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Araştırma Makalesi - Research Article

Solution of Workforce Planning Problem of a Holding Enterprises with the Markov Chains Method

Bir Holding İşletmesinin İşgücü Planlama Probleminin Markov Zincirleri Metodu ile Çözümü

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ABSTRACT

Stochastic processes are processes that involve randomness. Any process can be random for many reasons. A true physical process is stochastic as events are observed. Randomness may occur due to lack of information about the process. The models established for the process may not be able to represent the process. Changes in processes depending on human behavior may cause randomness. If there are parts of the processes that cannot be known, predicted and modeled, these processes are random. The random processes in which the previous state affects the next state are examined as Markov chains.

Markov chains can be applied to different areas such as education, health, accounting and manufacturing. In this study, Human Resources Planning study belonging to a holding has been discussed. Enterprises operating in different sectors of the holding can meet their personnel needs from other companies belonging to the holding within the scope of the holding's human resources policies. This situation not only enables employees to have different experiences by finding the opportunity to work in different businesses than their current ones, but also increases employee satisfaction. In the study, based on the previous years' personnel transfers between companies, the number of personnel who will transfer between enterprises in the coming years has been determined. This study supported the determination of workforce planning and human resources strategies that the holding companies will need in the coming years.

Keywords- Stochastic Processes, Markov Chains, Workforce Planning, Human Resources

ÖZ

Stokastik süreçler, rastgeleliği içeren süreçlerdir. Herhangi bir süreç birçok nedenden dolayı rastgele olabilir. Gerçek bir fiziksel süreç, olaylar gözlemlendiğinden stokastiktir. Süreç hakkında bilgi eksikliği nedeniyle rastgelelik oluşabilir. Süreç için kurulan modeller süreci temsil etmeyebilir. İnsan davranışına bağlı olarak süreçlerde meydana gelen değişiklikler rastgeleliğe neden olabilir. Bilinmeyen, tahmin edilemeyen ve modellenemeyen süreçlerin bölümleri varsa, bu süreçler rastgeledir. Bir önceki durumun bir sonraki durumu etkilediği rastgele süreçler Markov zincirleri olarak incelenir.

Markov zincirleri eğitim, sağlık, muhasebe ve imalat gibi farklı alanlara uygulanabilir. Bu çalışmada bir holdinge ait İnsan Kaynakları Planlama çalışması ele alınmıştır. Holdingin farklı sektörlerinde faaliyet gösteren işletmeler,

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personel ihtiyaçlarını holdingin insan kaynakları politikaları kapsamında holdinge ait diğer şirketlerden karşılayabilmektedir. Bu durum, çalışanların mevcut işyerlerinden farklı işletmelerde çalışma fırsatı bularak farklı deneyimler yaşamalarını sağlamakla kalmaz, aynı zamanda çalışan memnuniyetini de artırır. Çalışmada şirketler arası geçiş yapan personel sayısı baz alınarak önümüzdeki yıllar için işletmeler arası geçiş yapacak personel sayısı belirlenmiştir. Bu çalışma, holding şirketlerinin önümüzdeki yıllarda ihtiyaç duyacağı işgücü planlaması ve insan kaynakları stratejilerinin belirlenmesine destek olmuştur.

Anahtar Kelimeler- Stokastik Süreçler, Markov Zincirleri, İş Gücü Planlaması, İnsan Kaynakları

I. INTRODUCTION

In today's business world, all resources such as capital, labor, raw materials and information are on the move due to globalization. As competition is intense in every field, all disciplines are working to manage these resources in an optimum way. Businesses have competitive power to the extent they manage these on-the-go resources efficiently. For this reason, businesses that will exist in the future will be the ones that have managed all resources in the most optimum way. This study covers the most efficient use of human resources, which is the most important resource of enterprises, and the creation of human resources strategies that will carry the businesses of a holding to the future.

