Optimization and Post-Optimization Analysis of the Personnel Structure of Local Self-Government Bodies to Improve the Reintegration of Veterans*

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Abstract

This paper addresses the critical issue of veteran reintegration into civilian life, focusing on the optimization of human resource policies within local self-government bodies in Ukraine. Leveraging integer programming and post-optimization sensitivity analysis, the study aims to enhance the efficiency of veteran support services. A mathematical model is developed to optimize the staffing levels of veteran assistants and social workers within a local community, using GEKKO, a Python-based optimization tool. Parametric sensitivity analysis, employing the "One-Factor-At-a-Time" approach, is used to evaluate the impact of employee efficiency on optimal staffing solutions. The results demonstrate that the efficiency of social workers is a more sensitive parameter, highlighting the importance of their professional development and resource allocation. This study underscores the significance of sensitivity analysis in integer linear programming for identifying critical parameters and improving the overall effectiveness of social services management, ultimately contributing to the successful reintegration of veterans.

Keywords

veteran reintegration, post-optimization analysis, sensitivity analysis, integer programming

1. Introduction

After completing military service, which requires adaptation to extreme conditions, veterans face the challenge of reintegrating into civilian life. Reintegration is a multidimensional and long-term process that involves physical and psychological recovery, social adaptation, and professional realization. The success of this process largely depends on the support of family, the community, and society as a whole. However, the key role is played by the state.

Effective reintegration of veterans is not only a social responsibility of the state but also a crucial factor in ensuring social cohesion and economic development. The state possesses the resources and mechanisms to create a favorable environment for veterans' return to civilian life. However, ineffective or insufficient government policies can significantly complicate this process.

One of the key elements of reintegration policy is the human resource potential of local self-government bodies, which work directly with veterans and their families. Optimizing the staffing of these bodies enhances service quality, ensures an individualized approach to veterans' needs, and accelerates their social adaptation.

Therefore, studying the role of state institutions in the social reintegration of veterans and improving the human resource policies of local self-government is a significant contribution to the

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development of the state support system for veterans, strengthening social inclusion, and enhancing overall societal well-being [1].

2. Optimization of Management Processes

For Ukraine, ensuring an adequate standard of living for veterans is of utmost importance today. This entails not only restructuring the departments that provide relevant assistance but also enhancing the efficiency of their staff. Achieving this requires a strategic approach to optimizing human resources and adapting management processes to properly address the specific needs of this crucial category of citizens. Effective human resource management is a key factor in the comprehensive administration of both operational and administrative processes [2].

Opportunities for improving personnel management in local government departments will be examined using the example of one of the territorial communities in Lviv Oblast—Davydiv Village Council of Lviv District, Lviv Oblast, with a population of over 20,000 people. As veterans return to their communities, the Davydiv Village Council has recorded a growing number of inquiries from both veterans themselves and their families. Most of these requests relate to assistance with processing social benefits, consultations on pension entitlements, opportunities for retraining or acquiring new education, as well as issues of rehabilitation and free medical treatment. The scope and nature of support largely depend on the veteran's status—whether they are simply recognized as a combatant or have acquired a disability due to military service. Families of veterans also frequently seek help in resolving household issues.

Typically, a veteran first contacts the local Administrative Services Center (CNAP), where, depending on the nature of the request, either a veteran's assistant or a social department worker assists them. The latter primarily provides social support in addressing everyday issues.

As of July 6, 2024, Cabinet of Ministers of Ukraine Resolution No. 779 has come into effect, introducing the position of veteran's assistant within local government bodies. This resolution defines the veteran's assistant as a specialist who helps veterans reintegrate into civilian life and access their entitled benefits and services.

Thus, the process of handling inquiries from veterans and their families, as well as addressing their requests for household assistance, involves two categories of employees: veteran's assistants and social workers. The specific nature of this activity within the village council will be formulated as a task of optimizing the staffing structure of local government departments.

3. The Problem of Optimizing the Staffing of Local Government Departments

Based on the analysis of job responsibilities and workload of veteran assistants and social workers, it can be generalized that on average, a veteran assistant processes 10 requests per week related to document support and 1 request concerning household issues. In contrast, a social worker handles 1 request for document processing support and 5 requests for household issues per week. Also, among the veteran assistant`s activities, there is a participation in internships or training programs to update their knowledge on available opportunities for veterans. However, such training is not mandatory for social workers. When evaluating the effectiveness of a veteran assistant's work, the Starosilska Village Council emphasizes the need for at least one veteran assistant on staff. Suppose that each week, the social department of the village council receives at least 25 requests for document processing support and 35 requests for assistance with household issues. It is necessary to determine the minimum staffing levels, i.e., the number of veteran assistants and social workers

required to ensure the timely processing of all citizens' requests. To do this, we will build a mathematical model for the corresponding problem, and since the solution involves determining the number of employees, this problem falls under integer programming.

