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Forecasting of Human Capital Reproduction in Russia Using the Dynamic Input-Output Model

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1. A little bit from the history of the question ...

- Classics of analysis of human capital - American economists Theodore Schulz (Nobel Prize winner in economics 1979) and Gary Becker (Nobel Prize winner in economics 1992).

- Theodore Schultz was the first to formulate and use the concept of human capital in the 1950s. Under human capital, T. Schulz understood "the person's acquired personal values that can be strengthened by appropriate investments"

- T. Schultz distinguished types of human capital by types of investment in it (investments in school education, on-the-job training, investments in health care, etc.). He calculated the size of the total human capital of the United States by multiplying the value of the year of training of each level by the number of man-years of education accumulated by the population during the period under study (60s). Together with his students, he proved that for a long time the American economy received a higher income from human capital than from the material one.

- Gary Becker substantially developed the theory of human capital [3], developed the foundations of the theory of human capital for the micro level.

- Just like T. Schulz, G. Becker proposes to analyze the reproduction of human capital taking into account the investments directed into it. He considers human capital not only on the part of education: he is also noted as an important investment in health care, migration, etc. He considered human capital to be a stock of knowledge, skills and motivations.

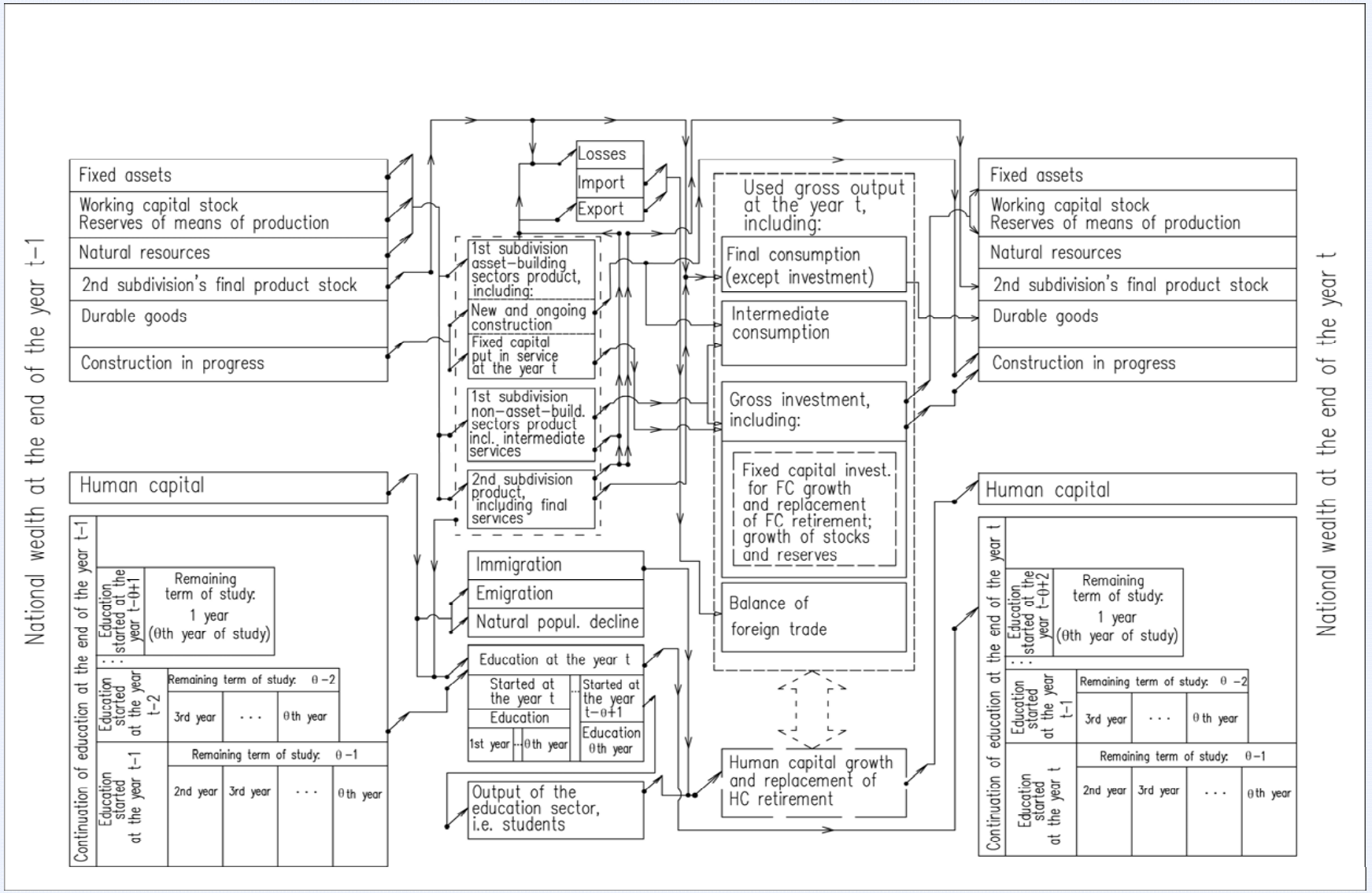
- Investments in human capital can bring returns, both to the investor himself and at the same time to the employee and any company where he will work. Depending on this, different schemes of financing investment in human capital can be constructed. By analogy with investments in fixed assets and the effect of its use in the form of positive financial flows, G. Becker in his studies discounted the investments in human capital and the effect of their use.

- The influence of human capital on economic growth has long been studied using macro-economic growth models - for example, the Uzawa-Lucas model and its modifications [4]. However, the possibilities of such models are limited to the analysis and forecasting of the consequences of investing in human capital at the macro level. The use of the DIOM apparatus opens the possibility of analyzing and predicting the structural consequences of building the human capital potential and its impact on the dynamics of the industries. The rationale for the macroeconomic consequences of investments in human capital in the DIOM is tied to the variation in the sectoral structure of production.

