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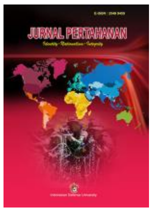

DETERMINATION OF THE PERIOD OF MARKOV CHAIN'S TRANSITION MATRIX FOR MILITARY MANPOWER PLANNING IN INDONESIAN NAVY

Agus Wahyuli
Naval Human Resource Advisor, Indonesia Navy Headquarters
Hankam Street, Building B3, Indonesia Navy Headquarters, Cilangkap, Indonesia 13870
agus.wahyuli.ssi@gmail.com

I Made Sumertajaya
Department of Statistics, IPB University
Meranti Wing 22 Street Level 4, IPB Campus, Dramaga, Bogor, West Java, Indonesia 16680
imsjaya.stk@gmail.com

Bagus Sartono
Department of Statistics, IPB University
Meranti Wing 22 Street Level 4, IPB Campus, Dramaga, Bogor, West Java, Indonesia 16680
bagusco@ipb.ac.id

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Abstract

Human resources are very important organizational assets thus it is only natural that every organization gives more attention to human resource management, including the Indonesian Navy (TNI AL). The approach to human resource planning in military organizations focuses on two aspects, including long term planning with strategic objectives and short term planning with operational objectives. This long term planning is oriented towards the continuation of the procurement, availability, and balance of the number of personnel (human resources) in each rank in the future. An analysis to find out and plan the condition of Navy personnel in the future is needed, which is called the analysis of the Markov chain. There are at least three stages of the Markov chain process, including determining the state, the transition matrix, and the initial vector value. The transition matrix describes changes from one state to another state in the next period of time. The transition matrix formed is the basis of the subsequent analysis, including the calculation of the number of personnel per rank in the future. Determining the length of the matrix period is done by comparing several transition matrices with various moving average orders. The result obtained suggests that the best transition matrix is the one with moving average orders six, including the transition matrix with the smallest value of Mean Square Error (MSE).

INTRODUCTION

Human resources are very important organizational assets, thus their roles and functions are irreplaceable. Recognized or not, the success of an organization is greatly influenced by the quality of its human resources. Therefore, human resource management is one of the determinants of organizational success.

Human resource management is a systematic forecast by organizations to see the future relates to demand and supply of labor by determining the number and type of labor needed (William, Werther, & Davis, 1996). One important element in human resource management is procurement (recruitment), which is one of the functions estimating the amount of labor needed at a given time and avoiding the occurrence of vacancies in the organization for a long time (Mangkunegara, 2015). Considering the important role of human resource management in organizations, it is only natural that every organization gives more attention to this aspect, including the Indonesian National Armed Forces (TNI).

According to the Law Number 34 of 2004 on the Indonesian National Armed Forces (TNI), TNI consists of three forces including the Indonesian Army (TNI AD), the Indonesian Navy (TNI AL), and the Indonesian Air Force (TNI AU), conducting their duties in a formal or joint manner under the leadership of the TNI commander. Every military organization has a very strict hierarchical structure, meaning that this organization is a career-oriented organization applying strict rules in terms of human resource recruitment, including the policy of limiting positions for recruitment at the lowest level (Jaquette DL, Nelson GR, 1977; Wang, 2005; Hall, 2009). In military organizations, the approach to human resource planning (military manpower planning) focuses on two aspects, including long term planning with strategic objectives and short term planning with operational objectives (Abdessameud, Van Utterbeeck, Van Kerckhoven, & Guerry, 2018).

As part of the TNI, Indonesian Navy has an important role in maintaining the continued upholding of the Republic of Indonesia sovereignty, especially from the maritime aspect. The availability of the main defense systems (defense equipment) that are modern and sufficient is a mandatory requirement for securing Indonesia's marine areas. Professional personnel is needed in sufficient quantities to guard the availability of the defense equipment. Therefore, a proper formulation of calculations and planning is needed to determine the number of Indonesian Navy personnel in the future.

The soldier hierarchy in the Indonesian Navy organization is grouped according to rank. There are twenty-two ranks divided into three strata (ranks of position), including officers, non commissioned officers, and enlisted officers, as presented in Table 1.

