IJEASED

INTERNATIONAL JOURNAL OF EASTERN ANATOLIA SCIENCE ENGINEERING AND DESIGN

Uluslararası Doğu Anadolu Fen Mühendislik ve Tasarım Dergisi
ISSN: 2667-8764 , 3(1), 192-220, 2021
https://dergipark.org.tr/tr/pub/ijeased

Araştırma Makalesi / ***Research Article***
Doi: 10.47898/ijeased.817062

A Decision Support System For An Assignment and Rebalancing Problem in The Absence Of Staff

Abdurrahim BULUT [1*], Safak KIRIS [2]

[1] Nursen Cable Equipment, Kutahya, Tavsanlı, 43300, Turkey.

[2] Dumlupinar University, Graduate School of Science, Industrial Engineering, Kutahya, 43000, Turkey.

Yazar Kimliği / ***Author ID (ORCID Number)***	**Makale Süreci /** ***Article Process***	
[*]**Sorumlu Yazar /** *Corresponding author* : abulut@nursankd.com	**Geliş Tarihi /** ***Received Date*** :	27.10.2020
https://orcid.org/0000-0003-0737-9394 , A. Bulut	**Revizyon Tarihi /** ***Revision Date*** :	11.01.2021
https://orcid.org/0000-0002-7041-4722 , S. Kiris	**Kabul Tarihi /** ***Accepted Date*** :	20.02.2021
	Yayım Tarihi / ***Published Date*** :	15.07.2021

Alıntı / ***Cite :*** Bulut, A., Kiris, S. (2021). A Decision Support System For An Assignment and Rebalancing Problem in The Absence Of Staff, International Journal of Eastern Anatolia Science Engineering and Design, 3(1), 192-220.

Abstract

In today's intense competition environment, enterprises must use their production resources effectively in order to sustain their assets. The importance of this issue is increasing day by day. For this reason, enterprises are working to manage their resources in the best way with various methods.One of the most important sources for businesses is labor. It is necessary to make effective use of human factor in labor intensive enterprises. In addition, absence in the business is very common. In this study, a mathematical model was firstly proposed in order to assign the appropriate personnel instead of daily absentee staff in an automotive supplier industry and to distribute the work if necessary; afterwards, in order to answer the needs of the enterprise, the Decision Support System (DSS) has been designed. In the event that the personnel does not come to work in the operation with the proposed DSS, the most authorized personnel is assigned to the relevant work stations and the work is shared to the other stations where necessary. Therefore, with a systematic process management, sustaining of standard production and minimizing the losses which may occur are aimed.

Key Words: Assignment problem, Decision support system, Absence of staff.

Personel Devamsızlığında Atama ve Dengeleme Problemi için Karar Destek Sistemi

Özet

Günümüzün yoğun rekabet ortamı içerisinde işletmelerin varlıklarını sürdürebilmeleri için üretim kaynaklarını etkin bir şekilde kullanmaları gerekmektedir. Gün geçtikçe bu konunun önemi daha da artmaktadır. Bu nedenle işletmeler, çeşitli yaklaşımlar ile kaynaklarını en iyi şekilde yönetebilmek adına çalışmalar yapmaktadırlar. İşletmeler için en önemli kaynaklardan birisi iş gücüdür. Emek yoğun çalışan işletmelerde insan faktöründen etkin olarak faydalanmak gerekmektedir. Bunun yanında işletmelerde işe gelmeme durumuyla da çok sık karşılaşılmaktadır. İşe gelmeyen personelin yerine çalışacak personelin atanması, özellikle küçük ve orta büyüklükteki işletmelerde, işletme yöneticilerinin kişisel görüşlerine göre yapılmakta olup, genellikle istenilen hedeflere ulaşılamamakta ve görünmeyen kayıplar oluşmaktadır. Bu çalışmada bir otomotiv yan sanayi işletmesinde günlük devamsızlık yapan personelin yerine uygun personelin atanması ve gerekli ise işlerin dağıtılması için öncelikle bir matematiksel model önerilmiş, ardından işletme ihtiyaçlarına daha rahat cevap verebilmesi amacıyla bir Karar Destek Sistemi (KDS) tasarlanmıştır. Önerilen KDS ile işletmede personelin işe gelmemesi durumunda ilgili çalışma istasyonlarına, mevcut ekip içerisinden en yetkin personel atanmakta ve gerekli durumlarda da işler diğer istasyonlara paylaştırılmaktadır. Böylece sistematik bir süreç yönetimi ile oluşabilecek kayıpların en küçüklenmesi ve standart üretimin devam etmesi amaçlanmaktadır.

Anahtar Kelimeler: *Atama problemi, Karar destek sistemi, Personel devamsızlığı.*

1.Introduction

Today's rapidly increasing customer demands, limited resources and constantly increasing costs have necessitated firms to use their existing resources effectively and increase their efforts to minimize their costs.

At a firm that has a labor-intensive operation, the role of the human factor is undeniably large. This is why managers of firms should focus on efforts in terms of effective usage of their labor resources. In addition to this, another problem that is frequently encountered at labor-intensive firms is absence. Firms need to take the necessary precautions for such problems, too.

At installation lines that are designed to achieve large volumes of production, in the case of the absence of personnel that are assigned to workstations, the problem of replacing them with appropriate employment arises. To overcome this problem with the lowest degree of loss, firms need to find suitable solution recommendations. Here, the objective is to use the station capacity that is established for the purpose of operating an efficient installation line in the best way. The most significant problem that is encountered in the process of personnel assignment at firms for the case of absences is the absence of a systematic decision-making process for the problem of assigning new personnel to replace the absent to the relevant station. In the place of personnel that are absent, assigning personnel with the capacity to be able to work at that station would be appropriate.

Firms may achieve a solution by training personnel with such capacity and creating a separate team within themselves. These capable personnel, known as joker staff, are responsible for conducting operations at the station that are assigned to with the minimum loss of productivity. In cases of lacking sufficient substitute employees, the problem is aimed to be solved by distributing operations to the most suitable stations among others.

While the literature review revealed a limited number of studies on this topic, as the problems are unique to firms, it is believed that this study will contribute to the literature. This study firstly developed a mathematical model for assignment in the place of absent personnel per day. This model allows assignment of suitable personnel from the team of substitute personnel if there are sufficient substitute employees, and in the case that there are not sufficient substitute employees, assignment of the existing ones from the team and distribution of the remaining work load to other, suitable stations.

This proposed model was implemented by using the data of a firm operational in the automotive sector. The model was solved by using the Lingo 11.0 software.

The fact that solving a mathematical problem takes time and is not very suitable for daily usage requires a more practical solution for the firm. For this reason, a Decision Support System (DSS) was developed for the problem of assignment and rebalancing in cases of personnel absence. This system consists of interfaces that provide firm managers with ease of usage and information messages. The proposed DSS is a system that can systematically make decisions, provides the user with ease and is suitable for dynamic usage conditions. This way, against a problem, the firm will be able to find the most suitable solution for its goals in a fast and trouble-free manner.

In recent years, rapidly developing technology and constantly changing market conditions have led to the emergence of an intense competition environment. In the market conditions that have formed, in order to survive, sustain competition and increase revenues, firms need to reduce costs in their manufacturing systems and use their limited resources in the best way. This situation has increased the significance and number of studies that are carried out in the field of resource planning. When studies in the literature on personnel assignment are analyzed, several studies are observed to have used mathematical programming approaches such as integer programming, linear programming, dynamic programming and goal programming.

The topics covered in sections are as follows: In the second part, a literature research about assignment is included. In the third part, a mathematical model is created for the problem and a solution is proposed by using the data of the personnel group in a production line of the enterprise. In the fourth section, the proposed DSS is given under three headings and then an application on the system is evaluated. In the last section, results and recommendations are presented.

2. Literature Review

In recent years, rapidly developing technology and constantly changing market conditions have caused an intense competitive environment. It is necessary to reduce costs in production systems and to use limited resources in the best way in order to survive in the emerging market conditions, to sustain competition and to increase profits. This situation has increased the importance and number of studies conducted in the field of resource planning.

When the literature on staff assignment is examined, it can be seen that many studies encounter mathematical programming approaches such as integer programming, programming, programming and goal programming, programming and goal programming.

