



BIPLOT SIMULATION OF POWER FUNCTION TO DETERMINE GROWTH RATE OF ANIMALS

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ABSTRACT Data generated from the power function with the rate and the different constants, analyzed by biplot analysis with rotation promax kappa 90. The results of the biplot simulation, the power function which has a much smaller rate of 1 (one) is in quadrant IV, the rate which approaches 1 (one) is in the quadrant I, and a rate much greater than 1 (one) is in quadrant II. Meanwhile, the power function which has different constants at the same rate is at one point or coincident. The growth rate of organ, tissue or animal body parts are not all simultaneously with overall body size, there are some that grow more slowly, conversely some are also faster than the overall body size. The results of modeling of biplot power function can be expected to describe the rate growth of the organ, tissue or animal body parts. Organ, tissue or body parts of animals whose growth is almost equal to the size of the overall growth will be in quadrant II. Organ, tissue or body part that is growing more slowly than the overall body size is in quadrant IV, conversely the faster one is in quadrant I. While the magnitude of constants, namely that describes the percentage of the size of the organ, tissue or body part compared to the overall body size of a animals, does not affect its location in the quadrant.

KEYWORDS : power function, biplot, rotation promax kappa 90, quadrant, growth rate.

INTRODUCTION

Power function $Y = AX^b$ which has a domain $x > 0$ and co-domain $Y > 0$, A is a positive constant. If $b = 1$, then it will form a straight line which shows the change of co-domains comparable to the domain changes, if $b < 1$, then it will form a convex line that shows changes in the co-domain which is slower than the domain changes, conversely if $b > 1$, it will form a concave line that shows the co-domain changes faster than the domain changes. Regression analysis of power is a form of non-linear regression which usually used to find the relationship between two variables that have different increase within a certain time, so it can be determined which variables that have faster or stronger power increase.

Organ, tissue or animal body parts in a certain period of time will always experience growth, yet the rate of growth of each organ, tissue or animal body parts is different. If all measured size of organs, tissues, or body parts are summed up, it will get the overall body size (X). The growth rate of the size of the overall body is an average of the growth rate of all organs, tissues or body parts of animals, so that in each organ, tissue or animal body parts, there are some with the same growth rate, and some are faster or slower when compared with the overall body size. Analysis of power regression to determine the organ, tissue or animal body parts (Y) in which the rate of growth (b) is faster than the overall body size (X) and what percentage of size of organ, tissue or body part (A) is very important in analysis of growth. Differences in growth rate are due to physiological differences and the different functional demands, as well as its constituent components. Organ, tissue or animal body parts that function earlier, will grow first, then the growth rate is greater than the dimensions of the animal's body that functions later, the body dimensions of bones as constituent components first developed than that composed of muscle or fat, so that the growth rate during certain phase of life is different from the certain period of time (Swatland, 1984), Sampurna and Suatha, 2008).

However, research is often faced with too much number of organs, tissues or body parts and of different sizes, so that the presentation in the form of power function is less attractive, or not be presented in a single image description simultaneously. Therefore the presentation of the difference between the growth rate of organ, tissue or animal body parts will be demonstrated by approach of power function with different rate and constants in the simulation graph of biplot.

Biplot is an exploration method of multiple variable data analysis which can provide a graphic representation of the proximity between objects, the diversity of variables, the correlation between variables, and the relationship between the variables with the object. In addition, the biplot analysis is used to describe the relationship between

variables and objects that are in the high-dimensional space into a low-dimensional space i.e. two-dimensional (Gabriel, 2002). Graphical demonstration is expected to obtain a description of the object, for example, the proximity between objects, and description of the variables, both on its diversity and correlation, as well as the relationship between the objects with the variables. (Solimun and Rinaldo, 2008).

In order to make the interpretation of the factors considered relevant, the first selection step is generally followed by the maintained rotation factor, the rotation functions to make the output more understandable. Therefore, in practice, the rotation in the factor analysis is advisable to be in several sizes for the subspace of retained factors to assess the resilience of interpretation of rotation (Abdi, 2003). Orthogonal Rotation, namely rotating the axis of 90°, the results of this rotation will not cause a change in the proportion of the diversity of variables. Some rotations that belong to the orthogonal rotations are: Varimax, Quartimax, Equamax and Parsimax. While the non-orthogonal rotations (oblique) are assumed that the results of factors are correlated to each other, some rotations that belong to the oblique rotations are Promax, Procrustes, and Harris-Kaiser (Sharma, 2011).

