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MODELING OF SOCIAL EFFECT OF FOREIGN DIRECT INVESTMENT IN THE REGIONS OF KAZAKHSTAN¹

In this paper, the authors have made an attempt to evaluate the social effect of foreign direct investment (FDI) in the regions of Kazakhstan. For this purpose, the dynamics of FDI for currently operating foreign-invested enterprises and six socio-economic indicators of the regions has been studied for the period 2003–2013 based on the database of the Agency of Statistics of the Republic of Kazakhstan. The experiment involved 16 regions of Kazakhstan (14 regions and 2 cities of republican status: Almaty and Astana).

The study was performed using the mathematical apparatus of the “simplified” version of the analytic hierarchy process (AHP) developed by T. Saaty, and the MS Excel program. The developed economic and mathematical model for assessment of the FDI effect on the quality of life and well-being of the population in the regions is hypothetical since it uses expert evaluations of a hypothetical expert. The authors formulated a hypothetical possibility to get the tool for assessment of the social effect of FDI in the regions of Kazakhstan, i.e. the Rating of the regional priority of factors (RPF Rating).

The obtained RPF rating has enabled a prioritization of the factors, which determine the quality of life in the regions of the country, and calculation of the cumulative social effect of FDI in Kazakhstan, highlighting the directions of its influence on each of the six factors in a regional context. The study did not reveal the negative impact of FDI on socio-economic development of the regions; moreover, the cumulative social effect of FDI was revealed to be positive for all regions of Kazakhstan. According to the authors, the RPF Rating can be an important tool to enhance the validity of the socio-economic policy in the development of public-private partnerships in the regions of Kazakhstan, as well as to strengthen the positive social effect of FDI in the future. All these will contribute to the long-term growth of the quality of life and well-being of the population in the regions of the Republic.

Keywords: foreign direct investment, the regions of Kazakhstan, social effect, quality of life and well-being of the population, analytic hierarchy process, expert evaluations

1. Introduction

Nowadays, we can observe a high degree of differentiation of social and economic development of the regions of Kazakhstan, caused by the influence of a variety of inherently different factors, including foreign direct investment (FDI). The focus of this article is the impact of FDI on the well-being of the regions of Kazakhstan. By definition, FDI includes creation of companies, branches and enterprises abroad, acquisition of shares in the equity of foreign companies, granting of loans to own enterprises abroad or companies with an interest owned. Correspondingly, the object of this study is the investment activity of all currently operating foreign-invested enterprises (OFIE) in 16 regions of Kazakhstan (14 regions and 2 cities — Almaty and Astana). During the research, the social impact of the OFIE investment activity in the regions of Kazakhstan acquires special interest, i.e. the subject of our study is the social results of FDI impact, which, in our opinion, are closely linked to the concept of “social impact”, or “changes in people’s way of life, their culture and community, their environment, including the political system and their surroundings, their health and well-being, their aspirations and fears” (Vanclay F., 2002 [1]).

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As foreign practice shows, the social effect of FDI is expressed in the influence on labor productivity in local companies, on personnel management in the improvement of employees' professional skills, on employment level and salary levels and, therefore, on the well-being and quality of life (Liu et al, 2003) [2]. It has been confirmed by an analytical overview of the OECD (2008): "FDI can bring significant benefits via development of highly skilled employment with a high salary rate and better-working conditions". [3] The recent studies (Zhang et al, 2010; Hong and Sun, 2011; Lan et al, 2012; Herzer, Nunnenkamp, 2013) analyzed the external impacts of FDI ("spillovers") in different countries and estimated them using econometric methods [4, 5, 6]. It is important to note that foreign researchers have not identified the "social spillovers" as a separate category, but they consider them as part of the external influence of FDI. As for Russian scientists, Ivushkina N. (2001) studied the social effect of investments [7]; Sindiyashkina E. (2009) investigated the mechanisms of the advent of social effects of investment [8]; Volgina N. (2009) examined the different effects caused by FDI [9], etc.

Russian scientists Sagandykova S., Ospanov M., Mukhanbetov T., Bissenova G., Babayeva B. et al. studied various aspects of the impact of FDI. For example, Tulegenova S. and Murzabekova K. (2010) believe that investment should provide a social effect [10]; Batyrbekova A. (2011) and Beyseminova A. (2013) analyze the effectiveness of social investment in the system of public-private partnership [11, 12].

Thus, different authors give different definitions of social effect, which is, according to all accounts, connected with social changes, either positive or negative, but which has a significant influence on the quality of people's life. The latter factor is the subject of many studies and, by definition, "...describes the essence of development of individual, social groups and the whole society of the country linked to the degree of satisfaction of people's needs due to life conditions" [13, p. 227]. The study [7] proposes the following definition of social effect of investment processes: "it is a set of social results obtained via investment implementation in the real sector of the economy, projected onto the quality of social environment and having both positive and negative values". Moreover, the main indicators of social effect defining its essence are identified as "...raising the employment rate; increasing the level of provision of comfortable accommodation to the population; improving the environment; increasing the availability and quality of public services in transportation, healthcare, education, physical culture and sports, culture, housing and communal services" [14].

Based on all of the above, our definition of the social effect of FDI in the regions of Kazakhstan is formulated as all possible and actual results of the impact of FDI (including the ensuing consequences), which directly and/or indirectly affect the quality of life and well-being of the population in the regions. Thus, the goal of this study is to identify and assess the social effect of FDI in the regions of Kazakhstan using a model based on expert evaluations of a hypothetical expert and application of mathematical apparatus of the analytic hierarchy process. In accordance with the formulated goal, our main hypothesis is to obtain a tool to identify and assess the social effect of FDI in the regions of Kazakhstan.

2. Methodology

It is obvious that in order to achieve a social effect of FDI in the regions of the Republic the OFIEs should actively contribute to solving social problems in the regions. Consequently, the changes of socio-economic indicators of the regions of Kazakhstan, studied in conjunction with the FDI inflow, will generally indicate the presence of a social effect of FDI. For these purposes, a mathematical model is developed on the basis of mathematical apparatus of the Analytic Hierarchy Process (AHP). AHP was developed in the last century by Thomas Saaty (1980), a prominent Iraqi-American researcher, who worked in the field of decision-making [15].

According to many researchers, the AHP is a versatile tool for analysis of complex and contradictory problems in different areas of public life. It is widely applied as a good method with a clear and strict mathematical apparatus, which could be used for solving many problems regarding selection of different variants as part of multi-criteria analysis based on expert evaluations and ranking. The convenience and universality of this technique involve the possibility of mathematically assessing the expert evaluations of factors that are of a non-numerical nature. In our model, we used expert evaluations of a hypothetical expert.

