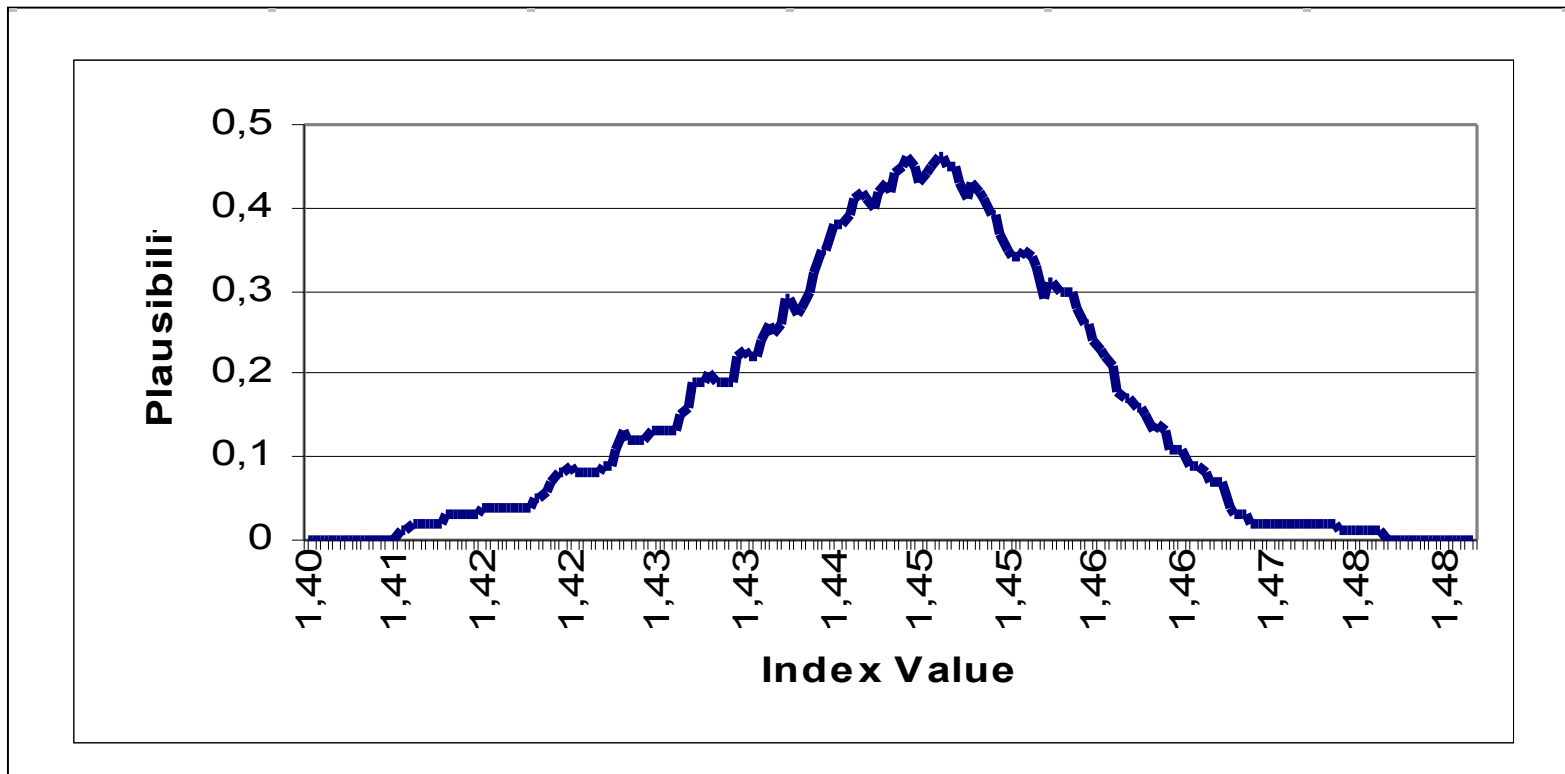




Fig 5. Membership function of a fuzzy growth rate of gross output of the first subdivision of the Russian economy, according to the optimistic scenario of its development, with a fuzzy assignment of the dynamics of materials output ratio under the variations range of +/-20%.

The level of stability is equal to 69.0 % (plausibility degree of coincidence of sample and standard indices).