Demonstration of biplot by factor analysis to describe the lines (object) and columns (variables) available on the data matrix simultaneously in a low-dimensional graphs is typically using varimax rotation. Matjijk and Sumertajaya (2002) reported that the variables will be described as a directed line. Two variables that have high positive correlation will be described as two lines in the same direction, or to form a narrow angle. Meanwhile, two variables that have a high negative correlation are presented in the form of two lines in the opposite direction, or to form an obtuse angle. Meanwhile, two variables that are not correlated will be described in the form of two lines at an angle approaching 90 degrees (angular). Variables with little diversity are described as a short vector whereas a large variety of variables described as a long vector. While the proximity between objects, two objects with the same characteristics will be described as an adjacent two points. The object that lies in the direction of a variable, it is said that on the object they are above average. Conversely, if another object is situated opposite to the direction of these variables, the object has a value below the average. Meanwhile, the object which is almost in the middle has a value close to the average. Sampurna et al. (2013) reported that the demonstration of biplot with rotation promax kappa 90 can describe the closeness of the relationship between variables; the shorter the distance between the variable the closer the relationship between variables and the correlation is closer to one. While the angle between the variables and the norm or vector length of a variable can not describe the magnitude of correlation between variables and the

diversity of these variables.

Simulation of biplot of exponential function by promax rotation kappa 90, showed that the exponential function which has the rate (k = 0:02 to 0:08) has negative abscissa and positive ordinate which is located in Quadrant II, the exponential function is classified into a function exponential that has the slower rate. Exponential function which has the rate (k = 0.3 - 0.6 has positive abscissa and positive ordinate which is located in Quadrant I, the exponential function is classified into a exponential function that has the medium rate. Exponential function which has the rate (k = 1.2 - 1.8) has positive abscissa and negative ordinate which is located in quadrant IV, the exponential function is classified into the exponential function which has a rapid rate (Sampurna et al, 2013). Simulation of biplot with rotation promax 90 on parts of the body of Bali local duck aged 0-16 weeks, which was growing following the exponential function of the age of 0-16 weeks, showed that the parts of the body (variable) of Bali local duck that grow slowly is in quadrant II, medium growth is positioned in quadrant I and rapid growth is in quadrant IV. While based on the age (object), the more mature the closer the distance, which shows slower growth (Sampurna, 2016).

Based on the description above, it was analyzed the biplot simulation of power function with different constant and rate that it is expected to get information regarding the closeness of relationship based on the growth rate. Two power functions with a similar rate is expected to be described as an adjacent two points, conversely the two functions of power at a rate that is much different will be described as a two points of which position is far apart to each other. While the constant power function that represents the percentage of organ, tissue or animal body parts than the the overall body are expected to be at one point, if the growth rate is the same. This information will be used to determine the differences in the growth rate of the organs, tissues or animal body parts without being influenced by the size, whether the organs, tissues or animal body parts are classified to have slower, medium or fast growth rates at a certain period of time.

RESEARCH METHODS

The data were generated from 10 pieces of power function, with the equation $Y = AX^b$, with a combination of different Constant (A) and Rate (b). Meanwhile, the magnitude of the same X value of 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100, so as to obtain the data in

Table 1. Data from Power Function at a Different Constant (A) and Rate (b).