The official statistical databases of the Statistics Agency of the Republic of Kazakhstan for the period from 2003 to 2013 were used as an information basis for this study. Based on these data the

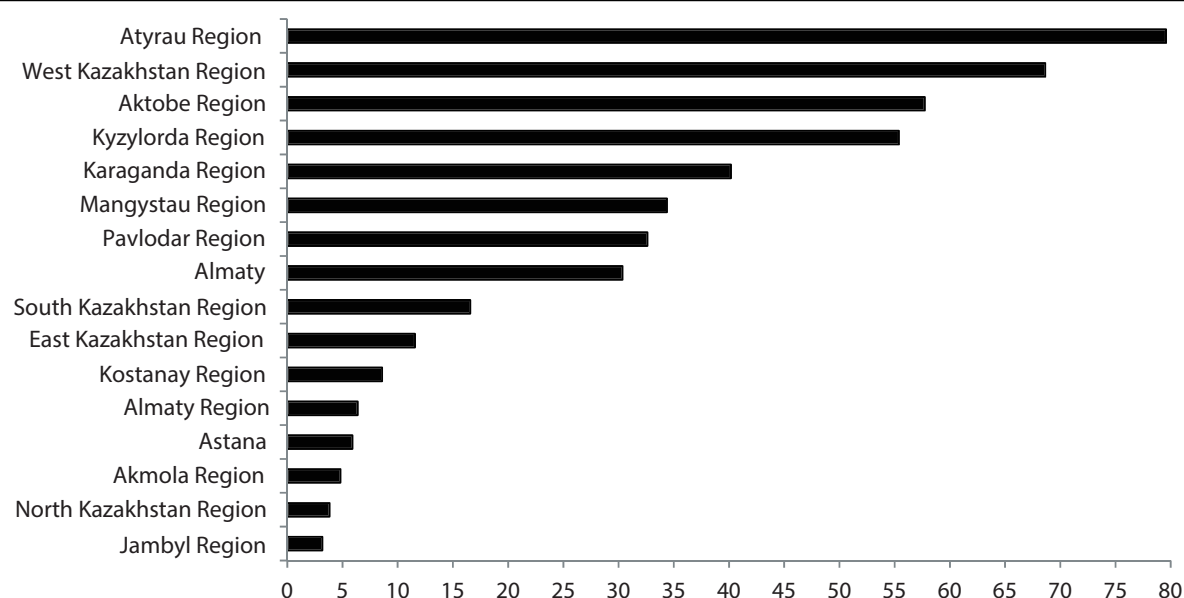


Fig. 1. Dynamics of FDI in the regions for the period 2003–2013, % (Source: On the activities of foreign-invested enterprises. Statistics Digest. Astana: AS RK, 2013. p. 518 (7))

following parameters were estimated: 1. The average rate of dynamics of the share of investment into fixed capital for the OFIEs in the total volume of investment into fixed capital in the regions during the period under investigation (Fig. 1).

The average rate of change of the six indicators of socio-economic development of the regions: 1) the number of employed population, thousand persons; 2) the volume of pollutant emission into the atmosphere, tons; 3) the capacity of healthcare organizations per 10,000 persons, the number of visits per shift; 4) the education enrolment of the population aged 6–24 years, %; 5) the share of the population with an income below the subsistence minimum, %; 6) average consumer spending per capita, KZT (Table 1).² These indicators were selected based on expert evaluations and are used as factors of the model to confirm the formulated hypothesis.

Table 1 clearly demonstrates an uneven dynamics of the six indicators in the context of the regions, which is positive and negative at the same time in different regions of the country during the period under investigation. Therefore, it is important to have positive dynamics for such indicators as employment, consumption, education enrolment and healthcare capacity because, in general, these factors characterize an improvement of the quality of life of the population in the regions. As for poverty and atmosphere contamination indicators, the negative dynamics, on the contrary, have a positive effect on the well-being of the population. At the same time, the data presented in Table 1 demonstrates the greatest rate of change of indicators of employment, poverty and consumption inequality in the regions.

A selection of these specific indicators is mainly determined by the fact that they are important indicators of quality and standard of living of the population, so their dynamics will reflect the social changes in the regions. In turn, the OFIE activity in the regions is directly related to these changes by completion of regional budgets with taxes, and so partially financing of the social infrastructure development by implementing a variety of socially significant projects. Furthermore, OFIEs contribute to an improvement in the education of the population in the regions. According to the subsoil legislation, OFIEs perform their contractual obligations on financing the education of company non-employees among the residents of the regions [16]. It is well known that education, health, and environment have a significant impact on the ability of people to find a job and to work. The OFIE activities, related to the implementation of major projects and fulfillment of liabilities, enhances the share of local personnel. Thereby, OFIEs contribute to an increase in employment in the regions of Kazakhstan. As for the regional indicators of poverty and consumer spending per capita, they "...are the key monetary indicators in the assessment of the population's well-being" [17]. At the same time, the OFIE activities have a significant impact on these indicators, increasing the difference in salary rate between different

² Regions of Kazakhstan. Astana: AS RK, 2014, p. 28.

Table 1

The average rate of dynamics of FDI and socio-economic indicators in the context of the regions for the years 2003–2013 [%]

Region of the Republic of Kazakhstan	Investment to the fixed capital of OFIE (FDI)	Number of employed population	Volume of pollutant emission to the atmosphere	Capacity of healthcare organization per 10,000 persons	Education enrollment of the population aged 6–24	Share of population with income below the subsistence minimum	Consumer spending per capita
Akmola Region	4.80	1.07	6.65	0.96	–0.08	–15.79	16.43
Aktobe Region	57.71	2.52	3.56	2.34	–1.09	–19.34	15.95
Almaty Region	6.36	2.97	0.5	0.13	–0.29	–22.76	22.57
Atyrau Region	79.56	3.44	2.31	3.13	–1.42	–21.11	17.7
West Kazakhstan Region	68.63	0.96	2.88	0.29	0.03	–16.58	16.26
Jambyl Region	3.17	1.66	12.01	0.79	0.02	–19.7	20.96
Karaganda Region	40.16	0.47	–7.71	1.34	–0.5	–21.17	17.69
Kostanay Region	8.58	0.18	–2.25	–3.15	–0.56	–20.90	18.05
Kyzylorda Region	55.37	2.53	7.53	4.87	–0.82	–20.12	19.56
Mangystau Region	34.38	5.78	1.31	7.3	–2.17	–18.61	17.22
South Kazakhstan Region	16.56	2.86	7.57	3.23	–0.53	–16.26	18.42
Pavlodar Region	32.59	0.96	2.66	1.77	–1.04	–19.30	17.66
North Kazakhstan Region	3.81	1.10	1.69	1.18	–0.29	–10.70	16.29
East Kazakhstan Region	11.55	0.25	–3.74	3.18	–0.69	–21.46	17.82
Astana	5.89	5.11	3.24	8.18	–2.17	–9.5	12.51
Almaty	30.34	3.21	–1.46	–1.43	–1.15	–7.93	17.09