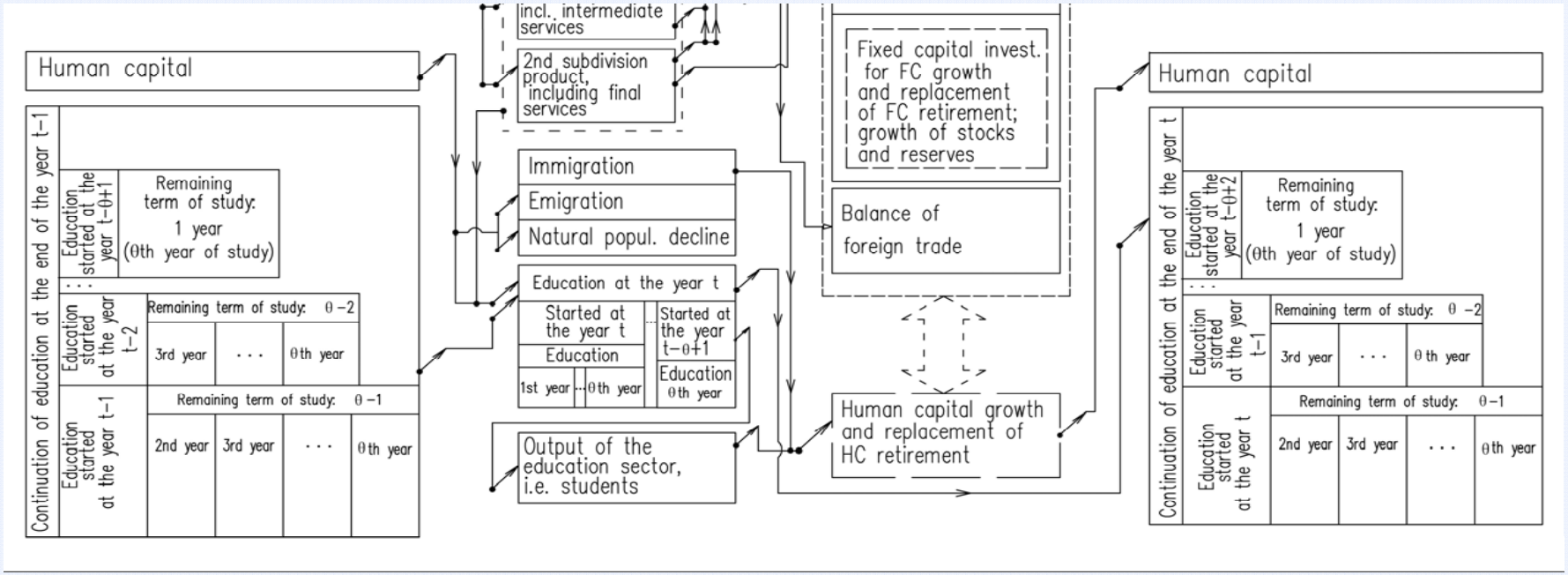
- When modeling the reproduction of human capital, can be used categories and corresponding indicators similar to investments in fixed assets, the fixed assets put in service, its replacement and depreciation rates. It is the idea that lies at the basis of constructing the DIOM with the human capital block [7].

- An analysis of the world economic literature shows that the work of creating a DIOM with a block of human capital was carried out by Chinese authors Hongxia Zhang and Xikang Chen-see [5], [6].

2. Scheme of National wealth reproduction



Scheme of National wealth reproduction (continuation)



3. Human capital and an expanded understanding of capital and accumulation

- Capital in the economy is the resources that can be used in the production of goods or the provision of services. In the classical economy, capital is one of the three factors of production; two others - land and work (British Encyclopedia).

- In classical political economy, "capital" usually means physical (real, productive) capital - means of production used for the production of goods and services: machinery, equipment, buildings, structures.

- Capital is not a thing, but a definite, social production relation, which is represented in a thing and gives this thing a specific social character. ("Capital," Karl Marx, vol. 1, Chapter 4, volume 3, Chapter 48).

- If we introduce the concept of human capital, the costs of its reproduction ensure its accumulation and replacement. Therefore, the products of economic activities forming it are transferred from the composition of expenditures for final consumption of the household and the state to the composition of accumulation. At the same time, the output of economic activities "Healthcare", "Education", "Culture" paid for by current accounts of firms (intermediate consumption), also forms human capital, but not at the expense of households and the state, but at the expense of companies. Therefore, in our opinion, it should also be attributed to accumulation.

- The redistribution of the output of "Healthcare", "Education", "Culture" from intermediate and final consumption in favor of gross accumulation changes the proportions between the elements of the gross output. Let's show this on the example of the Russian economy in 2015. The share of final consumption of households decreases most significantly from 37.7% to 32.5% of the total output produced. The share of intermediate consumption in the gross output is reduced insignificantly from 47.8% to 47.4%, since it accounts for only 9% of total economic activities in the form of human capital. The share of gross accumulation, including the accumulation of human capital, significantly increases compared with its traditional understanding - from 12.7% to 18.4% or about a third (see Table 1).

Table 1. Proportions of the gross output of the Russian economy in 2015
Source: Rosstat data [8], P. 22-25, authors' calculations

	Gross Output	Intermediate consumption	Final consumption	Gross accumulation	Net export
National accounts data, %, bln. Rub.	144 739,6	69 242,0	54 498,7	18 453,4	2 545,6
Structure, %	100,0	47,8	37,7	12,7	1,8
Data taking into account the cost of human capital, bln.rub.	144 739,6	68 534,3	46 976,8	26 682,9	2 545,6
Structure, %	100,0	47,4	32,5	18,4	1,8

Enhanced understanding of accumulation

- A look at "Healthcare", "Education", "Culture" as an industries that ensures the reproduction of human capital, leads to a *rethinking of the concept of "accumulation" at the macroeconomic level.*

- The intuitive understanding that "people decide everything" leads to the realization of the fact that the *main accumulation of society is investment in human capital.* Without people, their knowledge and experience, all fixed assets are a useless heap of iron, machinery, stones, pipes, etc.

- The costs of education, culture, public health are not current consumption, but the formation of a reserve for the future. With a reduction of the share of expenditures for these purposes in GDP, the basics of the development of society in the future are undermined. With an increase in the share of GDP directed to these goals, the best prospects for economic growth and, ultimately, the increase in people's welfare, are opened. Therefore, *when we determine the total amount of accumulation in the economy, it is necessary to include in it the costs of training, nurturing of people and maintaining people's health.* These costs determine the dynamics of economic development in the future to a decisive degree.

- It seems useful at the macro level to calculate the amount of accumulation in two ways. The first way is traditional. It includes in the accumulation the costs of reproduction of fixed capital and the increment of inventories of material working capital. *The second is the calculation of accumulation by the traditional method plus all the society's costs of education, culture and healthcare, that is, the costs of accumulating human capital.* In our opinion, the second approach to the definition of accumulation will allow to more accurately separate the costs of society for current consumption and its costs for the future.

- The calculation of the rate of GDP accumulation is also useful in two ways. The first is the ratio of traditionally understood accumulation to GDP, the second is the ratio of the expanded value of accumulation, including the accumulation of human capital, to GDP.