As a career-oriented organization that can only recruit personnel at the lowest rank of position, a promotion system thus becomes very important. The statement is in accordance with the results delivered by

Table 1. Ranks of Position in the Indonesian Navy

Strata		Rank
Officer	Flag Officer	Admiral
		Vice Admiral
		First Admiral (Commodore)
	Middle-ranked Officer	Colonel
		Lieutenant Colonel
		Major
Non-Commissioned Officer		Chief Warrant Officer
		Warrant Officer
		Sergeant Major
		Chief Sergeant
		First Sergeant
		Second Sergeant
Enlisted		Chief Corporal
		First Corporal
		Second Corporal
		Chief Seaman
		First Seaman
		Second Seaman

Source: Law Number 34, 2004

Table 2. Rules for Personal Promotion in the Indonesian Navy

Strata	Rank		Years in Grade
	From	To	
Officer	Second Lieuteant	First Lieutenant	3
	First Lieutenant	Captain	4
	Captain	Major	4
	Major	Lieutenant Colonel	5
	Lieutenant Colonel	Colonel	4
Lower Ranked Officer	Second Sergeant	First Sergeant	5
	First Sergeant	Chief Sergeant	5
	Chief Sergeant	Sergeant Major	5
	Sergeant Major	Warrant Officer	5
	Warrant Officer	Chief Warrant Officer	4
Enlisted	Second Seaman	First Seaman	3
	First Seaman	Chief Seaman	4
	Chief Seaman	Second Corporal	4
	Second Corporal	First Corporal	5
	First Corporal	Chief Corporal	5

Source: Law Number 34, 2004

Banyai and Landschutzer (Bányai, Landschützer, & Bányai, 2018), that promotion and recruitment rates have a great impact on the future employees' structure. According to Law Number 34 of 2004 on the Indonesian National Armed Forces, the rules for promotion in the Navy organization are listed in Table 2.

The imbalance of the number of Navy officers at a number of ranks compared to the existing office space leads to the ineffectiveness of organizational performance. Therefore, there needs to be an appropriate planning alternative that is useful for estimating the number or condition of officers in the future, so that it is expected to reduce the problem in the future.

Human resource planning, both in civilian and military organizations, has been studied by several researchers. Bartholomew (Evans, Bartholomew, & Forbes, 2006) describes three statistical methods for human resource planning (manpower planning), including regression, renewal theory and the Markov chain model. Hall (Hall, 2009) constructed a model of military manpower planning based on the concept of optimization and simulation for U.S. Army officers. In his research, Hall used two different methodologies for the concept of optimization, including linear programming and dynamic programming. In addition to Hall, Zais and Zhang (Zais & Zhang, 2016) also constructed a human resource planning model for the United States Army using a Markov simulation model. Thompson (Thompson, 1979) constructed a model of human resource planning based on an optimization concept that calculates the optimal number of promoted personnel, the number of retired personnel and the number of dismissed personnel, known as the transshipment model. Henry and Ravindran (Henry & Ravi Ravindran, 2005) calculated the number of recruitment officers using the goal programming method. Fasha (2010) calculated the number of nurses in Pamekasan District Hospital using the Markov chain model. Agustina (Agustina F, 2010) reviewed the planning of the needs of academic staff and employees at the Faculty of Engineering, the University of Trunojoyo using the Markov chain method. From this explanation, it can be concluded that human resource planning, both military and civilian organizations can be studied with several different methods, namely simulations, regression, Markov chain models, optimization concepts such as linear programming, dynamic programming, and transshipment model.

Markov chain analysis is a method that studies the properties of a variable in the present based on its characteristics in the past, in an effort to estimate the properties of these variables in the future (HA, 2007). The Markov chain model is very useful for analyzing movement from one state (class/group) to another state (MN, 2008).

The basic concept of Markov analysis is the state of the system or transition state. If the process is known to be in a certain situation, then the chance of developing the process in the future (X_{n+1}) only depends on the present (X_n) instead of on what has passed (X_{n-1}, X_{n-2}, …). In other words, the Markov chain is a series of event processes

where the chances of conditional events to come (X_{n+1}) only depends on the present (X_n).

