УДК 336.4:657.421.3:33

ESTIMATION AND FORECASTING OF THE VALUE OF NATIONAL INTELLECTUAL CAPITAL OF UKRAINE IN TERMS OF STRUCTURAL AND INNOVATIVE TRANSFORMATIONS

ОЦІНЮВАННЯ І ПРОГНОЗУВАННЯ ВАРТОСТІ ІНТЕЛЕКТУАЛЬНОГО КАПІТАЛУ НАЦІОНАЛЬНОЇ ЕКОНОМІКИ УКРАЇНИ В УМОВАХ СТРУКТУРНО-ІННОВАЦІЙНИХ ТРАНСФОРМАЦІЙ

Tetiana Sergiivna CHERKASHYNA
PhD (Economics), Associate Professor, Department of Political Economy
Simon Kuznets Kharkiv National University of Economics
E-mail: t.cherkashina@hotmail.com

Анотація. *Дослідженням встановлено, що в сучасній науці існують три основні групи методів визначення вартості інтелектуального капіталу національної економіки: методи прямого вимірювання (або витратні методи), методи ринкової капіталізації та методи нефінансової оцінки. Доведено, що найбільш доцільними для оцінювання вартості інтелектуального капіталу національної економіки в умовах структурно-інноваційних трансформацій є витратні методи, сутність яких полягає у тому, що вартість інтелектуального капіталу національної економіки розраховується як сума витрат основних макроекономічних суб'єктів (держави, підприємств, домогосподарств, зовнішньоекономічного сектора) на його формування, накопичення, використання і розвиток. Розраховано вартість інтелектуального капіталу національної економіки України у 2010-2016 рр. і на цій основі побудовано економетричну модель апроксимілюючої функції зростання вартості інтелектуального капіталу України, яка статистично підтвердила і поглибила гіпотезу автора про наявність тенденції (тренду) його збільшення.*

Аннотация. *Исследованием установлено, что в современной науке существуют три основные группы методов определения стоимости интеллектуального капитала национальной экономики: методы прямого измерения (или затратные методы), методы рыночной капитализации и методы нефинансовой оценки. Доказано, что наиболее целесообразными для определения стоимости интеллектуального капитала национальной экономики в условиях структурно-инновационных преобразований являются затратные методы, сущность которых состоит в том, что стоимость интеллектуального капитала рассчитывается как сумма затрат основных макроэкономических субъектов (государства, предприятий, домохозяйств, внешнеэкономического сектора) на его формирование, накопление, использование и развитие. Рассчитана стоимость интеллектуального капитала национальной экономики Украины в 2010-2016 гг. и на этой основе построена прогнозная эконометрическая модель, которая статистически подтвердила гипотезу автора о существовании тенденции (тренда) увеличения стоимости интеллектуального капитала Украины.*

Ключові слова: *інтелектуальний капітал, інтелектуальний потенціал, інтелектуальна власність, національна економіка, державні витрати, інноваційна діяльність, структурно-інноваційні трансформації.*

Ключевые слова: *интеллектуальный капитал, интеллектуальный потенциал, интеллектуальная собственность, национальная экономика, государственные расходы, инновационная деятельность, структурно-инновационные преобразования.*

Statement of the problem. Research of state and trends of the macroeconomic systems development in a globalised and strongly competitive world shows that the level of macroeconomic development mainly depends on intellectual capital that, in turn, causes to use a new models of using a labor force and to focus on intellectual capital development, its continuous improvement and advanced training. As

a consequence, the role of intellectual resources in the process of public production is becoming enormously important. For this reason, investigations devoted to the formation of national intellectual capital, the accumulation, the using, the estimation as well as the development is an actual scientific and practical task.