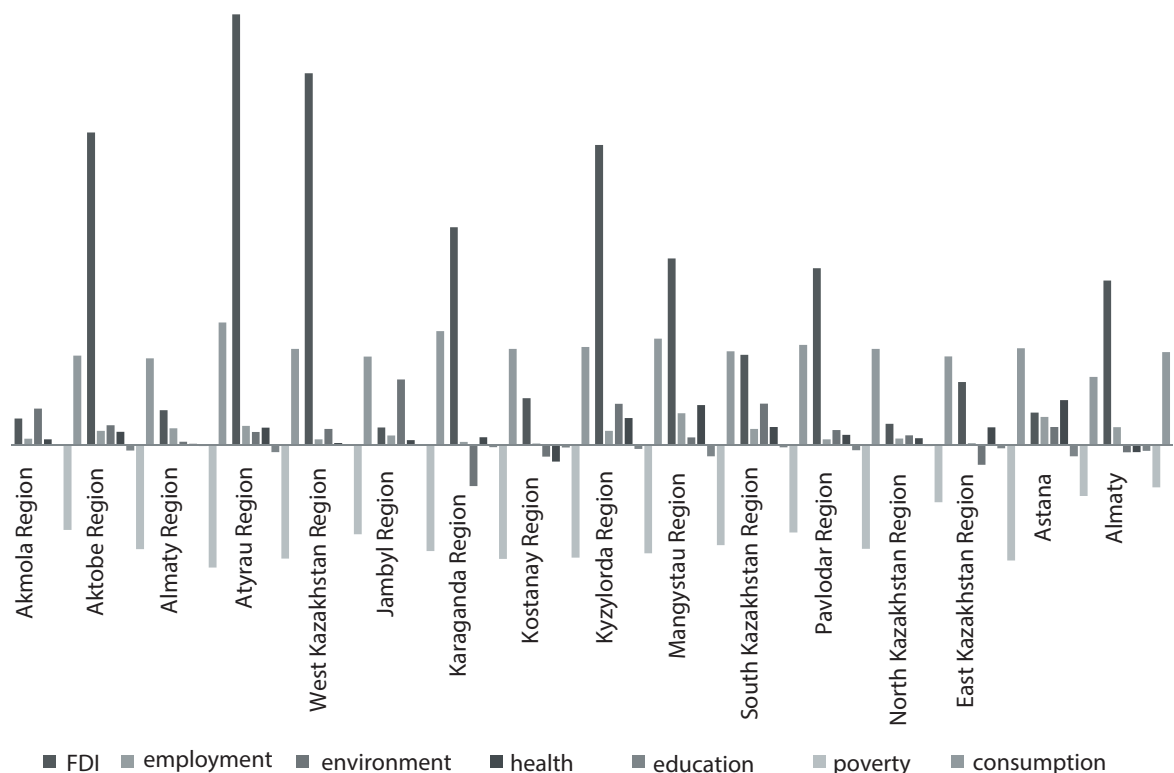


Fig. 2. Interconnection between FDI and socio-economic indicators of the regions of Kazakhstan

groups both within and between the regions. Figure 2 demonstrates the interconnection between the FDI inflow into the regions of Kazakhstan and the dynamics of socio-economic indicators.

The diagram clearly demonstrates that increasing the FDI inflow in some regions causes positive social changes, including employment rehabilitation, consumption growth, and medical care

improvement in the regions. At the same time, there are negative social changes such as increased pollutant emissions into the atmosphere in 12 regions, except Karaganda, Kostanay, East Kazakhstan regions and the city of Almaty. As for the poverty indicator, on the one hand, OFIEs increase income inequality within and between regions due to higher salary rate. On the other hand, OFIE activities have a positive effect on employment in the regions, promote the growth of income of the population and reduce the share of poor people. Perhaps, for this reason, a significant reduction of the poverty indicator in the most regions closely correlates with FDI growth in these regions. Concerning the dynamics of education enrollment in the regions, we can assume the positive effect of FDI on this indicator in the western regions of the country. This is because West Kazakhstan is a traditionally oil-producing region and it attracts the largest FDI. At the same time, OFIE activities are covered by subsoil legislation, under which the OFIEs have contractual obligations to finance training of companies' non-employees among the residents of the regions [16].

On this basis, we can say that the initial assumption regarding the presence of social effects of FDI in the regions of the Republic has been confirmed. Obviously, for complete proof additional mathematical calculations are required and a model should be developed to facilitate accurate assessment of the impact of FDI on the quality of life and well-being of the population in the regions of Kazakhstan. Thus, this analysis allowed us to determine in which areas FDI has a positive and negative effect that can serve as the basis for modeling the regional social effects of FDI.

A mathematical model for assessment of the social effect of FDI in the regions of Kazakhstan based on AHP. Looking for an answer to the main question, we have to model the social effect of FDIs in each of the 16 regions of Kazakhstan, where OFIEs operate. For this purpose, a mathematical model was developed based on Saaty's pairwise comparisons matrix (C-matrix), which will provide a tool for assessing the social effect of FDI. The C-matrix is based on the expert evaluations of a hypothetical expert (HE) and the Saaty's rating scale [15]. Mathematical calculations for the C-matrix will determine the priority scale for the factor of the model based on the evaluations of HE and will then obtain the Rating of the regional priority of factors by means of which the social effect of FDI in the regions of Kazakhstan will be assessed.

First, the structure of C-matrix is filled with elements obtained by means of pairwise comparison of one factor with others in the sequence to identify the level of their influence on the problem. The obtained values reflect the agreement reached in the judgments of the hypothetical expert regarding each pairwise comparison of factors for which Saaty's rating scale is used (Table 2). This helps to justify the subjective scale of measurements of any expert involved in a scientific experiment, through the transformation of expert evaluations into a normalized vector of preferences objectively.

Table 2

Saaty's Rating Scale

Numbers	Characteristics
1	Factors are equally relevant and important in order of their influence on the problem
3	There is a weak importance of one factor over the other
5	One factor has a strong importance over the others
7	There is a very strong importance of one factor over the other
9	Absolute importance of one factor over the other
2, 4, 6, 8	Intermediate numbers used to clarify the degree of importance of the key figures

Note: Formulated on the basis of the source [15].

Thus, the modeling of the social effect of FDI in the regions of Kazakhstan based on AHP includes two stages:

1st stage. To obtain the HE's scale of priority of factors.

2nd stage. To obtain the Rating of the regional priority of factors and to assess the social effect of FDI.

Algorithm of the 1st stage of the modeling.

Step 1. Determination of factors required for C-matrix development. Table 3 shows six factors of the model, i.e. six socio-economic indicators of the regions of the Republic that are used as the factors. The average rate of dynamics of these factors has been calculated and analyzed earlier.

Table 3

Indicators/factors that determine the social effect of FDI in the model

No.	Name of indicator	Characteristics of factor	Designation in model
1.	Number of employed population	Employment factor	Employment
2.	Volume of pollutant emissions into the atmosphere	Environmental factor	Environment
3.	Capacity of healthcare organizations per 10,000 persons	Population health factor	Health
4.	Education enrollment of population aged 6-24 years	Education level factor	Education
5.	Share of population with income below the subsistence minimum	Population poverty factor	Poverty
6.	Consumer spending per capita	Living standards factor	Consumption

Note: Formulated by authors.