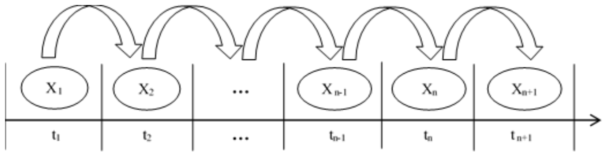

Figure 1. Series of Events in the Markov Chain
Source: HA, 2007

RESEARCH METHODS

Data

This research is aimed to study the planning of human resources of Indonesian Navy officers that will occur in the future by applying the Markov chain theory so that it is expected an alternative solution to the policy-making of human resource officers of the Indonesian Navy.

The data used in this study are secondary data obtained from the Naval Human Resource Advisor (Staf Personel Angkatan Laut or Spersal). The data collected is monthly data on the number of Navy officer personnel from January 2011 to December 2018.

The choice of place as the object of research because the authors are currently serving in a Naval Human Resource Service tasked with helping Naval Human Resource Advisor to formulate the Navy's human resource planning policy.

Data Analysis Procedure

The stages of data analysis conducted in this study are as follows:

State decision

The classification of the state in this study is based on the ranks of the Navy officers plus the state of addition of personnel and the state of personal separation. The classification of the states in this study can be seen in Table 3.

Table 3. Markov Chain Analysis State

State	Rank of Position
1	Second Lieutenant
2	First Lieutenant
3	Captain
4	Major
5	Lieutenant Colonel
6	Colonel
7	Addition of Personnel
8	Separation of Personel

Source: Author, 2019

Calculating interstate probability

The probability value between states is obtained from the transfer of a state to another state in that year.

Determination of the period of the transition matrix

The determination of the period of the transition matrix in this study is based on the smallest Mean Square Error (MSE) value for the various moving average orders of the transition matrix formed. The formation of the transition matrix with the smallest MSE value for various moving average orders is in accordance with the statement estimating the matrix of transition probability by utilizing current data and past data, providing better predictive results than current data only (Syafriandi, 1988).

RESULTS AND DISCUSSION

RESULTS

State Decision

As explained earlier, in this study there are eight states based on the ranks of Navy officers. They are in accordance with Table 3.

Value of Interstate Probability

The probability value between states displayed in the form of a matrix is called the transition matrix. Because each rank in the state has a year in grade (YiG) required for a promotion to the next rank as described in Table 2, the transition matrix formed in this study is the number of YiG per rank plus new state personnel and outgoing state personnel. Thus, the size of the transition matrix formed is 26 x 26. Figure 2 below is the transition probability matrix in 2018.

We can see from figure 2 the completed percentage of promotions and those that remained in the original position for all ranks in 2018. It is shown that 95% of 3 YiG the second lieutenant will be promoted to the first lieutenant, while around 5% remain at the level of the second lieutenant. It also displays three year YiG of the rank of second lieutenant, including 0 years second lieutenant YiG, 1 year second lieutenant YiG and 2 years second lieutenant YiG, suggesting that there will be a promotion from the second lieutenant to first lieutenant in the third year of YiG. As for the rank of the first lieutenant to colonel, the completed percentage of promotions and those that remained in the original ranks in 2018 can be seen in Figure 2.