Analysis of recent researches and publications. The problems related to the formation of national intellectual capital, its accumulation, using, estimation, and the development have been quite broadly covered in economic literature represented by the works both foreign and Ukrainian scientists. For instance, such outstanding foreign economists as S. Alexander, A. Buracas [2], D. Andriessen [1], N. Bonis, D. Ernst, C. Lin [3], T. Lin, I. Lopes [2], E. Pasher, J. Pomeda, S. Shachar, C. Stam [1], I. Young, A. Zvirblis [2] calculated the national intellectual capital of Izrael, Luxemburgh, Malaysia, New Zeland, Spain, Taiwan using mainly using quantitative macroeconomic indexes. On the other hand, R. Aleknaviciute [4], N. Gunchak [9], A. Karpenko, I. Karshin, I. Macerinskiene [4], M. Ovchinnikov, P. M. Sanchez [5], O. Sukhai [9], G. Vaganyan, L. Tumyan, T. Vasilkiv [9], E. Vashurina propose to estimate the national intellectual capital using both quantitative and qualitative indexes characterizing the level of national intellectualization. From this point of view, G. Vaganyan and L. Tumyan calculated the national intellectual capital of Brazil, Russia, India, China, South Africa belonging to the BRICS using so called "balanced indicator system". At the same time, O. Grishnova, Y. Malhotra, K. Marcin, D. Sedlyar, P. Stahle [6], S. Stahle [6] propose to determine aggregate indicators for each component of intellectual capital and, on its basis, to estimate the integral index of national intellectual capital. In the meantime, V. Allee, T. Baulina [8], L. Chagovets, J. Chen, L. Edvinsson [3], O. Panasenko, D. Weziak try to solve the problems of national intellectual capital forecasting. Despite the fact that all abovementioned scientists have considerably contributed to the research of the stated problem, there is a need to carry out further investigations related to the estimation and the forecasting of the value of national intellectual capital in terms of structural and innovative transformations.

Setting objectives. The purpose of this paper is to form the set of expenditure determining the value of national intellectual capital in terms of structural and innovative transformations in order to calculate the value of national intellectual capital of Ukraine in such terms and, on its basis, to forecast its trend.

Methodology. Investigation of the value of national intellectual capital and its forecasting has been implemented by the following steps (graph 1).

As graph 1 shows, first of all, it was estimated the value of national intellectual capital of Ukraine. Detailed study of the literature [1-9] and author's preliminary scientific investigations showed that modern researchers distinguish several groups of methods estimating the value of national intellectual capital:

1) those which directly measure the intellectual capital (IC-dVAL Aproach, Intellectual Asset Valuation, HR Statement, National Intellectual Property, Science Technology and Industry Outlook, The Value Explorer, etc.);

2) those within the scope of market capitalization of intellectual capital (Intellectual Capital Monitor, etc.);
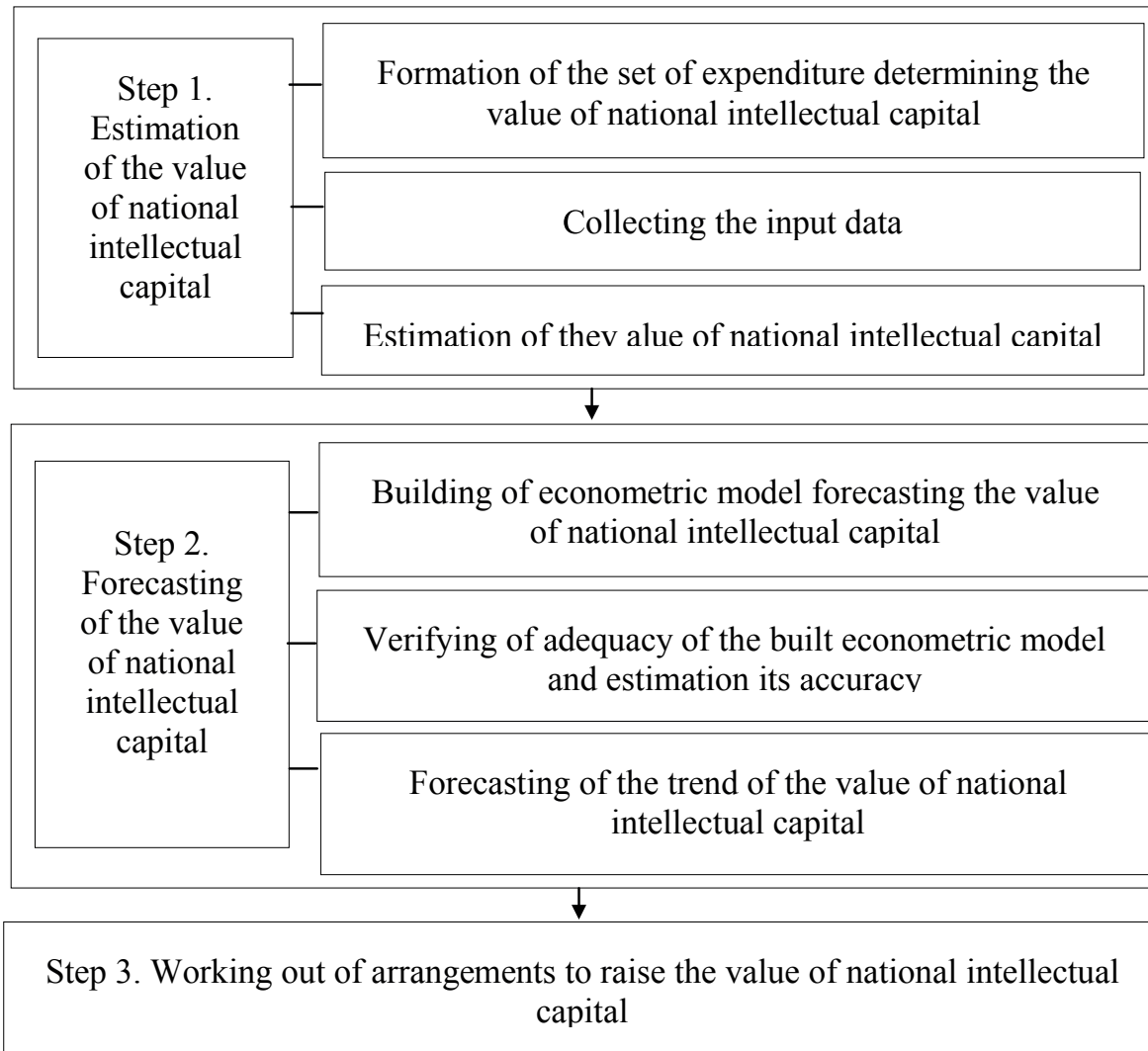
3) those within the scope of non-monetary estimation of intellectual capital (IC-Index, Intangible Assets Monitor, Knowledge Assessment Methodology, Innovation Union Scoreboard, Measurement System for National Intellectual Capital Performance, National Intellectual Capital Index, Scorecard for National Intangibles, etc.) [1, p. 490-492, p. 124; 3, p. 144-156; 5, p. 12].