The choice of these indicators as factors of the model, on the one hand, is caused by the nature and the matter of the social effect. On the other hand, these factors are the key indicators of the social effect, the quality of life and the well-being (living standards) of the population (as defined at the beginning of this study). It is well known that the quality of life is characterized by health, life expectancy, education, etc. The quality of life is expressed through such indicators as the number and quality of new jobs created, staff training, availability of public objects required for education, culture and arts, health, sports, transport services, including social security in the form of reduced delinquency and crime. Health and life expectancy depend on existing working conditions and their improvement, health sector development, the level of public services, the state of the environment, etc. [18]. The living standards of the population (well-being) can be measured by public consumption, the availability of consumer goods and services, and the volume of the consumption of these goods and services. Such indicators as the availability of housing, facilities for household purposes and public utilities are also very important. On this basis, the factors mentioned above determine the structure of the future C-matrix.

Step 2. Mathematical record of the model. There are n factors in the model, which are designated as A_1, A_2, \dots, A_n . It is assumed that specific positive value X_k , named as weight of factor A_k , $k = 1, 2, \dots, n$ corresponds to each A_k factor. These values have to be determined.

Matrix A is as follows:

$$A = (a_{ij})_{n \times n} = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix}, \quad (1)$$

where a_{ij}, a_{ji} — elements of matrix A; i — number of line, $i > 0$; j — number of column, $j > 0$.

Matrix A elements express relative weight of the vector X_k , which shows how many times the weight of factor A_i is more than the weight of factor A_j .

The following requirements for the A-matrix are implemented [19]:

- all elements of the matrix are positive, i.e. $a_{ij} > 0$, for all $i, j = 1, 2, \dots, n$; (2)
- the matrix is inversely symmetrical, i.e. $a_{ij} = 1 / a_{ji}$ for all $i, j = 1, 2, \dots, n$. In particular, $a_{ii} = 1$, $i = 1, 2, \dots, n$; (3)
- the matrix is consistent, i.e. $a_{ik}a_{kj} = a_{ij}$ for all $i, j, k = 1, 2, \dots, n$; (4)
- the number n is the maximal eigenvalue λ_{\max} of matrix A and for some single (normalized) column-vector $X = (x_1, x_2, \dots, x_n)^T$ with positive components the following equality is performed $AX_j = \lambda X_j$; (5)
- additional normalization requirement is $x_1 + x_2 + \dots + x_n = 1$. (6)

Thus, in the case of the C-matrix the factor number is $n = 6$ and the weight of these six factors must be found. On their basis, the social effect of FDI in each region of Kazakhstan will be assessed. Realization of the above-mentioned requirements (2)–(6) for C-matrix facilitates a definition of all its values based on expert evaluations of HE.

Step 3. Obtaining expert evaluations of a hypothetical expert (HE) an C-matrix development. To obtain expert evaluations of HE, pairwise comparisons of the six factors of the model between themselves must be performed in order of priority, and the question as to which of the two factors have the higher

influence on the task shall be answered. During the pairwise comparison of factors, the HE relies on the Saaty's rating scale. The received values are filled into cells of the table of the C-matrix according to the procedure established in AHP.

It is important to remember that when obtaining expert evaluations of HE and during C-matrix development, the fulfillment of requirement (4) of the mathematical record of the model is obligatory. It is a question of the C-matrix consistency, which is often violated in practice and leads to some "model" error while using AHP. Sometimes, it is impossible to evaluate this error. The study [11] proposed a "simplified version of AHP", which enables this problem to be solved. According to this version, based on elements of the first row of C-matrix, all other elements could be calculated using the expression (2) to (4). This method of C-matrix completion is based on the so-called "sample comparison circuit", where the first factor of the C-matrix represents the "sample". As a result, the model inconsistency is completely eliminated.

Thus, HE carries out the following scheme of pairwise comparison of the factors: the first factor "Employment" is compared with the other factors to obtain five pairs of comparisons that have to be evaluated by HE: 1) Employment — Environment; 2) Employment — Health; 3) Employment — Education; 4) Employment — Poverty; 5) Employment — Consumption. Let us suppose that the obtained evaluations of HE are the following: 7, 3, 2, 9, 7, 5. Due to the scale of relevance of Saaty, the value 7 means a significant advantage of Employment factor over the Environment factor regarding the level of influence on the task; 3 — moderate significance of Employment over Health; 2 — slight advantage of Employment factor over Education; 9 — very considerable advantage of Employment over Poverty factor; 5 — significant advantage of Employment over Consumption. These values shall be entered in the first row of the C-matrix.

In accordance with [19], the following equalities are available to calculate the values of elements of the second, third, fourth and fifth rows of the C-matrix above the main diagonal:

$$a_{ij} = a_{i1}a_{1j} = \frac{a_{1j}}{a_{1i}}, \text{ для } i = 2, \dots, n; j = 1, 2, \dots, n. \quad (7)$$

The C-matrix developed based on the formula (7) will fully meet the requirement of the pairwise comparison matrix consistency because all elements $i, j, k = 1, 2, \dots, n$ will fulfill the following equation [19]:

$$a_{ik}a_{kj} = \frac{a_{1k}}{a_{1i}} \frac{a_{1j}}{a_{1k}} = \frac{a_{1j}}{a_{1i}} = a_{ij}. \quad (8)$$

Table 4

Synthesis of C-matrix structure based on expert evaluations of HE

	Employment	Environment	Health	Education	Poverty	Consumption
Employment	1	7	3	2	9	5
Environment		1	3/7	2/7	9/7	5/7
Health			1	2/3	9/3	5/3
Education				1	9/2	5/2
Poverty					1	5/9
Consumption						1

Table 4 shows the received values of expert evaluation of HE, which have filled the top right corner of the C-matrix above the main diagonal. The values of the main diagonal equal one, because the pairwise comparison of any factor with itself is always equal to one.

The next step is to fill the C-matrix cells that are located below the main diagonal. For this purpose, the reciprocal values of elements that are located above the diagonal are calculated according to the expression (3). For example, for the elements of the first column: $a_{21} = 1/a_{12} = 1/7$; $a_{31} = 1/a_{13} = 1/3$; $a_{41} = 1/2$; $a_{51} = 1/9$; $a_{61} = 1/5$; etc. The final results of mathematical calculations are shown in Table 5.

