THE RIGHT PERSON TO THE RIGHT JOB: DEVELOPING A TWO-SIDED MATCHING METHODOLOGY BASED ON REAL EMPLOYEE DATA

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THE RIGHT PERSON TO THE RIGHT JOB: DEVELOPING A TWO-SIDED MATCHING METHODOLOGY BASED ON REAL EMPLOYEE DATA

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

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Talented employee is one of the most important factors that carries companies to success in today's business world. However, making employees work in the right position so that it is compatible with their ability, nature and capacity is a much more important factor for success. Ignoring this situation poses an obstacle to work in an efficient and effective way for the companies. The objective of this thesis is to provide a methodology to match employees with the right position by considering both technical and behavioural competencies. In this study, both the expectations of the employees and the positions are taken into consideration. Weights are given to these expectations. Then a multi objective optimization model is developed to make both employee and position satisfactory degree the most. Results of this study are used for the purpose of achieving high job satisfaction and productivity by improving bilateral matching of both employees and positions. This study may also be used as guidance in the planning of businesses related training and development activities. To show the applicability and contribution of the methodology developed, it is validated using real life data.

Keywords: Employee Selection, Multi Objective Optimization Model, Employee-Position Matching

ÖZ

DOĞRU ÇALIŞAN DOĞRU POZİSYONA: GERÇEK ÇALIŞAN VERİLERİNE DAYANAN ÇİFT TARAFLI BİR EŞLEŞTİRME METODOLOJİSİ GELİŞTİRME

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Yetenekli çalışan, günümüz iş dünyasında şirketleri başarıya taşıyan en önemli faktörlerden birisidir. Ancak, çalışanların yetenek, nitelik ve kapasitelerine uygun olacak şekilde doğru pozisyonlarda çalışmalarını sağlamak başarı için çok daha önemli bir faktördür. Bu durumun dikkate alınmaması, işletmelerin verimli ve etkin çalışabilmelerinin önünde büyük bir engel teşkil etmektedir. Tezin amacı, hem teknik hem de davranışsal yetkinlikler dikkate alınarak çalışanların doğru pozisyonlarda konumlandırılmalarına yardımcı olacak bir yöntem sunmaktır. Bu çalışmada hem çalışanların beklentileri hem de pozisyonların beklentileri dikkate alınmıştır. Bu beklentilere ağırlık değerleri verilmiştir. Sonrasında çalışan ve pozisyon tatminini maksimize eden çok amaçlı iyileştirme modeli geliştirilmiştir. Elde edilecek sonuçlar çalışan-pozisyon eşleşmesinin iki taraflı olarak iyileştirilmesinde kullanılarak bu sayede iş tatmininin ve verimliliğin artması sağlanabilecektir. Geliştirilen yöntem ayrıca işletmelerin eğitim ve geliştirme faaliyetleri ile ilgili planlamalarında da yol gösterici olarak kullanılabilecektir. Geliştirilen yöntemin uygulanabilirliğini ve katkısını göstermek için gerçek hayattan veri kullanılarak doğrulama yapılmıştır.

Anahtar Sözcükler: Çalışan Seçimi, Çok Amaçlı İyileştirme Modeli, Çalışan-Pozisyon Eşleştirme

To My Family

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LIST OF ABBREVIATIONS

R&D	Research and Development
NACE	The National Association of Colleges and Employers
LISS	Longitudinal Internet Studies for the Social Sciences
MOO	Multi-objective Optimization
PILP	Pure Integer Linear Program
MILP	Mixed Integer Linear Program
BIBB	Bundesinstitut für Berufsbildung (Federal Institute for Vocational Training)
BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Federal Institute for Ocuupational Safety and Health)
IAB	Institut für Beschäftigungsforschung (Institute for Employment Research)
NLYS	National Longitudinal Survey of Youth
LINGO	Language for Interactive General Optimization
NSGA	Non-Dominated Sorting Genetic Algorithm
RAMHECs	Randomized Mechanism for Hiring Expert Consultants
TOMHECs	Truthful Optimal Mechanism for Hiring Expert Consultants
MOPSO	Multiple Objective Particle Swarm Optimization

CHAPTER 1

INTRODUCTION

In today' s competitive world, having a professional human resources department is a crucial for institutions that are non-profit or profit (Aksakal et al., 2013). Human resource department is defined as a unit responsible for performing all employee related functions such as recruitment, training etc., in the organizations (Coşgun, 2016). Human resource department in organizations plays an important role in developing employee centred activities. One of these activities is personnel selection. Personnel selection is a fundamental activity of human resources. Personnel selection is defined as a process of placement of people into jobs (Personnel Selection, 2019a) Another definition is that it is the procedure of hiring the right individual to right position (Personnel selection is an important process for organization, 2019). Matching the right individual with right position has significant effect on improving performance of both employee and company (Golec and Kahya, 2007). It is very difficult because there is always a possibility that the performance of individual you employ can be disappointing or the performance of individual you refuse can be excellent (Moore, 2017). The intent in personnel selection process is choosing an individual who will make maximum contributions to the organizations (Personnel Selection, 2019b). To realize this intent successfully, it is necessary to evaluate the process from two ways as personnel and position. Greenberg states that when recruiting a person, person should be matched with the position and position should be matched with the person so both person and position should be understood (Job Matching to Hire Motivated Employees, 2019). Moyes, Shao & Newsome define the satiscation of employee as how happy an employee is about his or her position (Moyes, Shao and Newsome, 2011). On the other hand, position satisfaction from employee is about the employee compliance with his or her position and being sufficient enough to meet the needs of his or her position.

It is obvious that individuals' abilities, skills and characters are different from each other. Similarly, position also requires to different qualifications. Therefore, the required importance to both employee and position satisfaction should be given. If the required importance for personnel selection is not given, unwanted critical consequences may be encountered. The consequences in terms of worker are mental and physical health problems in addition to performance issues like inefficiency. If the performance of employee is insufficient, this affects entire organization in a negative way (Why Is the Human Resource Selection Process Important, 2019). One of the most important consequences in terms of organization is financial harm because of the loss investment in hiring and orientation (Weed, 2018). It causes also resource loss because of dismissal or resignation. This condition brings organizational unsuccess, loss of reputation as a result of defective or unfinished jobs.

Rohrbach-Schmidt and Tiemann (2016) states that mismatching between jobs and employees may cause negative results both from the point of employee such as unhappiness at work and from the point of his/her firm. They also specify that it can have negative effects on the economy. Wrong recruitment has consequences for employers like losing money and time because of the cost of finding, interviewing, teaching of new employers to adapt to work, equipment such as computers, phones and desks required for employers, salaries, taxes and benefits. Choosing the most appropriate personnel for the qualifications will reduce the costs caused by repeating recruitment operations and orientation training. The yearly cost of employment is estimated to be more than $550 billion dollars (How to Increase Employee Job Position Satisfaction Rates, 2019). Wrong recruitment also affects performance of employees at work, that is to say, a dismissal after a wrong recruitment is also bad for the entire team in terms of the morale. As a consequence, in today's world, new employees are seen as an investment and they are expected to give the most contributions to success of companies.

Also, wrong recruitment can cause unscheduled non-attendance by employees because there is a relationship between job satisfaction of employees and absence from work (Eiselt and Marianov, 2008). Companies suffer from this economically. 2005 CCH Unscheduled Absence Survey points out that absenteeism costs $660 for companies per employee annually (Costly Problem of Unscheduled Absenteeism Continues to Perplex Employers, 2019).

Davidson et al. (2012) defines that allocating employees who are different from each other in terms of qualifications, attributes and abilities is a challenging work for employment market. Because of this, it is normal that there are many highly skilled employees who are unemployed or underutilised. A considerable part of employees in most of the developed countries are working in a job for which they are underqualified or overqualified. According to the results of BIBB/IAB and BIBB/BauA Employment Surveys 1979 – 2006, from 1979 to 2006 the ratio of employees who feel under challenged by their job is increased (Rohrbach-Schmidt and Tiemann, 2016).

Before, it was known very little about the techniques and approaches of employment (Oyer and Schaefer, 2015). For example, there are some unofficial means such as family and friend relationships for employment, but they have negative effects on both employee and position satisfaction according to the results of experimental studies (Meliciani and Radicchia, 2010). For this reason, the process of personnel selection should be carried out in a professional and systematic manner. Lin (2010) states that because personnel selection is an important and complicated problem, it requires analytical methods. For instance, Schwartz (2007) explains that goal orientation matching increases satisfaction degree of workers with their jobs according to the results of the study conducted among social workers by herself.

Even in the simplest decisions, there are too many criteria that influence decision. For this reason, some techniques have been developed for decision making and problems have been tried to be solved with the help of these techniques. One of the success criteria of businesses in today's intense competition conditions is that businesses can use the scarce resources they possess, most efficiently. This depends on the choice of the best among the various alternatives. This thesis aims to develop such a structure as far as possible from subjective evaluations, functioning effectively and rapidly.

1.1 Importance of the Problem

Personnel selection is a crucial process for human resource management and its importance is gradually increasing because of today' s competitive market conditions. Both employee satisfaction and position satisfaction in personnel selection are crucial for the productivity, performance and success of the organizations because low satisfaction degree brings low motivation. Motivation is defined as mobilizing individuals in the right way for a particular aim (Ozdemir, 2016). Study by Yushadi et al. (2019) shows that motivation has positive and important effects on work performance. For this reason, one of the biggest dangers that low motivation creates is decrease of the performance of both employee who has low motivation and other employees because employee who has low motivation affects other employees. Therefore, the effects of employee satisfaction on the productivity and success of employee should not be ignored. The more the motivation improves, the more employee and company benefits (Pritchard and Ashwood, 2018).

Employee position matching based on objective rules enhances employee productivity and increase motivation in the workplace. In this way, satisfaction levels can be increased.

1.2 Purpose of the Problem

In this study, employee position matching is performed depending on scientific methods. Mathematical model for employee position matching is developed by considering both employee expectations from position and position expectations from employee. In other words, it considers both employee satisfaction and position satisfaction because we believe that there is a strong relationship between a firm' s productivity and both sides of the satisfaction. Employees who are not satisfied do not working at full productive capacity and their motivation is low. Motivation is a crucial aspect at the workplace for employees because it leads to the performance of the employees and even the performance of the firm (Ramlan, n.d.). Satisfied employees are happy to work and even the over work because they love their jobs and want to lead to firm' s success (Marin, n.d.). Therefore, increased employee satisfaction is one of the key factors that improve business success.

In this thesis, while we are solving the employee position matching problem, our initial objective, - and different from most other studies – is to widen the scope of the employee position matching and to create a two-sided approach for employee position matching. Establishing a bilateral matching motivates us in this study. For this reason, we propose a model that integrates employee satisfaction and position satisfaction. One of the goals of this model is to maximize the employee and position satisfaction. The model is formulated to be able to consider every technical and behavioural considerations whatever they are. Another objective of this thesis is to provide insights to drivers of satisfaction.

In this thesis, we decide the methodology we use and then we develop the model using this methodology. The model written in mathematical notation is solved with Lingo and results obtained are discussed.

By using the developed model in a company, it is envisaged that information technology in business is contributed.

1.3 Organization of the Study

The following chapters of this study are organized as follows:

In Chapter 2, the review of the literature is presented. Different methodologies for matching problems are described along with their advantages and disadvantages. In Chapter 3, the proposed approach of this study is explained. To illustrate the proposed approach, an example is given.

In Chapter 4, explanations for the validation step are provided. Results of the experiment are presented along with the discussion. In chapter 5, the conclusion of this thesis and possible future works are mentioned.

CHAPTER 2

REVIEW OF LITERATURE

There are many researches carried out about matching people with positions. Researchers have concerned with good matching or poor matching between employees and their jobs for a long time (Marin and Hayes, 2017). However, the number of the experimental study performed about the matching quality is limited by reason of describing the matching quality (Kok, 2014).

Researchers have used several methods about employee-position matching such as multicriteria decision making, genetic algorithms, and expert systems.

2.1 Methodologies

2.1.1 Multicriteria Decision Making

Zhang et al. (2015) examine a worker-position matching method. They propose a method of construction multi objective optimization model with fuzzy numbers by considering both company and worker satisfaction. In their study, satisfaction degrees of both person and position requirements specified linguistic terms called linguistic assessment information of matching satisfaction degree are transformed into corresponding triangular fuzzy numbers and weight vectors of evaluation index of matching satisfaction degree are composed. Then a fuzzy multi-objective optimization model about knowledge workers and company positions matching is constructed. Finally, this model is transformed into a single objective linear programming model and it is solved by using Lingo optimization software. They finally state that for validation of the method, more data is needed.

What is missing in their study is validation of the results of experiment performed by applying the developed model. Also, differently from this thesis, their study uses simple average method criterion to determine index weight.

Dodangeh et al. (2014) develops a fuzzy multicriteria decision making with fuzzy linguistic evaluation and group decision manager making for human resource selection process. In their study, after criteria and sub criteria related to the project selection issue and weights of each of criteria and sub criteria are determined according to the opinion of the experts, multicriteria decision making matrix are formed. Then, fuzzy multicriteria decision making model is built and the most suitable personnel is selected. The main contributions of their study are stated as combining subjective assessments of the responsible individuals for personnel selection and building a stronger personnel selection process.