In the literature review; the summaries of some recent studies on the assignment problem are given in Table 1.

Table 1. Literature review on assignment problems

Year	Writer	Summary of the Study
2006	Gomes da Silva et al.	Tried to establish a decision support system for mass production planning. They used mixed integer linear programming on the basis of this decision support system.
2007	Aktaş et al.	Proposed a decision support system to improve resource allocation efficiency in health services consisting of four steps. They have listed the steps of this system as follows. In the first step, they identified the main factors affecting system efficiency. In the second step, BBN (Bayesian Belief Networ) method is applied for conditional variables and imprecise variables. In the third step, sensitivity analysis was performed to determine the most critical variables affecting the system. In the fourth step, strategies are proposed to improve system efficiency.
2008	Çetinyokuş et al.	Presented a decision support system for determining the factors to be used in the performance evaluation process, which is the most important problem encountered in the performance evaluation process in enterprises, and evaluating the performance of employees objectively based on these factors.

2008	Dolgui et al.	Proposed a mixed integer model under certain constraints. These constraints; Minimizing the required number of workers used at the same time, not exceeding the determined assembly line cycle time and determining the required number of workers for each process. Taking these constraints into account, they have developed a model that aims to assign stations.
2011	Sadjadi et al.	Proposed a stochastic model that includes the factors of hiring, firing, holding stock and not meeting the demand. In this study, which includes solution method comparison analysis, three different solution methods are compared with each other. These solution methods are; Linear programming model in Lingo 11.0, genetic algorithm model in C ++ and simulation models in arena program. As a result of his studies, it is stated that the genetic algorithm gives more accurate results than linear programming by comparing it with the help ofsimulation results
2014	In her study, Johnes	Provided an example of stochastic customer demand and shift need and cash flow, and service levels and suggestions for the improvement of these levels.
2014	Smet et al.	Solved the staff scheduling problem with a new hybrid approach. They talked about the two-stage meta-heuristic approach, taking into account multiple capabilities.
2014	Wong et al	Presented a two-step intuitive approach to the planning problem of healthcare professionals. In the first stage of this study, constraints are achieved with the single shift assignment heuristic, and in the second stage, appointments are made considering the preferences of nurses.
2014	Harjunkoski, et al.	Investigated production scheduling models and solution methods in their study. Problem types are classified among themselves and solution methods are mentioned. In addition, real life applications and examples were solved. In the last part of their work, the authors also included their ideas about energy and raw materials, which are potential problems especially in the automotive industry.
2015	Li et al.	Offered a solution to the problem of equipment, workforce and service planning with genetic algorithm.
2015	De Bruecker et al.	Published literature research in the field of workforce planning according to abilities. In these studies, the authors focus on human skill-oriented workforce planning and guide researchers working in this field.
2016	Hidri et al.	Developed a model using certain constraints to solve an assignment problem that determines the number of nurses needed by dividing nurses working in intensive care units in three blocks of a hospital into certain groups. The developed model is an integer programming model.
2017	Varlı et al.	Designed a model to meet the number of personnel needed in shifts assigned to the intensive care, emergency and operating room services of a hospital that is open at all hours of the day. They used the goal programming approach while creating this model.
2018	Polat et al.	Developed a model that would minimize the deviation from the maximum allowable workloads if a worker is assigned to any station.

3. Personnel Absence Problem and the Proposed Model

A mathematical model was proposed for assignment of suitable personnel in the place of absent personnel per day, and if necessary, distribution of workloads at an automotive sub-industry firm. The proposed mathematical model has been applied to the production line of the enterprise. (Bulut, 2019).

In the place of absent personnel, it is needed to assign personnel that have the capacity to work the same job. For this objective, the firm created a team consisting of qualified personnel. The team consisted of personnel known assubstitute personnel. A substitute personnel is responsible for performing jobs at the station they are assigned with minimal loss of productivity. In cases where there are not sufficientsubstitute personnel, the workload of the station in question was distributed to the two closest other stations based on their own workloads.

The mathematical model for assignment of substitute personnelin the place of absent personnel based on the qualifications of the substitute personnel and distribution of workloads is given between Equations (3.1) and (3.17).

Indices

$i=\{i|i=1,2,3\ldots10\}$ station index

$j=\{j|j=1,2,3\ldots5\}$ substitute personnel index

$k=\{k|k=1,2,3\ldots6\}$ process index

Parameters

J= Number of substitute personnel, $J \in N$

t_i= Cycle time of the i^{th} station

q_{jk} = Score of the j^{th} substitute in the process k

S= Number of missing operators, $S \in N$

A_{ji}= New cycle time of the i^{th} station by assignment of the j^{th} substitute to the i^{th} station

F_{i+1}= New cycle time of the $(i+1)^{th}$ station by distribution of the workload of the absent personnel of the i^{th} station with the ratio of the coefficient K_{i+1}

F_{i-1}= New cycle time of the $(i-1)^{th}$ station by distribution of the workload of the absent personnel of the i^{th} station with the ratio of the coefficient K_{i-1}

<u>Decision variables</u>

$$x_{ji} = \begin{cases} 1, & \text{If the } j^{th} \text{ substitute personnel is assigned to the } i^{th} \text{station,} \\ 0, & \text{otherwise} \end{cases}$$

$$C_i = \begin{cases} 1, & \text{If the } i^{th} \text{ station does not come to work} \\ 0, & \text{otherwise} \end{cases}$$

$$Z_i = \begin{cases} 1, & \text{If the substitute personnel is assigned to the } i^{th} \text{ station,} \\ 0, & \text{otherwise} \end{cases}$$

<u>Objective function</u>

$$\sum_{j=1}^{5}\sum_{i=1}^{5} \mathrm{Min}Z = \left[C_i * \left|\left(t_i - A_{ji}\right)\right|\right] + (1 - Z_i) * (C_i * F_{i,i+1} + C_i * F_{i,i-1}) \qquad (1)$$

<u>Limitations</u>

$$\sum_{j=1}^{J} C_i{*}X_{ji} \leq 1, \ \forall i, \qquad j = 1,2,\ldots,J \qquad (2)$$

$$\sum_{i=1}^{m} C_i * X_{ji} \leq 1, \forall j, \qquad j = 1,2,\ldots,m \qquad (3)$$

$$\sum_{i=1}^{S} C_i{*}X_{ji} \leq \mathrm{Min}(S, J), \ \ \forall j, \ i = 1,2,\ldots,s \qquad (4)$$

$$1 - \sum_{j=1}^{J} X_{j1} \leq Z_1{*}M \ \ , \forall j \qquad (5)$$

$$1 - \sum_{j=1}^{J} X_{j2} \leq Z_2 * M \ \ , \forall j \qquad (6)$$

$$1 - \sum_{j=1}^{J} X_{j3} \leq Z_3 * M \ \ , \forall j \qquad (7)$$

$$1 - \sum_{j=1}^{J} X_{j4} \leq Z_4 * M \ \ , \forall j \qquad (8)$$

$$1 - \sum_{j=1}^{J} X_{j5} \leq Z_5 * M \ \ , \forall j \qquad (9)$$

$$\sum_{j=1}^{J} X_{ji} \leq \sum_{i=1}^{S} (1 - Z_i) * C_i \ \ , \forall ji \qquad (10)$$