Step 4. Determination of the Rating of priority of factors according to expert evaluations of HE. For this purpose, the eigenvector, eigenvalue λ and the scale of priority of factors for the C-matrix (all calculations are performed using the MS Excel software) have to be calculated. Analysis of the matrix eigenvalues, in our opinion, may be used to assess the impact of FDI in the regions of Kazakhstan,

Table 5

C-Matrix based on expert evaluations of HE

	Employment	Environment	Health	Education	Poverty	Consumption
Employment	1	7	3	2	9	5
Environment	1/7	1	3/7	2/7	9/7	5/7
Health	1/3	7/3	1	2/3	9/3	5/3
Education	1/2	7/2	3/2	1	9/2	5/2
Poverty	1/9	7/9	3/9	2/9	1	5/9
Consumption	1/5	7/5	3/5	2/5	9/5	1

Table 6

Results of calculations for the C-matrix

Factors	Eigenvector	Scale of Priorities	PF HE Rating
1. Employment	3.516	0.437	1. Employment — 43.7%
2. Environment	0.502	0.062	2. Education — 21.9%
3. Health	1.172	0.146	3. Health — 14.6%
4. Education	1.758	0.219	4. Consumption — 8.7%
5. Poverty	0.391	0.049	5. Environment — 6.2%
6. Consumption	0.703	0.087	6. Poverty — 4.9%

Note: Formulated by the authors

because “...the problem of eigenvalues plays a significant role in all the phenomena of unstable oscillations and vibrations, as the oscillation frequency is determined by the matrix eigenvalues, while the shape of these oscillations is indicated by the matrix eigenvectors...” [20]. Methods for matrix eigenvector calculation are explicitly developed, and their description can be found in [21, 22] and other sources.

It is recommended to use the four methods [15] of the AHP mathematical apparatus in order to calculate the eigenvector which, after normalization, becomes the scale of priorities of the factors of the matrix that determines the “weight” of each factor. Our calculations of the C-matrix eigenvector were performed using the fourth method (the most accurate according to Saaty). Following this method, the products of all elements in each row were calculated, and the n -th roots were taken of each of these products. Eigenvector normalization was performed by dividing each element by the sum of all vector elements while the performance of the expression (6) is obligatory. Table 6 shows the results of calculation of the eigenvector values and the scale of priorities. As a result, the first element of the scale of priorities becomes a priority of the first factor, the second element — of the second factor, and so on. Converting the “weight” of factors received in the scale of priorities into a percentage and then ranking them in order, we have received the Rating of priority of factors created by HE (PF HE Rating).

According to Table 6, the Employment factor has the first priority (43.7 %), the Education factor has the second priority (21.9 %), the Health factor has the third priority (14.6 %), the Consumption factor has the fourth priority (8.7 %), the Environment factor has the fifth priority (6.2 %), and the Poverty factor has the sixth priority (4.9 %). PF HE Rating, applied to the dynamics of indicators of the regions of Republic, will be used as a tool to determine the priority of the six factors within the regions of Kazakhstan.

Step 5. Validation of the C-matrix consistency. This is an obligatory requirement of the model, although the C-matrix has to be consistent by default [19]. Nevertheless, let’s remember that in the AHP the consistency of positive antisymmetric matrix is equivalent to the equality of maximal eigenvalue λ_{\max} of the matrix to the number of factors n . According to Saaty “...inequality $\lambda_{\max} \geq n$ is true in all cases. Assessment of the specific problem consistency could be done by means of comparison of the value of $(\lambda_{\max} - n) / (n - 1)$ with its value calculated for randomly chosen judgments and relevant inverse values of the matrix of the same size” [15]. This refers to the inbuilt mechanism of the expert quality assessment, i.e. determination of the relation of consistency RC value of the matrix. According to the AHP, it is acceptable if the $RC \leq 10\%$. In some cases, the $RC \leq 20\%$ is allowed, but not more [23, p. 112]. The RC is calculated as a ratio of consistency index CI to average random index RI, the values of which are calculated in the AHP for the 15th order matrix. Consistency index CI is determined based on

eigenvalue λ_{\max} and could be used as a criterion of quality of the expert work "...providing information regarding the degree of malfunction of numeric and transitive consistency of the expert judgments" [23].

Mathematical calculations for the C-matrix have demonstrated that $CI = 0$ and $RC = 0$ for $\lambda_{\max} = 6$. The initial assumption regarding the C-matrix consistency was confirmed by obtaining the maximal value of the matrix eigenvalue, which is equal to the number of the matrix factors, and zero values of the random index and consistency index.

Step 6. Interpretation of preliminary results of the 1st stage of modeling. PF HE Rating (see Table 6) determines the relative weights of the six factors and their influence on the problem formulated in the model. In turn, these relative weights help to identify and assess the priority of these factors in the context of the regions of Kazakhstan and, finally, to determine the level of FDI impact on the well-being and quality of life of the population and to assess the social effect of FDI in all regions of Kazakhstan.

It is obvious that employment, education and health of the population are the most important socio-economic factors that influence the quality of life and well-being of the population of the regions of Kazakhstan, just as for any other country. It is not for nothing that these factors took the first three positions in the PF HE Rating. It is interesting that the factor of population poverty took the lower priority, because, in our opinion, higher salary rate at the OFIEs additionally enhances financial inequality. As for consumption and environment factors, in our opinion, their impact on the problem has to be much higher in reality compared with the priorities obtained on the basis of the HE evaluations, because these factors are the key indicators of the social effect and render a strong influence on the quality of life and well-being of the population in the regions. However, it has to be taken into account that expert evaluations were obtained hypothetically. Therefore, interpretation of the PF HE Rating values at this stage is very relative. Nevertheless, accurate mathematical calculations allow these values to be used for modeling purposes.

An important objective of this study is to demonstrate the potential application of the AHP for assessment of the social effect of FDI in the regions of Kazakhstan. This study could be useful in the context of the application of its results as a tool for assessment of socio-economic development of the regions, as well as for assessment of the FDI social efficiency in the regions of Kazakhstan.

Algorithm of the 2nd stage of the modeling

Step 1. Mathematical calculations of the regional priority of factors. Following the rules of matrix and vector multiplication, we multiply the values of dynamics of the socio-economic indicators in the context of regions by the values of the PF HE Rating. As a result, we obtain 16×6 \hat{C} -matrix, applying the formula (9):

$$\hat{C} = (A)_{m \times n} X_n = \begin{pmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \dots & a_{mn} \end{pmatrix} \begin{pmatrix} x_1 & 0 & 0 \\ 0 & \dots & 0 \\ 0 & 0 & x_n \end{pmatrix} = \begin{pmatrix} a_{11}x_1 & \dots & a_{1n}x_n \\ \vdots & \ddots & \vdots \\ a_{m1}x_1 & \dots & a_{mn}x_n \end{pmatrix}, \quad m = 16; n = 6. \quad (9)$$