One of the main differences of their study from this thesis is that their study focuses on project manager selection problem.

Jinling et al. (2013) proposes an approach on the optimal matching between positions and employees. They describe a multi objective optimization model in order to maximize the two-sided matching degree which is based on the two-sided evaluation index system between positions and employees. They also give a numerical example to show the effectiveness of the proposed method.

Like many of the other studies, what is missing in their study is validation of the numerical example given to illustrate the effectiveness of the proposed methodology.

2.1.2 Genetic Algorithms

Arslanoglu and Toroslu (2007) compare different genetic algorithm methods which are Weighted Sum, VEGA and SPEA to solve the personnel assignment problem containing hierarchical ordering and team constraints. Also, different techniques which are Average Euclidian Distance to the Utopian Objective Vector, Set Coverage Metric and Illustrative Representation are used to evaluate the results of Weighted Sum, VEGA and SPEA methods. According to the analysis results, better results are obtained with Weighted Sum.

In this thesis, genetic algorithm is not preferred because it is hard to choose parameters such as population size and number of generations. How GA solution parameters used in their study are determined is referred to some other similar studies.

2.1.3 Expert Systems

Collu (2009) develops a web-based employee selection application using expert systems which emulates decision making ability of human experts in order to eliminate subjective thoughts and judgments while personnel selection process. Because the system is a web-based system, entering information and changing information can be performed over the internet dynamically. This is a convenience of the system for human resource specialists using the system who have no idea about the software. In the developed system, first, the questions related to the requirements of a selected position are determined. These questions are required to be answered by the candidates while applying for the position. Then, answer choices for each of the questions and the points of each of answer choices are determined. The weight values for each of the questions and the rules of the expert system for the selected position are defined. Finally, candidates are sorting by their scores calculated according to the defined expert system rules. His study shows that expert system can be used in area of personnel selection as used in other many areas. He mentions the following advantages of his system:

- Because the system is related to the information technologies, it contributes the organizations using this system on this subject.
- The need of the specialist for the personnel selection is minimized.
- Thanks to the internet-based system, cost is reduced, and selection process is speeded up.
- Information about the candidates can be used for different purposes later.

What is the main missing feature in his study is that it only considers position requirements. In other words, it does not take any notice of candidate expectations from a position.

2.1.4 Others

Davidson et al. (2012) offers a study about employee-firm matching but their study also deals with the role and effect of the globalization of the labour market on this matching. Their study consists of data about all private sector companies with more than or equal to 20 workers between 1995 and 2005 in Sweden and 2 million individuals. First, they separate individuals as low and high skilled and also separate companies as low and high technology. Also, they defined two types of matching, mismatch and positive match. A mismatch is defined as a matching high skilled employees with low technology companies or low skilled employees with high technology companies. A positive match is opposite of it, that is to say, high technology companies recruit high skilled employees or low technology companies recruit low skilled employees. Their study shows that positive matching increased from 1995 to 2005 while mismatching decreased in the same period. They also analyse the employee transition between the business by considering whether a business is export oriented or import oriented. Export-oriented business is defined as a business with positive net exports in 1995 and import-oriented business is described as a business not having positive net exports in the same year. According to their examination, matching of low skill employees improved in import-oriented businesses while reemployment of high skilled employees improved in export-oriented businesses.

Amine (2013) studies the impact of public policies especially unemployment benefits and minimum wage on selectivity and productivity of labour market using an employee-job matching model. In this matching model, the differentiation of employees and jobs is described by a circle. The location of an employee in this circle symbolizes his/her skill type while the location of job in the circle symbolizes its needs. The distance between them is about the matching degree of them. In other words, there is a perfect matching, if the distance equals to zero. Amine also considers the specialization of the jobs. If the specialization is increased for good matching (the distance is small), the productivity is also increased. An increase in specialization runs in the opposite direction for bad matching. In other saying, it decreases the productivity for bad matching. The mentioned study shows that increasing minimum wage improves the productivity of employee-job matching while increasing in unemployment benefits have a positive effect on matching quality.

Jackson (2013) has a study which states that researchers tend to examine the relationship between wage and performance of good matching because data on productivity of good matching is insufficient. However, this can bring to incorrect conclusions because of two reasons. One of them is that many factors apart from productivity can affect the wage and the other is that workers can want to quit or look for a job due to financial reasons. To keep away from these issues, he suggests that matching quality should be determined by using more realistic output and he prefers using a student dataset having a connection with teachers, schools and success of students. In this dataset, he considers teacher as employee, school as company, a teacher at a school as matching and success of the student as matching quality. Because the impact of matching is more meaningful for mobile teachers in the mentioned concept, experiment is performed for mobile teachers that means teachers who move another school. The used dataset including student's data from 3rd grade to 5th grade from 1995 to 2006 is from the North Carolina Education Research Data Center. Results obtained show that productivity of teachers after moving another school are higher than the productivity before moving and this can be interpreted as that employees change their jobs till they get a more productive job. Getting a more productive job means finding a matching of better quality. He also states that his study is the first study emphasizing the significance of matching in education.

Kok (2014) examines employee-job tasks matching in Netherlands and measured the matching quality considering the difference between employee skills and task needs. Employers want to employ high skilled employees and employees want to get a job with high complexity. The quality of matching is defined with the distance between job complexity and employee skills according to the model Suzanne proposed. Small distance means that the quality of matching is good, that is, as the distance between them is bigger, the quality of matching is getting worse. Her experiment consists of various information such as appropriateness to their job, qualifications, and characters of 3000 people in Netherlands from person level dataset, LISS. The appropriateness information is expressed by each of individuals and while deciding the quality of matching of employee and tasks, it is made use of this information. The choice of issue types, complicated issues or easy issues, of an employee indicates this employee' s strengths and task complication is defined with the significance of the task. Tasks and skills are divided into two types as cognitive and social. The matching quality is determined with the smallness of difference between the same type of task and skill, such as social skill and social task. Suzanne also tries to explain the difference between the matching qualities in cities with different size of labour markets in Netherlands. She states that the more market size increases, the more the employee-job task matching standard raises because business opportunities and wage rates are better in big labour markets than small ones. As a result of this, the matching standard in towns is higher than in countryside in Netherlands in that the size of business markets in towns is bigger than in countryside.

Rohrbach-Schmidt and Tiemann (2016) provides a study that examines matching in two aspects. One of them is that a matching between the worker skills and requirements of the work. The other is matching in educational perspective. In a word, they separate the (mis)matching into two types, educational related and skill related, differently from most other studies. They also express the financial loss of mismatching in Germany taking into consideration big data by using random intercept models in terms of both of mentioned aspects separately. The data they used is from a survey especially prepared for evaluating the mismatching. It is the BIBB/BAuA Employment Survey 2006 which consists of information about both employees and jobs such as employees' abilities, company information, job necessities, and workplace environment. According to the obtained results, most of employees with over or under educational level match with their jobs in Germany in a way to satisfy their jobs' necessities but there are some of these employees feeling overchallenged or underchallenged. They also state that financial penalties which mismatching causes is significant in Germany.

Marin and Hayes (2017) have a study that explains the matching as a more complex issue rather than only matching education level of employees with required education level of their job or matching employees' graduated study field with the required field of study for their job, as most of researches. They also state that some jobs are not connected with a specific study field strictly and this should be considered while deciding whether poor or good matching exists between individuals and their jobs.

Bowlus (1995) examines the effect of business cycle on the matching between employees and works. The data she used is NLYS data. Working time in position, job tenure, is used as a sign while determining the matching quality based on the hypothesis that if a matching between an employee and his/her job is good, this employee works at this job for a long time. According to the conclusion of the experiment conducted by Bowlus, following two results are obtained mainly. One of them is that slump has negative effects on matching quality because while there is slump in labour market, individuals tend to accept job offers more easily and quickly. The other is that during slump, individuals also receive a lower salary and this condition makes quitting job easier. In consideration of these results, it is reached the conclusion that business cycle causes mismatching.

2.2 Two-Sided Matching For Decision Making

There are some other areas as well as employee-position matching to which two-sided matching can be applied. For example, some of these areas are education, e-healthcare, ridesharing, e-commerce, etc. Some studies about them in the literature are explained as following.

Haas and Hall (2019) have a study that examines two-sided matching for mentor-mentee assignment. Their study focuses on two concepts which are multiple objectives and change of preferences of main stakeholders. Data sets they use are real data sets from Mentor-Mentee program in order to evaluate the results about the mentioned concepts. For the concept of multiple objectives, they take into account the solutions of different algorithms such as GATA-Mixed, McDermid, GSModified and deferred acceptance algorithm on multiple criteria and reach a conclusion that algorithms give similar good results close to the optimal solutions on the basis of three metrics - number of matched participant, welfare (average matched rank) and fairness (welfare differences of the two sides) – by using a simulation-based evaluation approach. However, the algorithm that provides better results than the others is multi-objective heuristics. For the concept of change of preferences, they evaluate the effects of change of the preferences on the solution quality and participants by using three manipulation methods which are truncation, re-ordering, and strategic re-ordering. On average, manipulation of preferences shows negative effects such as instability in the solution.

Yang et al. (2019) proposes a study about task allocation in a ridesharing firm by taking into account both the drivers and riders. They consider bi-directional matching between drivers and riders as one-to-one two-sided matching. Using prospect theory, they identify the psychological behaviour of drivers and riders by regarding the suitability of drivers and the acceptability of riders about matching. They perform experiments in order to evaluate and verify the proposed two-sided matching model with two objectives. According to the results of the performed experiments, the proposed model shows benefits for allocation of tasks and sustainability of operations.

Singh et al. (2017) proposes mechanisms for two-sided matching of patients and doctors by considering the problem of hiring expert consultants in healthcare field as a two-sided matching problem and validate these mechanisms with experiments. Their proposed mechanisms are RAMHECs (randomized mechanism for hiring expert consultants) and TOMHECs (truthful optimal mechanism for hiring expert consultants) and to validate the performance of these mechanisms, a considerable amount of analyses is performed. These analyses show that TOHMECs gives optimal and truthful results.

Miao et al. (2019) has a study about matching between domestic suppliers and overseas demanders considering satisfaction degree of shareholders. They develop an optimization model and perform experiments in order to test the performance and practicability of the model. As a result of the experiments, they state that their study makes contribution theoretically and practically.

2.3 Summary

After literature reviewing, it is seen that many matching methodologies exist. The well-known techniques are dynamic programming, multicriteria decision making, ontology, genetic algorithms and fuzzy method. In this study, we select linear programming because in solution of most of the employee-position matching problems in the literature use this technique.

In the literature, to the best of our knowledge, few of studies offers methods including two-sided matching between employee and positions. Also, most of researches about employee position matching usually only mention the results of their models rather than validation of the results obtained after their experiments. This thesis improves the prior researches by focusing bilateral matching between employee and positions considering different characteristics of employees and positions and validating the model with real employee data in order to indicate the effectiveness and feasibility of the method.

CHAPTER 3

METHODOLOGY

All relationships including those of employees and positions involve expectations. Expectations are not one-sided. If expectations are not met mutually, the relationship between employee and position is likely to run into trouble. If employee expectations are not met, they will eventually look elsewhere. If position expectations are not met, employee is dismissed.

This chapter explains the proposed methodology for matching employees in the right positions by meeting expectations for both employees and positions mutually. Both technical and behavioural attributes for employee are taken into consideration. Weight of each of attributes for employee and position are given. Because we aim at making both the position and employee achieve total satisfactory degree the most, a multi objective optimization model which maximizes satisfaction degree of both employee and position is developed to match employees with positions.

In this chapter, first, main expectations of employee and position as well as distribution of employee expectations and employer expectations based on surveys performed by M. Cemil Ozden (2001) and NACE (2017) respectively are given with the aim of learning about the expectations of employees and employers. These surveys are given as is. After that, multi objective optimization concept is mentioned and a multi objective optimization model considering attribute weight values is presented. Then, information about LINGO software which we preferred as an optimization program is given. Finally, a numerical example is given to explain the developed model more clearly.

3.1 Employee Expectations

What employees expect from a job includes several things like timely payment of salaries, safe working conditions, adequate training, fair treatment, constructive feedback from supervisors, and reasonable workloads. A research done by Ozden (2001) about employee expectations from his job/company is taken part as is in this thesis in order to provide insight and to create perceptions about employee expectations. In his study, results are obtained according to answers which participants give a questionnaire form prepared in the web environment. Participants of survey consist of qualified employees. Consequently, 132 forms are evaluated after excluding repeating ones and forms including missing information in his study.

Attribute groups and attributes with explanations under these groups for position from which employees expect are specified as following in the above-mentioned study performed by Ozden (2001).

1. Financial opportunities

    1.1. Salary level:

    A regular, periodic payment from an employer to an employee, typically paid on a monthly basis.

    1.2. Bonus plans:

    A form of additional compensation paid to an employee as a reward based on job performance in addition to his/her base salary.

    1.3. Social opportunities:

    Opportunities for employees like transportation service, lunch, private health insurance, company car etc. whose cost are covered by company.

