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Modeling of unstable economic systems based on the distribution of the population engaged in the economy of Tajikistan

Abstract

Object: The purpose of this study is to analyze and develop a mathematical model of the distribution of the employed population in the economy of the Republic of Tajikistan, according to the types of economic activity using the Sigma Plot program.

Methods: In the present study the mathematical and statistical modeling of the distribution of the population employed in the economy of the Republic of Tajikistan is used. Modern computer technologies and programs create opportunities for developing and verification of new models and also help to improve model-based research methods, as well as the methods for analysis and presentation of simulation results.

The narrowly professional use of modeling methods is giving way to the wide use of simulation models based on modern computer programs. And there is an inevitable need to put the issue of development of modeling in the context of real-life issues and interpretation of its fundamental concepts.

Findings: For the proposed models the mathematical regression equations are obtained and the coefficients of these equations are calculated using computer programs. By the proposed mathematical and statistical models the ratio of the employed population and the unused labour force in the Republic of Tajikistan is calculated. The results showed that in order to accelerate the industrialization of the country and ensure the sustainable development of industry, it is necessary to take into account this ratio in the country.

Conclusions: The developed mathematical model in the present work has been applied to show the dynamics of changes in the employed and unemployed labour force in the Republic of Tajikistan for the period 2006-2022. Consequently, we showed the possibility of using the unused labour force in order to solve one of the strategic goals of the republic, that is, the accelerated industrialization of the country.

Keywords: model, employment, economic systems, applied programs, schedule, regression, Labor resources.

Introduction

Mathematical models serve as a means of knowing the patterns and properties of the behavior of the original object by creating its image (substitute object), expressed in mathematical form.

Mathematical modeling is the process of establishing correspondence with a given real economic object of its mathematical model, studying the model by means of mathematics and interpreting the results in terms of the original mathematics.

A stochastic (non-deterministic, probabilistic) model is a mathematical model for which the parameters, operating conditions and characteristics of the state of the simulated object are represented by random variables and are connected by random dependencies.

Literature Review

Traditional problems of probability theory and mathematical statistics can be considered as the simplest problems of stochastic modeling, since they involve the analysis (by means of mathematics) of processes and phenomena of a random nature (Kucheryavy V.I., Milkov S.N., 2010; Kamenev G. K., Kamenev I. G. 2020; Kotliarova1 E.V. et al, 2021; Tleulesov A.K.. et al, 2021).

According to the annually Address of the President of Tajikistan, the Leader of the Nation "On the main directions of the domestic and foreign policy of the republic" the implementation of one of the strategic goals – the accelerated industrialization of the country will provide an opportunity to ensure the sustainable devel-

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opment of industry as a producer of high added value, resulting in the creation of tens of thousands of new jobs. Despite the provided benefits, there are still many unused opportunities and capacities for increasing the pace of accelerated industrialization. For instance, sufficient reserves of domestic raw materials allow to ensure the development of such industries as metallurgy, light industry, food and pharmaceuticals. The achieved result allows to enhance the volume of production, which assists to decide the export and import of substituting products. Thus, we will achieve an accelerated industrialization of the country through the complete processing of minerals, including non-ferrous expensive metals, as well as through the processing of agricultural products and medicinal herbs.

Therefore, all necessary measures should be taken to organize enterprises with modern technologies, innovation and technology parks, information processing centers, create new jobs and establish the production of final high quality products. Over the next 5 years, that is, within the framework of the "Years of Industrial Development", there is an opportunity to create new enterprises, restore existing capacities, increase the volume of mining and mineral processing, and it will be possible to start a number of large enterprises for the final processing of raw materials and the formation of thousands of new jobs (The annually Address of the President of the Republic of Tajikistan, Leader of the Nation, Respected Emomali Rahmon "On the main directions of the domestic and foreign policy of the republic", December 21, 2021).

Methods

Based on the above-mentioned priorities, we have set the task to analyze and develop computer-based mathematical models for the distribution of the engaged population according to the types of economic activity in the economy of the Republic of Tajikistan.