$$\frac{t_{i-1}}{(t_{i-1}+t_{i+1})} = K_{i+1} \qquad (11)$$

$$\frac{t_{i+1}}{(t_{i-1}+t_{i+1})} = K_{i-1} \qquad (12)$$

$$Z_i * t_i*(K_{i+1})+t_{i+1}= F_{i,i+1} \tag{13}$$

$$Z_i * t_i*(K_{i-1})+t_{i-1}= F_{i,i-1} \tag{14}$$

$$x_{ji} * \left(t_i * q_{jk}\right) = A_{ji} \tag{15}$$

$$\sum_{j=1}^{J} X_{ji} \leq J \tag{16}$$

$$M>>0 \tag{17}$$

$X_{ji}, Z_i, C_i,$ 0-1 integer

Equation (1) shows the objective function. In the objective function, if there are sufficient substitute personnel, by assigning the substitute personnel most suitable for the station in question, it is aimed to minimize the difference between the standard cycle time and the new cycle time after assignment of the substitute personnel. If there are not sufficient joker staff, the workload of the i^{th} station with absent personnel is distributed to the two closest stations by the ratios of the distribution coefficients given in Equations (11) and (12),K_{i+1} and K_{i-1}. This way, more workload is distributed to the station with less existing workload, while less workload is distributed to the station with more existing workload. Limitations (2) and (3) respectively show that only one substitute staff member can be assigned to one station, and on substitute staff member can be assigned to only one station at the same time. Limitation (4) shows that, for a team, only as many substitute personnel as the number of absent stations of the team can be assigned. Additionally, Limitation (4) facilitates assignment of existing substitute personnel in the case that there are not sufficientsubstitute personnel. Limitations (5), (6), (7), (8) and (9) show the limitations of the values that can be taken by the$Z_i$decision variable. Limitation (10) shows that as many personnel as the number of substitute personnel can be assigned to absent stations. Limitations (11) and (12) respectively show the distribution coefficients of the $(i+1)^{th}$ and $(i-1)^{th}$ stations in the case that the i^{th} station is absent. Limitations (13) and (14) respectively show the new cycle times of the $(i+1)^{th}$ and $(i-1)^{th}$ stations in the case that the workload of the i^{th} station is distributed to these stations. Limitation (15) shows the new cycle time of the i^{th} station in the case that the j^{th} personnel are assigned to the i^{th}station instead of the absent ones. Limitation (16) shows that the number of absent personnel must be equal to or smaller than the number of substitute personnel for assignment to take place.Limitation (17) shows that the number M is a very large number.

For the implementation, the daily absence data of the personnel in the production line where the door parts of automobiles were being installed at the firm were utilized. The mathematical model proposed for assignment of suitable substitute personnel in the place of absent personnel and distribution of the workload was solved. The processes of the team were as follows:

- Module preparation,
- Installing,
- Clip test,
- Electrical test,
- Visual inspection and packing.

There was one station for each process in the production line.

By examining the 6-month absence data of the firm, the number of substitute personnel for the remaining 3 months of the year was determined. When the 90-day absence data of the firm were analyzed in the MINITAB 16 software, as the p-value was larger than $\alpha=0.05$ as seen in the scatter plot given in Figure 1, the data were normally distributed. The histogram of the 90-day absence data of the firm also clearly showed that the data were normally distributed.

As the analyzed data showed normal distribution, the mean values of these data were utilized to determine the number of substitute personnel needed.

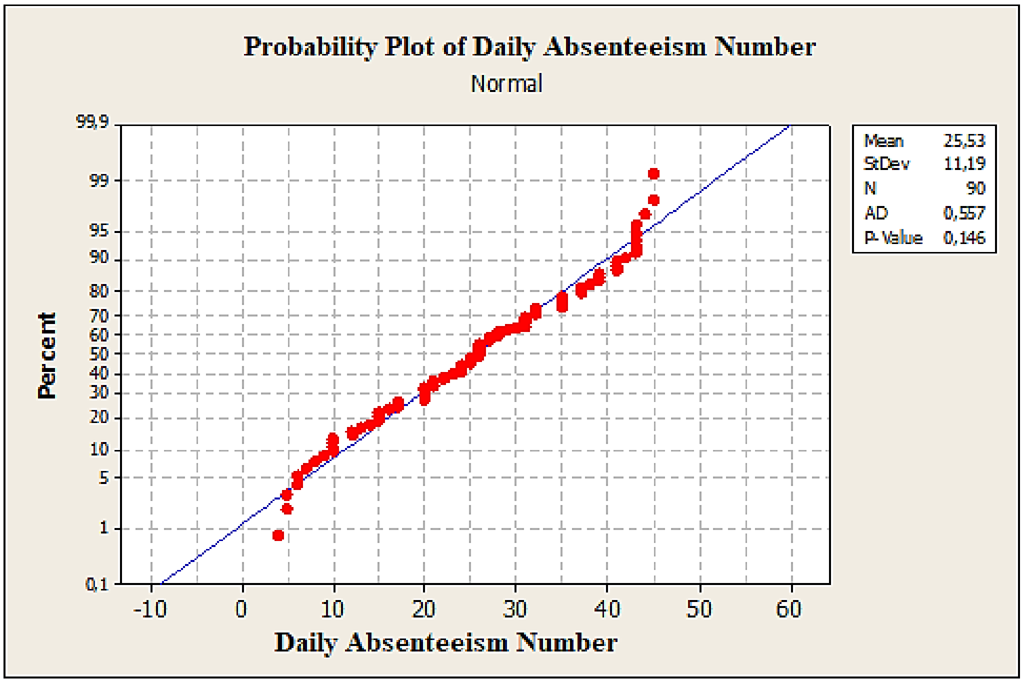

Figure 1. Scatter plot of absent personnel for ninety days.

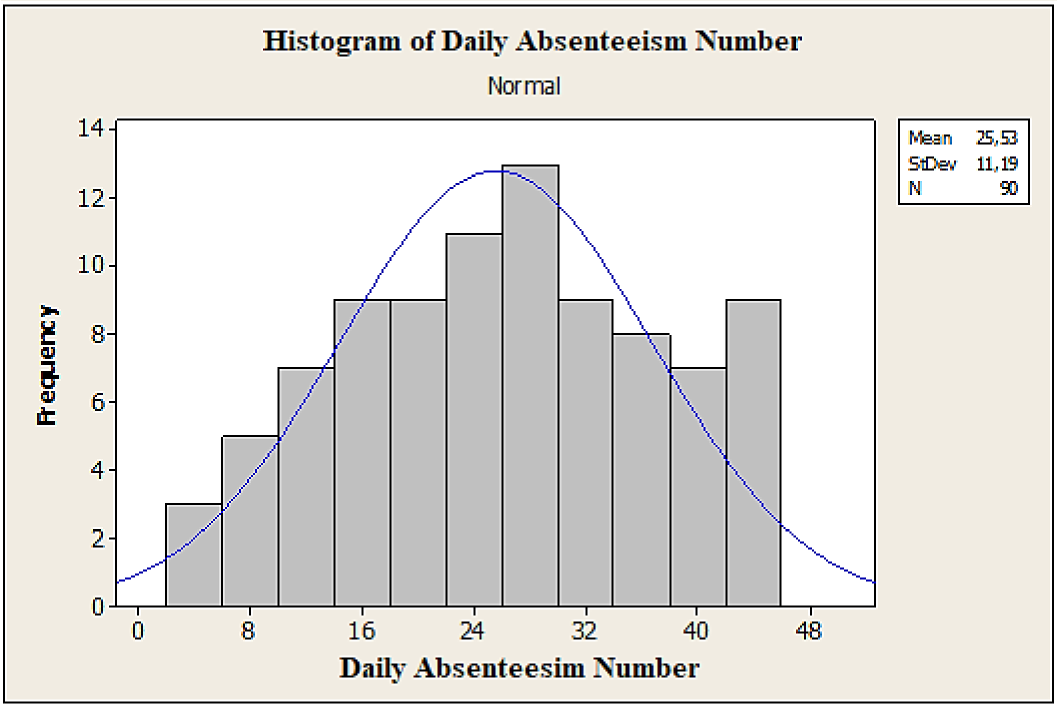

Figure 2. Histogram of absent personnel for ninety days.

Substitute personnel were selected by subjecting them to tests organized in certain periods of the year. The process-based competence matrix of the substitute personnel that could work at the door parts project of the automobile produced by the firm was formed as seen in Table 2.

Table 2. Process-based competence scores of substitute personnel that could work at the door parts project.

Substitute personnel no		Process no	1	2	3	4	5
		Station no	1	1	1	1	1
The substitute personnel team that can workproject of door installation	1	AU	0.8	0.6	0.8	0.3	0.1
	2	AK	0.7	0.8	0.2	0.3	0.5
	3	MA	0.9	0.7	0.2	0.2	0.4
	4	SÇ	0.8	0.5	0.3	0.1	0.3
	5	HŞ	0.5	0.8	0.3	0.1	0.1

Table 3shows the cycle times of the stations included in the processes. These were the standard times that were calculated as a result of time analyses.