Employee satisfaction, efficiency and productivity are increased by evaluating the employees of enterprises belonging to a holding in open positions in different enterprises within the holding. In order for the holding to plan the workforce that it will need in the future as required by its growth strategies, it wants to determine the number of personnel that will switch between businesses in the future. The number of personnel who will transfer to each business for the next periods was determined by using the Markov chains method over the number of transition numbers pertaining to the current situation and the number of personnel that the enterprises will need for the next years was determined.

If the probability value for the states of the random variable processes depends on a learned condition, this model has Markov property. Markov is a stochastic approach, and its future behavior relates only to the current situation; it is not related to other situations. A batch stochastic process: It is called the Markov chain if it has no connection with previous states. [1]. Markov analysis is a probabilistic method used to evaluate stochastic processes. [2].

Markov processes are essentially a process where the possibility of transition between states depends only on the situation that is finished, regardless of other states. Therefore, these processes are different from other approaches that try to predict the future based on probabilities [3].

Markov Chains is a method commonly used in dynamic and stochastic systems. In Markov chains, besides determining the situation at a certain time, there is also the ability to predict the long-term situation of the system. For this reason, Markov chains are a prediction method like simulation models [4].

Markov Processes are applied in many areas. It is possible to find applications of Markov processes in all areas in general. Markov processes have found the opportunity to be applied in fields such as biology, astronomy, physics, chemistry, as well as business and economics. Markov processes are frequently used in revealing the status of a material in the future, in the probability of a machine failure, in determining which amount of receivables is impossible to collect in the receivables problem, and in determining what amount of receivables is possible to collect in different terms and in predicting the future situation of the workforce in an enterprise [4].

Bhowmik and Malathi (2019) developed a prediction model for spectrum detection in CR. This article proposed a hybrid prediction model based on the actor critic neural network and the latent Markov model called the krill swarm. A hybrid prediction model has been developed to detect the energy efficiency spectrum in CR. The chosen approach is useful for use in a variety of areas including wireless medical networks and authentication applications [5].

Mehmood et al. (2017) aimed to increase the knowledge level of the transformation potential of big data in city-based transportation models. This model is designed to show how sharing at load of transportation in a smart city can increase efficiency in meeting the demand for city services. The continuous time Markov chain defined by the Chapman-Kolmogorov equation is used. A model with various scenarios was developed to explore a theoretical framework focused on matching city transfer services with transfer demands using big data [6].

Tee et al. (2018) stated in their study that the condition of average living and highway infrastructures is very important for developing appropriate inspection and maintenance strategies to renew existing aging highway infrastructures. The study aimed to discuss them. The study proposes a Markov Chain based distortion modeling using the linear transition probability (LTP) matrix method and the average life expectancy (MLE) algorithm. The proposed work has been evaluated and implemented using status improvements between the two successful audits. [7].

Nwadinobi et al. (2019) aimed to propose a software used to estimate required equipment performance parameters used for maintenance planning. The article is developed from steady state probability models derived using algebraic substitution and calculation of total operating time, malfunctions, total downtime, mean time between failures, and mean repair time of equipment in preventive and corrective maintenance situations [8].

Wei et al. (2017) aim to solve the problem of information overload and reduce research costs. The study proposes a model of social e-commerce online reputation building and a model introduced by the community government. System dynamics trend simulation was conducted to capture the relationship between sellers, buyers, and social e-commerce [9].

Li et al. (2019) aimed to suggest whether the retail service supply chain is a "quality bridge" in the dynamic development process and to discuss the system role, steady state characteristics and the dynamic evolution mechanism of system quality in the dynamic evolution process. This article proposes the RSSC's power distribution system structure with a Markov chain model (MCM) covering the RSSC service quality, under the steady state quality constraint. The study tests the objective existence of the steady state distribution of service quality and the current characteristics of the quality bridge, modeling China's retail businesses [10].

Öz and Erpolat (2010) made an application on the multivariate Markov Chain model in their studies. In this study, the multivariate Markov chain model based on Markov chains is explained theoretically. As a practice, monthly differences in dollar rate prices and monthly changes in IMKB National 100 Index values are determined as two categorical series, and how these series affect each other is determined by the multivariate Markov chain model [11].