To solve this issue, we analyzed the distribution of the population engaged according to the types of economic activity in the economy of the Republic of Tajikistan, using the statistical data of the Agency on Statistics under the President of the Republic of Tajikistan for 2021 (Annually statistical Journal).

Results

Table shows the number of employed and unemployed population of the Republic of Tajikistan in 2006-2021 (Annually statistical Journal, Tajikistan – 2021, 126-138).

Table. Employed and unemployed population of the Republic of Tajikistan 2006 – 2021

Years	Labor resources of the RT (N×1000 people)	Labor force, employed population in RT (N×1000 people)	Unused labor force in the economy of the Republic of Tajikistan (N×1000 people)	Including students (N×1000 people)
2006	4047	2137	1862	506
2007	4172	2150	1971	518
2008	4310	2168	2093	524
2009	4435	2219	2171	534
2010	4530	2233	2250	557
2011	4664	2249	2361	529
2012	4796	2291	2449	541
2013	4859	2307	2497	554
2014	4983	2325	2601	592
2015	5111	2380	2674	602
2016	5224	2384	2786	615
2017	5326	2407	2866	632
2018	5427	2426	2949	638
2019	5521	2463	3007	647
2020	5625	2506	3068	670
2021	5734	2639	3098	681
Note - compiled by the author				

Using Table and the Sigma Plot program, we analyzed the distribution of the labor force, the employed population in the economy of the Republic of Tajikistan according to the types of economic activity.

Sigma Plot is an excellent tool for scientific plotting and statistical analysis. The program is used in various scientific fields and offers analysts more than 100 types of charts, a wide range of graphic templates and

tools, as well as a full set of functions for accurate and fast data analysis and visualization. It allows you to quickly create complex graphs and charts. Integration with Microsoft Office provides access to Excel file data and its presentation in Microsoft PowerPoint. The program offers numerous options for modeling and graphical display of data and allows you to present any object in the form of Sigma Plot that is most suitable for scientific applications, which has all the necessary tools for statistical analysis and allows you to save a large amount of data. Using the Sigma Plot Regression Wizard, an equation is selected that matches the original data and a model is built for the data, taking into account the obtained results. Sigma Plot offers efficient data management and performing the necessary operations with them (Sigma Plot program. Instructions for use).

For several years, we have been using the Sigma Plot program in our work to analyze the results of experimental studies, for statistical processing of materials and for correlation analysis of data (Akramov M.B. et al, 2021, 9-13; Akramov M.B., 2021, 18-28; Akramov M. B. 2019, 41-45).

Analyzing the statistical data (Table), we determined the dependence of labor resources in the Republic of Tajikistan for the period 2006-2020.

Figure 1 shows the chronogram of the labor force in the Republic of Tajikistan for the period 2006-2021.

In order to accelerate the industrialization of the country and ensure the sustainable development of industry, it is necessary to take into account the ratio of the employed population and the unused labor force in the Republic of Tajikistan.