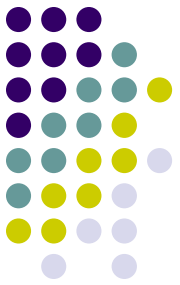
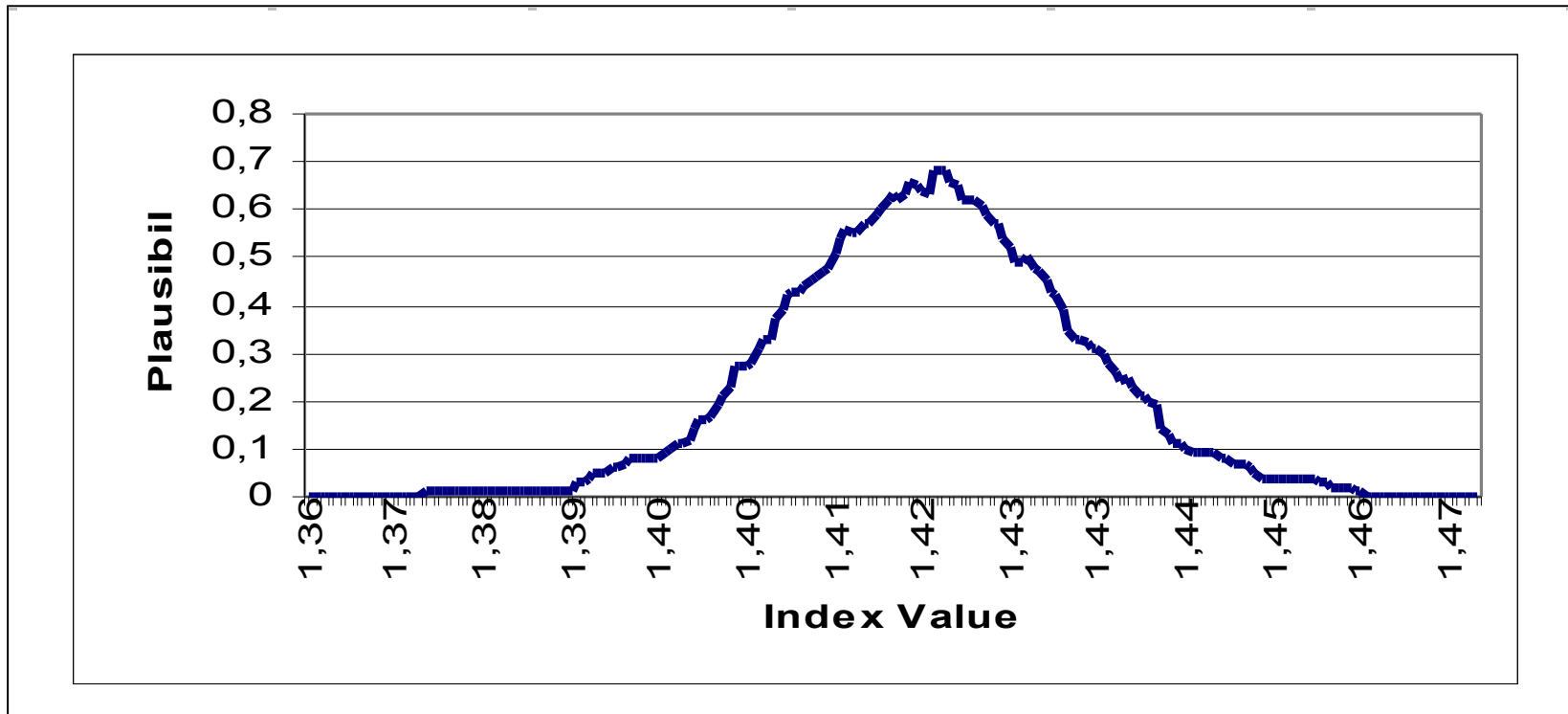


Fig 6. Membership function of a fuzzy growth rate of gross output of the second subdivision of the Russian economy, according to the optimistic scenario of its development, with a fuzzy assignment of the dynamics of materials output ratio under the variations range of +/- 10%.

The level of stability is equal to 89,5 % (plausibility degree of coincidence of sample and standard indices).