Objects	1	2	3	4	5	6	7	8	9	10
X	10	20	30	40	50	60	70	80	90	100
A0.2b0.84	1.38	2.48	3.48	4.43	5.35	6.23	7.09	7.94	8.76	9.57
A0.2b0.88	1.52	2.79	3.99	5.14	6.25	7.34	8.41	9.46	10.49	11.51
A0.2b0.92	1.66	3.15	4.57	5.96	7.31	8.65	9.97	11.27	12.56	13.84
A0.2b0.96	1.82	3.55	5.24	6.90	8.55	10.19	11.81	13.43	15.03	16.64
A0.2b1.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00
A0.2b1.04	2.19	4.51	6.87	9.27	11.69	14.14	16.59	19.07	21.55	24.05
A0.2b1.08	2.40	5.08	7.88	10.75	13.67	16.65	19.67	22.72	25.80	28.91
A0.2b1.12	2.64	5.73	9.02	12.45	15.99	19.61	23.31	27.07	30.89	34.76
A0.2b1.16	2.89	6.46	10.34	14.44	18.70	23.10	27.63	32.26	36.98	41.79
A0.4b0.84	2.77	4.95	6.96	8.87	10.70	12.47	14.19	15.87	17.52	19.15
A0.4b0.88	3.03	5.58	7.98	10.28	12.51	14.68	16.82	18.91	20.98	23.02
A0.4b0.92	3.33	6.30	9.14	11.91	14.63	17.30	19.93	22.54	25.12	27.67
A0.4b0.96	3.65	7.10	10.47	13.81	17.10	20.37	23.62	26.86	30.07	33.27
A0.4b1.00	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00
A0.4b1.04	4.39	9.02	13.75	18.54	23.39	28.27	33.19	38.13	43.10	48.09
A0.4b1.08	4.81	10.17	15.75	21.49	27.35	33.30	39.33	45.44	51.60	57.82
A0.4b1.12	5.27	11.46	18.05	24.91	31.98	39.23	46.62	54.14	61.77	69.51
A0.4b1.16	5.78	12.92	20.68	28.87	37.40	46.21	55.26	64.51	73.96	83.57
A0.7b0.84	4.84	8.67	12.19	15.52	18.72	21.81	24.83	27.78	30.67	33.50
A0.7b0.88	5.31	9.77	13.96	17.99	21.89	25.70	29.43	33.10	36.71	40.28
A0.7b0.92	5.82	11.02	16.00	20.84	25.59	30.27	34.88	39.44	43.95	48.43
A0.7b0.96	6.38	12.42	18.33	24.16	29.93	35.66	41.34	47.00	52.62	58.22
A0.7b1.00	7.00	14.00	21.00	28.00	35.00	42.00	49.00	56.00	63.00	70.00
A0.7b1.04	7.68	15.78	24.06	32.45	40.93	49.47	58.08	66.73	75.42	84.16
A0.7b1.08	8.42	17.79	27.57	37.61	47.86	58.28	68.83	79.51	90.30	101.18

Table 1. If the power function is drawn in the form of line graph, it is obtained Figure 1 as below. From Figure 1, it can be seen that the power function that has a rate of 1 (A0.2b1.00, A0.4b1.00 and A0.7b1.00) then line is straight, which indicates the rate of change in the value of Y equal to the change in the value of X. If b > 1, then the line will be concave, which suggests that the rate change of Y value is greater than the change in the value of X, otherwise if b < 1, then the line will be convex, which indicates that the rate of change in the value of Y is smaller than the change in the value of X. So the value of b is getting much greater than one (b >> 1), then the line will be more concave (A0.2b1.16 and A0.4b1.16), conversely, the value of b is getting much smaller than one (b << 1), then the line is getting more convex (A0.2b0.84, A0.4b0.84 and A0.7b0.84).

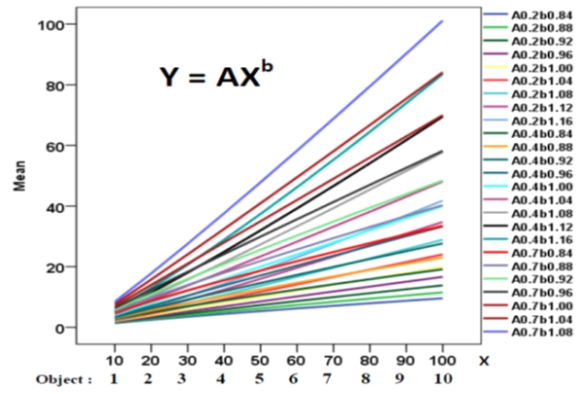


Figure 1. Graf Power Function at a Different Constant (A) and Rate (b).

Data generated from the power function in the form of tables and graphs, if too much it is rather hard to read, which lines are straight, concave or convex, especially of which constants are much different than it will be increasingly difficult to read which ones are more concave or convex. So to make it easier, it will be drawn on a biplot graph.

Data obtained were analyzed by factor analysis based on the correlation between variables, in order to obtain the correlation matrix and significance testing. The eigen vector was determined by the relationship $Rx_0 = \lambda x_0$, so $f(x) = |R - \lambda I| = 0$. Thus $f(\lambda) = 0$ is called the eigen equation of R matrix, the root of this equation is called the roots of eigen of R matrix and vector that corresponds to the eigen root is called eigen vector.