Table 2. The share of accumulation in GDP in the traditional sense and accumulation, taking into account the cost of human capital, in the GDP of some of the world's leading countries in 2013

	GDP	Accumulation of fixed assets and working capital increase	Expenditure on education and health care	The ratio of expenditure on human capital in GDP, %	The ratio of gross accumulation to GDP,%	The ratio of gross accumulation + expenditure on human capital to GDP, %
	1	2	3	4(3/1)	5(2/1)	6 (4+5)
USA, bln.$US	16691,5	3298,6	4673,6	28,0	19,8	47,8
China, bln. Yuan	58973,7	27417,7	6203,4	10,5	46,5	57,0
Russia, bln. Rub.	73133,9	16915,8	6421,8	8,8	23,1	31,9
Gemany, bln. $US	3752,5	732,2	765,5	20,4	19,5	39,9
Brasil, bln. $US.	2472,8	536,4	482,2	19,5	21,7	41,2

Sources: http://www.gks.ru/free_doc/new_site/vvp/vvp-god/tab24.htm ,

https://data.oecd.org/eduresource/private-spending-on-education.htm#indicator-chart

https://data.oecd.org/eduresource/public-spending-on-education.htm#indicator-chart

https://data.worldbank.org/indicator/SH.XPD.TOTL.ZS?locations=BR-CA-US

http://www.stats.gov.cn/tjsj/ndsj/2013/indexeh.htm

4. Results of experimental calculations for forecasting the development of the Russian economy using the DIOM with the human capital block

- The investment lag of investment in human capital is significant. In higher education (taking into account schooling) - 16 years. In health care and culture, it is difficult to assess it. The weighted average investment lag, determined by various methods for investment in human capital in Russia, is 7 years.

- In this regard, to determine the impact of changes in investment in human capital, there is a need to predict the development of the economy in the long term - for a period of 20-30 years. This raises the need to address a number of methodological problems of information support for the DIOM.

$$productiv = 53{,}3 + 0{,}11 \cdot invHC + 0{,}36 \cdot invFC$$

Variable	Coefficient	Standard error	t-statistics	p-value
invHC	0,11	0,046	2,41	0,025
invFC	0,36	0,064	5,68	0,000
Constant	53,3	5,26	10,14	0,000
Adjusted $R^2 = 0{,}79$		F(2, 21) = 43,12 (p-value 0,00)		
DW = 2,02				

Average annual growth rate for scenarios	**Basic**	**Optimistic**	**Pessimistic**
Fixed capital investment	103,9	104,6	101,8
Human capital investment	104,7	108,0	101,7
Forecast of average annual growth rate of productivity, %	103,3	103,9	102,2

Figure 1. Dynamics of investments in the human capital in Russia in 1992 - 2016, billion rubles, comparable prices of 2015.

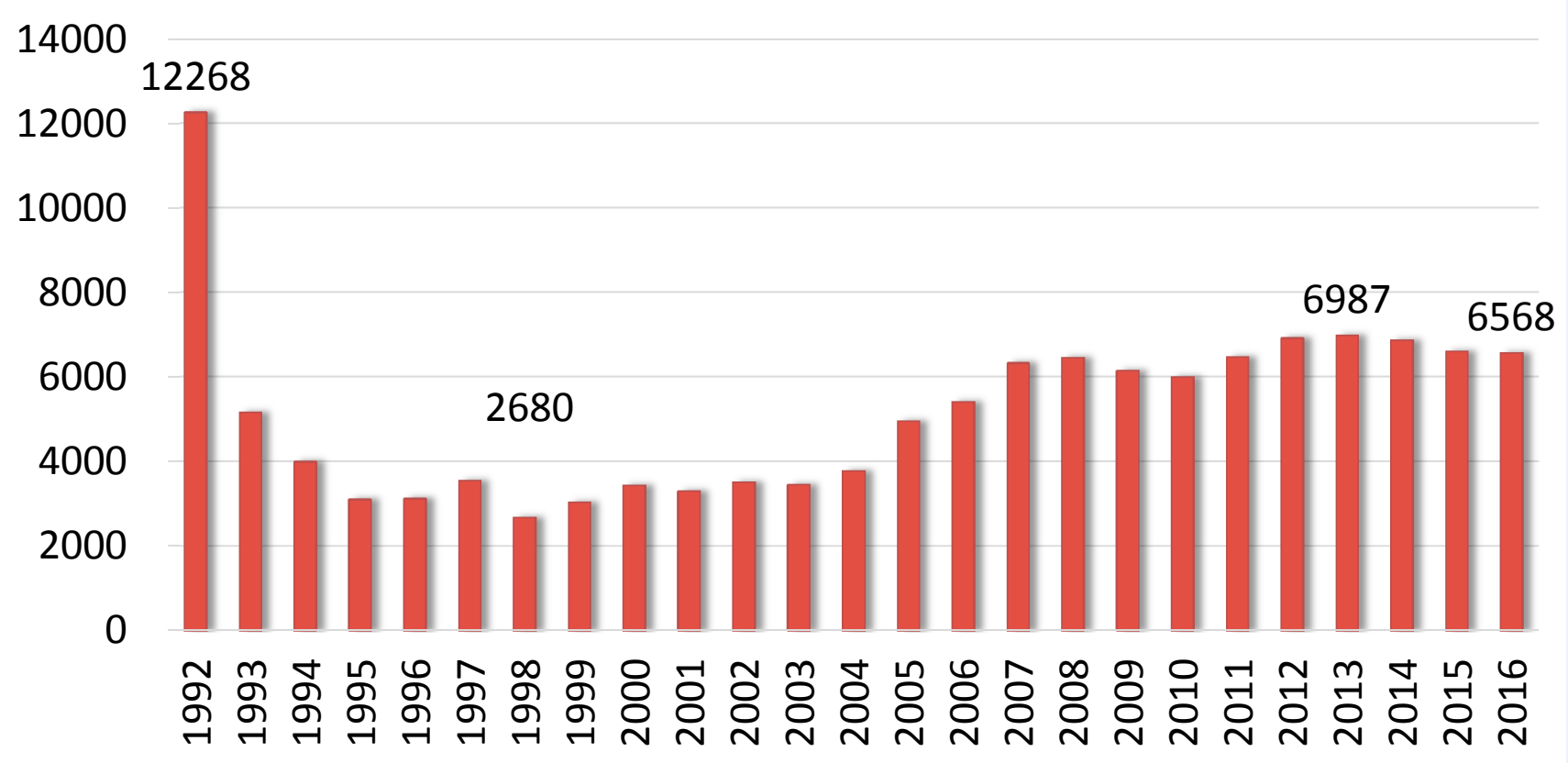


Figure 2. Dynamics of investments in human capital and human capital put in service in Russia in 2008 - 2016, billion rubles, comparable prices of 2015.