Using MS Excel, we calculate the \hat{C} -matrix extensional values and correct some of them by means of elementary manipulations with the matrix. Correction of \hat{C} -matrix values is required to avoid negative values in the columns relevant to the Environment and Poverty factors. From an economic point of view, these values are positive because the reduction of both atmosphere contamination and population poverty has a positive effect on the quality of life and living standards in the regions. However, the presence of negative values in the matrix, which will be used in the following mathematical calculations, could make the model results worse. At the same time, the negative values of the Health and Education factors were not corrected, because negative values of these factors do not have a positive impact on the quality of life and well-being of the population. Corrected matrix of the regional priority of the six factors in Kazakhstan has the form of \hat{C} -matrix:

$$\begin{pmatrix} 0,0047 & -0,0041 & 0,0014-0,0002 & 0,0077 & 0,0143 \\ 0,0110 & -0,0022 & 0,0034-0,0024 & 0,0095 & 0,0139 \\ 0,0130 & -0,0003 & 0,0002-0,0006 & 0,0112 & 0,0196 \\ 0,0150 & -0,0014 & 0,0046-0,0031 & 0,0103 & 0,0154 \\ 0,0042 & -0,0018 & 0,0004 & 0,0001 & 0,0081 & 0,0141 \\ 0,0073 & -0,0074 & 0,0012 & 0,0000 & 0,0097 & 0,0182 \\ 0,0021 & 0,0048 & 0,0020 & -0,0011 & 0,0104 & 0,0154 \\ 0,0008 & 0,0014 & -0,0046-0,0012 & 0,0102 & 0,0157 \\ 0,0111 & -0,0047 & 0,0071 & -0,0018 & 0,0099 & 0,0170 \\ 0,0253 & -0,0008 & 0,0107-0,0048 & 0,0091 & 0,0150 \\ 0,0125 & -0,0047 & 0,0047-0,0012 & 0,0080 & 0,0160 \\ 0,0042 & -0,0016 & 0,0026-0,0023 & 0,0095 & 0,0154 \\ 0,0048 & -0,0010 & 0,0017-0,0006 & 0,0052 & 0,0142 \\ 0,0011 & 0,0023 & 0,0046-0,0015 & 0,0105 & 0,0155 \\ 0,0223 & -0,0020 & 0,0119-0,0048 & 0,0047 & 0,0109 \\ 0,0140 & 0,0009 & -0,0021-0,0025 & 0,0039 & 0,0149 \end{pmatrix} = \tilde{C}. \quad (10)$$

Step 2. Interpretation of \tilde{C} -matrix results. \tilde{C} -matrix represents the relative weights of the six factors in a preference manner for the 16 regions of Kazakhstan. New values of the six factors were analyzed and their new priorities were obtained by determining the average value of priority for each factor as a result of comparison of the \tilde{C} -matrix values and the distribution of priorities in each region. Thereby, the hypothesis on the development of the tool for identification and assessment of the social effect of FDI in the regions of Kazakhstan (Rating of the regional priority of factors (RPF Rating) in Kazakhstan) was confirmed. Table 7 presents a comparison of the priority of the six factors obtained on the basis of HE evaluations and within the regions of Kazakhstan.

Table 7

Comparative analysis of priority change of the six factors

PF HE Rating	RPF Rating in Kazakhstan	Priority change: priority increasing (+) or priority decreasing (-)
1. Employment	1. Consumption	+ 3 positions (↑)
2. Education	2. Poverty	+ 4 positions (↑)
3. Health	3. Employment	- 2 positions (↓)
4. Consumption	4. Health	- 1 position (↓)
5. Environment	5. Environment	no change
6. Poverty	6. Education	- 4 positions (↓)

Note: Formulated by authors.

Comparative analysis of data presented in Table 7 demonstrates that, according to the PF HE Rating, used as a “reference”, the quality of life and well-being of the population in the regions of Kazakhstan have to be determined, first of all, by population employment, education and health, because these factors took the first three positions in the Rating. However, the RPF Rating in Kazakhstan demonstrates that consumption, poverty and employment factors, which took the first three positions in the Rating, are of higher importance. Health, environment and education factors are not crucial factors for the model. The health factor took the fourth priority, the environment factor took the fifth priority, and the education factor took the sixth priority.

Thereby, within the regions of Kazakhstan the following situation is created: development trends of socio-economic indicators of the regions for a 10-year period reveal the actual current background of the social problems in the regions of Kazakhstan. The results of preliminary mathematical calculations demonstrate the availability of both positive and negative social changes in the regions. The main output of performed analysis involves the following statement: as a result of synthesis of actual socio-economic indicators of the development of Kazakhstan regions and the Rating of the priority of the six

factors of HE, a sufficient change in factor priority distribution was obtained within the regions. It is likely that the input of real expert evaluations into our model will change the result. However, from a theoretical point of view, the analysis performed is useful, because it could be used as an instrument for assessment and analysis of the non-uniform development of the regions of Kazakhstan and, therefore, for assessment of the social effect of FDI.

Step 3. Mathematical calculations for determination of the social effect of FDI in the regions of Kazakhstan. Data on the FDI dynamics in the context of the regions for the period under investigation were entered into the model. Results on the regional priority of the six factors were brought into correlation with the results on FDI dynamics in the regions of the Republic for 2003–2013, as calculated in Table 1. For this purpose, let's present FDI for the 16 regions as a vector $X = (x_1, \dots, x_n)$, $n = 16$. The mathematical calculations are similar to calculations according to the formula (9) during Step 1. We multiply the \tilde{C} -matrix by the vector X (11) and obtain the 16×6 \tilde{C} -matrix.

$$\begin{pmatrix} 0,00022 & -0,00020 & 0,00007 & -0,00001 & 0,00037 & 0,00069 \\ 0,00636 & -0,00127 & 0,00197 & -0,00138 & 0,00547 & 0,00801 \\ 0,00083 & -0,00002 & 0,00001 & -0,00004 & 0,00071 & 0,00125 \\ 0,01196 & -0,00114 & 0,00364 & -0,00247 & 0,00823 & 0,01225 \\ 0,00288 & -0,00123 & 0,00029 & 0,00005 & 0,00558 & 0,00971 \\ 0,00023 & -0,00024 & 0,00004 & 0,000001 & 0,00031 & 0,00058 \\ 0,00082 & 0,00192 & 0,00079 & -0,00044 & 0,00417 & 0,00618 \\ 0,00007 & 0,00012 & -0,00039 & -0,00011 & 0,00088 & 0,00135 \\ 0,00612 & -0,00259 & 0,00394 & -0,00099 & 0,00546 & 0,00942 \\ 0,00868 & -0,00028 & 0,00366 & -0,00163 & 0,00314 & 0,00515 \\ 0,00207 & -0,00078 & 0,00078 & -0,00019 & 0,00132 & 0,00265 \\ 0,00137 & -0,00054 & 0,00084 & -0,00074 & 0,00308 & 0,00501 \\ 0,00018 & -0,00004 & 0,00007 & -0,00002 & 0,00020 & 0,00054 \\ 0,00013 & 0,00027 & 0,00054 & -0,00017 & 0,00121 & 0,00179 \\ 0,00132 & -0,00012 & 0,00070 & -0,00028 & 0,00027 & 0,00064 \\ 0,00426 & 0,00027 & -0,00063 & -0,00076 & 0,00118 & 0,00451 \end{pmatrix} = \tilde{C}. \quad (11)$$

We call the \tilde{C} -matrix obtained in (11) the matrix of the regional priority of the six factors in Kazakhstan depending on FDI. This matrix demonstrates the social changes of the six factors in each region of Kazakhstan caused by the impact of FDI.