Based on the obtained static values and using the Sigma Plot program, we have developed models of these dependencies. Figure 2 shows the dependence of labor resources on time for these two categories of labor in the Republic of Tajikistan for the period 2006-2021.
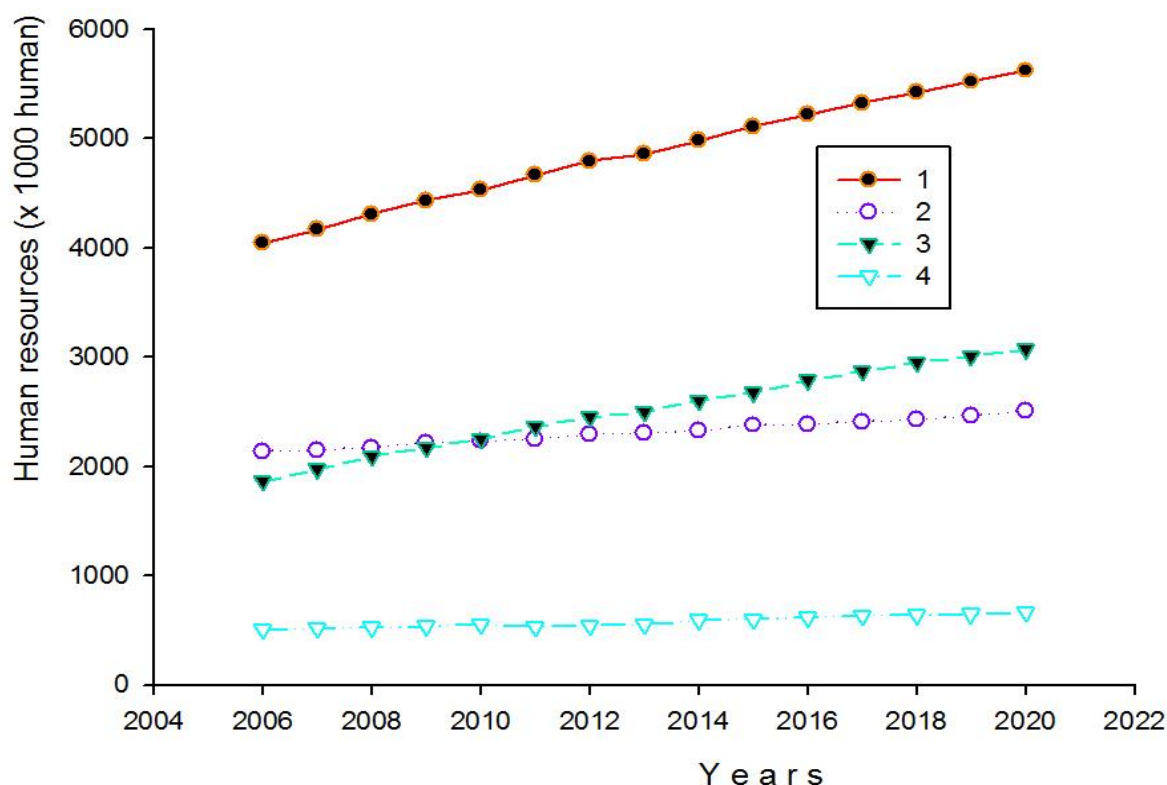

Figure 1. The chronogram of the labor force in the Republic of Tajikistan for the period 2006-2020
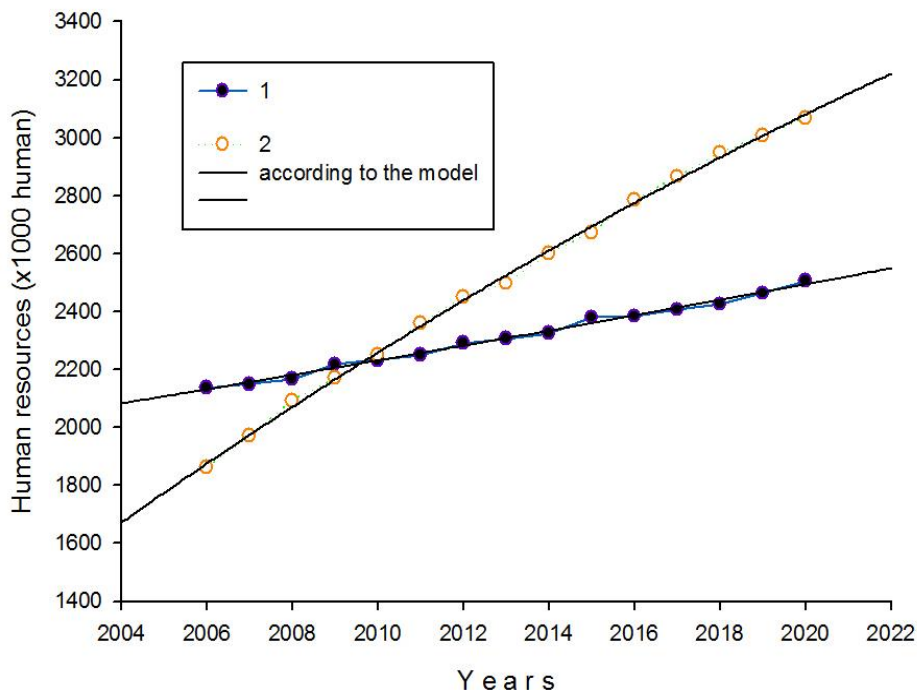
Note - compiled by the author