Determination of the Period of Transition Matrix

The next step after obtaining the transition

Rank	(2nd Ltn_0)	(2nd Ltn_1)	(2nd Ltn_2)	(1st Ltn_0)	(1st Ltn_1)	(1st Ltn_2)	(1st Ltn_3)	(Cpt_0)	(Cpt_1)	(Cpt_2)	(Cpt_3)	(Maj_0)	(Maj_1)	**(…)**
(2nd Ltn_0)	0	1	0	0	0	0	0	0	0	0	0	0	0	**…**
(2nd Ltn_1)	0	0	1	0	0	0	0	0	0	0	0	0	0	**…**
(2nd Ltn_2)	0	0	0.045	0.955	0	0	0	0	0	0	0	0	0	**…**
(1st Ltn_0)	0	0	0	0	1	0	0	0	0	0	0	0	0	**…**
(1st Ltn_1)	0	0	0	0	0	1	0	0	0	0	0	0	0	**…**
(1st Ltn_2)	0	0	0	0	0	0	1	0	0	0	0	0	0	**…**
(1st Ltn_3)	0	0	0	0	0	0	0.314	0.686	0	0	0	0	0	**…**
(Cpt_0)	0	0	0	0	0	0	0	0	1	0	0	0	0	**…**
(Cpt_1)	0	0	0	0	0	0	0	0	0	1	0	0	0	**…**
(Cpt_2)	0	0	0	0	0	0	0	0	0	0	1	0	0	**…**
(Cpt_3)	0	0	0	0	0	0	0	0	0	0	0.637	0.357	0	**…**
(Maj_0)	0	0	0	0	0	0	0	0	0	0	0	0	1	**…**
(Maj_1)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Maj_2)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Maj_3)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Maj_4)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Ltn Col_0)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Ltn Col_1)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Ltn Col_2)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Ltn Col_3)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Col_0)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Col_1)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Col_2)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Col_3)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(Col_4)	0	0	0	0	0	0	0	0	0	0	0	0	0	**…**
(In)	1	0	0	0	0	0	0	0	0	0	0	0	0	**…**

Rank	**(…)**	(Maj_2)	(Maj_3)	(Maj_4)	(Ltn Col_0)	(Ltn Col_1)	(Ltn Col_2)	(Ltn Col_3)	(Col_0)	(Col_1)	(Col_2)	(Col_3)	(Col_4)	(Out)
(2nd Ltn_0)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(2nd Ltn_1)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(2nd Ltn_2)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_0)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_1)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_2)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_3)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_0)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_1)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_2)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_3)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0.005
(Maj_0)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0.000
(Maj_1)	**…**	1	0	0	0	0	0	0	0	0	0	0	0	0
(Maj_2)	**…**	0	1	0	0	0	0	0	0	0	0	0	0	0
(Maj_3)	**…**	0	0	1	0	0	0	0	0	0	0	0	0	0
(Maj_4)	**…**	0	0	0.700	0.270	0	0	0	0	0	0	0	0	0.030
(Ltn Col_0)	**…**	0	0	0	0	1	0	0	0	0	0	0	0	0
(Ltn Col_1)	**…**	0	0	0	0	0	1	0	0	0	0	0	0	0
(Ltn Col_2)	**…**	0	0	0	0	0	0	1	0	0	0	0	0	0
(Ltn Col_3)	**…**	0	0	0	0	0	0	0.691	0.237	0	0	0	0	0.072
(Col_0)	**…**	0	0	0	0	0	0	0	0	1	0	0	0	0
(Col_1)	**…**	0	0	0	0	0	0	0	0	0	1	0	0	0
(Col_2)	**…**	0	0	0	0	0	0	0	0	0	0	1	0	0
(Col_3)	**…**	0	0	0	0	0	0	0	0	0	0	0	1	0
(Col_4)	**…**	0	0	0	0	0	0	0	0	0	0	0	0.819	0.181
(In)	**…**	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 2. Transition Matrix in 2018 (r_t) : A state in rank r serving in year t
Source: Author, 2019

matrix of the year 2011-2018 is determining the period of it. The transition matrix formed from this process is the one used for further analysis, as the determination of the period is one of the stages of the Markov chain analysis.

According to Syafriandi (Syafriandi, 1988), estimating the transition matrix by utilizing the current and past data gives a better predictive result than by only utilizing the current data. Based on the statement, this study will review determining the transition matrix with various moving average orders. The transition matrix that will be used for further analysis in this study is the best one, which is the one with a certain moving average order length that gives the smallest Mean Square Error (MSE).

For the sake of the analysis, the Indonesian Navy personnel data is first divided into two parts, including training data and test data. The training data is the one that will be used for the purpose of analysis, while the test data is the one that functions as validation data. The distribution of training data and test data depends on the length of the moving average order used. For example, suppose the moving average order length of the transition matrix used is one, then there are seven training data and seven test data used, including 2018 data as validation from 2017 data, 2017 data as validation from 2016 data and so on, until the 2012 data is used as validation from the training data for 2011. The result of estimating the MSE value of the transition matrix with the moving average order length is one presented as can be seen in Table 4.