Let x be the number of veteran assistants, and y be the number of social workers. We will convert the problem's conditions into a tabular

		Employee type		Requests number
		Veteran assistant	Social worker	
Types of tasks performed	Document processing	10	1	At least 25
	Household issues	1	5	At least 35
Number of employees		x, at least 1	y	

Figure 1: Tabular representation of the conditions.

Then, the integer programming problem can be written in the form (1)-(3)

Minimize

$$F = x + y, \tag{1}$$

Under conditions

$$\begin{gathered} 10x + y \geqslant 25 \\ y + 5y \geqslant 35 \\ x \geqslant 1 \end{gathered} \tag{2}$$

$$x, y \geqslant 0, x, y \in Z \tag{3}$$

To solve the integer programming problem (1)-(3), we will use GEKKO — a Python package for machine learning and solving integer and mixed optimization problems [3]. It is integrated with numerical solvers for linear, quadratic, nonlinear, and mixed-integer programming problems, as discussed by the authors in the work [4] in the context of nuclear waste recycling optimization.

Figure 2 presents the results of solving this problem.

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 ----------------------------------------------------
 Solver         :  APOPT (v1.0)
 Solution time  :   1.589999999850988E-002 sec
 Objective      :    9.00000000000000
 Successful solution
 ----------------------------------------------------