Both the methods of market capitalization of intellectual capital and the methods of non-monetary estimation of intellectual capital have rather low level of standardization and unification of input data as well as a subjectivity of some estimation parameters. For obvious reasons, it is therefore to propose to use the methods of direct measurement of intellectual capital for estimation the value of national intellectual capital in terms of structural and innovative transformations. The essence of this group of methods is that the value of national intellectual capital is calculated as the sum of expenditure of the main macroeconomic actors (goverment, firms, households, foreign sector) on formation, accumulation, using, and development of intellectual capital [1, p. 71-74; 2; p. 59-65; 5, p. 10-12].

An annotated review of existing publications devoted to this problem allowed author to conclude that the expenditure determining the value of national intellectual capital must include the following [4, p. 10-12; 6, p. 168-170; 8]:

1) state budget expenditure, in particular expenditure on education, expenditure on science, expenditure on innovation activity;

2) firms' expenditure, in particular expenditure on staff training, expenditure on conducting

```
┌──────────────────┬──────────────────────────────────────────────────────────┐
│  Step 1.         │  Formation of the set of expenditure determining the     │
│  Estimation      │  value of national intellectual capital                  │
│  of the value    ├──────────────────────────────────────────────────────────┤
│  of national     │  Collecting the input data                               │
│  intellectual    ├──────────────────────────────────────────────────────────┤
│  capital         │  Estimation of the value of national intellectual capital│
└──────────────────┴──────────────────────────────────────────────────────────┘
                                        │
                                        ▼
┌──────────────────┬──────────────────────────────────────────────────────────┐
│  Step 2.         │  Building of econometric model forecasting the value     │
│  Forecasting     │  of national intellectual capital                        │
│  of the value    ├──────────────────────────────────────────────────────────┤
│  of national     │  Verifying of adequacy of the built econometric model    │
│  intellectual    │  and estimation its accuracy                             │
│  capital         ├──────────────────────────────────────────────────────────┤
│                  │  Forecasting of the trend of the value of national       │
│                  │  intellectual capital                                    │
└──────────────────┴──────────────────────────────────────────────────────────┘
                                        │
                                        ▼
┌─────────────────────────────────────────────────────────────────────────────┐
│  Step 3. Working out of arrangements to raise the value of national          │
│  intellectual capital                                                        │
└─────────────────────────────────────────────────────────────────────────────┘
```

Graph 1. Consistency of the steps of estimation and forecasting of the value of national intellectual capital of Ukraine

scientific researches, expenditure on forming relations with suppliers and consumers, expenditure on protection intellectual property;

3) households' expenditure;

4) foreign expenditure, in particular expenditure on carrying out scientific and technical works, expenditure on financing other types of innovation activity.