Demonstrating the location of coordinates of variables X and each of the power functions were taken from the 2 eigen vectors corresponding to the first largest eigen root 1 (Component 1) as the X-axis (abscissa) and the second largest eigen root (Component 2) as Y (ordinate). Because of all of the variables have positive correlations and close to 1, then it was used a Rotation Promax kappa 90 so that the location of coordinates can describe the difference in the rate of (b) of the variable. Conversely, if it was used varimax rotation all the variables would coincide or form an angle of 0°, because in the rotation of varimax, the angle between variables describe the magnitude of the correlation, while in the promax rotation kappa 90, the angle between variables will describe the differences in rates so that those that have similar rates will coincide or form an angle of 0°.

Location of coordinates of each of the variables stated closeness of the relationship between these variables, variables that have a rate that is almost the same are located very close, on the contrary those that have much different rates, the location is away from each other. The use of Promax Rotation 90 is intended to divide the location of variables into 3 places (quadrants), While the location of coordinates of the object 1 to object 10 was carried by Factor Analysis of Scores Method Regression, factor 1 as abscissa and factor 2 as coordinates.

The procedure of analysis by using SPSS 22 (Statistical Product and Service Solutions version 22).

RESULTS AND DISCUSSION

The results of the factor analysis (Table 2) showed that all the variables, the X data and all the 10 power functions that combine constants and different rates can be described in two-dimensional eigen space, it can be described because the Cumulative on the Component 2 has shown 100%.

Table 2. Total Variance Explained Power Function at a Different Constant (A) and Rate (b).

Component	Initial Eigenvalues		Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings ^a
	Total	% of Variance	Total	% of Variance	Cumulative	Total
1	25.982	99.930	25.982	99.930	99.930	25.972
2	0.018	0.070	0.018	0.070	100.000	25.971

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Scree plot (Figure 2) shows that the roots of the eigen value of Component 1 and Component 2 were impaired significantly. This suggests that the use of two main Components is considered to be able to explain the diversity of the X data and the data of power functions with the combination of constants and the different rates.

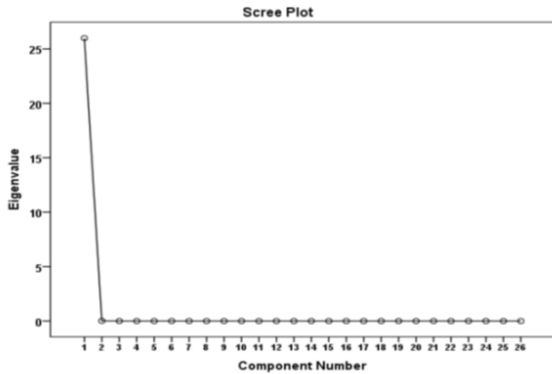


Figure 2. Scree Plot Eigen Value Power Function at a Different Constants (A) and Rate(b).

The results of factor analysis of Table 3, it was obtained the result that the matrix pattern of power function located at 3 different quadrants, the different location of quadrants is only affected by differences in rates (b) of the power function, the value of constants (A) does not affect the location of quadrant of the power function. Power function that forms a straight line that is at a rate of 1:00 and the data X is located at one point (0.431, 0.658), namely the absis of 0.432 and the ordinate of 0.658. This shows that the variables which had the same rate are located at one point. So if X is a the size of the overall animal body, the organs, tissues or body parts should be entitled the same rate as the overall size of the animal's body will located at one point, then the organs, tissues or animal body parts are growing simultaneously with the whole animal body. Power function that has the rate that approached to one (b = 0.92, 0.96, 1:00, and 1:04) is located in quadrant I, namely positive component 1 and component 2. Power function that has a much greater rate than one (b >> 1) is located on the quadrant II, namely positive component 1 and component 2, conversely the power function of much smaller rate of one (b << 1) is located on the quadrant IV, namely positive component 1 and negative component 2.

Table 3. Pattern Matrix Power Function at a Different Constant (A) and Rate (b).