Table 3. Cycle times of the door parts production line stations.

No	Process Name	Cycle Time (sec)
1	Preparing Modul Station	162
2	Installation Station	162
3	Clip Test Process	138
4	Electrical Test Process	144
5	Inspection and Packing Process	144

The mathematical model that was formed was solved based on three different scenarios that took place in the door parts production line of the automobile manufactured at the firm. The models and solutions of these scenarios are given in Appendix 1, while Table 3 shows the summary of the results. For solution of these scenarios, only the number of substitute personnel (J) and the number of absent personnel (S) parameters differed in the model.

The parameter values of the first scenario are given below:

- ✓ Substitute personnel number (J): 3,
- ✓ Absent personnelnumber (S): 2.

According to this scenario, as the number of substitute personnel was higher than the number of absent personnel, only assignment took place. The suitable substitute personnel were assigned in the place of the absent personnel.

The parameter values of the second scenario are given below:

- ✓ Substitute personnel number (J): 1,
- ✓ Absent personnel number (S): 2.

According to this scenario, as the number of substitute personnel was smaller than the number of absent personnel, both assignment and distribution took place. In this scenario, after assignment of the existing substitute personnel to the suitable workstation, the workload of the workstation where substitute personnel were not assigned was distributed to the two closest workstations. This distribution process was made based on the cycle times of the stations to receive new workloads. This way, more workload could be distributed to the workstation with a shorter cycle time.

The parameter values of the third scenario are given below,

- ✓ Substitute personnel number (J) 2,
- ✓ Absentpersonnelnumber (S) 2,

According to this scenario, the numbers of substitute personnel and absent personnel were equal. Therefore, only assignment took place. The suitable substitute personnel were assigned in the place of the absent personnel.

Table 4. Results of three different scenarios.

	The substitute personnelmember who come to the job, no	Station no of the staff Member that do not come to the job	Station cycle time(sec) of the Staff member that do not come to the job	The substitute personnelno that assign	New cycle time (sec)	The first nearest station cycle time(sec) to the station of the staff member that do not come to the job	The second nearest station cycle time(sec) to the station of the staff member that do not come to the job
		3	138	1	220	-	-
		5	144	4	216	-	-
Scenario 1	1,4,5	-	-	-	-	-	-
		3	138	-	-	226	217
Scenario 2	4	5	144	4	216	-	-
		3	138	1	220	-	-
Scenario 3	1,4	5	144	4	216	-	-

The mathematical model took on one team working at a single project at the firm and the substitute personnel that could work at this project. In normal conditions, there were 18 different projects at the firm, and 36 personnel teams working at these projects. Formation of the mathematical model to cover all teams would make it more difficult to solve the problem, and each solution in the Lingo 11.0 software requires approximately 10 min. If this operation is carried out for each case of absence, it poses a great loss of time for the firm. This is why there is a need for a DSS.

4. The Proposed Decision Support System

Decision Support Systems are interactive computer systems that allow defining and solving problems, completing a decision-making process and making decisions by using data, document, information and communication technologies and/or models.

Considering the increase in the data collected until the point of decision-making, the complex nature of decision-making processes and that the human brain is limited, using software becomes indispensable. The decision-making process in the scope of DSS is shown in Figure 3.

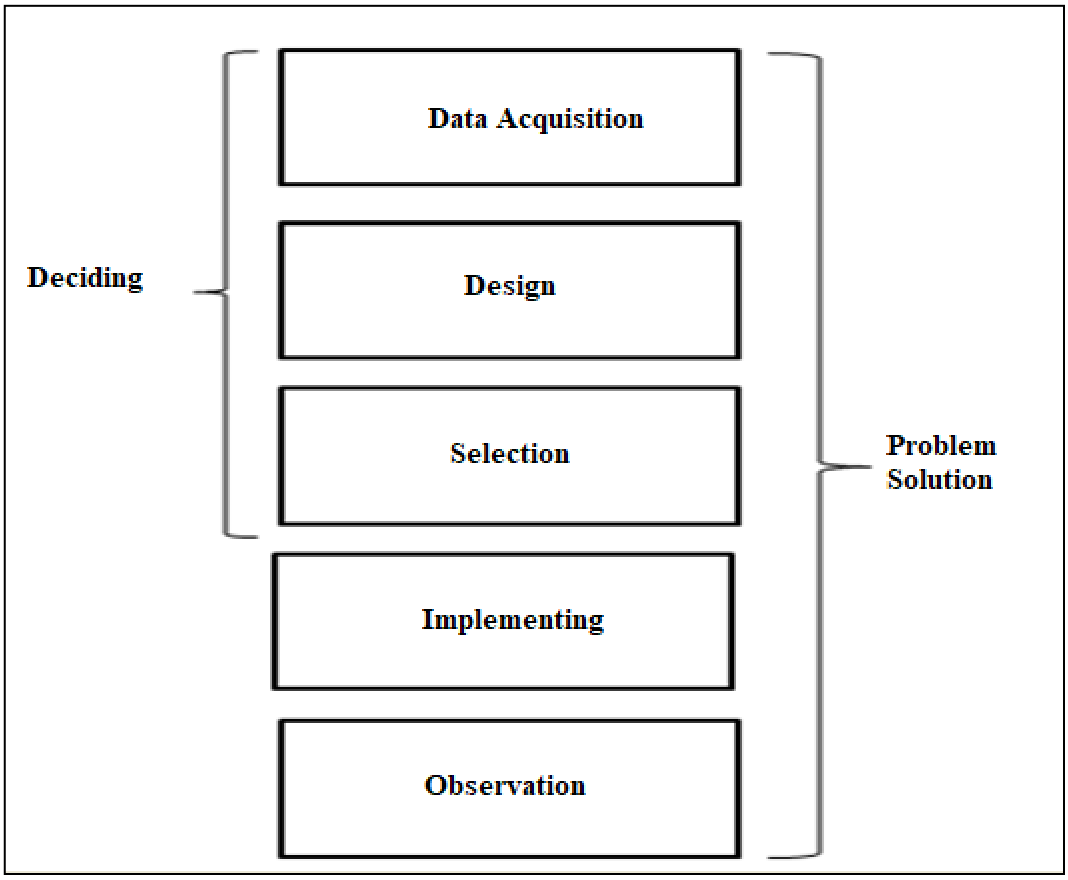

Figure 3. Decision-making process with DSS.

As seen in Figure 3, the process works in the form of decision-making, implementation of the decision and monitoring it. In DSSs, the software mainly consists of a database where the data are stored and components that operate the algorithms and formulae that process these data. In the case of increased amount of data and necessity of complicated calculation, the hardware also becomes an important component.

Due to the fact that solving a mathematical problem takes time and is not very suitable for daily usage, a Decision Support System (DSS) was developed adapting to the changes at the firm in a fast and easy way. To run such a system, a heuristic algorithm was proposed for assignment of substitute personnel and distribution (Bulut, 2019). The steps of this algorithm were as follows:

Step 1: Input the information of absent personnel per day into the system.

Step 2: Check sufficient number of substitute personnel.If there are sufficient personnel, continue with Step 3; if not, skip to Step 5.

Step 3: Check whether or not existingsubstitute personnel is connected to any station.

Step 4: From among the substitute personnel not connected to any station, assign the most suitable substitute personnel in the place of the absent personnel whose information was input, and return to Step 1.

Step 5: If no substitute personnel were left at Step 4 to be assigned, distribute the cycle time of the station with the absent personnel to the two closest stations based on the coefficients given by Limitations (3.11) and (3.12).

Step 6: If there are absent personnel left, return to Step 1; if not, end the process.

The firm managers decided upon assignment of the most suitable personnel in the place of absent personnel with the heuristic algorithm that was developed, or in the case of no substitute personnel left for assignment, distribution of the workload of the absent personnel. This way, the firm managers were able to systematically achieve assignment of suitable substitute personnel to the station of absent personnel or distribution of the workload of the station of absent personal. Therefore, they aimed to minimize the loss that could occur. This algorithm that was developed was coded by using the C# programming language, and for ease of operation for the user, user interfaces were created by using the same programming language.