    1.4. Job continuity:

    It is about approach of company against to dismissal.

2. The job itself

    2.1. Position level:

    It is about position location in organizational chart, employee count under the position, resource size under management of position.

    2.2. Corporate image:

    it is the public perception of the company.

    2.3. Corporate culture:

    It is the personality of a company including a variety of elements such as company goals, values, expectations, ethics, work environment, ethics, and company mission.

3. Development opportunities

    3.1. Training opportunities:

    It is about both general training policy of a company and training opportunities related to the position.

    3.2. Promotion:

    It is about both career management system of a company and promotion mechanism for related position.

3.3. <u>Performance applications</u>:

Performance management policy of a company and level of applications based on performance.

Distribution of employee expectations is given in Figure 1.

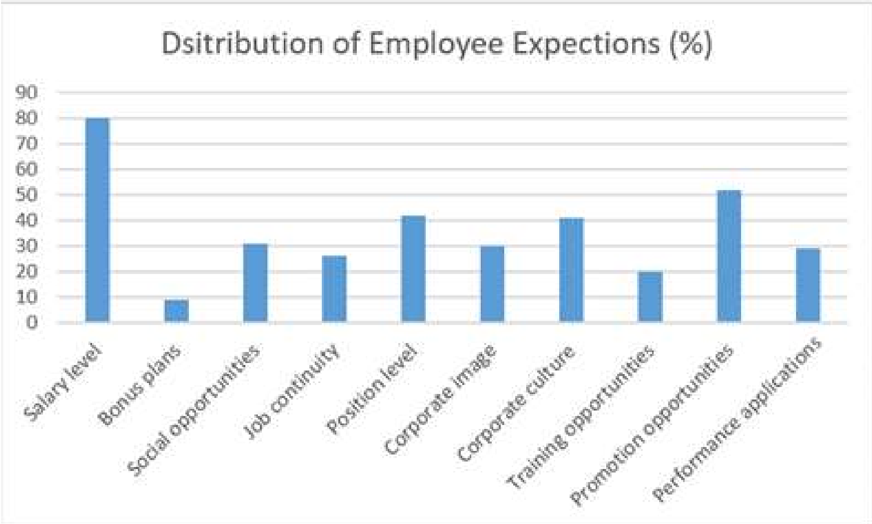

Figure 1: Distribution of employee expectations (%), Adapted from: Ozden (2001)

According to the results, 80% of participants select “salary level” among expectations which have effects on selection of a position or continuation in their current position. “Promotion opportunities” is the second highest expectation with the 50% percentage. “Position level” and “corporate culture” with the 40% percentage are seen as the important factors which have effects on employee choice.

Factors to which employees give importance in the business life are grouped into 3 categories which are “financial opportunities”, “the job itself” and “development opportunities” as mentioned before. These categories are compared by pairwise comparison.

First comparison is made between “financial opportunities” and “the job itself”. According to this comparison, “financial opportunities” has a higher value with a little difference than “the job itself”. The interesting thing here is that the difference is small when factors are taken into account in group. However, “salary level” is the most selected factor with a big difference when factors are taken into account individually. First comparison result is given in Figure 2.

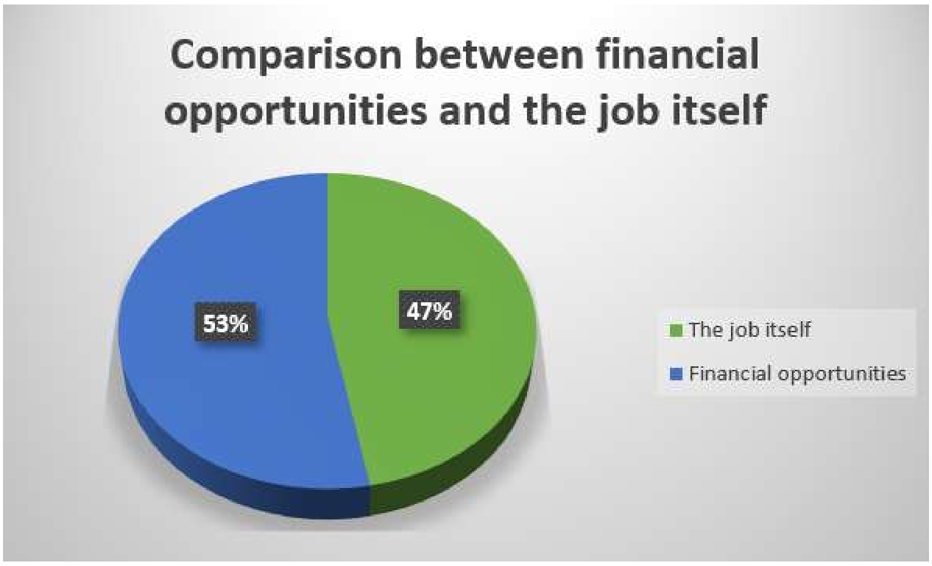

Figure 2: Comparison between financial opportunities and the job itself, Adapted from: Ozden (2001)

Second comparison is made between “financial opportunities” and “development opportunities”. According to this comparison, “development opportunities” has a higher value than “financial opportunities”. When factors are taken into account in group, most of the employees give priority to “development opportunities”. Figure 3 shows the results of the second comparison.

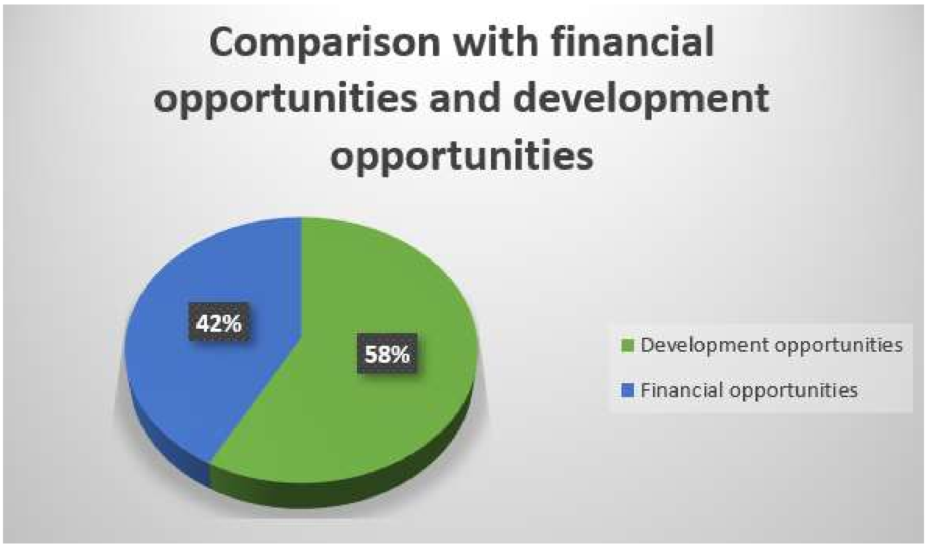

Figure 3: Comparison between financial opportunities and development opportunities, Adapted from: Ozden (2001)

Last comparison is made between "the job itself" and "development opportunities". According to this comparison, "development opportunities" has a higher value than "the job itself". In the last two comparison, difference is similar and bigger than the first comparison while difference is small for the first comparison. Figure 4 shows the results of the last comparison.

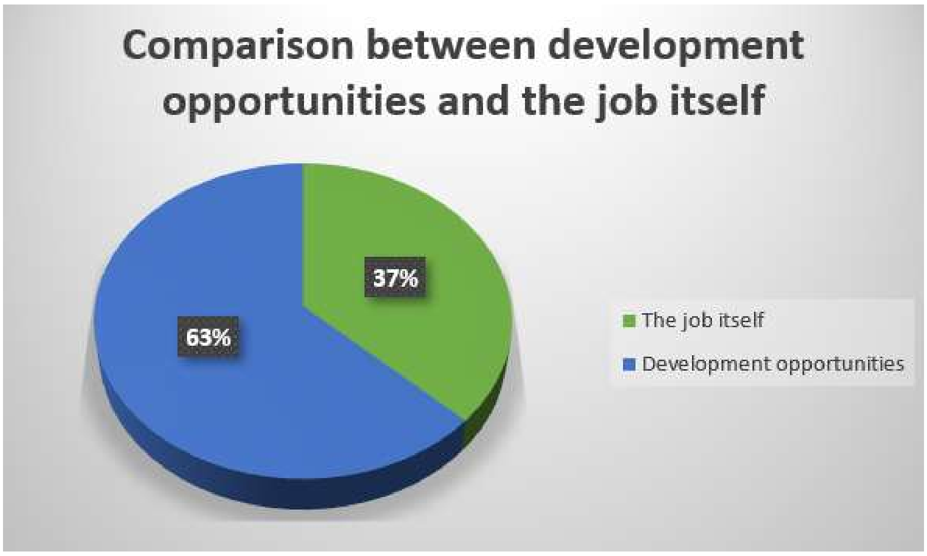

Figure 4: Comparison between development opportunities and the job itself, Adapted from: Ozden (2001)

3.2 Employer Expectations

There is a survey conducted by NACE (2017) to October 2, 2017 from August 9, 2017 about attributes what employers seek on students' resumes. In the mentioned survey, 201 forms were evaluated. The survey data were collected from NACE' s employer members. This survey is taken part as is in this thesis in order to provide insight and to create perceptions about employer expectations. When NACE asked participant employers which attributes, they give most value, employers indicated following attributes:

<u>Problem solving skills </u>(Ilgın, 2010):

It is one of the most essential skills what employers want in new hires in nearly every sector. It includes the steps given below:

- Generating possible solutions for the problem in the light of the collected data
- Analysing solutions
- Applying the solution
- Evaluating the results of the solution applied

The individual may demonstrate creativity and originality while offering solutions in this process.

Communication skills (Tchouabeh, 2018):

Communication is the process of providing and flowing information and it is separated into two groups, internal communication which is within the organization and external communication which is out of the organization.

Ability to Work in a Team (Doyle, 2019a):

It is the ability to work in a team collaboratively and efficiently which composes of people in different ages, cultures, genders, races, lifestyles, viewpoints and religions. All employees work with others. For example, they work on team projects, they share responsibilities with other people on the team, they want to achieve a common goal. Therefore, ability to work in a team is essential for employers. The individual needs to get along with others.

Leadership (Ward, 2019):

This ability helps people positively and effectively interact with team members or other employees. It is important, regardless of the role an employee has at a company. Leadership is the ability to act of leading an organization or a group of people. Leaders provides direction and guide their employees or coworkers in an efficient way.

Strong work ethic (Luenendonk, 2017):

A work ethic is described as a set of moral principles that an employee uses while doing his responsibilities or work. It is essential to an organization achieving its aims. The individual must have a good work ethic to contribute to the achievement of the company' s aims. A strong work ethic helps employees to handle challenges they face and keep the organization functioning at the top.

Analytical skill (Doyle, 2019b):

It is the ability to collect and analyse data and make decisions in a timely, efficient manner. Also, it is simply defined as problem solving skills. This type of ability increases an organization' s productivity. The individual with analytical skills is able to understand a problem from all angles before executing a solution.

Quantitative skill (Steele, 2018):

It refers to the ability to use numerical, measurable data systematically and handle data. This type of skill is essential in today's business environment and in nearly every field most particularly in marketing, business, finance, science, engineering, math and technology fields. Quantitative data analysis based on statistical and mathematical research methods. This type of skill can be used to predict long term trends and solve business problems. The individual with quantitative skills is able to understand and interpret data related to mathematics, budgeting, probability and some of other areas.

Initiative (Taking Initiative, n.d.):

It can be defined to identify opportunities and act a proactive way in putting ideas and solutions. It is also described as handling responsibilities and works without being told. This ability is more vital at small companies which must be more agile than large companies. The individual with initiative ability takes responsibility in his job, try to solve issues and challenges, rather than to pass them on to someone else, show enthusiastic actions, learn new skills and introduce ideas and improvements to the way things are. This ability helps the performance of the organizations.

Detail oriented (What is Detail Oriented, n.d.):

It means to pay attention to details and concentrate on a task in business aspect. Paying attention to details is very important because this ability provides better performance at work. In other words, employees with this ability work more effectively. They try to understand causes of a situation and reasons behind it instead of just its effects.

Flexibility/Adaptability (Adaptability&flexibility, n.d.):

It is about adapting to changing situations and environments and responding quickly to sudden changes in environments and circumstances. The individual with high adaptability is defined as flexible. Flexibility and adaptability are vital in today' s business environment because companies must adapt and conform to the latest changes on a real time basis. The individual must open to new thoughts, concepts and ideas and adapt to changing environments and circumstances.

Technical skills (Doyle, 2019c):

They are the abilities and knowledge required to complete mathematical, scientific, engineering or computer related tasks. Technical skill is one of the most important skills for jobs especially related to technology. The individual with this ability can carry out duties related to technical roles such as science, IT, finance, engineering or mechanics. Example for technical skills are programming, the use of specific tools or the analysis and interpretation of complex figures. For the majority of them, experience and intensive training to master are required.