3. Results

Based on analysis of the results (11), it could be concluded that the \tilde{C} -matrix values represent the social results of the OFIE investment activity in each of the 16 regions of Kazakhstan. Therefore, taking into account the definition that was adopted at the beginning of the research assuming that all possible and actual results of the impact of FDI (incl. all ensuing consequences), which directly and/or indirectly affect the quality of life and well-being of the population of the regions of Republic, will determine the social effect of FDI, it could be concluded that the \tilde{C} -matrix is a matrix of the FDI regional social effect.

Table 8 presents the percentage values of the social effect of FDI for all factors for each region of Kazakhstan, as well as the values of the social effect of FDI for each factor separately without reference to a specific region.

Values of the FDI cumulative social effect for different regions allow a ranging of the regions in order of a decreasing social effect of FDI (Figure 3). The highest values of the social effect were obtained for the following 6 regions: Atyrau Region — 3.25 %, Kyzylorda Region — 2.13 %, Aktobe Region — 1.92 %, Mangystau Region — 1.88 %, West Kazakhstan Region — 1.74 % and Karaganda Region — 1.35 %. Obviously, this situation could be explained by several facts. First, these regions (except the Karaganda Region) are traditionally oil-producing regions of Kazakhstan and the biggest OFIE in Kazakhstan are mainly concentrated in the abovementioned regions. Second, these regions implement

Table 8

Values of the social effect of FDI for different regions of Kazakhstan, %

Region of the Republic of Kazakhstan	Social effect on employment	Social effect on environment	Social effect on health	Social effect on education	Social effect on poverty	Social effect on consumption	FDI cumulative social effect for different regions
Akmola Region	0.02	-0.02	0.01	-0.001	0.04	0.07	0.12
Aktobe Region	0.64	-0.13	0.20	-0.14	0.55	0.80	1.92
Almaty Region	0.08	-0.002	0.001	-0.004	0.07	0.13	0.28
Atyrau Region	1.20	-0.11	0.36	-0.25	0.82	1.23	3.25
West Kazakhstan Region	0.29	-0.12	0.03	0.01	0.56	0.97	1.74
Jambyl Region	0.02	-0.02	0.004	0.0001	0.03	0.06	0.09
Karaganda Region	0.08	0.19	0.08	-0.04	0.42	0.62	1.35
Kostanay Region	0.01	0.01	-0.04	-0.01	0.09	0.14	0.2
Kyzylorda Region	0.61	-0.26	0.39	-0.10	0.55	0.94	2.13
Mangystau Region	0.87	-0.03	0.37	-0.16	0.31	0.52	1.88
South Kazakhstan Region	0.21	-0.08	0.08	-0.02	0.13	0.27	0.59
Pavlodar Region	0.14	-0.05	0.08	-0.07	0.31	0.50	0.91
North Kazakhstan Region	0.02	-0.004	0.01	-0.002	0.02	0.05	0.09
East Kazakhstan Region	0.01	0.03	0.05	-0.02	0.12	0.18	0.37
Astana	0.13	-0.01	0.07	-0.03	0.03	0.06	0.25
Almaty	0.43	0.03	-0.06	-0.08	0.12	0.45	0.89
FDI cumulative social effect for different factors	4.76	-0.58	1.64	-0.92	4.17	6.99	16.06

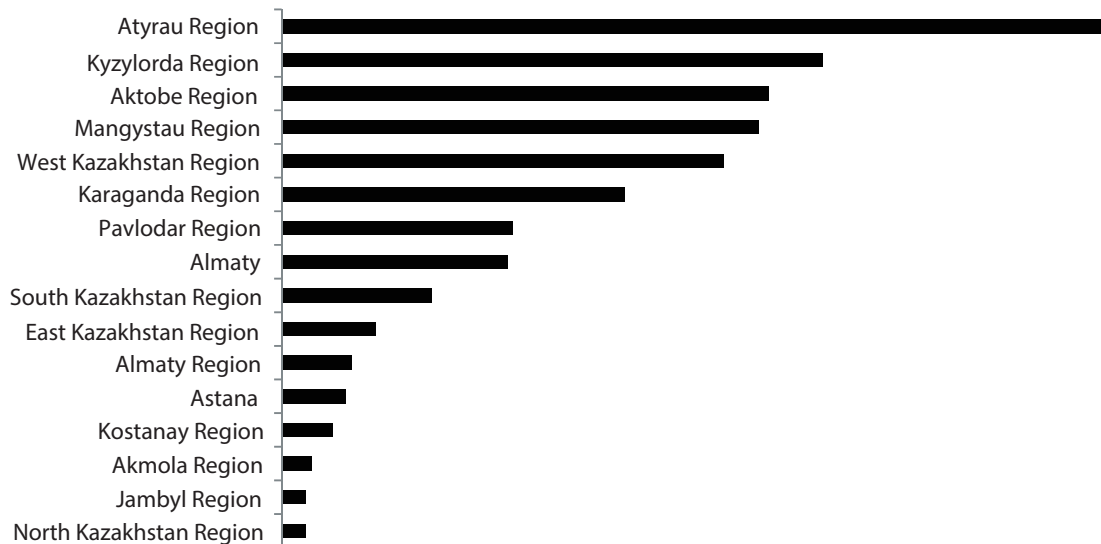


Fig. 3. Distribution of the social effect of FDI for the regions of Kazakhstan

large-scale investment projects on oil and gas recovery that require high FDI. This is confirmed by the following values of the social effect of FDI in these regions: Atyrau Region – 79.56 %, Kyzylorda Region – 55.37 %, Aktobe Region – 57.71 %, Mangystau Region – 34.38 %, West Kazakhstan Region – 68.63 % and Karaganda Region – 40.16 %.

Other regions of Kazakhstan demonstrate low values (less than 1 %) of the social effect of FDI. The social effect of FDI is 0.91 % for Pavlodar Region and even less, 0.59 %, for South Kazakhstan Region. The FDI inflow was 32.59 % and 16.5 % for these regions respectively. Lower values of the social effect of FDI are in East Kazakhstan Region – 0.37 %, Almaty Region – 0.28 % and Kostanay Region – 0.2 %. Relevant capital investments in the form of FDI for these regions were 11.55 %, 6.36 %, and 8.58 % respectively. The lowest values of the social effect of FDI are in Akmola Region – 0.12 %, North

Kazakhstan Region, and Jambyl Region – 0.09 %. This is a direct result of the FDI dynamics in these regions that are equal to 4.8 %, 3.81 %, and 3.17 % respectively.