4.1. Operation of the Decision Support System

The flow diagram of the decision-making process of the DSS that was developed is given in Figure 4. This flow diagram shows the decision-making mechanism of the DSS. The decision-making mechanism operates completely outside the own decision of the user and in a systematic way. Absence of the human factor in all decisions at the stage of decision-making facilitates the continuity and impartial decision-making of the system.

In the DSS flow diagram seen in Figure 4 on assignment and distribution in case of personnel absence, the capable substitute is assigned to the station of the absent employee in the relevant process. If there is no personnel to be assigned, the workload of the absent personnel is distributed to the two closest stations. By performing the distribution process based on distribution coefficients(K_{i+1},K_{i-1}), it is aimed to minimize the cycle times that would result.

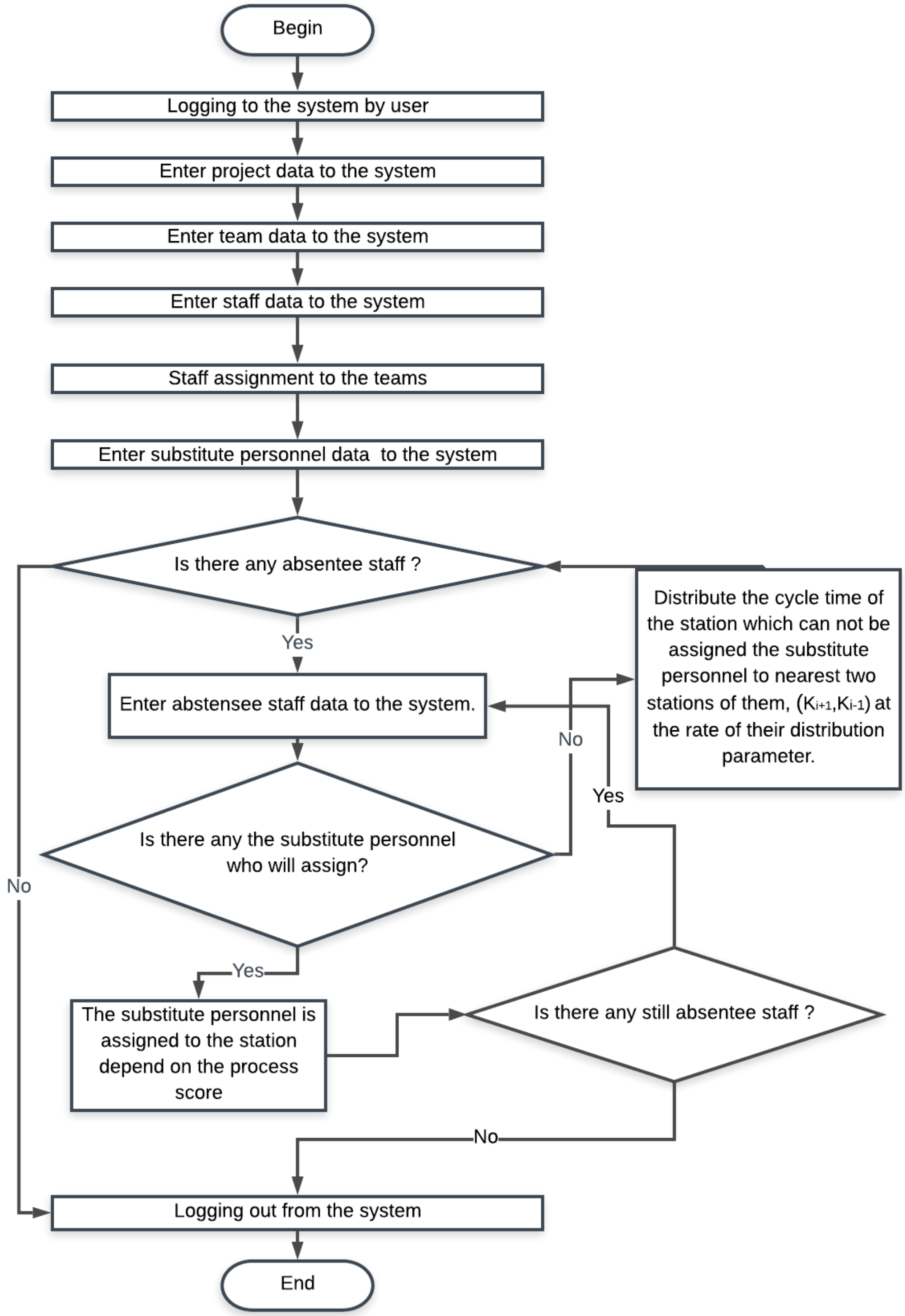

Figure 4. Flow diagram of the decision support system for the problem of assignment and rebalancing in the case of personnel absence.

4.2. User Interfaces and Definitions

The interfaces in the DSS are used for input and output of data to and from the system.

System entry interface

This interface is the first interface of the DSS. For opening this interface, the authorized staff member must input their username (ID) and password to the interface shown in Figure 5.

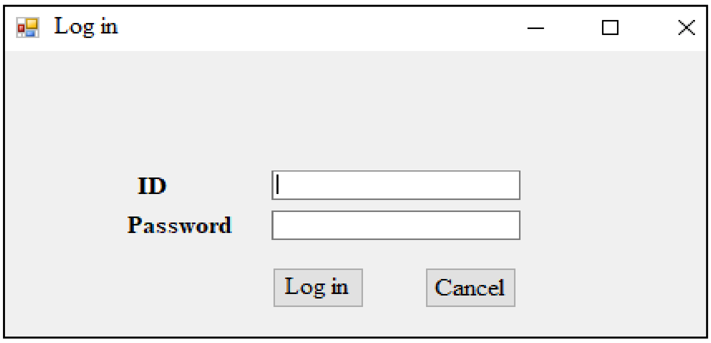

Figure 5. Entry Interface.

Main screen interface

When the user clicks the "Login" button by inputting their username and password in the entry interface of the DSS shown in Figure 5, they access the main screen interface shown in Figure 6.

Figure 6. Main screen interface.

The interface shown in Figure 6 is highly important for the user. If the user will make a change in the system, they are directed to the interface where the relevant change can be made by clicking the button for that interface. The operations that can be carried out by the user with this interface are as follows:

- Inputting absent personnel data in the “absence entry” section,
- Entry of new personnel data or deleting existing personnel data from the “new personnel add-delete” section,
- Entry of new project data or deleting existing project data from the “new project add-delete” section,
- Assigning stations to processes recorded in the system or removing a station from a process from the “process-station operations” section,
- Formation of a new team in the system and assignment of these teams to projects recorded in the system from the “team formation-project assignment” section,
- Assigning station to processes or removing stations from the “assign-remove stations in processes” section,
- Assigning personnel to teams from the “assign to teams” section,
- Organization of the substitute personnel team from the “update joker staff” section,
- Viewing the team members from the “view teams” section,
- Removing the assigned substitute personnel and restoring the main team from the “update teams” section,
- Adding new users to the system or removing existing users from the “add new user-delete” section.

The following sub-headings explain the interfaces where users will be directed from the sections in this interface and their descriptions.

Interface for inputting absentpersonneldata

This interface is opened by the “absence entry” button in the main screen interface shown in Figure 6. The user can perform three different operations in this interface. The first of these is to input the data of the absent personnel into the system, the second is to make a search in the absentee list, and the third is to delete information from the list.