Interpersonal skills (Lim, 2019):

They are about the way you interact, communicate and collaborate effectively and properly with other people. Interpersonal skills include a variety of skills from communication such as listening and questioning to attitude. These skills are important in all areas of life especially in working life because almost all aspects of work require communication. The individual with these abilities can motivate co-workers, develop rapport with other people, work well in a group or team which composes of different types of people. Therefore, they are likely more successful in their personal and working lives.

Computer skills (Computer Skills: Definitions and Examples, n.d.):

These skills are vital because no matter what type of position is, these types of skills are mostly involved in today's technocentric economy. Examples for computer skills that are looked for employers in a wide variety of sectors are Microsoft office, spreadsheets, PowerPoint, QuickBooks, email, web and social skills, graphic and writing skills and enterprise systems. The individual with these types of skills can utilize computers and related technology efficiently.

Organizational ability (Doyle, 2019d):

Organizational skills are very important skills because they help an employee to plan, organize and accomplish his or her works. These types of skills increase efficiency and productivity in the work by saving an organization money and time. The individual with these types of skills can prioritize tasks, structure his or her schedule and achieve his or her goals with systematic scheduling and planning even when unforeseen problems or delays occur.

Strategic planning skills (Doyle, 2019e):

Strategic planning is about setting a vision for an organization and realizing this vision by splitting into smaller goals and achieving these goals. Another definition for strategic planning is the process of determining strategy or direction and making decisions to pursue this strategy. The individual with strategic planning skills can help set goals, determine what acts required to be taken and help achieve these goals by guiding the implementation of actions.

Creativity (Naiman, n.d.):

Creativity can be defined as producing innovative ideas. In other words, it is a mechanism to being innovative and it opens the door to new opportunities in business environment and increase the productivity of an organization. The role of creativity in organization' s performance is important especially in some of the job fields like design and marketing. The individuals with this ability can dream up diverse and unique ideas and creative solutions. Also, they encouraged other employees to think different.

Outgoing personality (Munroe, 2019):

It is described as friendly and energetic and liking and enjoying being with other people. This type of skill is very important especially for positions which involve working directly with other people such as human resource specialist, marketing manager, project manager, public accountant, public relations specialist, recruiter and sales representative.

Tactfulness (Tact and Diplomacy, n.d.; How to Be Tactful, n.d.):

Tactful is the ability to use methods used to aid clear communication while being sensitive to people and not offending anyone. In other words, it means tell someone the truth in a way that considers other people feelings. This ability helps you give negative and difficult feedback without hurting people's feelings, especially in front of other people and tell the truth even if it is negative to preserve a relationship. It is vital especially in challenging and difficult situations. For example, when you have to provide critical and negative comment and feedback or deliver bad news in your business life, this ability is very important. Communicating tactfully demonstrates good manners and professionalism. It helps someone to build new relationships and preserve the existing ones.

Entrepreneurial skills/risk-taker (Risk-taking: the most necessary skill for a successful entrepreneur, 2017):

An entrepreneur can be defined as a someone who takes benefit of an opportunity, takes initiative and decides how, what and how much of a good or service will be produced as a decision maker. Entrepreneurs take big or small risks which are calculated the potential results. Taking risks help business growth in today' s competitive business world. A risk is a means of advancing their business and helping them achieve their current position for the majority of entrepreneurs. Generally speaking, it allows an entrepreneur to distinguish himself or herself from the competitors and progress usually involves risks. Taking risk teaches us planning and strategic thinking as well as how to calculate contingencies.

Fluency in a foreign language (Jolin, 2014):

Nowadays, communicating in more than one language and understanding a culture is important especially some jobs in the field of sales, retail, customer service, tourism, administration, transportation, banking, marketing, government, public relations and teaching because they allow individuals to communicate with different clients using a foreign language. Also, some companies may require employees to travel to another country for important works such as completing a deal, settling important cases, opening a new branch of the company and these employees are seen as the face of the company.

Distribution of employer expectations are given in Figure 5.

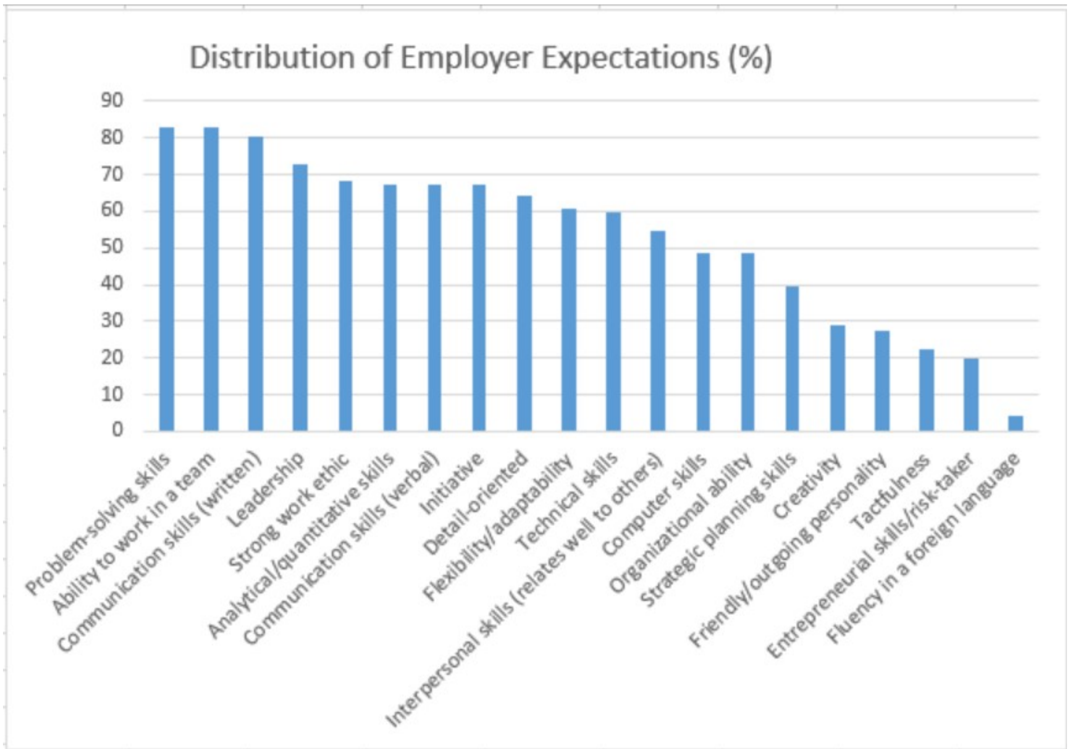

Figure 5: Distribution of employer expectations (%), Adapted from: NACE (2017).

According to the results, problem-solving skills and teamwork abilities with 82.9% percentage are the most desired abilities and they have equal importance. Another attribute which employers give the most value is written communication skills with 80.3% percentage. Leadership abilities, and a strong work ethic are also seen as the important factors and carry a lot of weight with employers.

3.3 Multi Objective Optimization

Multi objective optimization is defined by Marler and Arora (2004) as the operation of collecting multiple objective functions in a systematic and simultaneous way. It is also known as vector optimization. It is one of the fast-growing areas of Operations Research. It is used in many areas of engineering, business, economics and science (Rangaiah, 2009).

Most of the optimization problems include by definition multiple and conflicting objectives (Atlas, 2008). The goal of the optimization is to reach the best decision about the given problem under the existing constraints (Ersoz, 2015).

The simple definition of multi objective optimization problem is given as following by Marler and Arora (2004):

$$Min\ F(x) = [F_1(x), F_2(x), \ldots, F_k(x)]^T$$

$$subject\ to\ g_j(x) \leq 0, \ \ j = 1,2, \ldots, m$$

$$h_l(x) = 0, \ \ l = 1,2, \ldots, e$$

k: the number of objective functions

m: the number of inequality constraints

e: the number of equality constraints

$x \in E^n$: a vector of decision variables (n: the number of independent variables)

$F(x) \in E^k$: a vector of objective functions

There are a lot of algorithms to solve multi objective optimization problems. For example, weighted sum, epsilon constraint, lexicography, NSGA II and MOPSO (Seifollahi, 2015).

3.4 Optimization Model

The problem to be solved in this study is like the problem stated by Zhang et al. (2015). They also try to improve employee-position matching. The mathematical model is formed by being inspired from the model suggested by Zhang et al. (2015). However, there are a lot of differences between our model and the model of them. They propose a method of construction multi objective optimization model with fuzzy numbers by considering both company and worker satisfaction. In their study, satisfaction degrees of both person and position requirements specified linguistic terms called linguistic assessment information of matching satisfaction degree are transformed into corresponding triangular fuzzy numbers and weight vectors of evaluation index of matching satisfaction degree are composed. Then a fuzzy multi-objective optimization model about knowledge workers and company positions matching is constructed. Finally, this model is transformed into a single objective linear programming model.

The details of our model are explained as follows.

The set of employee is $A = \{A_1, A_2 \ldots A_n\}$, where A_i represents $i-th$ employee, The collection of position is $B = \{B_1, B_2 \dots B_m\}$, where B_j expresses $j-th$ position,

The set of attributes what employers seek for employee selection is $C = \{C_1, C_2 \dots C_f\}$, where C_h says $h-th$ attribute,

The normalized weight of attributes corresponding to the C is w= $\{w_{1j}, w_{2j} \dots w_{fj}\}$, where w_{hj} represents the weight of C_h for position j,

The assessment value of employee corresponding to the C is $a = \{a_{1i}, a_{2i} \dots a_{fi}\}$, where a_{hi} expressed as the evaluation value of C_h for employee i,

The set of attributes what employees expect from a job is $D = \{D_1, D_2 \dots D_k\}$, where D_q says $q-th$ attribute,

The normalized weight of attributes corresponding to the D is $v = \{v_{1i}, v_{2i} \dots v_{ki}\}$, where v_{qi} represents the weight of D_q for employee i,

The assessment value of position corresponding to the D is $b = \{b_{1j}, b_{2j} \dots b_{kj}\}$, where b_{qj} expressed as the evaluation value of D_q for position j,

The calculation formula of ρ_{ij} while ρ_{ij} represents how sufficient employee i to meet the needs of position j is expressed in formula (1).

$$\rho_{ij} = \sum_{h=1}^{f} w_{hj} \,.\, a_{hi} \qquad , i = 1,2, \dots n; \quad j = 1,2, \dots m \qquad (1)$$

The calculation formula of β_{ij} while β_{ij} represents the satisfaction value of employee i from position j is expressed in formula (2).

$$\beta_{ij} = \sum_{q=1}^{k} v_{qi} \,.\, b_{gj} \qquad , i = 1,2, \dots n; \quad j = 1,2, \dots m \qquad (2)$$

According to description above, a multi objective optimization model developed is shown in formula (3). In this formula, x_{ij} means the matching of employee A_i and position B_j . Another variable r_j means the maximum value of employee who can be recruited for position j.

$$\text{Max}\, z_1 = \sum_{i=1}^{n} \sum_{j=1}^{m} \rho_{ij} \,.\, x_{ij} \qquad (3)$$

$$\max z_2 = \sum_{i=1}^{n} \sum_{j=1}^{m} \beta_{ij} \,.\, x_{ij}$$

s.t.

$$\sum_{j=1}^{m} x_{ij} \leq 1 \qquad , i = 1,2, \dots n$$

$$\sum_{i=1}^{n} x_{ij} \leq r_j \qquad , j = 1,2, \dots m$$

$$x_{ij} = 0 \; or \; 1$$

One of the commonly used methods in Operations Research that has been performed in most of fields is optimization. To maximize or minimize a function which is called as an objective function under a set of constraints is the goal in optimization. However, there is often a need to optimize multiple objective functions. This need brings multi-objective optimization (MOO) concept (Pike-Burke, n.d.). One of the widely used approaches suggested for multi-objective optimization is the weighted sum method (Jakob and Blume, 2014). Weighted sum method is one of the approaches for creating a single objective problem from multi objective problems (Karasay, 2016). In this approach, a single objective function is a weighted sum of the objective functions (Simpson, n.d.). To calculate the weighted sum, a weight value must be chosen for each of objective functions (Jakob and Blume, 2014). There are two objective functions in our model above. The first objective function makes position satisfaction maximum as much as possible and the second one makes employee satisfaction maximum. We assumed that employee satisfaction and position satisfaction are equally important for us and because of this, we decide weight values as equal. In principle, the weights can take different positive values according to the preference of decision maker (Ustun, 2013), but often the sum of weights is assumed as 1 (Simpson, n.d.). Therefore, we assign weights as 0.5 to objective functions. When the objective functions are in different scales, they should be normalized (Jakob and Blume, 2014). However, in our model, objective functions have the same scale, so there is no need to normalize them.

Models may have one objective function at most in LINGO format (Developing a LINGO Model, n.d.). Objective functions presented above are combined into one while the LINGO model is coded using weighted sum approach because the simplicity of its application as following. As mentioned before, u_1 and u_2 which are the weight of the first and second objective function respectively are selected as 0.5.

$$\max z = u_1 . \sum_{i=1}^{n} \sum_{j=1}^{m} \rho_{ij} \, . \, x_{ij} + u_2 . \sum_{i=1}^{n} \sum_{j=1}^{m} \beta_{ij} \, . \, x_{ij}$$

One of the studies in which different methods applied to solve multiple objective functions in the literature is the study about logistics system performed by Ecer (2014). The model in her study has two objective functions. The first objective function is maximization of the road safety and the second one is minimization of the length of the route. While the solving the problem, firstly, she runs the model only with the first objective function as considering it as the primary goal without the second objective function. Then, the obtained value of the first objective function after the run is added to the model with the second objective function and model is run again with the second objective function this time.