Table 4. The MSE Value of the Transition Matrix of Moving Order One

Training Data (year)	Test Data (year)	MSE Value
2017	2018	0.0001223
2016	2017	0.0000902
2015	2016	0.0001426
2014	2015	0.0000534
2013	2014	0.0004810
2012	2013	0.0005466
2011	2012	0.0000114
Average		0.0002068

Source: Author, 2019

Table 4 suggests that the MSE value of the transition matrix with moving average order length one is 0.0002068. Furthermore, the MSE value of the transition matrix with moving average order one will be compared to the MSE value of the transition matrix with other moving average order, ie the moving average order two to moving average order seven. Table 5 presents the MSE values of the transition matrices from moving average order two to moving average order seven.

Table 5. The MSE Value of the Transition Matrix of Moving Order Two

Training Data (year)	Test Data (year)	MSE Value
2017 & 2016	2018	0.0007855
2016 & 2015	2017	0.0004121
2015 & 2014	2016	0.0020404
2014 & 2013	2015	0.0030475
2013 & 2012	2014	0.0015373
2012 & 2011	2013	0.0077715
Average		0.0025991

Source: Author, 2019

Table 5 shows the value of the transition matrix with moving average order length two. It can be seen that the MSE value of the transition matrix with moving average order length two is 0.0025991. The MSE value was obtained from the average MSE value of six transition matrices which functioned as training data evaluated with six test data matrices, namely the average of training matrices data for 2017 and 2016 evaluated by the 2018 test data matrix, average training data matrices for 2016 and 2015 which was evaluated by the 2017 test data matrix and so on until the average training data matrices for 2012 and 2011 was evaluated by the 2013 test data matrix. The MSE values of the transition matrix of moving average order three can be seen in Table 6.

Table 6. The MSE Value of the Transition Matrix of Moving Order Three

Training Data (year)	Test Data (year)	MSE Value
2017 - 2015	2018	0.0009016
2016 - 2014	2017	0.0003278
2015 - 2013	2016	0.0031707
2014 - 2012	2015	0.0015939
2013 - 2011	2014	0.0006996
Average		0.0013387

Source: Author, 2019

Table 6 shows the value of the transition matrix with moving average order length three. It can be seen that the MSE value of the transition matrix with moving average order length three is 0.0013387. Same as before, this transition matrix with moving average order length three is also obtained from the average MSE value of five transition matrices which functioned as training data evaluated with five test data matrices, namely the average of training matrices data for 2017 to 2015 evaluated by the 2018 test data matrix, average training data matrices for 2016 to 2014 which was evaluated by the 2017 test data matrix and so on until the average training data matrices for 2013 to 2011 was evaluated by the 2014 test data matrix. Table 7 presents the MSE values of the transition matrix of moving average order four.

Table 7. The MSE Value of the Transition Matrix of Moving Order Four

Training Data (year)	Test Data (year)	MSE Value
2017 - 2014	2018	0.0009796
2016 - 2013	2017	0.0008384
2015 - 2012	2016	0.0027020
2014 - 2011	2015	0.0010067
Average		0.0013817

Source: Author, 2019

Table 7 suggests that the MSE value of the transition matrix with moving average order length four is 0.0013817. The value of 0.0013817 is obtained from the average MSE value of four transition matrices which functioned as training data evaluated with four test data matrices, namely the average of training matrices data for 2017 to 2014 evaluated by the 2018 test data matrix, average training data matrices for 2016 to 2013 which was evaluated by the 2017 test data matrix and so on until the average training data matrices for 2014 to 2011 was evaluated by the 2015 test data matrix.

Table 8 presents the MSE values of the transition matrix of moving average order five. It suggests that the MSE value of the transition matrix with moving average order length five is 0.0014404. The value of 0.0014404 is obtained from the average MSE value of three transition matrices which functioned as training data evaluated with three test data matrices, namely the average of training matrices data for 2017 to 2013 evaluated by the 2018 test data matrix, average training data matrices for 2016 to 2012 which was evaluated by the 2017 test data matrix and average training data matrices for 2015 to 2011 was evaluated by the 2016 test data matrix.