Alp and Öz (2009) analyzed their portable computer preferences using the Markov Chain method in their study. A questionnaire was conducted with 1068 people to analyze the preferences of portable computer brands. The people in the questionnaire were asked about the brands of portable computers they currently use and, if any, previously used. For analysis, a study was carried out to compute the transition probability matrix and equilibrium vectors, known as the basis of Markov Chains. Markov transition probability matrices are presented by considering the number of passes to portable computer brands [12].

Özdağoğlu et al. (2012) made an application that will contribute to existing methods. In this sense, the study aimed to deal with the price movements of gold and to make gains on the structure of price movements with the help of the Markov chain. The study period is between 2005-2009 and the study period was taken as 1 day, the Markov chain was calculated from the relative frequency values by coding the price ranges. The findings point to meaningful results in terms of the probability of transitions between price ranges [13].

Köse et al. (2015) examined a school that is responsible for training staff in a public institution and providing four-year education. In the study, future studies were examined to prevent the public institution from experiencing a shortage of trained personnel. Markov Analysis was used as a method in the study. The contribution of the study is to offer a solution to a real problem [3].

Kıral (2018) evaluated 750 people living in Adana according to the results of the survey conducted on mobile operator preferences for the last 7 years. In the study, mobile operator preferences of people living in Adana and operator preference probabilities in the long term were estimated. Markov chains were used to calculate the values [2].

Büyüktatlı et al. (2013) aimed to demonstrate the use of the Markov process as a forward-looking estimation tool. In the study, the initial payments of TAEK's investment program between 1998-2009 and the realization percentages of the expenses of the institution were used. With the Markov analysis, the percentage of realization of the 2011 investment program was estimated and the results were interpreted. [14].

In the study, open positions were evaluated with real data of a food business in Sakarya and growth strategies were examined. According to these strategies, it is aimed to increase employee satisfaction and contribute to the creation of human resources strategies. Planning studies have been carried out in different areas in the literature. In our study, it is aimed to make improvements for the personnel by examining a holding company. It is thought that the study is an original study that will contribute to the literature in terms of increasing personnel and, accordingly, customer satisfaction and optimizing service quality.

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The aim of the study is to manage resources optimally and to determine the number of personnel required for future years. Thus, thanks to the study, it was ensured that the necessary strategies for the business were organized.

II. MATERIALS AND METHODS

Markov process is a stochastic process that states that all the information that can be known about the future is at current prices. Accordingly, when a stochastic process in the form of $X = \{X_{(t)}, t \geq 0\}$ defined in continuous time is the Markov process, it is expressed as follows in Eq. (1).

$$Prob(X_{(t)} \leqslant x \setminus X_{(u)}, 0 \leqslant u \leqslant s) = Prob(X_{(t)} \leqslant x \setminus X_{(s)}) \quad (1)$$

In this definition, with $s < t$, $X_{(t)}$ represents the random variable that occurs for each time, and X shows the actual values.

For a stochastic process expressed as the Markov Chain $\{S_t, t = 0,1, ...\}$, it is expressed as a finite or countable number of integers (i). The probability of occurrence of any S_{t+1} future value is denoted by j. The Markov Chain is defined as follows, St, which represents the current situation, only depending on the present and independent from its past values in Eq. (2).

$$P\{S_{t+1} = j | S_t = i_t, S_{t-1} = i_{t-1}, S_1 = i_1, S_0 = i_0\} = P\{S_{t+1} = j | S_t = i_t\} = p_{ij} \quad (2)$$

pij refers to the state change that occurs in the transition from the previous state i state to the next state j, in the "transition possibility" [15].

Transition Probability Matrix:

The transition probabilities of a Markov Chain with state space $S= \{0,1,2, . . ., s\}$ are shown with a sxs dimensional transition matrix as in Figure 1 [16].