There are three constraints in our model above. The first one of the constraints is expressed as: employee A_i can be recruited into one position at most. The second constraint means that at most r_j employee can be recruited into position B_j. The last one means following: $x_{ij} = 1$ means employee A_i and position B_j match and $x_{ij} = 0$ means employee A_i and position $B_j$do not match.

Validation of the model is performed with different experiments with real data gathered from different companies and in the validation data set, the weight of attributes what position seeks for employees are given by human resources specialists and they are provided from the companies. Similarly, the weight of attributes what employee expects from a job are given by the employees and they are also provided from the companies. These weights are used as is and they are out of 5. Attributes with larger values means these attributes have more importance than attributes with smaller values. These weights are normalized before embedding them into the model. The assessment value of employees in terms of the attributes what positions seek for employee are gotten by employee self-evaluation and they are also provided by the companies. The assessment value of positions corresponding to the attributes what employees expect from position are based on human resource specialist' s knowledge and they are also provided by the companies. All these values mentioned are used as is.

3.5 LINGO

There are many optimization programs used in the markets. Commonly used ones are LINGO, MPL, OPL and MATLAB (Narlı, 2007). We prefer using LINGO because it is very close to the mathematical modelling language.

LINGO is a tool which designed to build and solve optimization models such as linear, nonlinear, global, integer etc. faster and more efficient (LINGO, n.d.). It is one of the optimization modelling software products of LINDO Systems Inc. It can be used for many areas such as production, marketing, distribution etc. (What are LINGO and Lingo, 2018).

3.6 Numerical Example

Validation of the model is performed by using real data. Because of the privacy of the companies that provide validation data, in order to explain the developed model more clearly, an example is given below.

In this example 2 positions (B_1, B_2) and 3 employees (A_1, A_2, A_3) are used. Also 3 attributes (salary level, promotion and training opportunities) what employees expect from a job and 4 attributes (computer skills, communication skills, ability to work in a team, fluency in a foreign language) what employers seek for employee selection are used. The maximum value of employee who can be recruited for each position (r_1, r_2) is assumed as 1. As mentioned before, all values in this numerical example are not real and this example is only given in order to explain the concept more clearly.

In this example, the weight values are given using 10-point scale system. The weight is a sign of the importance of the attributes. 1 is used for the minimum importance degree and 10 is for the maximum importance degree. Also, the performance evaluation rating scale used is 10-point scale system and point 6 according to the definitions in 10-point scale system means that employee produces average results with regards to meeting the set targets. The weight of attributes what position B_j seeks for employees and the weight of attributes what employee A_i expects from a job are given in Table 1 and Table 2 respectively.

Table 1: The weight of attributes what position B_j seek for employees

	Positions (B_j)	
Attributes (C_h)	B_1	B_2
Computer skills	10	2
Communication skills	5	10
Ability to work in a team	4	5
Fluency in a foreign language	6	3

Table 2: The weight of attributes what employee A_i expect from a job

	Employees (A_i)		
Attributes (D_q)	A_1	A_2	A_3
Salary level	10	8	10
Promotion	4	6	9

Training opportunities	6	6	6

After weight of attributes in Table 1 and Table 2 are determined, these values are normalized. Normalization values are calculated as following for Table 1 as an example:

Sum of column B_1 and column B_2 in Table 1 is 25 and 20 respectively. Normalized values are ratio of each weight to the sum of the related column values. According to this explanation, normalized values are shown in Table 3 and Table 4.

Table 3: The normalized weight of attributes what position B_j seek for employees – (w_{hj})

w_{hj}	**Positions (B_j)**	
Attributes (C_h)	B_1	B_2
Computer skills	$\frac{10}{25} = 0.4$	$\frac{2}{20} = 0.1$
Communication skills	$\frac{5}{25} = 0.2$	$\frac{10}{20} = 0.5$
Ability to work in a team	$\frac{4}{25} = 0.16$	$\frac{5}{20} = 0.25$
Fluency in a foreign language	$\frac{6}{25} = 0.24$	$\frac{3}{20} = 0.15$

Table 4: The normalized weight of attributes what employee A_i expect from a job – (v_{qi})

v_{qi}	**Employees (A_i)**		
Attributes (D_q)	A_1	A_2	A_3
Salary level	$\frac{10}{20} = 0.5$	$\frac{8}{20} = 0.4$	$\frac{10}{25} = 0.4$
Promotion	$\frac{4}{20} = 0.2$	$\frac{6}{20} = 0.3$	$\frac{9}{25} = 0.36$
Training opportunities	$\frac{6}{20} = 0.3$	$\frac{6}{20} = 0.3$	$\frac{6}{25} = 0.24$

Respectively, Table 5 and Table 6 show the assessment value of employee A_i corresponding to the attributes what positions seek for employee i and the assessment value of position B_j corresponding to the attributes what employees expect from position j. In this example, the point scale of assessment values of employees and positions is out of 10.

Table 5: The assessment value of employee A_i corresponding to the attributes what positions seek for employee i – (a_{hi})

$\boldsymbol{a_{hi}}$	**Employees ($\boldsymbol{A_i}$)**		
Attributes ($\boldsymbol{C_h}$)	$\boldsymbol{A_1}$	$\boldsymbol{A_2}$	$\boldsymbol{A_3}$
Computer skills	9	8	7
Communication skills	2	3	4
Ability to work in a team	4	5	3
Fluency in a foreign language	6	6	7

Table 6: The assessment value of position B_j corresponding to the attributes what employees expect from position j – (b_{qj})

$\boldsymbol{b_{qj}}$	**Positions ($\boldsymbol{B_j}$)**	
Attributes ($\boldsymbol{D_q}$)	$\boldsymbol{B_1}$	$\boldsymbol{B_2}$
Salary level	8	5
Promotion	6	6
Training opportunities	4	7

The model is applied on the mentioned example by using LINGO software and the LINGO code is given in Appendices section, Appendix A. Also, solution report of this model is presented in Appendices, Appendix B. According to the solution report, global optimal solution is found. In this solution report, according to the "Value" column, variables in the model are taken following values in the global optimal solution in Table 7:

Table 7: Variable values in the global optimal solution (x_{ij})

Variable	**Value**
x_{11}	1
x_{12}	0
x_{21}	0
x_{22}	1
x_{31}	0
x_{32}	0

According to this, employee A_1 matches with position B_1; employee A_2 matches with position B_2; employee A_3 does not fit any positions.

To validate the model results, the method followed is given below:

If an employee is currently working in the matched position, his or her performance evaluation score is checked whether it indicates the good performance or not. The evaluation scores indicating good performance is changed according to the performance evaluation rating scale used by companies. If an employee is not currently working in the matched position, his or her manager is asked to evaluate the employee about the attributes for what the matched position seeks, and manager evaluation score is taken into account. More information about the validation is given in section 4.3, “The Evaluation of the Proposed Model” section.

To get back the numerical example at hand, let us suppose that employee A_1 is currently working in the matched position $B_1$and the performance evaluation score of employee A_1 shows the good performance. In this case, it is considered that the developed model gives the right decision for employee A_1 and position B_1.

Let us suppose that the current position of employee A_2 is not position B_2. In this case, the manager of employee A_2 evaluates the employee A_2 in terms of the criteria what position B_2 seeks for employee. Because the weight of attributes what position seeks for employees are on a 10-point scale, manager evaluation values are also given on a 10-point scale. Let us assume that the manager evaluation for employee A_2 is as the following table, Table 8:

Table 8: Manager evaluation values for employee A_2 in terms of attributes what position B_2 seek for employees

Attributes	**Manager Evaluation Value**
Computer skills	5
Communication skills	6
Ability to work in a team	4
Fluency in a foreign language	10

After the evaluation of the manager, the manager evaluation value is multiplied by the weight of the attribute and the results of the operations of multiplication for each of the attribute are summed up. Finally, the manager evaluation result is obtained by dividing the sum of multiplication results by the sum of weights of the criteria what position B_2 seeks for employee.

The results of the operations of multiplication of manager evaluation value and weight of the attribute what position B_2 seek for employees are presented in Table 9:

Table 9: The results of the operations of multiplication of manager evaluation value and weight of the attribute what position B_2 seek for employees

Attributes	**Results of Multiplications**
Computer skills	$5 \times 2 = 10$
Communication skills	$6 \times 10 = 60$
Ability to work in a team	$4 \times 5 = 20$

Fluency in a foreign language	$10 \times 3 = 30$

Sum of multiplication results $= 120$

Sum of weights of the criteria what position B_2 seeks for employee $= 20$

Manager evaluation value for employee A_2 in terms of the criteria what position B_2 seeks for employee is obtained as 6 by calculating as following:

$$\frac{Sum\ of\ multiplication\ results}{Sum\ of\ weights\ of\ the\ criteria} = \frac{120}{20} = 6$$

Point 6 means that employee produces average results with regards to meeting the set targets according to the definitions in 10-point scale system as mentioned before.

In the light of this information, it is decided that the model gives the right decisions for both of two matchings.

As mentioned before, this is just a numerical example and this example is only used to present the details of the mathematical model. Validation of the developed model is performed with real data whose details are not given because of the privacy issues.

Validation of the model is performed with different experiments with real data gathered from different companies

CHAPTER 4

MODEL TESTING AND COMPUTATIONAL STUDY

The goal of this part is to explain this computational study and to evaluate the validity and correctness of the model expressed in the previous section, Section 3.

4.1 Test Problem Data and The Environment

4 experiments with different data are performed to evaluate the validity of the model that we propose, and data used in these experiments is real data. Data used in three of these experiments consists of 4 positions, 7 employees, 3 attributes what employees expect from a position and 3 attributes what employers look for. The fourth experiment is performed with 3 positions, 7 employees, 3 attributes what employees expect from a position and 3 attributes what employers look for. Both the weight values for the criteria and the evaluation values for the criteria are used in 5-point scale system. Employee satisfaction weight and position satisfaction weight are considered as equally important and their value is selected as 0.5 in the model. The purpose of each of runs with this problem set is to obtain optimal solution for our problem. The details are not presented to protect privacy of the companies by which data is provided. Only general information about the solution of the model for each run is given in Appendix C. This information is useful for observing the dimensions of our model and the progress of the solver.

As mentioned before, only data set provided by the companies are used. In other words, attributes, employees, and positions are provided by the companies whose information is not given. Weight value of attributes what employee and position expect are also provided by the companies. The assessment value of positions corresponding to the attributes what employees expect from position are based on human resource specialist' s knowledge and they are also provided by the company. The assessment value of employees corresponding to the attributes what positions seek for employee are obtained by employee self-evaluation and they are also provided by the companies. All of them provided by the companies are used as is.

Model is implemented by using LINGO which is a modelling language and an optimization software on a PC with a 2.60 GHz Intel Core i7 6600U CPU and 16.0 GB of RAM. Model for optimal solutions is solved by LINGO 17.0 that is limited.

4.2 Test Results

The results obtained throughout the experiments are explained in this section.

Solver Status windows which contains information about the model and the solution progress for each of 4 experiments are presented respectively in Appendix C. According to the Variables box in the Solver Status windows given in Appendix C, there are 28 variables which are the total number of variables in the model for the first three run and there are 21 variables in the fourth run. The count of the total number of integer variables in the model for each of the first three run is displayed as 28. The fourth run contains 21 integer variables. The Variables box in the Solver Status window also shows the number of the total variables which are nonlinear (LINGO The Modeling Language and Optimizer, 2018). There are no nonlinear variables in our model. The total constraints in the model and the number of these constraints which are nonlinear are 12 and 0 respectively according to Constraints box in the specified Solver Status windows for each of the first three run. In the fourth run, there are 11 constraints in total. There are 84 nonzero coefficients in total in the model for each of the first three run and there are 63 nonzero coefficients in the fourth run. Any of these appear on nonlinear variables as stated in Nonzeroes Box in the Solver Status window. The total nonzero coefficient count can be viewed as the total number of times variables seen in all the constraints (LINGO The Modeling Language and Optimizer, 2018). Similarly, it can be seen that the nonlinear nonzero coefficient count is the number of times variables appear nonlinearly in all the constraints (LINGO The Modeling Language and Optimizer, 2018).