Table 8. The MSE Value of the Transition Matrix of Moving Order Five

Training Data (year)	Test Data (year)	MSE Value
2017 - 2013	2018	0.0013885
2016 - 2012	2017	0.0006880
2015 - 2011	2016	0.0022447
Average		0.0014404

Source: Author, 2019

Table 9 presents the MSE values of the transition matrix of moving average order six. It shows the value of the transition matrix with moving average order length six. It can be seen that the MSE value of the transition matrix with moving average order length six is 0.0009686. The value of 0.0009686 is obtained from the average MSE value of two transition matrices which functioned as training data evaluated with two test data matrices, namely the average of training matrices data for 2017 to 2012 evaluated by the 2018 test data matrix and average training data matrices for 2016 to 2011 which was evaluated by the 2017 test data matrix.

Table 10 presents the MSE values of the transition matrix of moving average order seven. It shows that the value of the transition matrix with moving average order length seven is 0.0012802. The value 0.0012802 is obtained from the average of training matrices data for 2017 to 2011 evaluated by the 2018 test data matrix.

Table 9. The MSE Value of the Transition Matrix of Moving Order Six

Training Data (year)	Test Data (year)	MSE Value
2017 - 2012	2018	0.0013694
2016 - 2011	2017	0.0005679
Average		0.0009686

Source: Author, 2019

Table 10. The MSE Value of the Transition Matrix of Moving Order Seven

Training Data (year)	Test Data (year)	MSE Value
2017 - 2011	2018	0.0012802

Source: Author, 2019

Based on the calculation of the MSE value of the transition matrix with a variety of different moving average orders from Table 4 to 10, the following results are obtained and can be seen in Table 11.

Table 11. MSE Value of the Transition Matrix with Different Moving Average Orders

Moving Average Order of Transition Matrix	MSE Value
1 Year Before	0.0002068
2 Year Before	0.0001884
3 Year Before	0.0000970
4 Year Before	0.0001001
5 Year Before	0.0001044
6 Year Before	0.0000702
7 Year Before	0.0000928

Source: Author, 2019

Based on the results of the MSE Value comparison of different moving average orders in table 11, the best transition matrix in this study is the transition matrix with the length of moving average order six, including the transition matrix with the smallest MSE Value. Furthermore, the transition matrix with the moving average order six is used as the basis for the next stage of analysis. The following is a transition matrix with moving average order six.

DISCUSSION

The transition matrix with the moving average order six formed in accordance with Figure 3 is the basis of the subsequent analysis, including the calculation of the number of personnel per rank in the future.

The next step after getting the best transition matrix value is to calculate the number of personnel for each future power rank. Before calculating the number of personnel in the future; first, the initial vector value must be determined first, which is the number of personnel currently in the organization for each year in grade (YiG) of all ranks plus the number of newly recruited personnel. The results of multiplication between the transition matrix formed by the initial vector value will produce a vector, where the vector value is the number of personnel per rank in the first year, second year and so on until the n_{th} year.

Rank	(2nd Ltn_0)	(2nd Ltn_1)	(2nd Ltn_2)	(1st Ltn_0)	(1st Ltn_1)	(1st Ltn_2)	(1st Ltn_3)	(Cpt_0)	(Cpt_1)	(Cpt_2)	(Cpt_3)	(Maj_0)	(Maj_1)	(…)
(2nd Ltn_0)	0	1	0	0	0	0	0	0	0	0	0	0	0	…
(2nd Ltn_1)	0	0	1	0	0	0	0	0	0	0	0	0	0	…
(2nd Ltn_2)	0	0	0.110	0.890	0	0	0	0	0	0	0	0	0	…
(1st Ltn_0)	0	0	0	0	1	0	0	0	0	0	0	0	0	…
(1st Ltn_1)	0	0	0	0	0	1	0	0	0	0	0	0	0	…
(1st Ltn_2)	0	0	0	0	0	0	1	0	0	0	0	0	0	…
(1st Ltn_3)	0	0	0	0	0	0	0.215	0.785	0	0	0	0	0	…
(Cpt_0)	0	0	0	0	0	0	0	0	1	0	0	0	0	…
(Cpt_1)	0	0	0	0	0	0	0	0	0	1	0	0	0	…
(Cpt_2)	0	0	0	0	0	0	0	0	0	0	1	0	0	…
(Cpt_3)	0	0	0	0	0	0	0	0	0	0	0.645	0.350	0	…
(Maj_0)	0	0	0	0	0	0	0	0	0	0	0	0	1	…
(Maj_1)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Maj_2)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Maj_3)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Maj_4)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Ltn Col_0)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Ltn Col_1)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Ltn Col_2)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Ltn Col_3)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Col_0)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Col_1)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Col_2)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Col_3)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(Col_4)	0	0	0	0	0	0	0	0	0	0	0	0	0	…
(In)	1	0	0	0	0	0	0	0	0	0	0	0	0	…