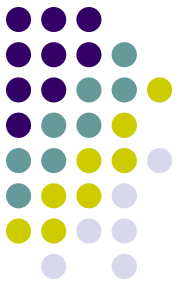
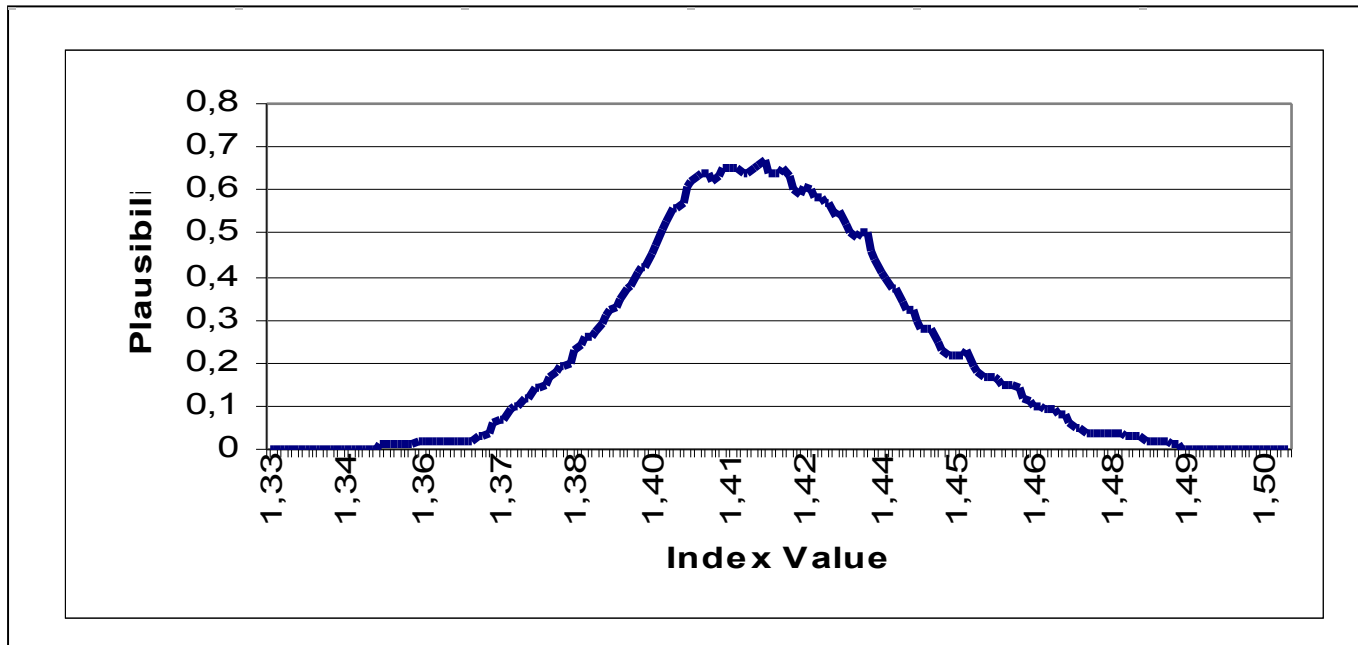


Fig 7. Membership function of a fuzzy growth rate of gross output of the second subdivision of the Russian economy, according to the optimistic scenario of its development, with a fuzzy assignment of the dynamics of materials output ratio under the variations range of +/-20%.

The level of stability is equal to 88,8 % (plausibility degree of coincidence of sample and standard indices).





Basic Conclusions

1. For the Russian economy to join the path of stable economic growth with a considerable (of at least two times) growth of GDP in 10 years (2008-2017) it is necessary to increase investments into fixed assets approximately two times in 2008-2012, including investments into the machines and equipment of at least 2.1 – 2.2 times.
2. The quantitative assessment of parameters of a rapid renewal of fixed assets show that the retirement compensation rate of fixed assets should grow from 1.2% in 2007 to 2.8% in 2012, while for the active part of fixed assets (machines and equipment) it should increase from 1.6 in 2007 to 4.9 in 2012.
3. The results of estimates based on the Dynamic Input-Output Model show that in the period 2008 – 2012 the gross output of asset-building sectors of the engineering industry and construction should grow at the rate of approximately 210 % and 180 % correspondingly. If it is not possible to provide such growth rates of asset-building sectors, there should be a considerable growth of import of machines and equipment, which will have negative consequences for balancing the balance of payments.
4. A fuzzy assignment of parameters for the Dynamic Input-Output Model and the computation of fuzzy values of projected indices can be interpreted as the assessment of stability of the computed fuzzy indices (gross output, fixed assets, etc.) in the conditions of a fuzzy description of model parameters.
5. A fuzzy description of growth rates of materials output ratio with different degrees of their “excitation” demonstrated a much greater resistance of the second subdivision to variations of this index in comparison with the first one.
6. A fuzzy description of the size of fixed assets put into service and labour productivity in the Dynamic Input-Output Model showed that in the projected period the economy of Russia demonstrates high instability if these parameters vary. It implies that sustainable economic growth that ensures a considerable improvement of the living standard of the population is possible only in the conditions of a stable renewal of fixed assets by means of providing high rates of fixed assets put in service leading to a marked increase of labour productivity.