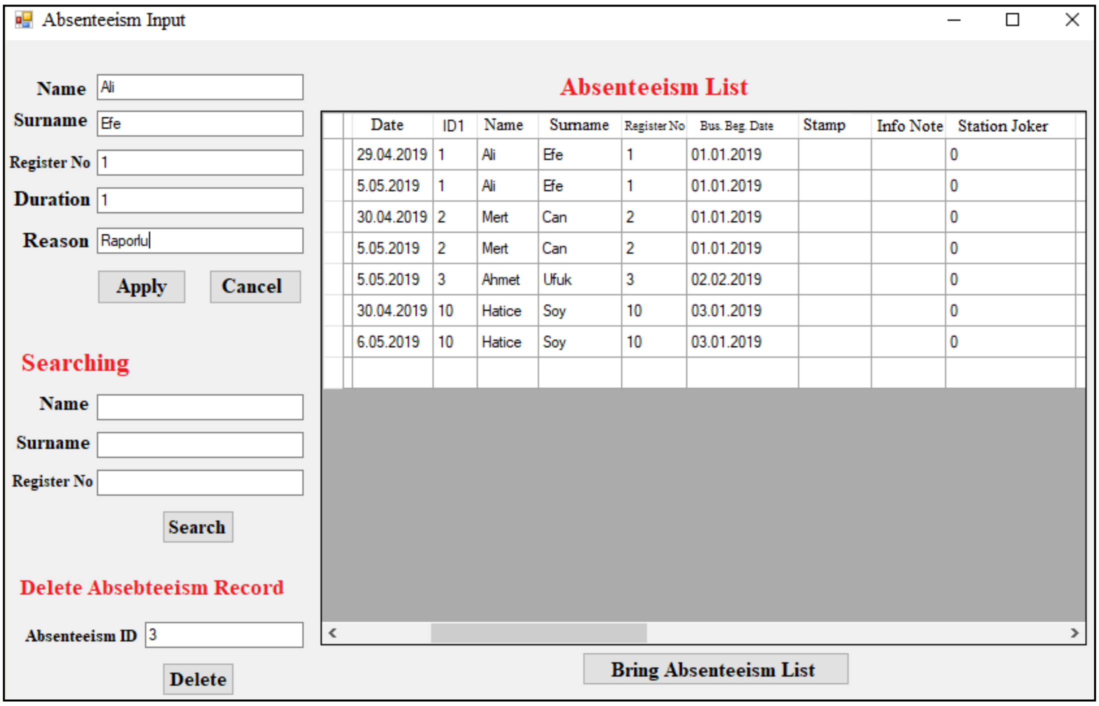

Figure 7. Interface For Inputting Absent Personnel Data.

After the user inputs the data of the relevant personnel in the absence entry interface shown in Figure 7 and clicks the "submit" button, the pop-up note shown in Figure 8 is displayed. When the user answers this note with the "OK" button, the operation of inputting absent personnel data is completed.

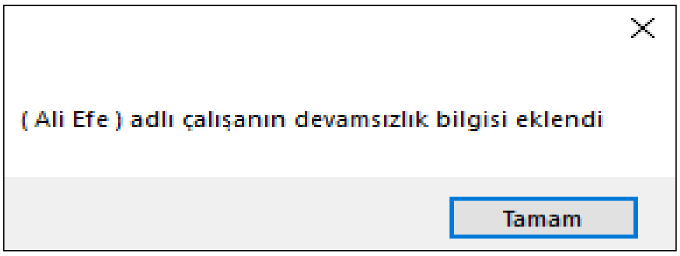

Figure 8. Submission message for inputting absent personnel data into the system.

<u>Assignment in the place of absent personnel</u>

After the user inputs the data of the relevant personnel in the absence entry interface shown in Figure 7 and clicks the "submit" button, the pop-up note shown in Figure 8 is displayed. When the user answers this note with the "OK" button, if the staff member whose absence data is input into the system is registered as an employee of a team, the system shows the pop-up message shown in

Figure 9 to direct the user to the substitute personnel table. When the user responds to this message by clicking the "Yes" button, the "Assign Personnel" interface shown in Figure 10 is opened.

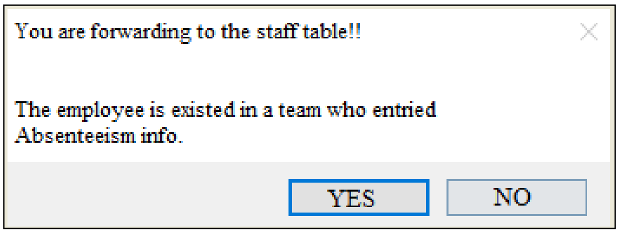

Figure 9. Submission message for assigning in the place of absent personnel.

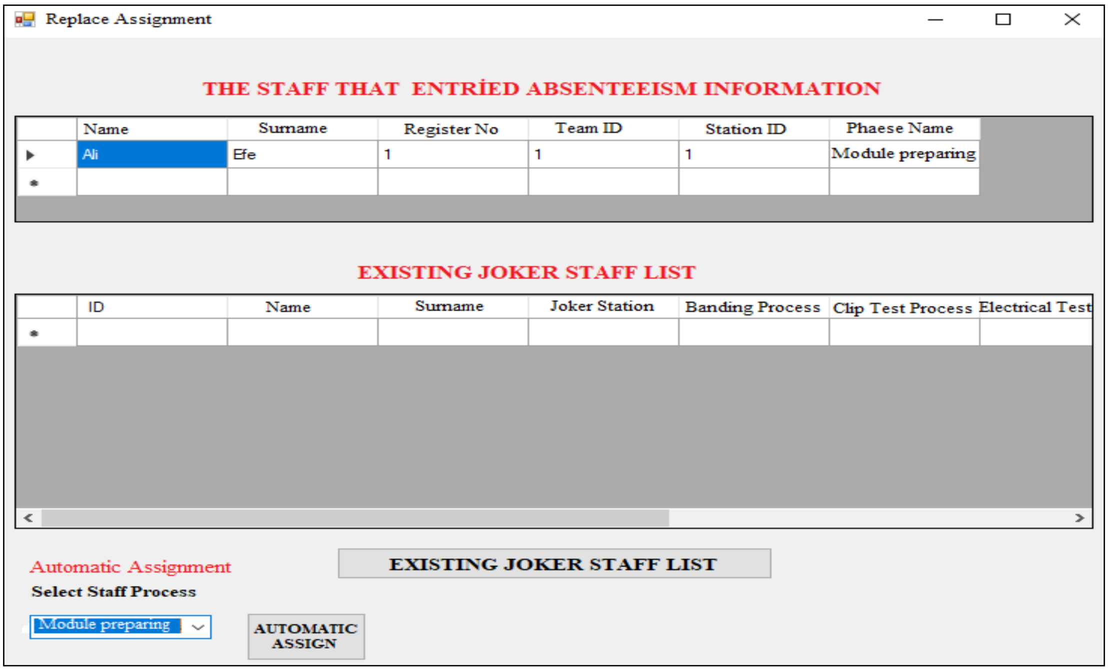

Figure 10. Interface for making an assignment in the place of absent personnel.

The user performs the operation of assigning substitute personnel in the place of the absent personnel through this interface. The user needs to follow the steps given below for the assignment operation.

- ✓ Selection of the process of the personnel to be assigned from the "select personnel process" shown in Figure 10,
- ✓ Clicking on the "assign automatically" button.

When the user follows these steps in order, assignment of the substitute personnel to work in the relevant process is made according to process-based scores from among all substitute personnel.

This operation is carried out for each staff member who shows absence. The user can perform this operation at any time in the day.

After the substitute personnel are automatically assigned in the system in the place of the absent personnel, if there are no substitute personnel left, the system submission message shown in Figure 11 is displayed. When the user answers this message by clicking on the "OK" button, the cycle time of the station of the absent personnel is distributed to the two closest stations based on their existing workloads. Therefore, by assigning more workload to the station with less existing workload and assigning less workload to the station with more existing workload, the deviation from the standard station cycle time is minimized.

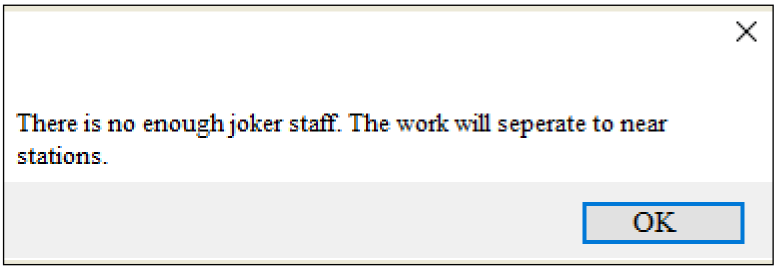

Figure 11. Submission message in the case that there are no personnel left to be assigned in the place of absent personnel.

4.3. Implementation for the DSS

For the DSS proposed in this study, two scenarios were established by utilizing the data on two different cases of absence encountered on a day of operation for the firm.