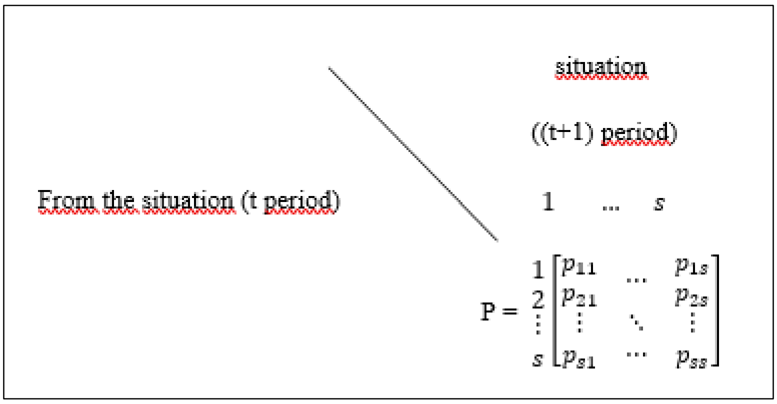

Figure 1. Transition probability matrix

A system in state i at time t will necessarily be in one of the state s at time t + 1. Accordingly, the rows of the transition matrix should satisfy the following conditions in Eq. (3) [17].

$$0 \leq p_{ij} \leq 1 \text{ (for all i and j values) } \sum_{j=1}^{s} p_{ij} = 1 \quad i = 1,2, \ldots, s. \quad (3)$$

The properties of Markov chains can be summarized as follows:

- Markov feature,
- Discrete and finite state space; $S = \{0,1,2, \ldots, s\}$
- Transition possibilities that do not change with time (p_{ij})

Some of the states of a Markov chain are called engulfing and others are called engulfing chains. In engulfing chains, a temporary state is passed from a state of absorbing and the process ends.

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In order to make the necessary calculations, the transition matrix must be rescheduled. If it is assumed that there are m swallowing states and s-m transient states, the transition matrices can be written in Figure 2.

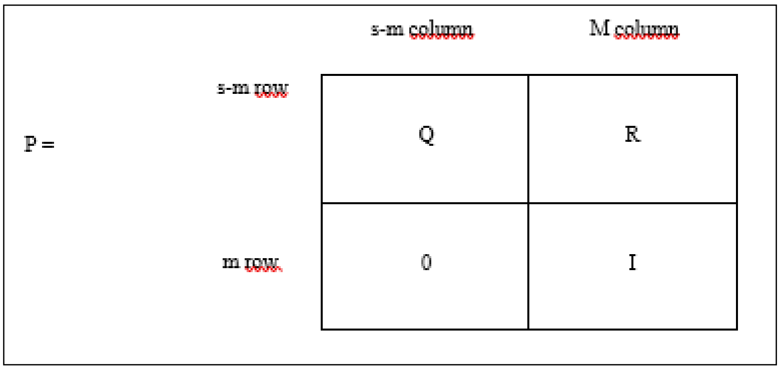

Figure 2. The transition matrice

Here Q is a (s-m) x (s-m) dimensional matrix showing the transition between transient states; R is a (s-m)xm dimensional matrix showing the transition from transient states to engulfing states; 0 is the mx(s-m) dimensional zero matrix showing that one cannot pass from an absorbing state to other states and all elements are zero, and I is the mxm-dimensional unit matrix, which shows that when a state is switched to an absorbing state, it will remain in that state. The next step is to find the base matrix (T) by inverting the matrix (I-Q) in Eq. (4).

$$T=(I-Q)^{-1} \tag{4}$$

III. RESULTS AND DISCUSSIONS

A Holding operating in various sectors has 7 different businesses. Some of these businesses operate in the food sector, some in the personal care and hygiene products sectors, and some in the retail and merchandising sectors. In order to increase employee satisfaction and to use the potential of internal dynamics efficiently, the Holding has a Human Resources system that enables employees to evaluate the opportunities in different businesses through intercompany internal announcements. With this system, employees can view open positions in other companies belonging to the holding through a portal and they can apply for positions they think are suitable for them. After the Human Resources Department evaluates the employee and decides on the suitability for the position, the employee leaves his current business and starts his new position in his new business

The Holding Human Resources General Directorate wants to carry out a study in order to take the system one step further, increasing employee satisfaction, productivity gains by rotation and the most efficient use of the human resources of the Holding. This study covers the determination of personnel movements between enterprises, determination of personnel transfer rates between enterprises based on the determined rotations, and determination of the future Human Resources needs of the Holding. With this study, it is planned to create a Human Resources pool in accordance with the values and vision of the Holding, which will allow budget studies for the number of personnel that businesses will need in the future. The number of personnel transfers between enterprises is given in Table 1.