Rank	(…)	(Maj_2)	(Maj_3)	(Maj_4)	(Ltn Col_0)	(Ltn Col_1)	(Ltn Col_2)	(Ltn Col_3)	(Col_0)	(Col_1)	(Col_2)	(Col_3)	(Col_4)	(Out)
(2nd Ltn_0)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(2nd Ltn_1)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(2nd Ltn_2)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_0)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_1)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_2)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(1st Ltn_3)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_0)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_1)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_2)	…	0	0	0	0	0	0	0	0	0	0	0	0	0
(Cpt_3)	…	0	0	0	0	0	0	0	0	0	0	0	0	0.005
(Maj_0)	…	0	0	0	0	0	0	0	0	0	0	0	0	0.000
(Maj_1)	…	1	0	0	0	0	0	0	0	0	0	0	0	0
(Maj_2)	…	0	1	0	0	0	0	0	0	0	0	0	0	0
(Maj_3)	…	0	0	1	0	0	0	0	0	0	0	0	0	0
(Maj_4)	…	0	0	0.730	0.246	0	0	0	0	0	0	0	0	0.024
(Ltn Col_0)	…	0	0	0	0	1	0	0	0	0	0	0	0	0
(Ltn Col_1)	…	0	0	0	0	0	1	0	0	0	0	0	0	0
(Ltn Col_2)	…	0	0	0	0	0	0	1	0	0	0	0	0	0
(Ltn Col_3)	…	0	0	0	0	0	0	0.782	0.180	0	0	0	0	0.038
(Col_0)	…	0	0	0	0	0	0	0	0	1	0	0	0	0
(Col_1)	…	0	0	0	0	0	0	0	0	0	1	0	0	0
(Col_2)	…	0	0	0	0	0	0	0	0	0	0	1	0	0
(Col_3)	…	0	0	0	0	0	0	0	0	0	0	0	1	0
(Col_4)	…	0	0	0	0	0	0	0	0	0	0	0	0.867	0.133
(In)	…	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3. The transition matrix with the length of average moving order six (r_t): A state in rank r serving in year t
Source: Author, 2019

In this article, the calculation of the number of future personnel is not discussed. this journal only focuses on determining the length of the period of the transition matrix in the Markov chain, which is the first step in calculating future numbers of personnel. The calculation of the number of personnel in the future time will be discussed in the next article.

CONCLUSIONS AND RECOMMENDATIONS

This research is aimed to study the planning of human resources of Indonesian Navy officers that will occur in the future by applying the Markov chain theory so that it is expected an alternative solution to the policy-making of human resource officers of the Indonesian Navy.

The Markov chain model can be used to view and estimate future conditions of the Navy's organization regarding human resource planning. There are at least three stages of the Markov chain process, including determining the state, the transition matrix, and the initial vector value. There are eight states arranged based on the ranks of the Navy officers in this study. While the best transition matrix formed in this study is the transition matrix with the length of moving average order six, including the transition probability matrix with the smallest MSE Value. The transition matrix with the moving average order six formed is the basis of the subsequent analysis, including the calculation of the number of personnel per rank in the future

This study uses Markov chain analysis with 8 year period of data to determine the best candidate of the transition probability matrix. For further research, it is recommended to use data of a longer period to hopefully obtain a pattern from the MSE value of transition matrix based on the length of the data period used. In addition to using Markov chain analysis, it is recommended also to use other analytical methods, so that the results can be compared between the methods, for example, transshipment models, goals programming or dynamic programming.

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