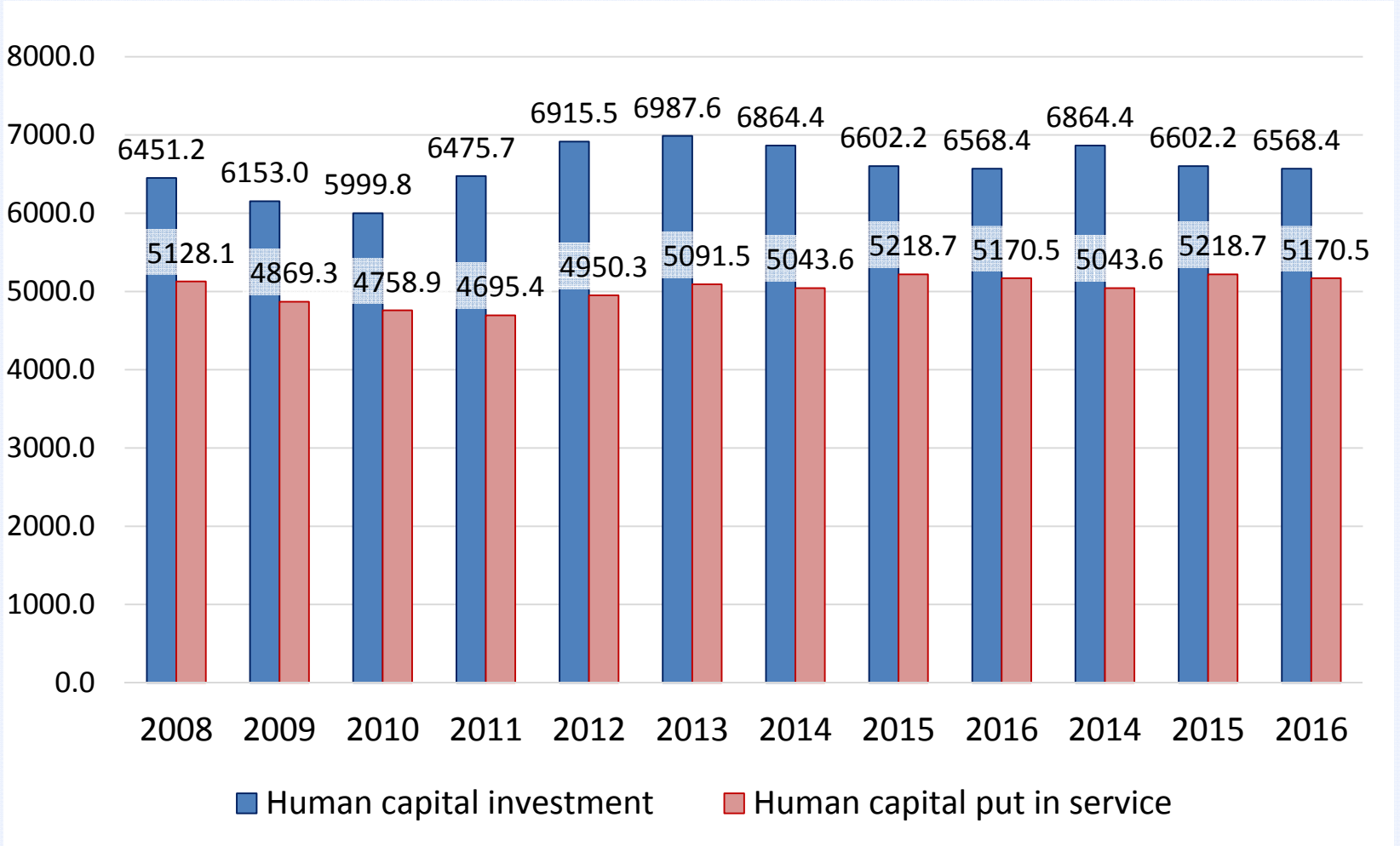


Figure 3. Dynamics of human capital in Russia in 2008 - 2016, billion rubles, comparable prices of 2015.