This set of expenditure has the following advantages. The first point is that all types of expenditure are considered as equal that is especially important because the sources of formation and growth of national intellectual capital are not clear enough. Another important thing is the visibility and the simplicity of output data. Additionally, proposed set of expenditure will result in reliable, objective and adequate estimation of the value of national intellectual capital and its changes, which,

in its turn, can become the basis for scientific policy decisions how to raise national intellectual capital.

Equipped with this detailed knowledge, it is now possible to calculate the value of national intellectual capital of Ukraine in terms of structural and innovative transformations (Tabl. 1) [8-9]. Tabl. 1 shows that the value of national intellectual capital of Ukraine has slightly increased during 2011-2016 by 43,2% (from UAH 61,68 billion in 2010 to UAH 88,37 billion in 2016). State budget expenditure were a significant part of structure of the value of national intellectual capital of Ukraine and have increased by 27,44% in given period: from UAN 27,33 billion to UAN 34,83 billion. First of all, it is state budget expenditure on financing education which has increased by UAH 6,02 billion (or by 20,9%). That indexes have considerably risen in 2011-2012 (from UAH 27,23 billion to

Table 1

Input data to estimation the value of national intellectual capital of Ukraine [10]

Indexes, UAN billions	Years						
	2010	2011	2012	2013	2014	2015	2016
Government							
Expenditure on education, of which	28,81	27,23	30,24	30,94	28,88	30,18	34,83
secondary education	0,76	0,18	0,2	0,22	0,19	0,19	0,2
higher education	25,1	24,2	26,43	27,04	25,53	27,95	31,88
other types of education	2,93	2,85	3,61	3,68	3,16	2,04	2,75
Expenditure on science, of which	4,95	4,84	5,43	6,52	6,29	5,58	5,64
scientific works	4,62	4,64	5,13	6,13	5,96	5,28	5,29
scientific infrastructure and technical base	0,33	0,2	0,3	0,39	0,33	0,3	0,35
Expenditure on innovation, of which	6,46	7,82	9,34	9,49	9,49	8,32	13,39
internal scientific and technical works	3,27	3,96	4,71	4,76	4,09	4,27	4,1
external knowledge	0,01	0,21	0,06	0,01	0,01	0,04	0,05
equipment and machinery	3,18	3,65	4,57	4,72	5,39	4,01	9,24
Firms							
Expenditure on staff training	1,72	1,74	1,89	1,91	1,84	2,1	2,2
Expenditure on conducting scientific researches	9,00	10,35	11,25	11,78	10,95	12,61	11,53
Expenditure on forming relationship with suppliers and consumers	2,1	2,2	2,6	3,1	2,5	2,9	3,01
Expenditure on protection intellectual property	5,06	6,01	6,84	6,75	6,29	6,9	7,1
Households							
Expenditure on education	0,12	0,1	0,2	0,08	0,9	1,12	1,13
Foreign sector							
Expenditure on scientific and technical works	2,34	2,48	2,05	2,41	2,04	2,22	8,64
Expenditure on other types of innovation activity	1,12	1,1	1,2	1,25	0,14	0,06	0,9
Total	61,68	63,87	71,04	74,23	69,32	71,99	88,37

UAH 30,24 billion) and 2015-2016 (from UAH 30,18 billion to UAH 34,83 billion). Similarly, state budget expenditure on innovation activity have increased by 71,2% from UAH 7,82 billion to UAH 13,39 billion during 2011-2016. Among these types of expenditure, expenditure on renewal the fixed capital have sharply increased by 2,9 times and, in that way, have achieved high scores in 2016. It is quite reasonably because that situation creates the basis for sustainable macroeconomic growth and national intellectual capital in the future. In contrast, the dynamics of state budget expenditure on implementation internal scientific and technical works were not sustainable. The sustainable growth in 2011-2013 (from UAH 3,96 billion to UAH 4,76 billion) have changed slight decreasing in 2015-2016 (from UAH 4,27 billion to UAN 4,1 billion). It is most likely that these trends have been caused by the processes of transformation of property relations and the reform of public institutions at that time. It is also should be noted that state budget expenditure on scientific activity were considerable over the last six years and equaled almost 95% whereas state budget expenditure on development scientific infrastructure and upgrading material and technical base were insignificant (only about 5%).