Table 1. Number of Personnel Who Switched Between Businesses Last Year

	Business 1	**Business 2**	**Business 3**	**Business 4**	**Business 5**	**Business 6**	**Business 7**
Business 1	100	25	10	5	15	30	15
Business 2	30	60	5	10	20	15	10
Business 3	5	5	40	10	5	5	5
Business 4	15	10	5	45	10	5	10
Business 5	20	15	5	10	50	10	5
Business 6	25	15	10	5	15	70	10
Business 7	5	10	5	15	10	20	65

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When the Holding headquarters General Directorate of Human Resources initiated this work, the personnel numbers of 7 enterprises belonging to the holding are given in Table 2.

Table 2. Existing Staff Numbers of Businesses

Business 1	Business 2	Business 3	Business 4	Business 5	Business 6	Business 7
300	225	125	150	170	240	220

The Holding wants to determine the number of personnel that the enterprises at the end of the 3rd year and the 5th year will need by doing a study. For this reason, it wants to determine the number of personnel who will transfer to each business in the 3rd year and the 5th year. The Holding has determined the number of personnel it will need for each enterprise in line with its growth targets at the end of 3 years and at the end of 5 years, and it is given in Table 3. The Holding wants to create tables regarding the number of personnel it will need after personnel transfers between enterprises and to make Human Resources planning in this direction.

Table 3. Number of Personnel That Will Be Needed After 3 Years and 5 Years For Businesses

	Business 1	Business 2	Business 3	Business 4	Business 5	Business 6	Business 7
The number of personnel that will be needed after 3 years	340	250	140	160	220	275	235
The number of personnel that will be needed after 5 years	350	275	150	175	245	300	250

We find the transition probability matrix by using the density method with the number of personnel transferring between enterprises in Eq. (5) below.

$$P_{ij} = \frac{F_{ij}}{f_i} \tag{5}$$

F_{ij} : Number of personnel transferred from entity i to entity j

f_i : Total number of staff in business i

The transition probabilities matrix between enterprises is specified below as the P matrix in Table 4.

Table 4. The Transition Probabilities

0.5	0.125	0.05	0.025	0.075	0.15	0.075
0.2	0.4	0.033	0.067	0.133	0.1	0.067
0.067	0.067	0.533	0.133	0.067	0.066	0.067
0.15	0.1	0.05	0.45	0.1	0.05	0.1
0.174	0.13	0.043	0.087	0.435	0.088	0.043
0.167	0.1	0.067	0.033	0.1	0.466	0.067
0.038	0.077	0.038	0.115	0.077	0.155	0.5

In order to find the number of personnel who will transfer between companies at the end of the 3rd year, we need to find the probability matrix P^3 Transition probabilities. P^3 matrix is found as follows in Table 5.

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Table 5. P^3 Transition Probabilities

0.259	0.151	0.084	0.082	0.130	0.181	0.113
0.234	0.174	0.075	0.098	0.148	0.162	0.110
0.168	0.126	0.196	0.144	0.123	0.132	0.114
0.210	0.143	0.082	0.161	0.138	0.139	0.127
0.228	0.155	0.079	0.106	0.177	0.153	0.101
0.221	0.144	0.093	0.087	0.137	0.210	0.110
0.163	0.132	0.077	0.127	0.131	0.176	0.193

At the end of the 3rd year, a study will be made to determine the number of personnel in the enterprises and to determine the number of personnel that each enterprise will need.

From the formula m = n.Pn, the number of personnel that will occur as a result of the transitions in each enterprise at the end of the 3rd year are as follows.

n: It is the vector of the number of personnel available per period of enterprises.

m: It is the vector of the number of personnel available at the end of the period for the enterprises.

n = (300 225 125 150 170 240 220)

m = (310.423 211.650 131.406 155.518 199.989 243.104 177.866)

At the end of the 3rd year, the number of personnel belonging to each enterprise is found as in Table 6.