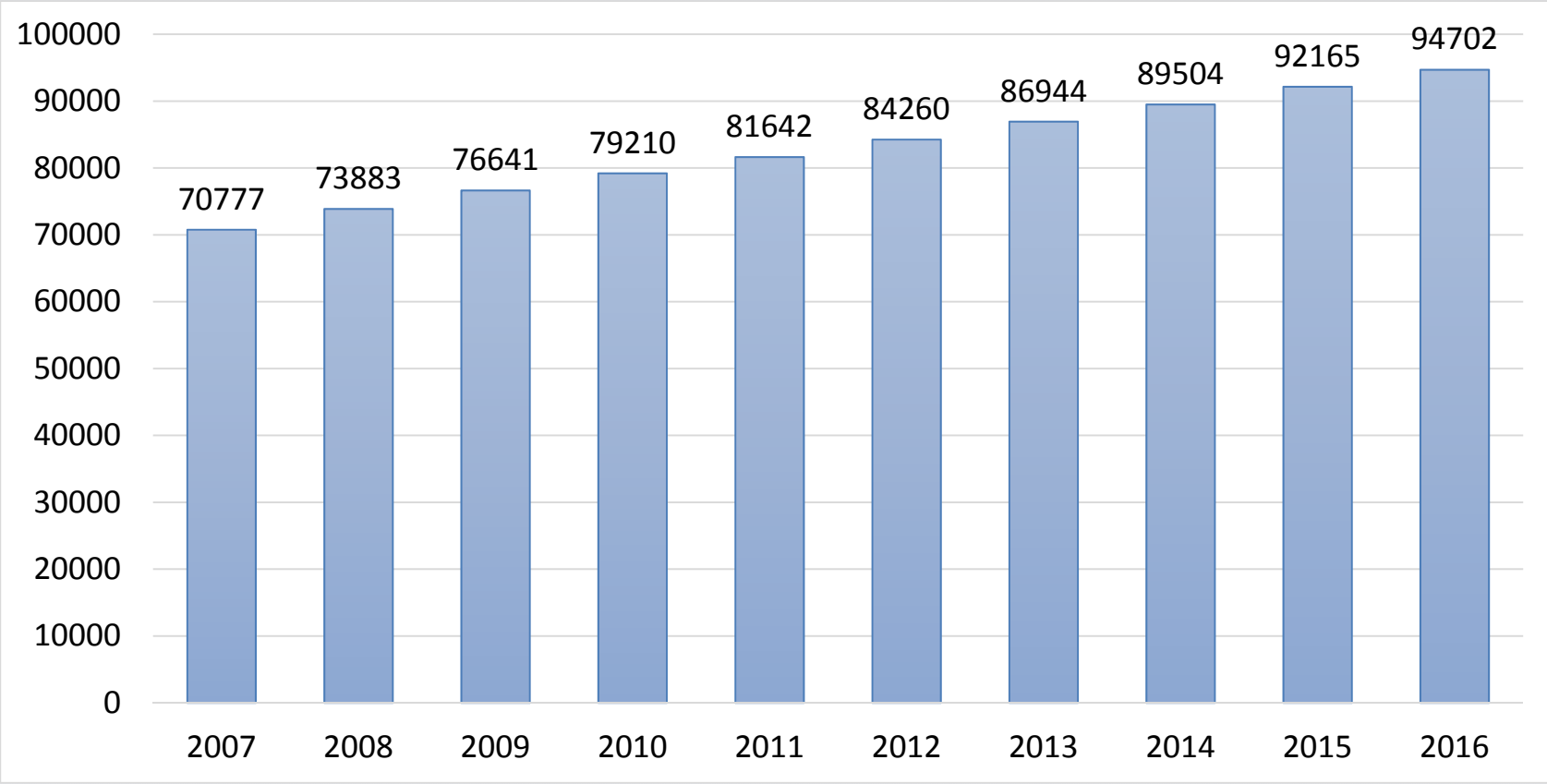


Figure 4. The projected average annual growth rate of investment in human capital in Russia in 2016-2045 by variants,%

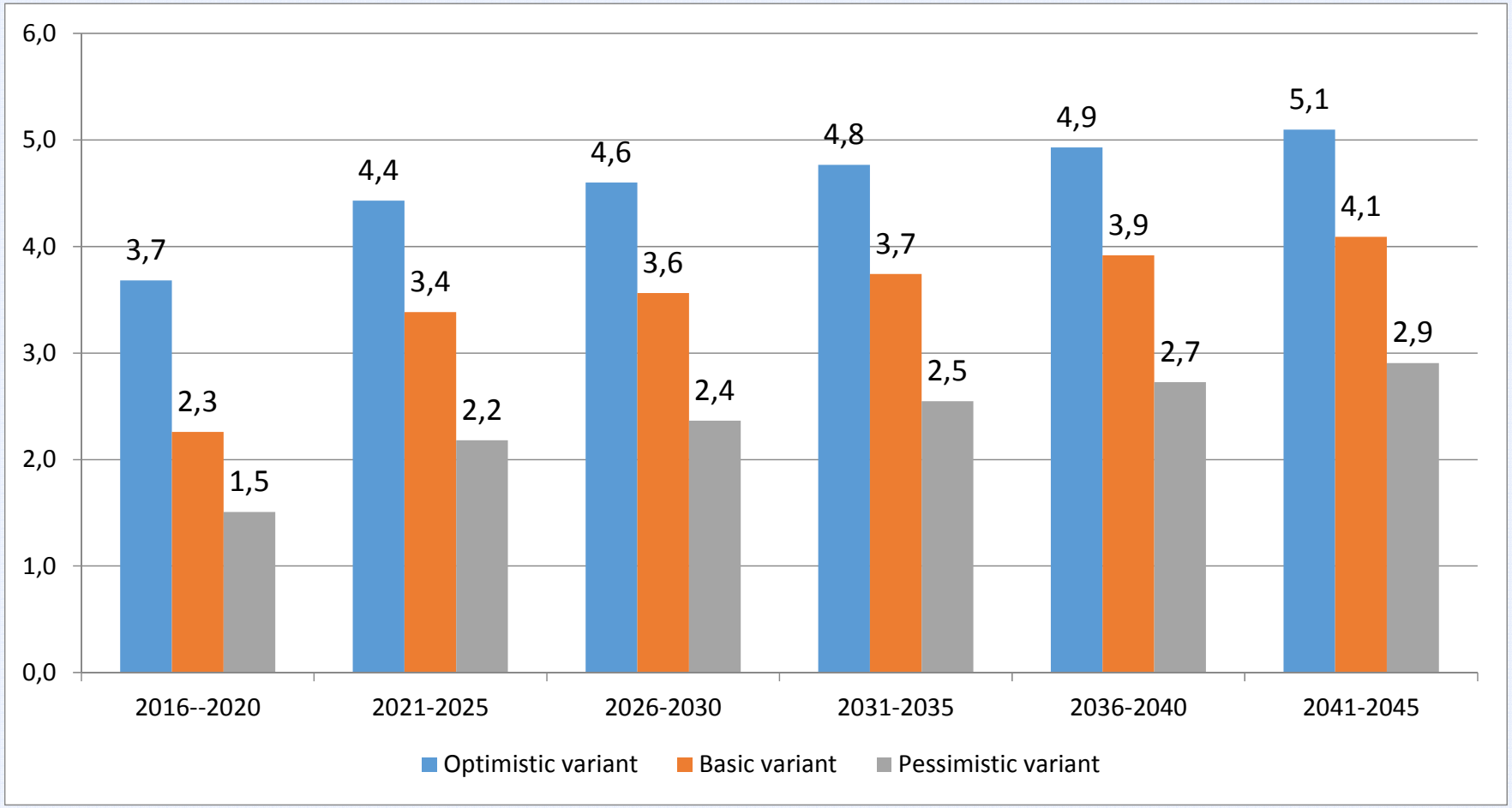


Table 3. Average annual growth rates of GDP, investment in human capital and a human capital in 2016-2045, %.