Two cities of republican status, Almaty, and Astana were included in this research among the 16 objects. These metropolises took part in the scientific experiment together with 14 regions of Kazakhstan as separated local units and demonstrated significantly different values of the social effect of FDI: 0.89 % for Almaty and 0.25 % for Astana. Comparison of these data demonstrates that the social effect of FDI for Almaty is more than 3 times higher than the relevant value for the new capital of Kazakhstan. Obviously, this is connected with the FDI inflow for these cities that is equal to 30.34 % for Almaty and 5.89 % for Astana.

On the one hand, the economic sense of the values presented in Table 8 consists of describing the FDI influence on the change of the six factors that determine the quality of life and well-being of the population in the regions of Kazakhstan. Moreover, these values confirm the availability of the positive and negative social effects of the FDI in the context of the regions. Positive social changes are relevant to employment, health, poverty and consumption of the population while negative social changes are relevant to the environment and education factors. As for the poverty factor, it is referred to the FDI role in reducing poverty in the regions of Kazakhstan, because during the entire period under investigation the share of people with substandard income was constantly reducing according to official statistics. Thus, the introduction of the FDI factor to the model has no negative effect on the development dynamics of trends of these factors in the 16 regions of Kazakhstan during 2003–2013. To the contrary, it is important to mention that initial negative values of some factors reduce the total value of the positive cumulative social effect of FDI in the regions. Therefore, it could be supposed that FDI, in general, has no negative effect on the socio-economic development of the Republic's regions, which depends on a variety of factors that are different in their nature (including the FDI).

Also, we have made an attempt to analyze the structure of the FDI cumulative social effect in terms of different factors. For this purpose, the cumulative values of the social effect of FDI, presented in the last row of Table 8, were analyzed. It is important to note that these values are independent of the territorial origin of the social effect of FDI. This analysis has demonstrated positive values of the social effect of FDI for four factors (employment, consumption, poverty and health). Moreover, this analysis helps to identify the negative components of the social effect of FDI that could not be identified in the cumulative values for the regions, because for each region positive values of some factors exceed the negative values of others, so the total value is positive. Negative values of the social effect are relevant to the environment and education factors that are presented in Figure 4 as cut-out parts of the “pie”.

As shown in Figure 4, the consumption factor is of the highest importance (6.99 %). The second position is taken by the employment factor (4.76 %), the third – by the poverty factor (4.17 %), the fourth – by the health factor (1.64 %), the fifth – by the environment factor (0.58 %), which has a negative value. The lowest position is taken by the education factor (0.92 %), which also has a negative value. The Rating of the regional priority of factors confirmed the determining influence of the following three factors (the share of consumption, employment and poor people) on the quality of life and well-being of the population of the regions of Kazakhstan. This analysis allows us to identify the fourth factor that is also very important in terms of its influence on the quality of life of the population.

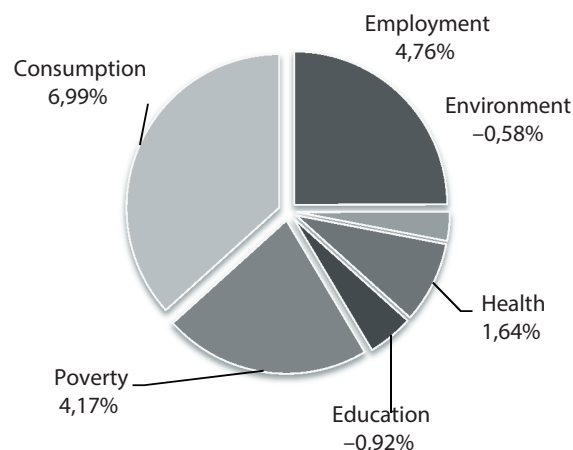


Fig. 4. Factor-based decomposition of the social effect of FDI, %

This factor is public health, and it has a positive value. At the same time, unfortunately, analysis of the social effect of FDI structure for different factors confirmed a low priority of the education and environment factors due to their negative values.

4. Conclusions

In general, it could be stated that the target goal to identify the social impact of FDI in the regions of Kazakhstan and to assess the impact of FDI on the quality of life and well-being of the population in the regions has been achieved. Therefore, the main results of this research could be formulated as follows:

1. As part of the research, a positive cumulative social effect of the FDI in the regions of Kazakhstan was preliminary identified and assessed using the model based on the AHP mathematical apparatus and expert evaluations of a hypothetical expert. In addition, it was found that the OFIE investment activity in the regions of the Republic, in general, did not have a negative impact on socio-economic development of the regions, or on the quality of life and well-being of the population in these regions during the period under investigation.

2. The model helps to obtain a tool for ranking factors, according to the priority of their influence on the problem. This tool was used to develop the Rating of the regional priority of factors, which helped to identify the determining factors for the quality of life and well-being of the population in the regions of Kazakhstan. These factors are consumption, employment, poverty, and health. On the other hand, it was revealed that the education and environment factors are characterized by a lower priority of influence on the quality of life and living standards of Kazakhstan citizens in the regions.

3. Factor-based decomposition of the social effect of FDI confirmed the positive impact of FDI on the four factors of the model: consumption and employment, poverty and health. It also revealed the negative components of the social effect of FDI for two factors: education and environment. In this way, positive and negative trends of the dynamics of these factors, which were earlier calculated based on the official statistics data, were confirmed.

4. The positive result of the modeling allows us to make recommendations for development of the positive social effects of FDI in the regions of Kazakhstan, because it will facilitate economic growth and strengthen the competitive advantages of the national economy as a whole. For these purposes, it is recommended to broaden OFIE social responsibility towards Kazakhstan society. This could be done by means of the active involvement of OFIE into solving social problems of the regions of the Republic, which are currently “solved”, first of all, via implementation of large-scale, state-funded social programs that, unfortunately, are characterized as low-efficient. Therefore, it is important to develop actively the public-private partnership with OFIE, especially to address the problem of employment, which should be a “significant” factor in the RPF Rating that defines the quality of life and well-being of Kazakhstan citizens in the regions.

5. We also recommend improving the legal framework of OFIE activities in the regions by including compulsory social programs aimed at achieving a positive social effect of FDI in the regions. For these purposes, we believe it is important to perform obligatory monitoring and analysis of social results of OFIE activities in the regions. This analysis could be based on OFIE social reports, which will measure their achievements and the ability to provide favorable living standards to the residents of regions, in which OFIE are operated.

6. In turn, the OFIE social reports will allow, for example, to develop a rating of “socially friendly” foreign-invested companies in every region of the country. Such a rating could be a useful tool not only for assessing their social activity in the regions, but also for calculating the overall index of the quality of life in the regions of Kazakhstan. On this basis, it could be possible to identify and rank the “socially favorable” regions of the Republic. This is important in terms of increasing of investment attractiveness of these regions that will provide a long-term, positive impact on the economic development of the country.

Therefore, Saaty’s analytic hierarchy process, which was applied in this research for assessment of the social effect of FDI in the regions of Republic, could become a useful tool to enhance the validity of socio-economic policy in the development of public-private partnerships in the regions of Kazakhstan, to ensure regional development and to increase the positive social effect of FDI in the future.

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