Substitutepersonnel assignment operation

In the DSS,substitute personnel assignment operations are performed as follows:

- ✓ Inputting the absent personnel data into the relevant areas in the absence information entry interface shown in Figure 7,
- ✓ Clicking on the "submit" button,
- ✓ Responding to the submission message shown by the system and displayed in Figure 9 by clicking on the "Yes" button,
- ✓ Selecting the relevant process in the "automatically assign" section in the "assignment in the place" interface that is opened after the submission message,

- ✓ Clicking on the “automatically assign” button.

These steps are repeated for each absent staff member, and this way, the most suitable substitute personnel can be assigned in the place of absent personnel.

The case that the number of substitute personnel is equal to or higher than the number of absent personnel

In this scenario, the numbers of absent personnel and substitute personnel are equal and 30.

After completing all steps of the operation of assigning joker staff, if there are no substitute personnelleft, the system shows the information message given in Figure 11. When the user responds to this message by clicking on the “OK” button, the system automatically distributes the cycle time of the absent personnel to the two closest stations based on their coefficients of distribution.

Table 5. Process-based scores of the substitute personnel assigned to the stations of the absent personnel at the firm.

No (ID)	Name - Surname	Employee of beeing joker state	Model preparing process point	Banding process point	Clip test process point	Electrical test process point	Eyes control process point	Packing process point	Moving goods process point process point	Process no	Team no	The employee that be absent station no be absent station no	Team no
1	AP	1	9	6	4	7	8	2	1	1	1	1	Team1
2	BD	1	3	9	4	2	5	6	8	2	1	2	Team1
3	FZ	1	5	4	6	8	1	5	4	4	1	3	Team1
4	AÇ	1	8	2	3	4	8	4	6	1	2	4	Team2
5	CÇ	1	2	3	8	1	6	2	6	3	2	5	Team2
6	GM	1	7	9	5	7	8	8	9	2	2	6	Team2
7	ŞÖ	1	9	1	7	2	5	6	4	1	2	7	Team2
8	SE	1	4	2	8	7	4	6	4	3	2	8	Team2
9	BK	1	6	2	8	9	1	4	7	4	3	9	Team3
10	GB	1	1	2	2	5	8	2	4	5	3	10	Team3
11	MT	1	8	7	6	3	7	4	6	1	3	2	Team3
12	GA	1	9	8	6	4	3	7	8	1	3	6	Team3
13	GK	1	4	9	6	5	7	5	6	2	4	2	Team4
14	ST	1	1	2	8	4	7	5	6	3	4	4	Team4
15	MS	1	2	4	6	8	9	5	7	5	4	7	Team4
16	HA	1	8	5	7	9	2	3	4	4	5	21	Team5
17	EÇ	1	9	1	4	6	8	7	4	1	5	16	Team5
18	VK	1	2	4	5	8	9	4	2	6	5	10	Team5
19	AY	1	2	8	1	4	7	1	5	2	9	2	Team9
20	HC	1	2	4	5	7	5	4	9	7	5	3	Team5
21	ÇB	1	1	2	8	3	3	3	9	7	6	8	Team6
22	YD	1	1	4	4	9	2	4	8	4	6	10	Team6
23	İÜ	1	9	2	1	4	2	6	8	1	6	15	Team6
24	FA	1	1	5	7	5	8	4	5	5	10	5	Team1
25	İE	1	7	5	9	1	5	7	1	3	6	2	Team6
26	AS	1	2	4	7	9	5	8	4	4	7	7	Team7
27	SE	1	1	9	8	5	6	4	7	2	7	4	Team7
28	CG	9	4	5	7	2	2	8	4	4	7	1	Team7
29	FM	1	8	9	6	5	7	5	6	2	7	9	Team7
30	MA	1	9	1	8	7	6	4	2	1	8	11	Team8

By assigning the qualified substitute personnel from the substitute personnel team shown in Table 6 in the place of the 30 personnel of the ten teams working at different projects, Table 4 is formed. As shown in Table 6, the relevant process scores of the substitute personnel that were assigned in the place of absent personnel were higher than those of the other personnel. This way, it is seen that qualified substitute personnel is assigned in the place of the absent personnel.

Table 6. Process-based scores of the substitute personnel.

No(ID)	Name-Surname	Processes							
		Employee of beeing joker state	Model preparing process point	Banding process point	Clip test process point	Electrical test process point	Eyes control process point	Packing process point	Moving goods process point
1	YD	1	1	4	4	9	2	4	8
3	ÇB	1	1	2	8	3	3	3	9
4	GK	1	7	9	5	7	8	8	9
5	AP	1	9	6	4	7	8	2	1
6	BD	1	3	9	4	2	5	6	8
7	FZ	1	5	4	6	8	1	5	4
8	AÇ	1	8	2	3	4	8	4	6
9	CÇ	1	2	3	8	1	6	2	6
9	MA	1	9	1	8	7	6	4	2
10	ŞÖ	1	9	1	7	2	5	6	4
11	ZE	1	4	2	8	7	4	6	4
12	HAA	1	8	5	7	9	2	3	4
13	VK	1	2	4	5	9	8	4	2
14	HC	1	2	4	5	9	5	4	1
15	BK	1	6	2	8	9	1	4	7
16	AY	1	2	8	1	4	7	1	5
17	EÇ	1	9	1	4	6	8	7	4
18	GB	1	1	2	2	5	8	2	4
19	MT	1	8	7	6	3	7	4	6
20	İÜ	1	9	2	1	4	2	6	8
21	GA	1	9	8	6	4	3	7	8
22	FA	1	1	5	7	5	8	4	5
23	FG	1	8	9	6	5	7	5	6
24	MS	1	2	4	7	9	5	8	4
25	CG	1	4	5	7	9	2	8	4
26	İE	1	7	5	9	1	5	7	1
27	GK	1	4	9	6	5	7	5	6

28	MS	1	2	4	6	8	9	5	7
29	SE	1	1	9	8	5	6	4	7
30	ST	1	1	2	8	4	7	5	6

<u>*The case that the number of substitute personnel is lower than the number of absent personnel*</u>

In this scenario, the number of absent personnel is 32, while the number of substitute personnel is 30.

If there are no sufficient personnel, the system shows the submission message given in Figure 11. After the user approves this message, the system distributes the cycle time of the personnel to the two closest stations based on their workloads. This way, less work is assigned to the station with more workload.

At the firm, in the case of illness of personnel of the stations 9 and 16 of Team 10, the number of absent personnel rises to 32. In this case, as the number of substitute personnel is 30, the number of absent personnel is higher than the number of substitute personnel. The system distributes the cycle times of the stations 9 and 16 of Team 10 where substitute personnel could not be assigned to the stations 8, 10 and 15, 17 by the ratios of their distribution coefficients. The new cycle times of the Team 10 stations that are formed as a result of this rebalancing are shown in Table 7.

Table 7. Team names of the absent personnel at the firm and the station numbers that are assigned to.

	Team Name									
	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	Team 9	Team 10
Absentee Station No	2	4	2	2	3	2	1	11	2	2
	3	5	6	4	10	8	4			9
	5	6	9	7	16	10	7			16
		7	10		21	15	9			
		8								

As the jobs of the stations in the process are usually related to each other, while performing the process of distribution, the workload of the station of absence is distributed to the two closest stations.

Table 8. Cycle times of the stations of team 10 before rebalancing in the database.

Station no	First station that is assigned workload	Second station that is assigned workload	Process no	Cycle time (min.)
1	-	-	1	3
2	-	-	1	3
3	-	-	1	3
4	-	-	2	3,5
5	-	-	2	3,5
6	-	-	2	3,5
7	-	-	2	3,5
8	-	-	3	4
9	-	-	4	4
10	-	-	5	3
11	-	-	5	3
12	-	-	5	3
13	-	-	5	3
14	-	-	5	3
15	-	-	5	3
16	-	-	6	4
17	-	-	6	4
18	-	-	6	4
19	-	-	6	4
20	-	-	7	3
21	-	-	7	3
22	-	-	7	3

Table 9. New cycle times in the case that there are no substitute personnel to be assigned to the stations 9 and 16 of team 10.