Results of authors' calculations using the DIOM with the human capital block

	2016--2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	Total 2016-2045	Increase in the growth rate of GDP per unit of growth rate of investment in human capital for the entire period 2016-2045
GDP								
Optimistic variant	3,7	4,4	4,6	4,8	4,9	5,1	4,6	0,7
Basic variant	2,3	3,4	3,6	3,7	3,9	4,1	3,5	0,9
Pessimistic variant	1,5	2,2	2,4	2,5	2,7	2,9	2,4	1,2
Investment to human capital								
Optimistic variant	3,6	7,0	7,0	7,1	7,1	7,1	6,5	
Basic variant	2,0	4,0	4,0	4,0	4,0	4,0	3,7	
Pessimistic variant	1,1	2,2	2,2	2,2	2,2	2,2	2,0	
Human capital								
Optimistic variant	2,5	3,6	4,7	5,7	6,5	7,1	5,0	
Basic variant	2,3	2,7	3,1	3,5	3,7	3,9	3,2	
Pessimistic variant	2,1	2,2	2,2	2,2	2,2	2,1	2,2	

Table 4. Average annual growth rate of GDP and a Human capital, %

	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	**2016-2045**
GDP							
Optimistic variant	3,7	4,4	4,6	4,8	4,9	5,1	**4,6**
Basic variant	2,3	3,4	3,6	3,7	3,9	4,1	**3,5**
Pessimistic variant	1,5	2,2	2,4	2,5	2,7	2,9	**2,4**
Human capital							
Optimistic variant	2,5	3,6	4,7	5,7	6,5	7,1	**5,0**
Basic variant	2,3	2,7	3,1	3,5	3,7	3,9	**3,2**
Pessimistic variant	2,1	2,2	2,2	2,2	2,2	2,1	**2,2**

Figure 5. Average annual projected rates of GDP growth in 2016-2045 by variants, %

Results of authors' calculations using the DIOM with the human capital block

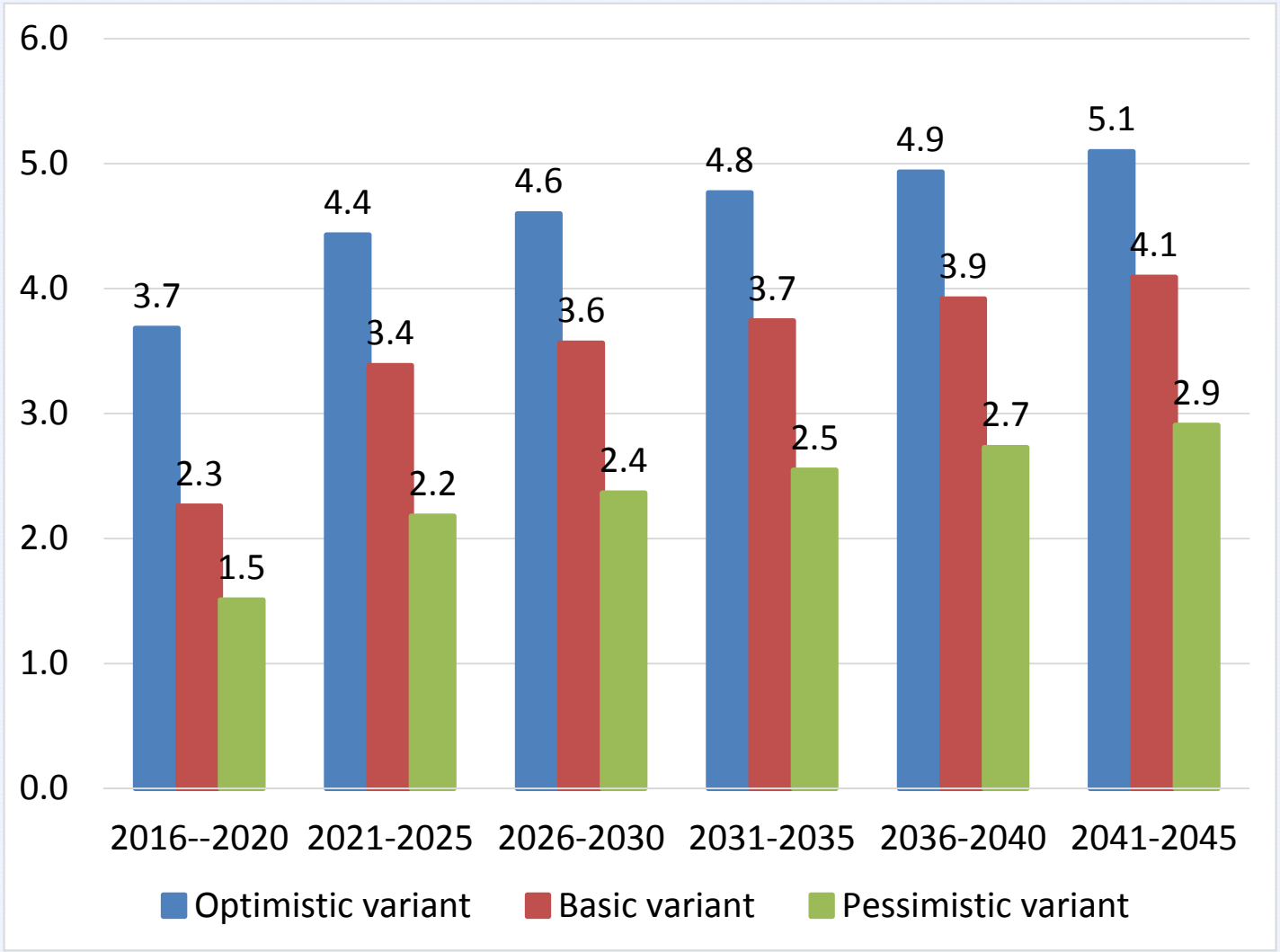


Figure 6. The average annual growth rate of labor productivity in the Russian economy in 2016 - 2045 (by gross output),%