Objective:  9.0
x:  2.0
y:  7.0
```

Figure 2: Results of solving the integer programming problem (1)-(3), obtained using the GEKKO package.

Thus, the solution to problem (1)-(3) can be formulated as follows: to successfully process the volume of requests received by the social department, its staff must consist of at least 2 veteran assistants and 7 social workers

4. Post-optimization analysis of the problem

The formulation of the staffing optimization problem for local government departments as an integer programming problem not only allows for finding the optimal solution but also enables post-optimization analysis, or sensitivity analysis, to investigate the impact of changes in the initial parameters on the result.

For linear programming problems, sensitivity analysis may involve determining the type of constraints, finding the range of changes in the objective function coefficients, and determining the value of resources. However, for integer programming problems, applying these approaches may only provide approximate results, or the results may be difficult to interpret in the context of the problem. To perform sensitivity analysis for the integer programming problem (1)-(3), we will use the parametric method, as described by the authors in [5] for analyzing the optimal size of solar panels. By applying the parametric method, we will assess the stability of the optimal solution and identify the parameters that most significantly impact the results. We will assume that stability refers to the ability of the optimal solution to remain unchanged or to change only slightly when the input data is altered.

The sensitivity analysis will be conducted in three stages [6]:

1. Identify the model parameters that will be subject to analysis.

2. Compute the solutions to the corresponding integer programming problem with the given parameters.

3. Analyze the impact of each parameter on the model based on the computed indicators and their visualization.

The parameters for analysis will be selected based on the following considerations. The input data for the problem (1)-(3) is structured in a table on Figure 1: it includes the productivity of specialists — the number of requests processed per week — as well as the number of various types of requests received by the social department. For this problem, the number of requests received by the social department is an uncontrollable parameter, meaning it cannot be influenced. On the other hand, the input parameters, which denote the number of requests processed per week by an employee, can be adjusted up to a certain limit, so these values will be analyzed in the parametric analysis. The variability in the number of tasks performed may reflect the change in work efficiency due to acquired experience and, as a result, the improvement in employee qualifications.

We will use the "One-Factor-At-a-Time" approach [6], where only one parameter is changed during modeling while the others remain constant. We will investigate the impact of changes in the number of tasks performed by social workers on the optimization results. We will make two assumptions.

1. The effectiveness of the assistant's work is constant, meaning the coefficients for the variable x will remain fixed, while the effectiveness of the social worker's work will vary between 1 and 15 tasks per week.

2. Additionally, we will assume that a social worker cannot perform more than 16 tasks per week in total, combining both types of tasks, due to the time-consuming nature of these tasks.

In Figure 4, we present a heatmap of the results for calculating the optimal number of staff for different parameters—the number of tasks a social worker completes per week. The element (1,3) of this heatmap matrix contains the value "13 (2;11)", which can be read as "at least 13 employees are needed to handle the requests (2 veteran assistants and 11 social workers), provided that a social worker performs 1 document processing request and 3 social assistance requests per week." The

GEKKO package was also used to solve the respective tasks. On the heatmap, results that are intentionally impossible are omitted: for example, the cell (10,10) should contain the optimal number of workers for the condition where a social worker can complete 10 document processing support cases and 10 household issue cases per week.

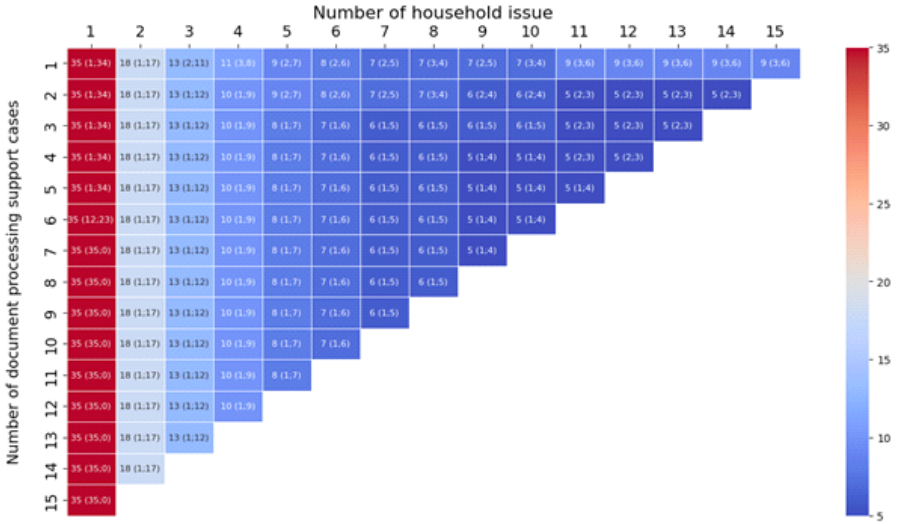

Figure 3: Heatmap of the results of the parametric analysis of the social worker's efficiency.

Similarly, we will investigate the impact of changes in the number of tasks performed by the veteran's assistant on the optimization results. Figure 4 presents a heatmap illustrating the results of calculating the optimal number of staff members for different values of the number of tasks performed by a veteran's assistant per week.

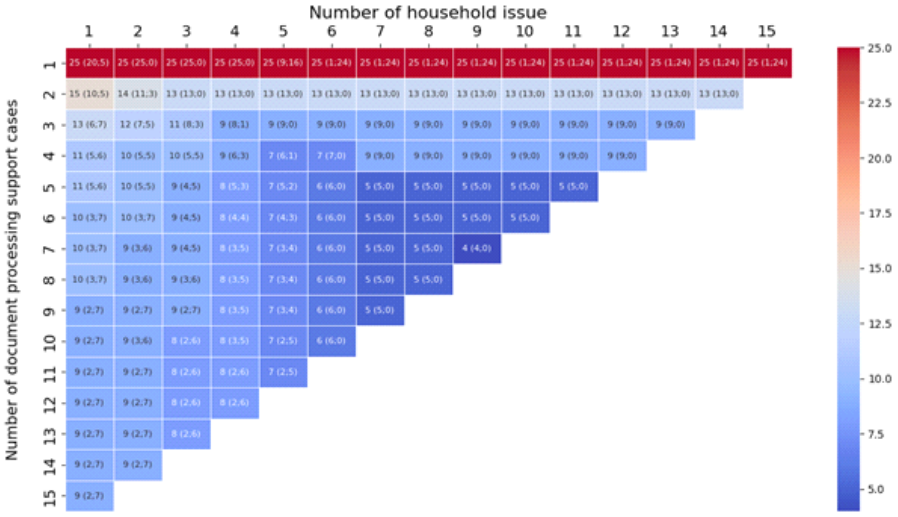

Figure 4: Heatmap of the results of the parametric analysis of the veteran assistant's efficiency.

The results exhibit a certain degree of symmetry. As illustrated in the heatmap in Figure 3, the number of employees decreases across the columns from left to right as the number of tasks performed increases. A similar downward trend in the number of employees can be observed across the rows in the heatmap in Figure 4.

The next step is to analyze the results obtained from Figures 4 and 5 to assess which data set indicates greater sensitivity of the studied parameter. To do this, we will calculate the standard deviation [6] across the rows and columns for each data set. We will compare the computed values — for the data set with a higher standard deviation, we can conclude that the values in this set are more spread out around the mean, meaning that the data variation is greater. This parameter is critical and requires more attention. The calculations were performed using Python's numpy and matplotlib.pyplot libraries. Computed numerical data are at Figure. 5, and Figure 6 presents a visualization of the computed standard deviation values.