Station no	First station that is assigned workload	Second station that is assigned workload	Process no	Cycle time (min.)
1	-	-	1	3
2	-	-	1	3
3	-	-	1	3
4	-	-	2	3,5
5	-	-	2	3,5
6	-	-	2	3,5
7	-	-	2	3,5
8	-	-	3	4,9
9	8	10	4	4
10	-	-	5	5,3
11	-	-	5	3
12	-	-	5	3
13	-	-	5	3
14	-	-	5	3
15	-	-	5	5,3
16	15	17	6	4
17	-	-	6	5,7
18	-	-	6	4
19	-	-	6	4
20	-	-	7	3
21	-	-	7	3
22	-	-	7	3

Table 8 shows the cycle times of Team 10. Table 9 shows the new cycle times of Team 10 after the assignments. As the Station 9 was not assigned joker staff, its workload was distributed to the Stations 8 and 10 that were the closest to it, while, as the Station 16 was not assigned joker staff, its workload was distributed to the Stations 15 and 17 that were the closest to it. This way, the workload of the station of the absent personnel was distributed by the ratios of the distribution coefficients (K_{i+1},K_{i-1}).

With the proposed DSS, it becomes possible for the stations at the firm that are emptied due to absence or illness of personnel to continue their work suitably. This way, fast and suitable solutions will be found for the problems that arise, and jobs will not be interrupted.

5. Conclusion and Recommendations

The increasing competition and decreasing profit rates in the automotive sector force firms into development. One of the most important topics for firms is the human factor. At labor-intensive firms, in addition to effective usage of the labor force, it is also required to find the best solution in human-factor problems such as absence and apply this solution immediately. Work should be carried out on this issue to stay standing up in the competition environment.

In this study, for the purpose of personnel assignment in the place of absent personnel, or if needed, perform workload rebalancing at an automotive sub-industry firm, firstly a mathematical model was developed. In this model, if there are sufficient joker staff, suitable personnel from the substitute personnel team are assigned, and if not, the personnel that are sufficient are assigned, and the remaining workloads are distributed to the suitable stations.

Based on the daily variability of the absence situation of the personnel at the firm, the proposed model needs to be operated at the beginning of each working day, and its results need to be analyzed. As the number of personnel employed at the firm is high, the length of the solution of the mathematical model, and therefore the probability of making a mistake, will increase. For this reason, it was decided to develop a decision support system for the problem of assignment and/or rebalancing in the case of personnel absence. This decision support system that was developed was coded in the C# programming language, and interfaces that provided the user with ease of usage were designed.

With the decision of the management of the firm, a substitute personnel team including personnel with qualifications that would allow them to work at stations with absent personnel was created. This team was established by considering their process-based competencies. In the case that a member of personnel other than the substitute personnel is absent, the most qualified person from this team who can work at the relevant station is selected and assigned to the station. It will be possible to obtain solution recommendations by running the proposed DSS at the beginning of each working day. The method of solution varies based on the status of sufficiency of the number of substitute personnel. In the case that there are sufficient substitute personnel for the stations of the absent personnel, suitable assignments can be made. In the case that there are not, after assigning the existing joker staff, the workloads of the stations where there are still absent personnel can be distributed to the two closest stations in the most suitable way. This way, in the case that absence and illnesses, the losses that may occur are aimed to be minimized.

With the DSS that is proposed in the study, an opportunity is presented for productive usage of labor resources, which constitute a significant item of cost for firms. The practical, fast and dynamic structure of the DSS brings a systematic solution recommendation. This situation also prevents unforeseeable costs that could occur during problems that are encountered.

When the 2018-2019 data of the enterprise were examined, it was observed that 40% of the total loss of productivity was due to the wrong assignment of wildcard personnel and incorrect job distribution in case of absenteeism. The proposed DSS was used for 12 months, and when the annual cost data were analyzed, it was observed that the loss of productivity due to the wrong assignment of wildcard personnel and job distribution in case of absenteeism improved by 80%. Thus, 32% improvement was achieved from the total yield loss using the proposed DSS.

By defining the other projects of the firm and the personnel teams working at these projects into the system, the DSS is expanded for the general firm. The management of the firm will achieve monitoring of the personnel's momentary absence situations from the system by integrating this DSS with the Enterprise Resource Planning (ERP) program that is used in the firm. It is thought that, this way, the usability of the system will increase.

The proposed DSS could also be used at different labor-intensive firms. This way, in the case of the absence of personnel, it will be possible to make accurate and systematic decisions fast and suitably in the personnel assignment and rebalancing process.

Authors Contribution

Both authors contributed equally in the study.

Conflict of Interest Statement

There is no conflict of interest between the authors.

Research and Publication Ethics Statement

Research and publication ethics were followed in the study.

Acknowledgments

The authors would like to acknowledge the Nursan Kablo Donanımları A.Ş. involved in this research for thecollaboration and support.

References

Aktaş, E., Ülengin, F. ve Önsel Şahin, Ş. (2007). A Decision Support System To Improve The Efficiency Of Resource Allocation In Healthcare Management, Socio-Economic Planning Sciences, 41, pp. 130-146.

Bulut, A. (2019). A Decision support system for an assignment and rebalancing problem in the absence of staff: A case study, Unpublished Master's Thesis (Supervisor Kırış, Ş.), Dumlupınar University Institute of Science, Kütahya.

Çetinyokuş, T., Gökçen, H. (2008). A decision support system and application for employee performance evaluation, Gazi Univ. Eng. Mime. Fak. Der. J. Fac. Eng. Arch. Gazi Univ. 23 (1), pp. 239-248

De Bruecker, P., van den Bergh, J., Beliën, J. ve Demeulemeester, E. (2014). Workforce Planning Incorporating Skills: State Of The Art, European Journal of Operations Research, 243, 1- 16.

Dolgui, A., Kovalev, S., Kovalyov, M. Y., Malyutin, S., Soukhal, A. (2018). Optimal workforce assignment to operations of a paced assembly line", European Journal of Operational Research 24(1), pp. 200-211.

Gomes da Silva, C., Figueira, J., Lisboa, J. ve Barman, S. (2006). An Interactive Decision Support System For An Aggregate Production Planning Model Based On Multiple Criteria Mixed Integer Linear Programming, Omega, 34(2), pp. 167–177.

Harjunkoski, I., Maravelias, C. T., Bongers, P., Castro, P. M., Engell, S. ve Grossmann, I. E. (2014). Scope For Industrial Applications Of Production Scheduling Models And Solution Methods, Computers and Chemical Engineering, 62, pp. 161–193.

Hidri, L., Labidi, M. (2016). Optimal physicians schedule in an Intensive Care Unit, IOP Conf. Series: Materials Science and Engineering 131, pp. 1-8 .

Johnes, J. (2015). Operational Research In Education, European Journal of Operations Research, 243 (3), pp. 683–696.

Li, G., Jiang, H. ve He, T. (2015). A Genetic Algorithm-based Decomposition Approach To Solve An Integrated Equipment-workforce-service Planning Problem, Omega, 50, pp. 1–17

Polat, O., Mutlu, Ö., ve Özgörmüş, E. (2018). A Mathematical Model For Assembly Line Balancing Problem Type 2 Under Ergonomic Workload Constraint, The Ergonomics Open Journal, 11(1).

Sadjadi, S. J., Soltani, R., Izadkhah, M., Saberian, F. ve Darayi, M. (2011). A New Nonlinear Stochastic Staff Scheduling Model, Scientia Iranica,18(3), pp. 699–710.

Smet, P., Wauters, T., Mihaylov, M. ve Vanden Berghe, G. (2014). The Shift Minimisation Personnel Task Scheduling Problem: A New Hybrid Approach And Computational Insights, Omega, 46, pp. 64–7.3

Varlı, E., Eren, T. (2017). Hemşire Çizelgeleme Problemi ve Bir Hastanede Uygulama, Akademik Platform Mühendislik ve Fen Bilimleri Dergisi, 5(1), pp. 34-40.

Wong, T. C., Xu, M. ve Chin, K. S. (2014). A Two- stage Heuristic Approach For Nurse Scheduling Problem: A Case Study In An Emergency Department, Computers and Operations Research, 51, pp. 99