Results of authors' calculations using the DIOM with the human capital block

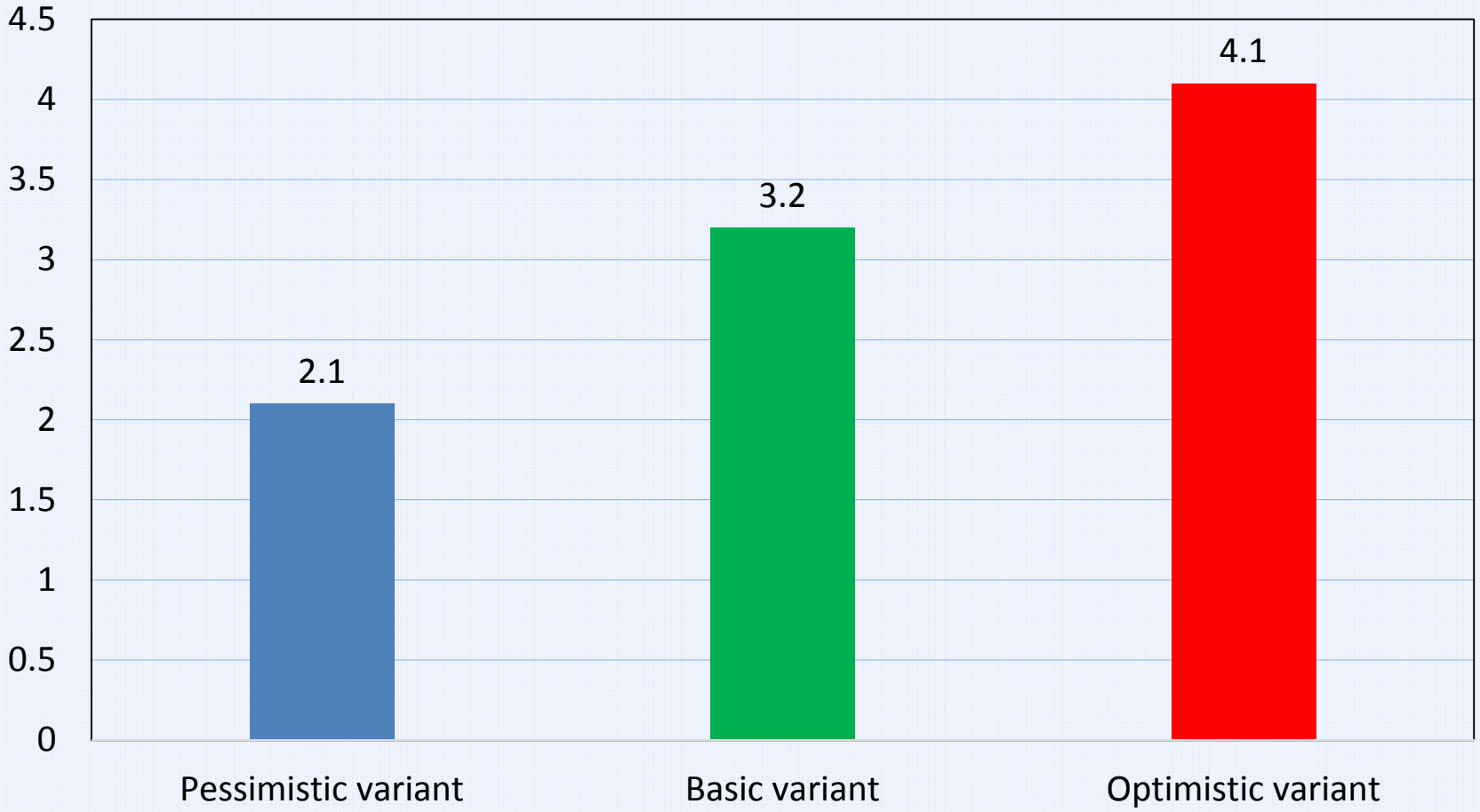


Table 5. Average annual growth rates of gross output by industry by variants in 2016-2045,%

	Basic scenario	Optimistic scenario	Pessimistic scenario
1. Manufacture of machinery and equipment	3.2	5.9	1.5
2. Construction of buildings and structures	2.8	5.5	1.1
3. Branch of formation of the human capital	3.6	6.0	2.2
4. Agriculture, hunting and forestry, fishing and fish farming	4.0	4.0	2.9
5. Gas extraction	1.5	1.4	0.8
6. Oil extraction	1.2	1.1	0.6
7. Extraction of other fuel and energy minerals	1.6	1.9	0.8
8. Extraction of minerals, except for fuel and energy	2.0	3.0	0.9
9. Manufacture of food products and tobacco	4.1	4.3	3.0
10. Textile and clothing manufacture. Manufacture of leather, leather goods and footwear	5.1	5.7	3.7

Table 5 – continuation. Average annual growth rates of gross output by industry by variants in 2016-2045,%

	Basic scenario	Optimistic scenario	Pessimistic scenario
11. Wood processing and production of wood products. Pulp and paper industry, publishing and printing activities	3.1	3.6	2.0
12. Manufacture of coke	2.6	2.9	1.6
13. Production of petroleum products	1.9	2.2	1.2
14. Chemical production. Manufacture of rubber and plastic products	3.6	4.5	2.3
15. Manufacture of other non-metallic mineral products (building materials)	3.0	4.8	1.5
16. Manufacture of ferrous metals	2.2	3.4	1.0
17. Manufacture of non-ferrous metals	2.0	3.5	0.8
18. Manufacture of fabricated metal products	3.6	5.4	1.9
19. Mechanical engineering non-fund forming (production of spare parts, weapons, etc.)	2.9	4.0	1.6
20. Other production	3.3	3.8	2.1

Table 5 – continuation. Average annual growth rates of gross output by industry by variants in 2016-2045,%

	Basic scenario	Optimistic scenario	Pessimistic scenario
21. Production and distribution of electricity, gas and water	3.2	3.5	2.1
22. Collection, purification and distribution of water	3.3	3.7	2.2
23. Non-fund forming construction (production of current repair of buildings and structures)	3.1	3.9	1.9
24.Wholesale and retail trade, repair, hotels and restaurants	3.5	3.9	2.4
25. Transport	3.0	3.2	2.0
26. Communication	4.0	4.2	2.9
27. Financial activities	3.5	3.8	2.4
28. Operations with real estate, renting and provision of services (with the exception of R & D)	3.6	3.9	2.6
29. Public administration and military security. Social Security	4.0	4.2	3.0
30. Research and Development	3.4	3.7	2.3
31. Provision of other communal, social and personal services	3.7	4.0	2.5

Table 6. Change in average annual growth rates increase by industry in 2016-2045,%.

	Optimistic - basic	Pessimistic - Basic
1. Manufacture of machinery and equipment	2.7	-1.7
2. Construction of buildings and structures	2.8	-1.7
3. Branch of formation of the human capital	2.4	-1.4
4. Agriculture, hunting and forestry, fishing and fish farming	0.0	-1.1
5. Gas extraction	-0.1	-0.6
6. Oil extraction	0.0	-0.5
7. Extraction of other fuel and energy minerals	0.3	-0.8
8. Extraction of minerals, except for fuel and energy	1.0	-1.1
9. Manufacture of food products and tobacco	0.2	-1.1
10. Textile and clothing manufacture. Manufacture of leather, leather goods and footwear	0.6	-1.4

Table 6 – continuation. Change in average annual growth rates increase by industry in 2016-2045,%.