Firms, entrepreneurial sector, did not play a great role in the process of formation the value of national intellectual capital of Ukraine. For instance, firms' expenditure on carrying out scientific and technical works have gone up only by 13,8% in 2011-2013 and by 15,16% in 2014-2015. Although the dynamics of enterprises' expenditure on obtaining and protecting the intellectual property rights have tended to increase, these indexes were significantly lower than similar indexes of developed countries of the world. It is also justified to admit that a low activity of households in formation the value of intellectual capital was one of the main peculiarities of the development of Ukrainian economy in terms of structural and innovative transformations. Undoubtedly, it is caused by low aggregate incomes of Ukrainian households. As a consequence, households' expenditure on education do not exceed 1,5%. In addition to this, the role of foreign sector is not principal in formation the value of national intellectual capital that is proved by the dynamics of foreign expenditure on financing innovation activity.

At the second step of the research the author built the econometric model forecasting the value of national intellectual capital of Ukraine. All needed calculations was produced in programme environment Excel 2010. The main purpose of this step is to analyse the statistical relation between regularity and randomness in formation of the values of time series of the national intellectual capital and to estimate the quantitative measure of its influence. That is due to the fact that the regularity explains the dynamics of the value of national intellectual capital in 2010-2016 can be used to predict its trend in the future. In turn, the randomness record will allow us to determine the probability and the possibility of a deviation of time series (Module "Tools of analysis"). Undoubtedly, it is the simplified reflection of reality, but due to the strictly mathematical approach it gives a quantitative description of the relation, the dependence and the conditionality of abovementioned indexes. As a result, we can estimate the national intellectual capital development of Ukraine more precisely that, in its turn, will help to determine external economic reserves for raising the value of national intellectual capital.

So the econometric model of forecasting of the value of national intellectual capital was built as the linear autoregression model. First of all, built model was tested for goodness-of-fit, homogeneity and independence of the law of normal distribution as well as for non-random component in time series of the value of national intellectual capital of Ukraine (Module "Analysis of data"). For this purpose, the mediums for each group of data input (2010-2013; 2014-2016) was calculated and they turned out a differ. Accordingly to the rules of mathematical statistics [7, p. 379-384], all this proved that there is a trend (or non-random component) of the time series of the value of national intellectual capital of Ukraine. In addition, the hypothesis about the equality of mathematical expectations was tested (Module "Two-sample test with the same dispersions"). The critical limit of it is the combination of two intervals: [-∞, -2,160; 2,160, ∞]. Taking into account that the calculated criterion equals -0,459, it does not include these intervals and therefore the main hypothesis about the equality of mathematical expectations is assumed.

After that the author determined some indicators of describing statistics, in particular Student's exact test, Fisher's criteria and determination coefficient. Student's exact test (or T-Statistic) which helps to compare two indexes if the difference between them is significant and it equals 1,70 in our case. Fisher's criteria (or F-test)

is used to study similarities between groups of data input and it equals 3,26. Determination coefficient (or R-squared) shows how well the model of the regression sample line is constructed and gives more accurate result for explaining the behavior of the dependent variable compared with its average value. That coefficient in our forecasting model equals 0,9784 that proves close correlation between indexes. Accordingly to the rules of mathematical statistics [7, p 404], all this also proved that there is a trend (or non-random component) of the time series of the value of national intellectual capital of Ukraine.

Curve of the trend of the value of national intellectual capital of Ukraine was presented as the polinomial regression (graph 2):