Quadrant	Power Function	Component	
		1	2
II	A0.2b1.16	-0.638	1.637
	A0.4b1.16	-0.638	1.637
	A0.2b1.12	-0.377	1.376
	A0.4b1.12	-0.377	1.376
	A0.2b1.08	-0.111	1.111
	A0.4b1.08	-0.111	1.111
I	A0.7b1.08	-0.111	1.111
	A0.7b1.04	0.158	0.842
	A0.2b1.04	0.158	0.842
	A0.4b1.04	0.158	0.842
	X	0.432	0.658
	A0.2b1.00	0.432	0.658
	A0.4b1.00	0.432	0.658
	A0.7b1.00	0.432	0.658
	A0.2b0.96	0.709	0.291
	A0.4b0.96	0.709	0.291
IV	A0.7b0.96	0.709	0.291
	A0.2b0.92	0.990	0.010
	A0.4b0.92	0.990	0.010
	A0.7b0.92	0.990	0.010
	A0.2b0.88	1.275	-0.275
	A0.4b0.88	1.275	-0.275
IV	A0.7b0.88	1.275	-0.275
	A0.7b0.84	1.563	-0.564
	A0.2b0.84	1.563	-0.564
	A0.4b0.84	1.563	-0.564

Extraction Method: Principal Component Analysis.
 Rotation Method: Promax with Kaiser Normalization.
 a. Rotation converged in 3 iterations.

These results can be used to determine the growth rate of organs, tissues or animal body parts. Organs, tissues or animal body parts are located in quadrant I, the growth rate is equal to the size of the overall body. If the organs, tissues or body parts are in quadrant II, shows that the organs, tissues or animal body parts are in faster growth rate than the overall body size. Conversely, if the organs, tissues or body parts are in quadrant IV, indicates that the organs, tissues or animal body parts are in slower growth rate than the overall body size. Knowledge of the differences in the rate of growth of organs or tissues at a certain time is needed to determine the function of organs, tissues or body parts at a certain time. While the differences in the growth rate of the animal body parts such as pieces of carcass is important to determine the dominant constituent components; whether the bone, muscle or fat

(Swatland, 1984), (Sampurna and Suatha, 2008). Organs, tissues or body parts will have faster growth rate than the overall body size at a certain time if the function is optimal and there is a growth in its constituent components.

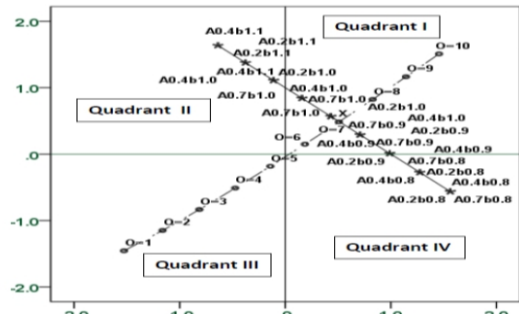


Figure 3. Biplot Power Function at a Different Constant (A) and Rate (b).

The coordinate location of the power function with constant (A) and the different rates (b) can be seen in Figure 3. The power function that has a rate of one (b = 1.00) with constant A (0.2, 0.4 and 0.7) is located at 1 point. Location of the power function which has a rate of more or less than 1.00, the more distant the location or the distance is even greater. Location of the power function with the rate which is getting larger or smaller than one (b >> 1) or (b << 1), the location will be even further away from location of coordinates of X. This illustrates that the organs, tissues or body parts that have faster or slower growth rate than the overall size of the animal's body will be located more distant.

Thus, based on the biplot simulation, it can be described the distance between variables is determined by the difference in the rate (b), if it has the same rate then the distance is 0 (coincident), a greater rate difference will be the further distance. A Meanwhile, constant A has no effect on the location of coordinates of these variables. Location of coordinates of the variables in the biplot simulation is divided into 3 quadrants i.e. quadrant I is classified as medium rate, quadrant II as faster rate and quadrant IV as slower rate.

Based on the objects of observation that is the period of observation (O=1 to O=10), lies in a line through the third quadrant and the first quadrant, and cut the variable line on the variables X and at a rate of 1 (b = 1). Coordinates O=1 to O=5 are in quadrant III, this object in opposite directions with variable, these results demonstrate the large object sizes smaller than the average. While O=6 through O=10 are in quadrant I, the object is in line with the variables, the results suggest a large object size is greater than the average (Mattjik and Sumertajaya, 2002). This may describe the organs, tissues or body parts to experience growth of O=1 (younger age) to O=10 (older age), because organs, tissues or body parts of the the younger age to the older age always experience growth or minimally constant (atrophied). So the younger the age of the animal, the organs, tissues or body part size will be below average, whereas the older the animal, the size will be above average.