	Optimistic - basic	Pessimistic - Basic
11. Wood processing and production of wood products. Pulp and paper industry, publishing and printing activities	0.5	-1.1
12. Manufacture of coke	0.3	-1.0
13. Production of petroleum products	0.3	-0.7
14. Chemical production. Manufacture of rubber and plastic products	0.8	-1.3
15. Manufacture of other non-metallic mineral products (building materials)	1.8	-1.5
16. Manufacture of ferrous metals	1.2	-1.2
17. Manufacture of non-ferrous metals	1.5	-1.2
18. Manufacture of fabricated metal products	1.8	-1.7
19. Mechanical engineering non-fund forming (production of spare parts, weapons, etc.)	1.1	-1.3
20.Other production	0.5	-1.2

Table 6 – continuation. Change in average annual growth rates increase by industry in 2016-2045,%.

	Optimistic - basic	Pessimistic - Basic
21. Production and distribution of electricity, gas and water	0.3	-1.1
22. Collection, purification and distribution of water	0.4	-1.1
23. Non-fund forming construction (production of current repair of buildings and structures)	0.8	-1.2
24.Wholesale and retail trade, repair, hotels and restaurants	0.4	-1.0
25. Transport	0.2	-1.0
26. Communication	0.2	-1.1
27. Financial activities	0.3	-1.1
28. Operations with real estate, renting and provision of services (with the exception of R & D)	0.2	-1.0
29. Public administration and military security. Social Security	0.3	-1.0
30. Research and Development	0.3	-1.1
31. Provision of other communal, social and personal services	0.4	-1.1

Table 7. Changes in the structure of the gross output by variants for the period 2016-2045

	2015, %	2045, %			Difference between 2045 and 2015, percentage points		
		Basic variant	Optimistic variant	Pessimistic variant	Basic variant	Optimistic variant	Pessimistic variant
1. Manufacture of machinery and equipment	3.2	3.1	5.4	2.6	-0.1	2.2	-0.6
2. Construction of buildings and structures	6.5	5.6	9.8	4.8	-0.9	3.3	-1.7
3. Branch of formation of the human capital	5.7	6.3	9.8	5.8	0.6	4.2	0.1
4. Agriculture, hunting and forestry, fishing and fish farming	4.4	5.4	4.2	5.5	1.0	-0.1	1.1
5. Gas extraction	0.8	0.5	0.4	0.5	-0.3	-0.4	-0.2
6. Oil extraction	5.4	2.9	2.3	3.5	-2.5	-3.1	-1.9
7. Extraction of other fuel and energy minerals	0.6	0.3	0.3	0.4	-0.2	-0.3	-0.2
8. Extraction of minerals, except for fuel and energy	0.8	0.5	0.6	0.5	-0.2	-0.2	-0.2

Table 7 - continuation. Changes in the structure of the gross output by variants for the period 2016-2045

	2015, %	2045, %			Difference between 2045 and 2015, percentage points		
		Basic variant	Optimistic variant	Pessimistic variant	Basic variant	Optimistic variant	Pessimistic variant
9. Manufacture of food products and tobacco	4.6	5.9	4.9	6.0	1.3	0.3	1.4
10. Textile and clothing manufacture...	0.3	0.6	0.6	0.6	0.2	0.2	0.2
11. Wood processing and production of wood products.	0.9	0.8	0.8	0.8	0.0	-0.1	0.0
12. Manufacture of coke	0.1	0.1	0.1	0.1	0.0	0.0	0.0
13. Production of petroleum products	4.8	3.3	2.8	3.6	-1.6	-2.1	-1.2
14. Chemical production. Manufacture of rubber and plastic products	2.5	2.8	2.8	2.6	0.3	0.3	0.1
15. Manufacture of other non-metallic mineral products (building materials)	1.0	0.9	1.2	0.8	-0.1	0.2	-0.2

Table 7 - continuation. Changes in the structure of the gross output by variants for the period 2016-2045

	2015	2045			Difference between 2045 and 2015		
		Basic variant	Optimistic variant	Pessimistic variant	Basic variant	Optimistic variant	Pessimistic variant
16. Manufacture of ferrous metals	2.2	1.6	1.8	1.6	-0.6	-0.4	-0.6
17. Manufacture of non-ferrous metals	1.3	0.9	1.1	0.9	-0.4	-0.2	-0.4
18. Manufacture of fabricated metal products	0.8	0.9	1.2	0.7	0.1	0.4	-0.1
19. Mechanical engineering non-fund forming (production of spare parts, weapons, etc.)	2.4	2.2	2.4	2.1	-0.2	0.0	-0.4
20.Other production	0.9	1.0	0.9	1.0	0.0	-0.1	0.0
21. Production and distribution of electricity, gas and water	4.8	4.7	4.0	4.7	-0.1	-0.7	-0.1
22. Collection, purification and distribution of water	0.2	0.2	0.2	0.2	0.0	0.0	0.0
23. Non-fund forming construction (production of current repair of buildings and structures)	0.4	0.4	0.4	0.4	0.0	0.0	0.0

Table 7 - continuation. Changes in the structure of the gross output by variants for the period 2016-2045

	2015	2045			Difference between 2045 and 2015		
		Basic variant	Optimistic variant	Pessimistic variant	Basic variant	Optimistic variant	Pessimistic variant
24.Wholesale and retail trade, repair, hotels and restaurants	15.0	16.0	14.1	16.5	1.0	-1.0	1.4
25. Transport	7.0	6.4	5.4	6.7	-0.5	-1.6	-0.3
26. Communication	1.3	1.7	1.4	1.7	0.3	0.1	0.3
27. Financial activities	2.9	3.2	2.7	3.2	0.2	-0.2	0.3
28. Operations with real estate, renting and provision of services (with the exception of R & D)	7.0	7.8	6.6	8.0	0.8	-0.4	1.0
29. Public administration and military security. Social Security	5.8	7.2	6.1	7.4	1.3	0.3	1.6
30. Research and Development	2.4	2.5	2.1	2.5	0.1	-0.3	0.1
31. Provision of other communal, social and personal services	3.9	4.3	3.8	4.3	0.5	-0.1	0.5

Brief conclusions on the results of predictive calculations using the DIOM with the human capital block

1) The accelerated growth rate of human capital in basic and optimistic variants leads to an increase in the gross output the share of industries that form human capital (education, healthcare, culture), food industry, textile, sewing and leather-shoe industries, chemical industry, construction materials industry, communications, public administration and security services.
2) Simultaneously, the share of all mining industries, production and processing of wood, ferrous and non-ferrous metallurgy, non-fund-producing branches of engineering and construction, production and distribution of electricity, gas and water, as well as transport, is declining.
3) Accelerated investments in human capital lead to a significant acceleration of labor productivity growth rate, the formation of a more diversified structure of production in the Russian economy - an increase of the share of services in a gross output and a number of industries directly providing for the needs of the population, as well as a reduction of the share of mining industries.

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THANK YOU