$$t = b_0 + b_1 ... b_k x^k$$

where — value of national intellectual capital of Ukraine; — years; — (≤ 6).
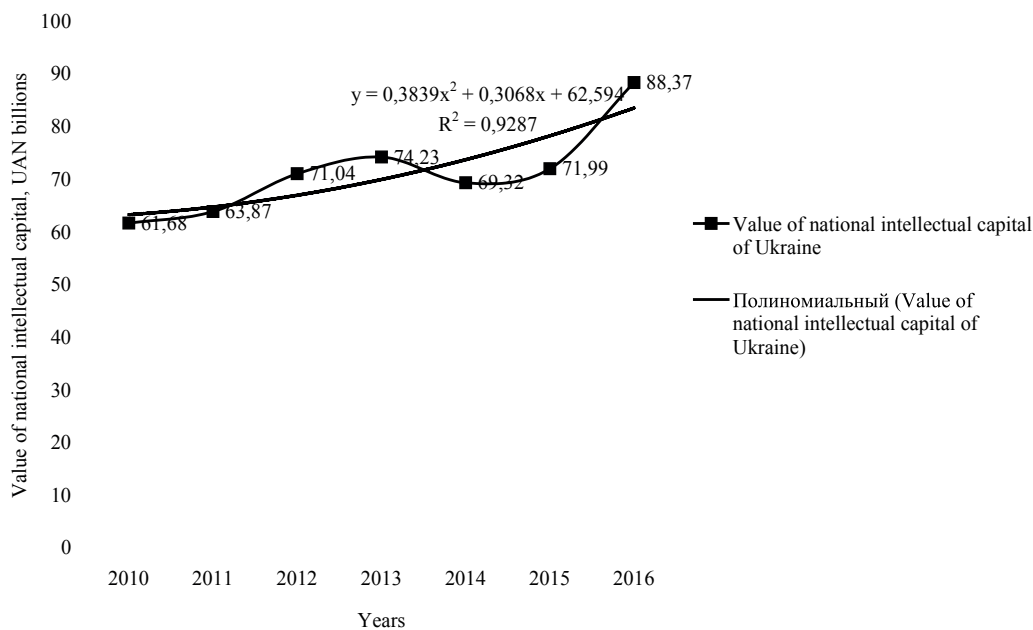
Graph 2. Polynomial curve of trend of the value of national intellectual capital of Ukraine

As graph 2 shows, despite the fact that dynamics of the value of national intellectual capital of Ukraine in terms of structural and innovative transformations was not sustainable the general variablility of this index tendenced to the increase.

Concluding remarks. The results of analyse allow us to draw the conclusion that expenditure of the main macroeconomic actors (government, firms, households, foreign sector) determining the value of national intellectual capital of Ukraine are still lagging behind similar indexes of developed countries of the world. It caused by the fact that there is a lack of demand for high-skilled workers producing new ideas and taking decisions. As a result, despite on considerable intellectual potential, national intellectual capital of Ukraine is rather low and ranged from UAN 61,68 billion in 2010 to UAN 88,37 billion in 2016. In this regard, further author's scientific researches will involve findings on making the practical recommendations for determining the motivational mechanisms of increasing the aggregate expenditure determining the value of national intellectual capital.

Література

1. Andriessen D. The Intellectual Capital of the European Union 2008: Measuring the Lisbon Strategy for Growth and Jobs / D. Andriessen, C. Stam // Electronic Journal of Knowledge Management. – 2008. – Volume 7. – № 4. – P. 489-500.
2. Buracas A. R. Metaeconomics approach and intellectual resources evaluation / A. R. Buracas, I. T. Lopes, A. O. Zvirblis. – Lima: Lambert Academic Publishing, 2012. – 208 p.
3. Edvinsson L. National intellectual capital: comparison of 40 countries / L. Edvinsson, C. Y. Lin. – New-York: Springer, 2011. – 392 p.

4. Macerinskiene I. O. Comparative evaluation of national intellectual capital: measurement models / I. O. Macerinskiene, R. H. Aleknaviciute // Business: Theory and Practice. – 2015. – Issue 16 (1). – PP. 1-14.

5. Sánchez P. M. National intellectual capital assessment models: A literature review / P. M. Sánchez // Journal of Intellectual Capital. – 2013. – Issue 21. – PP. 10-15.

6. Stahle S. Towards measures of national intellectual capital: an analysis of the CHS model / S. Ståhle, P. Ståhle // Journal of Intellectual Capital. – 2012. – Voume 13. – Issue 2. – PP. 164 – 177.

7. Wooldridge J. I. Introductory Econometrics: A modern approach / J. I. Wooldridge. – Mason: South-Western, Cengage Learning, 2013. – 910 P.

8. Бауліна Т. В. Інтелектуальний капітал: стратегічний ресурс трансформації національного господарства : монографія / Т. В. Бауліна. – Київ-Херсон: ПП Вишемирський В. С., 2009. – 276 с.

9. Гунчак Н. В. Державне регулювання процесу інтелектуалізації економіки України : монографія / Н. В. Гунчак, Т. Г. Васильців, О. Є. Сухай. – Львів : Апріорі, 2016. – 256 с.

10. Офіційний сайт Державного комітету статистики України. – Режим доступу: www.ukrstat.gov.ua.