```
Metric                  Values
-------------------------------------------------------------------------------------------------
Mean Rows (data1)       [35.  18.  13.  10.1  8.2  7.2  6.2  6.2  5.6  5.7  5.8  6.   6.3  7.  9. ]
Std Rows (data1)        [0.  0.  0.  0.3 0.4 0.4 0.4 0.4 0.4 0.7 0.7 1.6 1.7 1.9 2.  0. ]
Mean Columns (data1)    [11.1  9.9 10.  10.2 10.7 11.3 12.  12.9 13.9 15.2 16.8 19.  22.  26.5 35. ]
Std Columns (data1)     [7.  7.8 8.1 8.4 8.6 8.8 9.  9.2 9.4 9.6 9.7 9.7 9.4 8.5 0. ]
Mean Rows (data2)       [11.2 10.9 10.5 10.  9.4  9.  9.  9.5 10.  11.  12.2 14.  15.7 19.  25. ]
Std Rows (data2)        [4.1 4.1 4.4 4.7 5.2 5.7 6.3 6.5 6.8 6.8 6.9 6.6 6.8 6.  0. ]
Mean Columns (data2)    [25.  13.2  9.7  9.  6.9  7.  7.  7.4  7.6  7.8  8.2  8.5  8.7  9.  9. ]
Std Columns (data2)     [0.  0.6 1.3 1.1 2.2 2.  2.  1.8 1.5 1.1 0.7 0.5 0.5 0.  0. ]
```

Figure 5: Computed average and standard deviation.

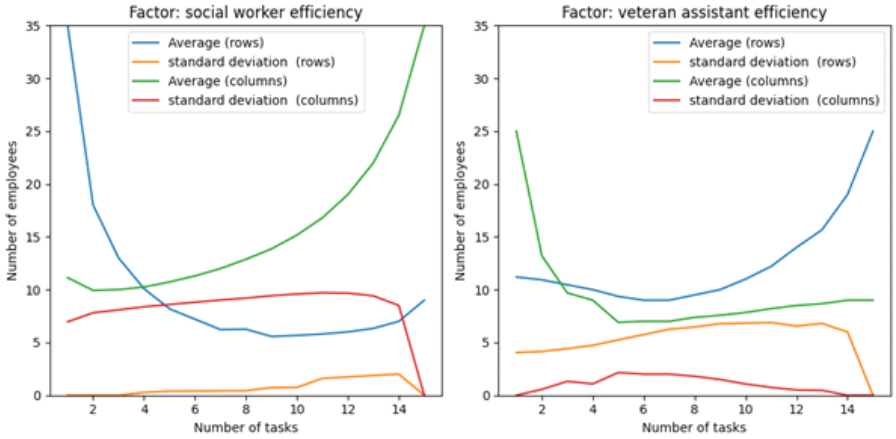

Figure 6: Visualization of the computed standard deviation values for the results of the parametric analysis.

As seen from Fig. 6, the standard deviation values for the results of the parametric analysis of the social worker's performance are higher, which we take as an indication of greater sensitivity of the studied parameter to the optimal solution. Thus, to improve personnel management in local government departments, all other things being equal, it is advisable to focus efforts on increasing the efficiency of social workers, for example, by ensuring their professional development, improving the material and technical base, etc. Another conclusion from the results of the post-optimization analysis may be that the veteran's assistant effectively performs his/her work, and if there are a sufficient number of such specialists, veterans' requests will be processed in a timely manner.

5. Conclusions

Sensitivity analysis in integer linear programming problems is an essential tool for assessing the critical parameters of a problem. For the formulated problem of optimizing the staffing of departments of local government bodies involved in meeting the needs of veterans, we studied how

changes in employee effectiveness impact the size and composition of the minimum staff required for the timely processing of requests.

In this case, the input parameter "number of requests" is not an object of sensitivity analysis. Instead, parameters related to the number of tasks performed by employees can be analyzed in post-optimization research. A parametric method based on the "One-Factor-At-a-Time" principle ([6]) was used for such an investigation. The sensitivity of each type of worker's effectiveness (the number of tasks performed) on the optimal solution was analyzed.

From the analysis of the computed standard deviation values, we can conclude that the effectiveness of the social worker is a more sensitive parameter, which should be considered when organizing the work of the social department. Taking the results of such analysis into account can be used to improve the allocation of human resources, predict potential changes in workload, and increase the overall effectiveness of social services management. The results can also be used for adjusting workforce recruitment plans, ensuring their training, and rationally distributing responsibilities among employees.

6. Declaration on Generative AI

The authors have not employed any Generative AI tools.

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