In the Solver Status box, there are some fields whose descriptions are explained in the following table, Table 10 and their values for each of runs are given in Table 11 (LINGO The Modeling Language and Optimizer, 2018):

Table 10: Explanations of fields in Solver Status Window

Field	**Field Description**
Model Class	Summarizes the properties of the model. Some of the possible values and their descriptions are given below: PILP: Pure Integer Linear Program (All variables are restricted to integer values and all expressions are linear) MILP: Mixed Integer Linear Program (Some of variables are restricted to integer values and all expressions ae linear)
State	Shows the status of the current solution. Some of the possible values and their descriptions are given below: Global Optimum: When the solver can find no more better solutions to the model, it will finish in “Local Optimum” or “Global Optimum” state. If there are not any nonlinear constraints in the model, any locally optimal solution will be considered as global optimum. Feasible: When the LINGO finds a solution which satisfies all the constraints, the solver will finish in “Feasible” state.
Objective	Current value of objective function
Infeasibility	Amount constraints are violated by

Iterations	Number of solver iterations (Number of fundamental operations performed by LINGO' s solver)

Table 11: Field values in Solver Status Window for each of experiments

Experiment No	Model Class	State	Objective	Infeasibility	Iterations
Experiment 1	PILP	Global Optimum	15.9115	0	0
Experiment 2	PILP	Global Optimum	16.1535	0	0
Experiment 3	PILP	Global Optimum	16.1855	0	0
Experiment 4	PILP	Global Optimum	12.38	0	0

According to the results gotten for each of experiments, employee position matching is showed in Table 12 in order to show the results.

Table 12: Employee-position matching results

Experiment	Employee	Matched Position
Experiment-1	Employee A	Business analyst
	Employee D	Test specialist
	Employee E	Software development specialist
	Employee G	Product owner
Experiment-2	Employee L	Product owner
	Employee N	Software development specialist
	Employee P	Business analyst
	Employee R	System analyst
Experiment-3	Employee U	Product owner
	Employee V	System analyst
	Employee Y	Software development specialist
	Employee Z	Business analyst
Experiment-4	Employee GK	Software development specialist
	Employee CA	Business analyst
	Employee SY	Test specialist

In the light of these results, employees who are not matched with any of the positions for each of experiments are given in Table 13.

Table 13: Employees not matched with any positions for each experiment

Experiment	Employees not matched with any positions
Experiment-1	Employee B, Employee C, and Employee F
Experiment-2	Employee H, Employee K, and Employee M
Experiment-3	Employee S, Employee T, and Employee W
Experiment-4	Employee BÜ, Employee AS, Employee ÖÖ, and Employee İİ

4.3 The Evaluation of the Proposed Model

Validation is performed using real data. Namely; employees in some workplaces are subject to the performance evaluation process each year and at the end of the process, employees are given a certain performance score. For example, employees are evaluated over 5 points in some workplaces and the range of 3 – 5 is considered as good performance. These values can vary according to the workplace. For example, in some workplaces, employees are evaluated over 100 points and above 75 points is considered as good performance. The method we use, for example, matches the person X to the position Y. Because we do our experiments on real data, we have the information on which position, X is located. If person X is actually in position Y, relevant performance evaluation scores are available on a yearly basis. We use these performance scores while concluding how successful our method is. If the person X is in position Y and the performance note is in the good performance range, then we make a decision that our method for this pairing is a correct pairing (or an incorrect pairing if it is not in the good performance range). Let's say that our method matches person K to position N and person K is not in position N. In this case, we reach a conclusion according to the opinion of the superior of the person K about the position N. In other words, the superior of the person K evaluates person K in terms of criteria what position N seek for employees.

The used data in the experiments are different from each other and they are real data. They belong to companies in which the 5-point rating scale system is used in order to evaluate personal performance and description for each rate is given in Table 14. In this system, a rating of 3 is viewed as an average performance. The rate 3 and the rate above 3 are considered as acceptable. In other words, it shows good performance. An employee with good performance means that he/she achieves set targets. That is to say, there is not a gap between performance of the employee and the objectives set for that employee.

Table 14: 5-point performance rating scale system

Scale Value	Description
1	Unsatisfactory performance
2	Needs development
3	Fully meets expectations
4	Exceed expectations
5	Exceptional performance

In our experiment, if an employee is matched with a position and this employee is already located in this position, his/her performance score is checked. In the light of the information given about performance rating scale system, if this employee is assigned to a rating of 3 at least, then it is concluded that the model gives the right decision.

Experiment-1

According to the results explained in Section 4.2, for Experiment-1, three employees who are Employee A, Employee D and Employee G are working in the matching positions they are already working in. When taking the last performance evaluation results of the mentioned employees, it is concluded that the model makes the right decision for these employees because their performance scores are not less than 3.

Employee E is working as test specialist, but the model matches this employee with software development specialist position. For this employee, we ask her manager about the evaluation by considering the criteria what software development specialist position seek for employees. Then, by taking into account both the evaluation of the manager for this employee and the weights of the criteria what software development specialist position seeks for employees, we concluded that Employee E is also suitable with software development specialist position. We reach this conclusion in the way that we calculate the evaluation value per weight, and we find it as 2.89. If the evaluation value for each of the criteria what software development specialist position seeks for employees was 5, the evaluation value per weight would be 5. By the way, we would like to remind that the evaluation is performed by using 5-point scale system. 1 is used for the minimum importance degree and 5 is for the maximum importance degree. Because the evaluation value per weight, 2.89, is rounded to 3, we decide that she is also suitable with software development specialist position. While making this decision, we ground that the rate 3 and the rate above 3 are considered as good performance in 5-point rating system for performance evaluation and after rounding 2.89 up, we get 3

Experiment-2

For Experiment-2, two employees who are Employee P and Employee R are working in the matching positions they are already working in. According to the last performance evaluation results of these employees, it is determined that the model makes the right decision because the performance scores of these employees are not less than 3.

Although Employee L is working as system analyst and Employee N is working as business analyst, the model matches Employee L with product owner position and Employee N with software development specialist position. For these employees, we ask the manager of Employee L about the evaluation by considering the criteria what product owner position seeks for employees and the manager of Employee N about the evaluation by considering the criteria what software development specialist position seeks for employees. Then, by taking into account both the evaluation of the managers for these employees and the weights of the criteria what related positions seek for employees, we concluded that Employee L is also suitable with product owner position and Employee N is also suitable with software development specialist position because the related evaluation values per weight for Employee L and Employee N are calculated as 5 and 4.67 respectively. Since the evaluation values per weight for both employees are greater than 3, it is concluded that Employee L is suitable with product owner position and Employee N is suitable with software development specialist position.

Experiment-3

For Experiment-3, only Employee Z is working in the matching positions he is already working in. When we consider to the last performance evaluation result of this employee, it is determined that the model makes the right decision because the performance score of this employee is not less than 3.

Although Employee U is working as system analyst, Employee V is working as software development specialist, and Employee Y is working as business analyst, the model matches Employee U with product owner position, Employee V with system analyst position and Employee Y with software development specialist position. For these employees, we ask the manager of Employee U about the evaluation by considering the criteria what product owner position seeks for employees, the manager of Employee V about system analyst position and the manager of Employee Y about software development specialist position. Then, by taking into account both the evaluation of the managers for these employees and the weights of the criteria what related positions seek for employees, we concluded that Employee U is also suitable with product owner position, Employee V is also suitable with system analyst position and Employee Y is also suitable with software development specialist position because the related evaluation values per weight for Employee U, Employee V and Employee Y are calculated as 5, 4.66 and 4.42 respectively. Since the evaluation values per weight for all employees are greater than 3, it is concluded that Employee U is suitable with product owner position, Employee V is suitable with system analyst position and Employee Y is suitable with software development specialist position.

Experiment-4

For Experiment-4, one employee who is Employee SY is working in the matching position she is already working in. According to the last performance evaluation results of this employee, it is determined that the model makes the right decision because her performance score is not less than 3.

Although Employee GK is working as business analyst and Employee CA is working as test specialist, the model matches Employee CA with business analyst position and Employee GK with software development specialist position. For these employees, we ask the manager of Employee CA about the evaluation by considering the criteria what business analyst position seeks for employees and the manager of Employee GK about the evaluation by considering the criteria what software development specialist position seeks for employees. Then, by taking into account both the evaluation of the managers for these employees and the weights of the criteria what related positions seek for employees, we concluded that Employee CA is also suitable with business analyst position and Employee GK is also suitable with software development specialist because the related evaluation values per weight for Employee CA and Employee GK are calculated as 5 and 4.22 respectively. These values are greater than 3.

Full evaluation matrix for this experiment is given in Table 15. The matching results are highlighted in this table.

Table 15: Employee evaluation matrix

	Position		
Employee	Business analyst	Software development specialist	Test specialist
BÜ	Perf. Score≥3	Mngr. Eval= 5	Mngr. Eval= 5
GK	Perf. Score≥3	Mngr. Eval= 4.22	Mngr. Eval= 4.25
AS	Perf. Score≥3	Mngr. Eval= 5	Mngr. Eval= 5
ÖÖ	Mngr. Eval=4.33	Perf. Score≥3	Mngr. Eval=4.38
İİ	Mngr. Eval=4	Perf. Score≥3	Mngr. Eval=4
CA	Mngr. Eval= 5	Mngr. Eval= 5	Perf. Score≥3
SY	Mngr. Eval= 3	Mngr. Eval= 2.88	Perf. Score≥3

According to the results of this experiment, employee GK and employee CA are not matched with the positions in which they are already working.

According to the manager evaluation results for employee GK, it is seen that she is more suitable with test specialist position than software development specialist position because manager evaluation value for test specialist position, 4.25, is higher than manager evaluation value for software development specialist position, 4.22.

According to the manager evaluation results for employee CA, it is seen that manager evaluation values for both test specialist position and software development specialist position are equal.

However, it should not be overlooked that manager evaluations are made by considering only the expectations of positions. In other words, employee expectations are not taken into considerations in manager evaluations. However, developed model in this study considers both employee and position expectations and aims at maximization of two-sided satisfaction.

4.4 Comparison the Validation with the Literature

In the literature, to the best of our knowledge, studies usually only mention the results of their models rather than validation of the results obtained after their experiments. For example, a study performed by Zhang et al. (2017, 2015) , thesis written by Collu (2009), thesis by Arslanoglu (2006), article by Eiselt and Marianov (2008), paper by Jinling et al. (2013) are some of them mentioning only results of their studies rather than the validation of them. Therefore, when we compare the validation of this study with validation of similar previous studies, we have difficulties to find sufficient data for comparison.

One of the rare studies about employee-job matching in the literature whose results are validated is the study performed by Jackson (2013). He adapts the employee-job matching concept to education. To make it clear, he considers teacher as employee, school as company, a teacher at a school as matching and success of the student as matching quality because he wants to obtain match quality depended on actual output. He uses student achievement as a determinant of matching quality. He performs his experiment with mobile teachers because in the mentioned framework, the impact of matching is more meaningful for them. The analysis compares the performance of teachers at one school with the performance of another. Results of his study shows that quality of matching of mobile teachers who switches their school is higher than before switching their school.

CHAPTER 5

CONCLUSION

5.1 Summary

Employee-position matching is the subject of many researches from different aspects. It is an important topic which has both personal and business sides. Employee productivity can be increased, and companies can profit from correct employee position matching. Employee satisfaction, employee loyalty and company satisfaction can improve with this way. For position satisfaction, requirements of positions and ability of employees have to match. On the other hand, benefits and gainings of position meet the needs of employees for employee satisfaction. Establishing a bilateral matching is very important point for this thesis – that is to say, increasing both position and employee satisfaction together constitutes the focus of this thesis.

In this thesis, linear programming is used as a method for solving the employee-position matching problem. Any of the criteria whether an employee expects from a position/job or a position/job expects from an employee can be added to the model. All criteria have not the same importance degree. To overcome this issue, weight values for each of the criteria which are decided by the companies are used.

The assessment values of employee A_i corresponding to the attributes what positions seek for employee i are got by making a questionnaire and each of participants evaluates himself. According to the results of the questionnaire study, it is noticed that the employee in the above position can give lower points to himself or herself than the employee in the beyond position.

In this study, a methodology for employee-position matching is aimed to be built. For this purpose, a mathematical model is offered considering both employee satisfaction and job/position satisfaction. Model is implemented by using LINGO which is a mathematical modelling language. It is solved by LINGO 17.0 and optimal solutions are obtained. Four validation experimentations are conducted, and each of the first three experiments consists of data with 4 positions, 7 employees, 3 attributes what employees expect from a position and 3 attributes what employers look for. The fourth experiment is performed by using 3 positions, 7 employees, 3 attributes what employees expect from a position and 3 attributes what employers look for. The experiments have been carried out with real and different data, but details are not explained by considering the privacy of the companies that provide the data.

In this study, 3 of 4 employees in the first experiment, 2 of 4 employees in the second experiment, 1 of 4 employees in the third experiment, and 1 of 3 employees in the fourth experiment are matched with positions in which they are already working successfully according to the performance evaluation results. The other employees in all experiments can be considered as being capable of succeeding in the matched positions when we take into account both the evaluation of the managers for these employees and the weights of the criteria what related positions seek for these employees. In the light of all of these, we accept the developed model as successful.

As a result, in this study a mathematical programming model is developed for employee-position matching by aiming both employee and position satisfaction and tested with real data in order to analyse the results of the model in a real life. This study shows the possibilities for the improvement in personnel selection process.

5.2 Limitations of the Study

An important limitation of this study is the limited size of data set used in the validation of the developed model. Model validation can be strengthened by using bigger data set in order to test the model. Also, model can be validated by using data of many companies in different areas. This helps increasing the reliability of the model.