Figure 2. Dependence of labor resources for two categories of labor force in the Republic of Tajikistan for the period 2006 - 2020 1 - employed population, 2 - unused labor force

Note - compiled by the author

According to the graph, the share of unused labor force has been increased gradually. On the graph, solid lines show theoretical calculations, according to the proposed models.

The model of the chronology of the dependence of the employed population in the Republic of Tajikistan can be represented as a linear equation of the type

$$N = y0+a*x+b*x,$$

where N – labor resources.

Taking into account the regression coefficients, the equation can be rewritten as

$$N =- 4125417, 9 + 4015,19*x. \tag{1}$$

The model of the chronology of the dependence of the unused labor force in RT can be represented as a parabolic fiction of the type

$$N = y0 + a*x+b*x^2,$$

Taking into account regression coefficients

$$N = 362072, 49 - 383,34 *x +0,1016*x^2. \tag{2}$$

Regression R == 0,9963.
The calculation and other regression and variation parameters are given below.
Nonlinear Regression.
Data Source: Data 20.07.2022 1 in Notebook 2
Equation: Polynomial; Quadratic
f=y0+a*x+b*x^2

R	Rsqr	AdjRsqr	Standard Error of Estimate
0,9963	0,9925	0,9913	10,8548

	Coefficient	Std. Error	t	P	VIF

y0	362072,4925	684653,6494	0,5288	0,6066	59675073750,6092<
a	-383,3413	680,2345	-0,5635	0,5834	238703033337,0485<
b	0,1016	0,1690	0,6016	0,5586	59677101262,5263<

Analysis of Variance:

Uncorrected for the mean of the observations:

	DF	SS	MS
Regression	3	80206271,0912	26735423,6971
Residual	12	1413,9088	117,8257
Total	15	80207685,0000	5347179,0000

Corrected for the mean of the observations:

	DF	SS	MS	F	P
Regression	2	187869,4245	93934,7123	797,2343	<0,0001
Residual	12	1413,9088	117,8257		
Total	14	189283,3333	13520,2381		

Statistical Tests:

PRESS   2322,4514

Durbin-Watson Statistic   2,3010 Failed

Normality Test   Passed (P = 0,9458)

K-S Statistic = 0,1305   Significance Level = 0,9458

Constant Variance Test   Passed (P = 0,7728)

Power of performed test with alpha = <0,0001: 0,0000

The power of the performed test (0,0000) is below the desired power of 0,8000.

You should interpret the negative findings cautiously.

Regression Diagnostics:

Row	Std. Res.	Stud. Res.	Stud. Del. Res.
1	0,5113	0,6990	0,6833
2	- 0,5554	- 0,6489	- 0,6325
3	-1,1802	-1,2921	-1,3333
4	1,2165	1,3008	1,3438
5	0,1857	0,1981	0,1900
6	-0,6795	-0,7297	-0,7147
7	0,8318	0,9003	0,8927
8	-0,0709	-0,0769	-0,0737
9	-0,8080	-0,8745	-0,8653
10	1,8447	1,9812	2,3124<
11	-0,2196	-0,2343	-0,2249
12	-0,5523	-0,5906	-0,5739
13	-1,2723	-1,3929	-1,4566
14	-0,3527	-0,4122	-0,3975
15	1,1009	1,5046	1,5993

Influence Diagnostics:

Row	Cook's Dist	Leverage	DFFITS
1	0,1415	0,4649	0,6369
2	0,0513	0,2675	-0,3823
3	0,1105	0,1657	-0,5942
4	0,0810	0,1255	0,5091
5	0,0018	0,1211	0,0705
6	0,0272	0,1329	-0,2798
7	0,0464	0,1464	0,3698
8	0,0004	0,1511	-0,0311
9	0,0437	0,1464	-0,3583
10	0,2008	0,1330	0,9058
11	0,0025	0,1215	-0,0836
12	0,0167	0,1255	-0,2174
13	0,1285	0,1657	-0,6492

| 14 | 0,0207 | 0,2680 -0, | 2405 |
| 15 | 0,6549 | 0,4646 1, | 4899 |

95% Confidence:

Row	Predicted	95% Conf-L	95% Conf-U	95% Pred-L	95% Pred-U
1	2131,4501	2115,3239	2147,5764	2102,8249	2160,0753
2	2156,0287	2143,7959	2168,2614	2129,4019	2182,6554
3	2180,8105	2171,1828	2190,4382	2155,2755	2206,3455
4	2205,7957	2197,4166	2214,1747	2180,7047	2230,8866
5	2230,9841	2222,7545	2239,2137	2205,9427	2256,0255
6	2256,3758	2247,7547	2264,9969	2231,2031	2281,5486
7	2281,9709	2272,9202	2291,0215	2256,6478	2307,2940
8	2307,7692	2298,5754	2316,9630	2282,3946	2333,1438
9	2333,7708	2324,7229	2342,8188	2308,4487	2359,0930
10	2359,9758	2351,3494	2368,6021	2334,8012	2385,1504
11	2386,3840	2378,1393	2394,6288	2361,3376	2411,4304
12	2412,9956	2404,6180	2421,3731	2387,9052	2438,0860
13	2439,8104	2430,1826	2449,4382	2414,2753	2465,3455
14	2466,8285	2454,5859	2479,0712	2440,1972	2493,4599
15	2494,0500	2477,9289	2510,1710	2465,4277	2522,6722

Fit Equation Description:

[Variables]

$x = col(10)$

$y = col(11)$

reciprocal_y = 1/abs(y)

reciprocal_ysquare = $1/y^2$

'Automatic Initial Parameter Estimate Functions

$F(q)=ape(x;y;2;0;1)$

[Parameters]

$y0 = F(0)[1]$ ''Auto {{previous: 362072}}

$a = F(0)[2]$ ''Auto {{previous: -383,341}}

$b = F(0)[3]$ ''Auto {{previous: 0,10165}}

[Equation]

$f=y0+a*x+b*x^2$

fit f to y

''fit f to y with weight reciprocal_y

''fit f to y with weight reciprocal_ysquare

[Constraints]

[Options]

tolerance=1e-10

step size=1

Iterations=200

Number of Iterations Performed = 3

This model includes random variables to produce many different results under different conditions.

The proposed model can also be applied in the theory of employment of the non-labor force in the Republic of Tajikistan.

Discussions and conclusions

Using statistical data, the employment of the population of the Republic of Tajikistan for the period 2006-2021 was analyzed.

The possibilities of using the Sigma Plot program in dynamic systems are shown.

A computer-mathematical model has been developed and applied to determine the dynamics of changes in the employed and unemployed labor force in the Republic of Tajikistan for the period of 2006-2020.

The possibility of using the unused labor force to solve one of the strategic goals of the Republic, i.e. accelerated industrialization of the country.

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М.Б. Акрамов, А.Н. Нұрализода, У.М. Вохидов, Н.Н. Нұрализода

Тәжікстан экономикасында жұмыс істейтін халықты бөлу негізінде тұрақсыз экономикалық жүйелерді модельдеу

Аңдатпа

Мақсаты: Зерттеудің мақсаты *Sigma Plot* бағдарламасын пайдалана отырып, экономикалық қызмет түрлері бойынша Тәжікстан Республикасының экономикасында жұмыспен қамтылған халықты бөлудің математикалық моделін талдау және әзірлеу.