Table 6. Number of personnel at the end of the 3rd year of the enterprises

Enterprise 1	Enterprise 2	Enterprise 3	Enterprise 4	Enterprise 5	Enterprise 6	Enterprise 7
310	212	131	156	200	243	178

In order to find the number of personnel who will transfer between companies at the end of the 5th year, we need to find the probability matrix P^5 Transition probabilities. P^5 matrix is found as follows in Table 7.

Table 7. P^5 Transition Probabilities

0.2254	0.1495	0.0909	0.1017	0.1393	0.1736	0.1197
0.2241	0.1518	0.0881	0.1049	0.1424	0.1694	0.119
0.2046	0.1425	0.1168	0.1222	0.1367	0.1575	0.1216
0.2174	0.1478	0.0896	0.1167	0.1406	0.1636	0.124
0.2235	0.1504	0.089	0.1066	0.1453	0.1667	0.1168
0.2209	0.1484	0.0936	0.1037	0.1406	0.1756	0.1189
0.2059	0.1445	0.0886	0.1145	0.1392	0.1704	0.1353

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From the formula m = n.Pn, the number of personnel that will occur as a result of the transitions in each enterprise at the end of the 5th year is as follows.

n: It is the vector of the number of personnel available per period of enterprises.

m: The vector of the number of personnel available at the end of the period belonging to the enterprises.

n = (300 225 125 150 170 240 220)

m = (312.5429 211.9671 132.2484 155.0882 201.0593 242.3867 174.6582)

Since the number of personnel will be integers, the vector m is considered as

m = (313 212 132 155 201 242 175)

At the end of the 5th year, the number of personnel belonging to each enterprise is found as in Table 8.

Table 8. Personnel numbers of businesses at the end of the 5th year

Enterprise 1	Enterprise 2	Enterprise 3	Enterprise 4	Enterprise 5	Enterprise 6	Enterprise 7
313	212	132	155	201	242	175

IV. CONCLUSIONS

In this study, the changing number of personnel of enterprises due to personnel rotation between 7 different enterprises operating in different sectors of a holding was examined. The number of new personnel to be formed in each enterprise in the next years due to the rotation was calculated with the method of Markov chains. In addition, in line with the growth strategies of the enterprise, the number of new personnel that will be needed after the rotations have been determined since the number of personnel that will be needed for each enterprise after 3 and 5 years has been determined.

The number of new personnel that the holding will need for each enterprise after 3 and 5 years is shown in Table 9.

Table 9. Number of new personnel required at the end of the 3rd and 5th year of the enterprises

	Enterprise 1	Enterprise 2	Enterprise 3	Enterprise 4	Enterprise 5	Enterprise 6	Enterprise 7
The number of personnel that will be needed after 3 years	30	38	9	4	20	32	57
The number of personnel that will be needed after 5 years	37	63	18	20	44	58	75

In line with the studies carried out, the Holding's Human Resources Department will be able to make budget studies in line with the workforce needed by each enterprise, and plan for the timely employment of the required personel.

The article aims to maximize the balance and efficiency between employers and employees. As a result of the implementation, the necessary budget planning is be able to be made more accurately and labor productivity was increased. In this respect, the study provides positive returns to businesses and has been a useful application for the literature. In the next studies, optimum efficiency can be achieved in larger enterprises by making different stochastic process analyzes in the longer term:

- Businesses with more staff can be identified
- By examining the strategies of these businesses, deficiencies can be determined with diagrams suitable for the business.

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- By investigating the suitability of the identified key points with Markov chains, improvements involving personnel and business lines can be aimed.
- Future planning can be done on a larger scale by aiming to ensure long-term efficiency of potential studies.
- In this way, the deficiencies of the companies that contribute to the field on a larger scale in terms of planning are determined and improvements are made in this direction
- Production and service optimization is also maximized by providing more efficiency on personnel.
- The output will be increased for both the company, the consumer and the employee.

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