Another limitation is the capacity of the version of LINGO which is an optimization modelling software used for solving our optimization model. In some LINGO versions, some model properties such as total variables, integer variables, nonlinear variables, and constraints are limited. If this limit is being exceeded, solving is not allowed to be performed by LINGO. In such a case, you should either simplify the model by making it smaller or use a larger version of LINGO.

The third limitation is about the way of getting the evaluation values of employees for each of corresponding attributes what positions seek for employee. These values are obtained by asking each of employees to evaluate himself/herself. In other words, bias caused by the participant's answer is one of our limitations. Because this method can be subjective, results obtained after model running can be affected adversely.

5.3 Contributions of the Study

This study has following contributions to the literature:

- To the best of our knowledge, there are only few of the methods considering two-sided matching between employee and position. With this study, a model aiming at two-sided matching validated with real data is added to the literature. Researchers can receive benefit from this study.
- By explaining both employee and position expectations and requirements from each other and providing the distribution of employee and employer expectations based on the surveys, insights about key elements of both employee and position satisfaction are created.
- The model is constructed to be able to handle every attribute of employee and position whatever they are.
- Both employee and position satisfaction have crucial influence on the performance and success of the company and employee. Unsatisfaction is one of the key factors that cause unproductivity and unproductivity affects performance in a negative way (Inuwa, 2016). This study points out the importance of satisfaction of both sides together.
- Reliability of results as well as results of the study are important (Selman, 2013). However, to the extent I know, this study about employee-job/position/task matching is one of the rare studies whose results are validated. As far as I searched, in general, only results of the experiments performed for the developed models or methods in the studies are mentioned. Study performed by Zhang et al. (2017, 2015), thesis written by Collu (2009), thesis by Arslanoglu (2006), article by Eiselt and Marianov (2008), paper by Jinling et al. (2013) are some of them. However, the developed model in this study is validated with real data. The main contribution of this study to the literature is the validation of the results of experiments performed in order to test the practicability of the developed model.

- Using the developed model, individuals whose skills, attributes and characteristics match the demands and requirements of a given job/position in the best way come into view. Therefore, unmatched individuals can see the skills, qualities and attitudes need to be improved.

5.4 Future Work

The assessment values of employee A_i corresponding to the attributes what positions seek for employee i are obtained by making a survey so they are subjective. In other words, because they are opinion based, they are subject to interpretation. The model testing can be performed with a dataset which is gained in a more objective way.

There are a lot of criteria which employee look for while job seeking. Similarly, positions also seek lots of criteria for employees. In this study, only small set of these criteria are used. Model validation can also be performed for different set of these criteria in order to investigate the effect of which criteria are used.

The weight of attributes what position seeks for employees and what employee expects from a position are provided by the companies and they are used as is. There are different studies deal with the methods of determining the weights of criteria (Ustinovičius, 2001). Different methods can be tried in future studies.

There are software tools can be used for optimization such as R-software, MATLAB and CPLEX. One of these tools except for LINGO can be preferred in future works.

In this study, the assessment value of employee corresponding to the attributes what position seeks for employee and the assessment value of position corresponding to the attributes what employee expects from position are in integer format. However, there are a variety of formats such as yes/no answers, decimal number, and language information. There can be some attributes more suitable one of these attributes. This situation should be considered in the future studies.

Extra constraints about following can be added to the model:

- Does every employee have to be hired?
- Does every position have to be filled?

The developed model can be adapted in other areas such as supply demand matching. Also, the results of the model can be used in order to develop educational programs scheduled for employees in the companies by deciding the deficiencies to be improved. Just to make it clear, after the model is run, employees which are not suitable to the positions in which they have already worked are decided. After deciding the employees, to make more suitable them to the positions, educational programs can be arranged.

The developed model is tested with four experiments with real and different data set. In each of the first three experiments, test data consists of 4 positions, 7 employees, 3 attributes what employees expect from a position and 3 attributes what employers look for. In the fourth experiment is performed by using 3 positions, 7 employees, 3 attributes what employees expect from a position and 3 attributes what employers look for. It is important to highlight that the provided datasets are small. Experiments can be carried out considering large scale problems. In other words, the developed model can also be tested with bigger datasets.

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APPENDICES

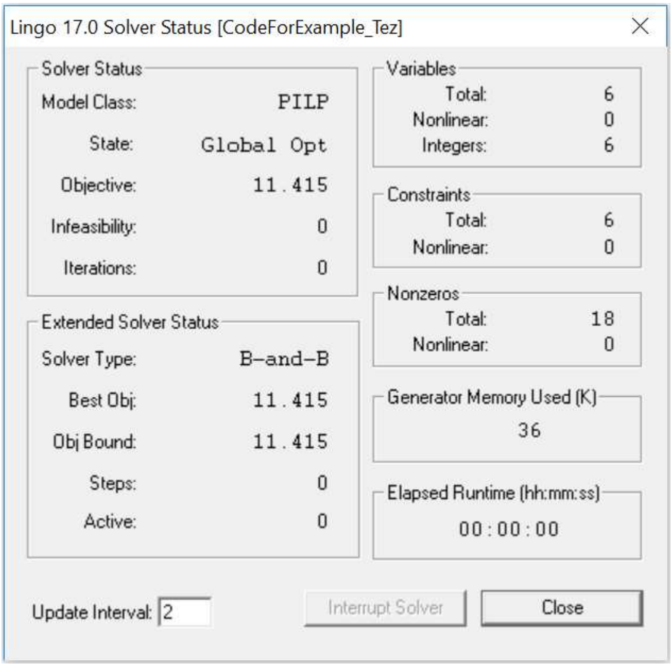
APPENDIX A

LINGO CODE FOR NUMERICAL EXAMPLE

```
MODEL:
SETS:
      EMPLOYEE/1..3/; !i;
      POSITION/1..2/: r; !r-j: the maximum value of employee who can be recruited for
position j;
      EMPLOYEECRITERIA/1..3/; !q: Attributes what employees expect from a job;
      POSITIONCRITERIA/1..4/; !h: Attributes what employers seek for employee selection;
      EMPLOYEEPOINT(POSITIONCRITERIA,EMPLOYEE): a; !a-hi : The assessment value of
employee i for corresponding attribute h.;
      POSITIONPOINT(EMPLOYEECRITERIA,POSITION): b; !b-qj : The assessment value of
position j for corresponding attribute q.;
      POSITIONCRITERIAWEIGHT(POSITIONCRITERIA,POSITION) : w ; !w-hj : The normalized
weight of attribute h for position j.;
      EMPLOYEECRITERIAWEIGHT(EMPLOYEECRITERIA,EMPLOYEE) :v ; !v-qi : The normalized weight
of attribute q for employee i.;
      EMPLOYEEPOSITIONMATCH(EMPLOYEE,POSITION) : x,ps,es;!x is the attribute from the
derived set EMPLOYEEPOSITIONMATCH that represents the matching.
      x(i,j) = 1 if employee i is matched with the position j.
      ps: position satisfaction degree
      es:employee satisfaction degree;
ENDSETS
DATA:
   a= 9 8 7 2 3 4 4 5 3 6 6 7; !a11 a12 a13 a21 a22 a23 a31 a32 a33 a41 a42 a43;
   b= 8 5 6 6 4 7; !b11 b12 b21 b22 b31 b32;
   w= 0.4 0.1 0.2 0.5 0.16 0.25 0.24 0.15; !w11 w12 w21 w22 w31 w32 w41 w42;
   v= 0.5 0.4 0.4 0.2 0.3 0.36 0.3 0.3 0.24; !v11 v12 v13 v21 v22 v23 v31 v32 v33;
   r= 1 1; !r1 r2;
ENDDATA
!x(i,j) is a binary value. x(i,j)=1 means employee i and position j match and x(i,j)=0
means employee i and position j don't match;
@FOR(EMPLOYEEPOSITIONMATCH(i,j): @BIN(x(i,j)));
!employee i can be recruited into one position at most;
@FOR(EMPLOYEE(i): @SUM(EMPLOYEEPOSITIONMATCH(i,j):x(i,j))<=1);
!at most r employee can be recruited into position j;
@FOR(POSITION(j): @SUM(EMPLOYEEPOSITIONMATCH(i,j):x(i,j))<=r(j));
!ps(i,j) represents how sufficient employee i to meet the needs of position j;
@FOR(EMPLOYEE(i): @FOR(POSITION(j): @SUM(POSITIONCRITERIA(h):w(h,j)*a(h,i))=ps(i,j)));
!es(i,j) represents the satisfaction value of employee i from position j;
@FOR(EMPLOYEE(i): @FOR(POSITION(j): @SUM(EMPLOYEECRITERIA(q):v(q,i)*b(q,j))=es(i,j)));
!objective function
the first part of objective function makes positions to employees satisfaction maximum as
much as possible
the second part makes position satisfaction maximum ;
MAX = (0.5)*@SUM(EMPLOYEEPOSITIONMATCH(i,j):x(i,j)*ps(i,j))+(0.5)*@SUM
(EMPLOYEEPOSITIONMATCH(i,j):x(i,j)*es(i,j));
END
```

APPENDIX B

SOLUTION REPORT FOR NUMERICAL EXAMPLE



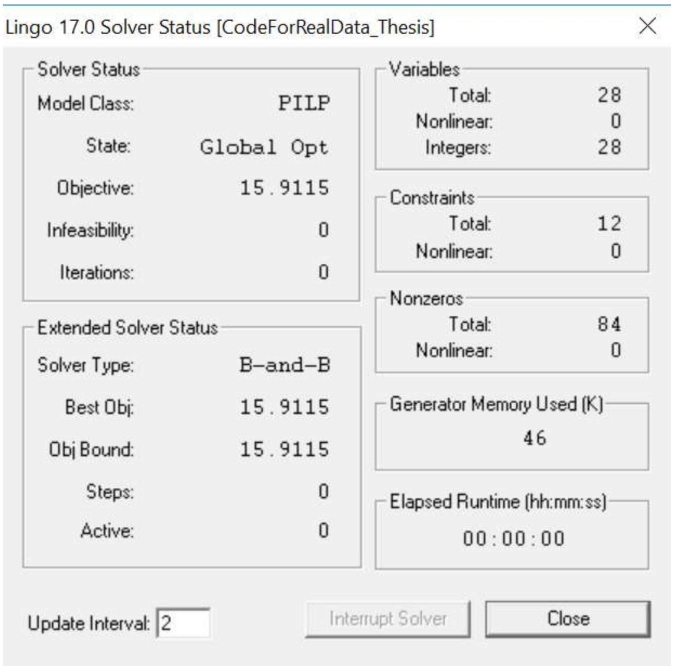

```
Global optimal solution found.
Objective value:                              11.41500
Objective bound:                              11.41500
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.05

Model Class:                                      PILP

Total variables:                      6
Nonlinear variables:                  0
Integer variables:                    6

Total constraints:                    6
Nonlinear constraints:                0

Total nonzeros:                      18
Nonlinear nonzeros:                   0
```

Variable	Value
R(1)	1.000000
R(2)	1.000000
A(1, 1)	9.000000
A(1, 2)	8.000000
A(1, 3)	7.000000
A(2, 1)	2.000000
A(2, 2)	3.000000
A(2, 3)	4.000000
A(3, 1)	4.000000
A(3, 2)	5.000000
A(3, 3)	3.000000
A(4, 1)	6.000000
A(4, 2)	6.000000
A(4, 3)	7.000000
B(1, 1)	8.000000
B(1, 2)	5.000000
B(2, 1)	6.000000
B(2, 2)	6.000000
B(3, 1)	4.000000
B(3, 2)	7.000000
W(1, 1)	0.4000000
W(1, 2)	0.1000000
W(2, 1)	0.2000000
W(2, 2)	0.5000000
W(3, 1)	0.1600000
W(3, 2)	0.2500000
W(4, 1)	0.2400000
W(4, 2)	0.1500000

Variable	Value
V(1, 1)	0.5000000
V(1, 2)	0.4000000
V(1, 3)	0.4000000
V(2, 1)	0.2000000
V(2, 2)	0.3000000
V(2, 3)	0.3600000
V(3, 1)	0.3000000
V(3, 2)	0.3000000
V(3, 3)	0.2400000
X(1, 1)	1.000000
X(1, 2)	0.000000
X(2, 1)	0.000000
X(2, 2)	1.000000
X(3, 1)	0.000000
X(3, 2)	0.000000
PS(1, 1)	6.080000
PS(1, 2)	3.800000
PS(2, 1)	6.040000
PS(2, 2)	4.450000
PS(3, 1)	5.760000
PS(3, 2)	4.500000
ES(1, 1)	6.400000
ES(1, 2)	5.800000
ES(2, 1)	6.200000
ES(2, 2)	5.900000
ES(3, 1)	6.320000
ES(3, 2)	5.840000