The distance between objects in the biplot simulation showed the magnitude of differences in the size of one object the subsequent objects, the farther the distance, the greater the difference. The distance between O=1 to O=2, O=2 with O=3 onwards that is the distance between O=9 with O=10, some are in similar position and some are also different. This suggests that some have similar changes in the average size of the object from one object to the other objects and some are not the same. Differences distance between objects on the analysis of animal growth is very important to know at what age the animal is growing rapidly and at what age the animals grow slowly, even stopped growing. So, it is to help deciding at what age these cattle are slaughtered to get optimal yields.

CONCLUSIONS

Biplot simulation of power function with a combination of constants and the different rate by Promax rotation kappa 90 located at 3 quadrants, the coordinates of each of the power functions is only determined by its rate.

Biplot simulation by rotation kappa 90 can be used to determine the growth rate of organs, tissues or animal body parts.

SUGGESTION

Before performing the biplot simulation of the organs, tissues or animal body parts, power regression analysis should be carried out beforehand to ascertain whether the growth of organs, tissues or body parts of animals within a certain time has followed the power functions.

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REFERENCES

1. Abdi, H. 2003. Factor Rotations in Factor Analyses. Program in Cognition and Neurosciences, MS: Gr.4.1, The University of Texas at Dallas, Richardson, TX75083-0688, USA <http://www.utdallas.edu/~herve/Abdi-rotations-pretty.pdf>
2. Aldrich, John . 2006. "Eigenvalue, eigenfunction, eigenvector, and related terms", in Jeff Miller (Editor), Earliest Known Uses of Some of the Words of Mathematics, retrieved 2006-08-22
3. Alexander B. 2008. Applied matrix algebra in the statistical sciences. Elsevier Science Publishing Co. (North-Holland), Inc., New York, 1983. xiii + 389 pp. ISBN 0-444-00756-3 Article first published online: 18 DEC 2008. <http://onlinelibrary.wiley.com/doi/10.2307/3314921/abstract>
4. Gabriel, K. R. (2002). Goodness of fit of biplots and correspondence analysis. *Biometrika*, 89(2), 423-436
5. Mattjik, AA, and Sumertajaya M. 2002. Applications Multiple Variable Analysis. Bogor Exercise books SPSS Statistics
6. Sampurna, I P dan I K Suatha. 2008. The Allometric growth of Length and Circumference Body Dimension of Bali cattle Males. *Journal of Veterinary* 9: \ 1 March. 2008, ISSN: 1411-8327, Higher Education Accreditation No. 55 / DIKTI/Kep/2005. Page1: 41-44.
7. Sampurna, I P., I K Saka, I G. L. Oka dan P. Sentana. 2013. Biplot Simulation of Exponential Function to Determine Body Dimensions' Growth Rate of Bali Calf. *Canadian Journal on Computing in Mathematics Natural Sciences Engineering and Medicine*. Vol. 4. No. . ISSN : 1923-1660.
8. Sampurna, I P. 2016. Biplot Simulation to Determine the Growth Rate of Body Dimension in Local Bali Ducks 2016. *Journal of Biometrics & Biostatistics*. Vol.7. Issue 2. *J Biom-Biostat* 7 : 284. Doi : 10.4172/2155-6180.1000284.
9. Sharma, S. 2011. Applied Multivariate Techniques. University of South Carolina John Wiley & Sons, Inc. New York Chichester Brisbane Toronto Singapore. Pub.mm April 2011 <https://www.slideshare.net/divyaj82/applied-multivariate-techniques>
10. Shores, Thomas S. (2007). Applied linear algebra and matrix analysis, Springer Science+Business Media, LLC, ISBN 0-387-33194-8
11. Solimun, N dan A. A. Rinaldo. 2008. Structural Equation Modeling Approach PLS and SEM. Faculty of Science and the Graduate Program UB.
12. Swatland HJ. 1984. Structure and Development of Meat Animals. Prentice-Hall Inc., Englewood Cliff, New Jersey Stephen Andrilli and David Hecker 2009. Elementary Linear Algebra. Fourth Edition ISBN : 9 7 8 - 0 - 1 2 - 3 7 4 7 5 1 - 8 . <http://books.google.co.id/books>
13. Roman, Steven (2008). Advanced linear algebra (3rd ed.), New York, NY: Springer Science + Business Media, LLC, ISBN 978-0-387-72828-5