Әдістері: Осы зерттеуде Тәжікстан Республикасының экономикасында жұмыспен қамтылған халықтың таралуын анықтауға математикалық және статистикалық модельдеу қолданылған. Қазіргі компьютерлік технологиялар мен бағдарламалар жаңа үлгілерді әзірлеу және тексеру үшін мүмкіндіктер жасайды, сонымен қатар модельдер негізіндегі зерттеу әдістерін, сондай-ақ модельдеу нәтижелерін талдау және ұсыну әдістерін жетілдіруге көмектеседі.

Модельдеу әдістерін тар кәсіби түрде қолдану заманауи компьютерлік бағдарламалар негізінде имитациялық модельдерді кеңінен қолдануға жол беріп отыр. Ал модельдеуді дамыту мәселесін нақты мәселелер мен оның іргелі ұғымдарын түсіндіру контекстіне қоюдың сөзсіз қажеттілігі туындайды.

Қорытынды: Ұсынылған модельдер үшін математикалық регрессия теңдеулері алынған және осы теңдеулердің коэффициенттері компьютерлік бағдарламалармен есептелген. Ұсынылған математикалық және статистикалық модельдердің көмегімен Тәжікстан Республикасында жұмыспен қамтылған халық пен пайдаланылмаған жұмыс күшінің арақатынасы есептелді. Нәтижелер елді индустрияландыруды жеделдету және өнеркәсіптің тұрақты дамуын қамтамасыз ету үшін елдегі бұл байланысты ескеру қажет екенін көрсетті.

Тұжырымдама: Бұл жұмыста әзірленген математикалық модель 2006-2022 жылдар аралығындағы Тәжікстан Республикасындағы жұмыспен қамтылған және жұмыссыз жұмыс күшінің өзгеру динамикасын көрсету үшін қолданылды. Демек, пайдаланылмайтын жұмыс күшін республиканың стратегиялық мақсаттарының бірі, яғни елді үдемелі индустрияландыруды шешуге пайдалану мүмкіндігі көрсетілген.

Кілт сөздер: модель, жұмыспен қамту, экономикалық жүйелер, қолданбалы бағдарламалар, кесте, регрессия, еңбек ресурстары.

М.Б. Акрамов, А.Н. Нурализода, У.М. Вохидов, Н.Н. Нурализода

Моделирование нестабильных экономических систем на основе распределения населения, занятого в экономике Таджикистана

Аннотация

Цель: Целью данного исследования является анализ и разработка математической модели распределения занятого населения в экономике Республики Таджикистан по видам экономической деятельности с использованием программы *Sigma Plot.*

Методы: В настоящем исследовании используется математическое и статистическое моделирование распределения населения, занятого в экономике Республики Таджикистан. Современные компьютерные технологии и программы создают возможности для разработки и верификации новых моделей, а также помогают совершенствовать методы исследования на основе моделей, а также методы анализа и представления результатов моделирования.

Узкопрофессиональное использование методов моделирования уступает место широкому использованию имитационных моделей, основанных на современных компьютерных программах. И существует неизбежная необходимость поставить вопрос о развитии моделирования в контексте реальных проблем и интерпретации его фундаментальных концепций.

Результаты: Для предложенных моделей получены математические уравнения регрессии и коэффициенты этих уравнений рассчитаны с помощью компьютерных программ. С помощью предложенных математических и статистических моделей рассчитано соотношение занятого населения и неиспользуемой рабочей силы в Республике Таджикистан. Результаты показали, что для ускорения индустриализации страны и обеспечения устойчивого развития промышленности необходимо учитывать это соотношение в стране.

Выводы: Разработанная математическая модель в настоящей работе была применена для отображения динамики изменений в занятой и безработной рабочей силе в Республике Таджикистан за период 2006–2022 гг. Следовательно, мы показали возможность использования неиспользуемой рабочей силы для решения одной из стратегических целей республики, то есть ускоренной индустриализации страны.

Ключевые слова: модель, занятость, экономические системы, прикладные программы, график, регрессия, трудовые ресурсы.