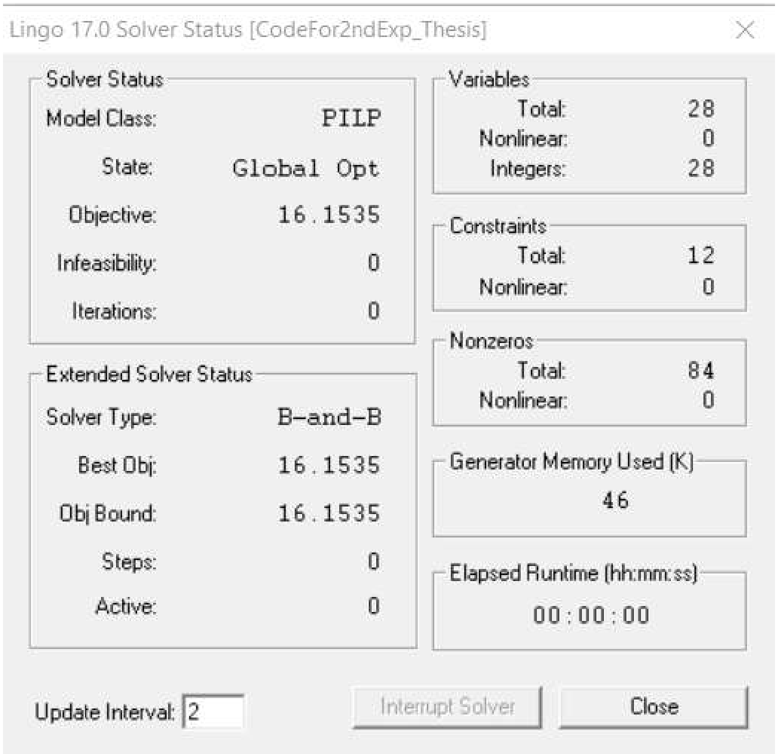
APPENDIX C

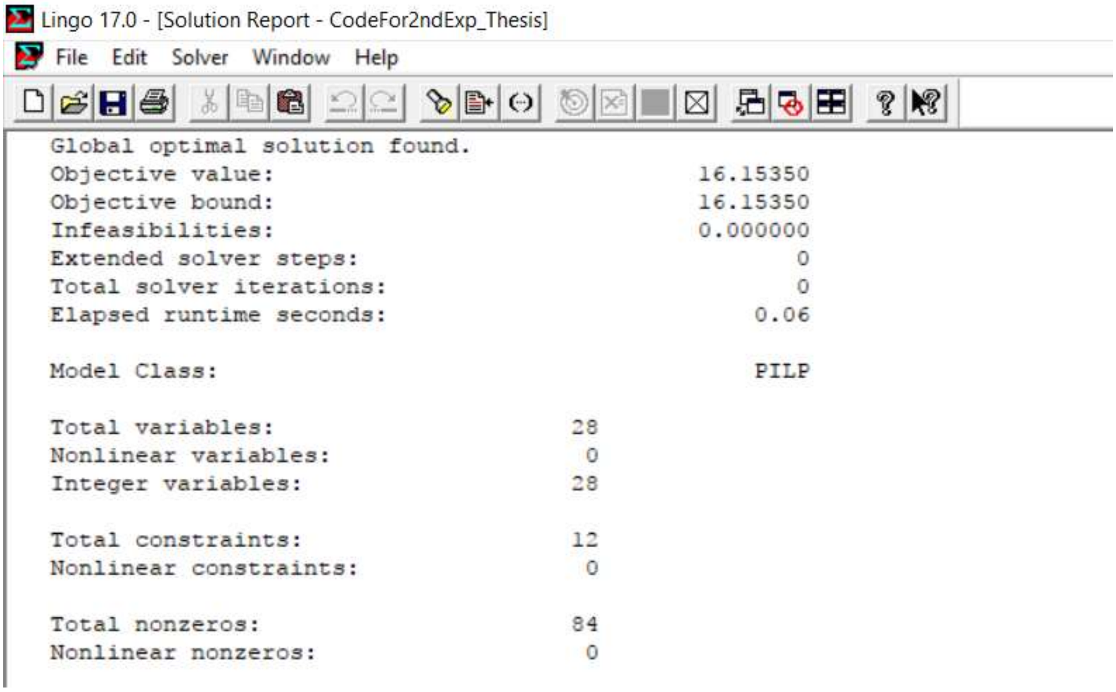
EXPERIMENT-1



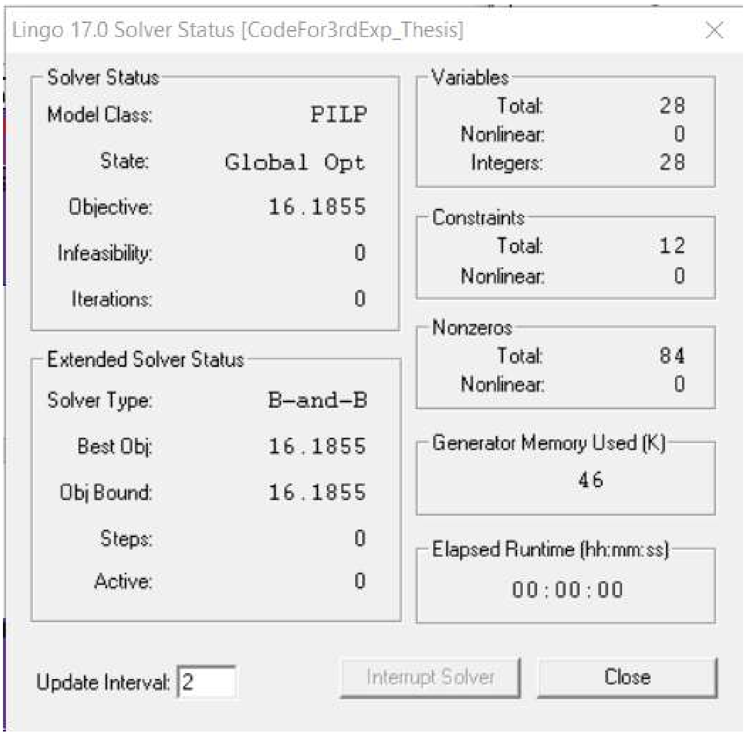

```
Global optimal solution found.
Objective value:                              15.91150
Objective bound:                              15.91150
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.05

Model Class:                                      PILP

Total variables:                     28
Nonlinear variables:                  0
Integer variables:                   28

Total constraints:                   12
Nonlinear constraints:                0

Total nonzeros:                      84
Nonlinear nonzeros:                   0
```

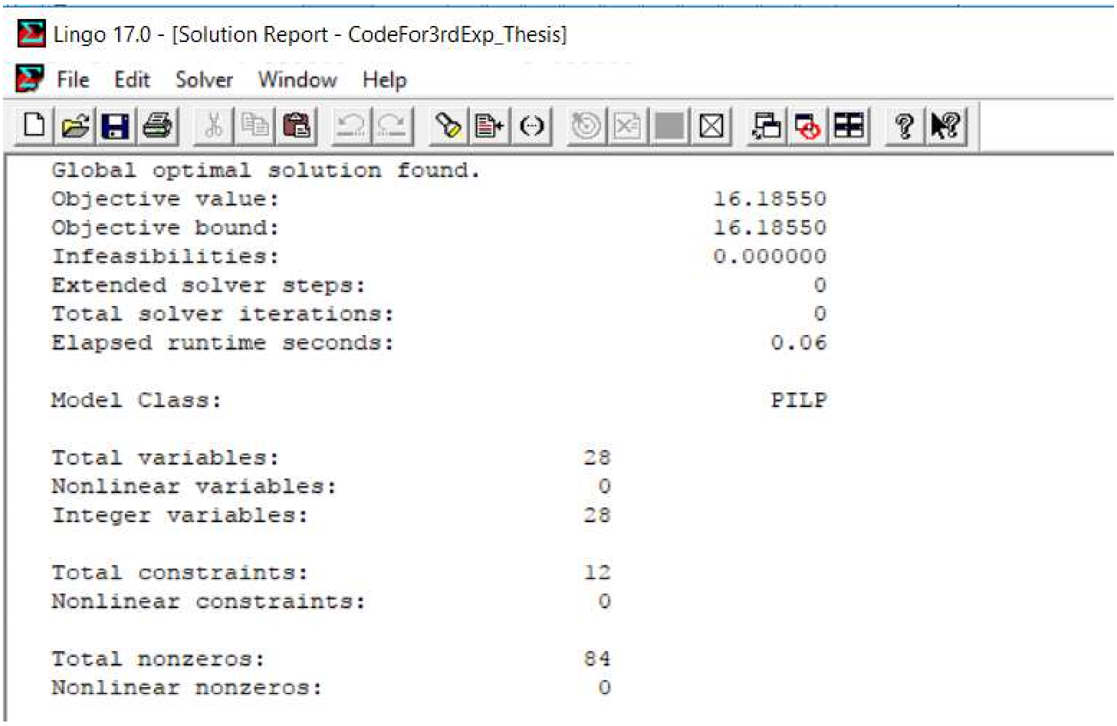
EXPERIMENT-2





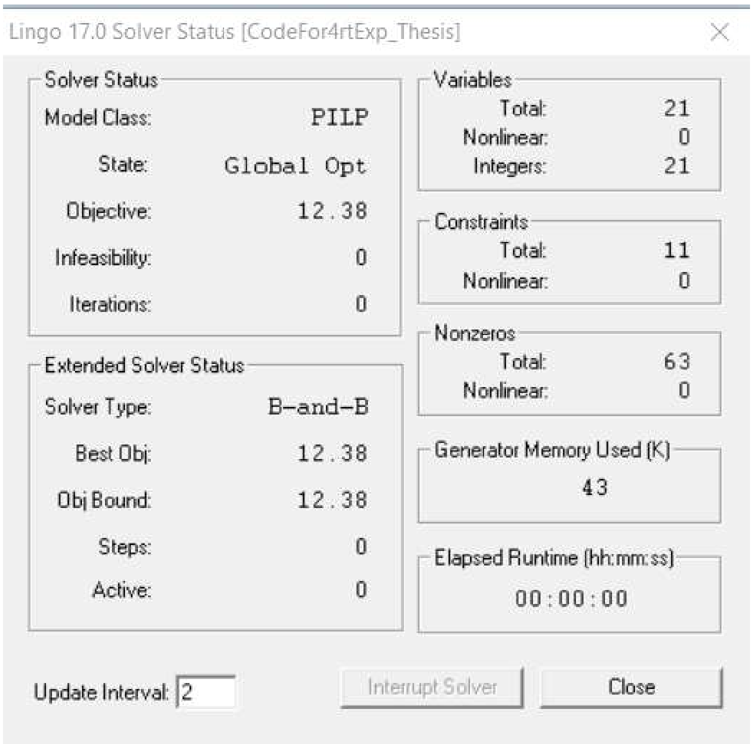
EXPERIMENT-3

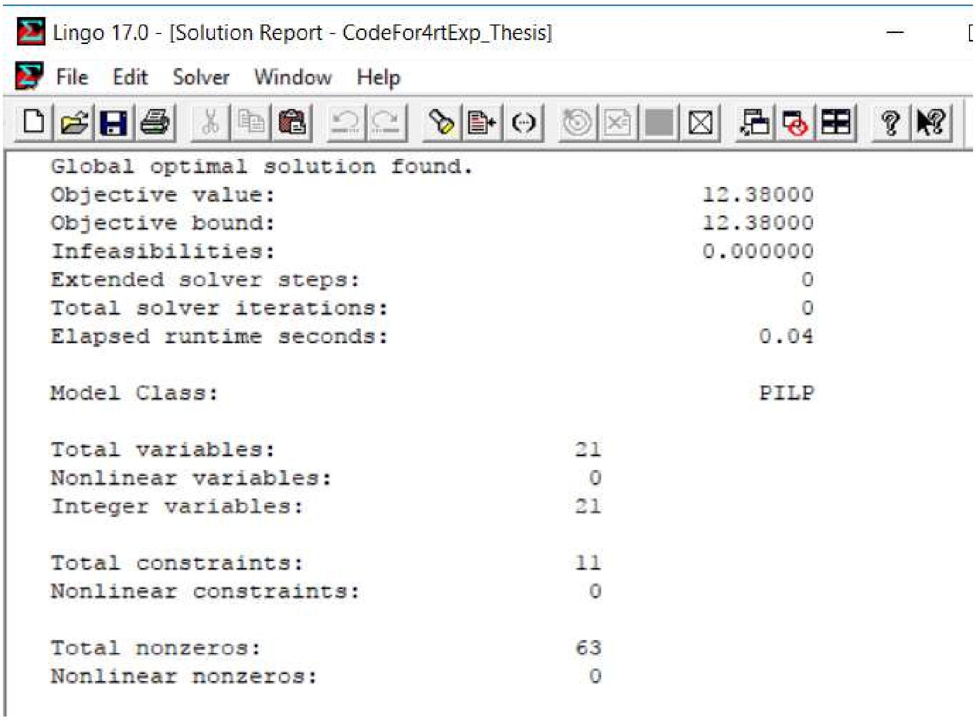





```
Global optimal solution found.
Objective value:                              16.18550
Objective bound:                              16.18550
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.06

Model Class:                                      PILP

Total variables:                     28
Nonlinear variables:                  0
Integer variables:                   28

Total constraints:                   12
Nonlinear constraints:                0

Total nonzeros:                      84
Nonlinear nonzeros:                   0
```

EXPERIMENT-4





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