PRODUCTION TARGET ACHIEVEMENT MODEL DEVELOPMENT USING BINARY LOGISTIC REGRESSION METHOD IN P T. HANSAE KARAWANG INDONESIA

Ade Momon S.[1], Ikbal Wijaya[2]

Karawang Singaperbangsa University, Karawang, Indonesia
[1]ademomon@staff.unsika.ac.id, [2]ikbalwijaya@gmail.com

ABSTRACT

PT. Hansae Karawang, Indonesia is one of garment company focusing on apparel exports to several countries in Asia, Europe and America. However in fact, PT Hansae Karawang often deal with some obstacles mainly in export goods delivery, which is frequently unable to meet market orders. This problems raises from unreachable production targets due to some problems associated with production, such as fluctuative number of man power, the machine is not available to operated well as well as working overtime to reach production targets.

In this study the authors develop a model regarding production target achievement using binary logistic regression method. Binary logistic regression itself according to Kleinbaum (1994) is a mathematical modeling approach that can be used to explain the relationship between several variables X to response variables Y that are dichotomous or binary.

Based on the mathematical model and using the common formulation of logistic regression. It result a mathematical models g(x) = (-132.063) + 0.029 Man power + 4251 availibility machine + 2598 Over time. With this such mathematical model, the author obtain some probabilities for production target achievement in some conditions to obtain the optimal probability.

***Keywords**: binary logistic regression, target production, probability.*

1. INTRODUCTION

Garment is one of commodity poten-tially developed in the global market. Benny Sutrisno, (2007) Chairman of the Indonesian Textile Association said that the needs of textile and apparel products (garments) will be increased from year to year.

Considering its large market potential, the competition of garment products in the world market is very tight. The largest exporter of garment products for the world market respectively are countries joined the European Union, China, Hong Kong, Turkey, Mexico, India, USA, Romania and Indonesia. Garment exporting countries should have high productivity, high quality as well as high competitiveness. The rapid development brought to competition among industries, especially for production personnel. Production personnel should be able to maintain or even improve the performance and quality of its products. These demands will be met if there is a good production system, so that the resulting product can fulfill the required quality and quantity standard.

The system can be described as an integrated component series to carry out an activity or a process starting from input and resulting an output. In this regard, input includes raw materials, labor, machinery and working time in good quality that will meet the production process, therefore it will produce an output such a finished products that meet the expected quality and quantity standards.

Unfavorable input will produce unfavo-rable output (product). The number of labor is one factor that can hamper the produc-tivity of the company itself. Similarly with labor, machinery became one of the most important factor in the production process, the machine with the good level of availability could produce products with expected quality and quantity. To meet the expected production company target, not only depending on labor and machinery aspect, but also working time in the production process. As we know, long production time will lead to higher production.

The hampered production process due to poor quality inputs (man power, machinery and time) cause it can't fulfill the market demand, and as the consequences, the consumers will choose other competitor products. Considering the importance of good quality input in the production process to meet expected quality and quantity product, this study proposes an analysis of modeling the production process to meet expected production targets of the company. Studi cases and research activities of the production process was carried out at PT. Hansae Karawang.

PT. Hansae Karawang as a company operated in the field of garment industry focuses on the delivery of export products, to the importing countries such as Japan, America and European countries. Unfortunately in fact, it can't fulfill the market demand in the said importing countries, due to the number of finished products didn't comply with market demand as well as the rejected products so it failed to export. The failure to reach production targets was influenced by several factor, such as the unstable man power quantity, due to recruitment of *outsourcing* and uncontracted daily man power. Meanwhile, the condition of production machine could also affect the production target. Unoptimal machine such as reduced lifetime machine or exceed utilization of the machine could also decrease the machine performance and reduce production capacity. Other factor that also play important role is working time. The working time that using only one shift could cause working *overtime* for almost 4 hours, and this impact to employee physical condition which is getting tired to work on the next day.

In this study, the author is interested to conduct the research to create mathematical modeling using *logistic regression binary* by describing model of the production targets achievement in PT. Hansae Karawang based on the number of man power, machine availability and additional man hours (overtime), including determining the probability in achieving production targets, and to see the relationship pattern among these factors.

2. RESEARCH METHOD

2.1. Object and Data Research

The research object and data in this study are apparel products particularly on production target achievement, considering the following factor i.e. machine availability, man power and *overtime.*

2.2. Identification Variables

The dependent variable in the logistic regression equation has a categorical value. In such model, the value of *y* will be 0 and 1 wherein each of these values represent "achieved or not" categories for the target determined by the company. The independent variable in this study is the number of man power, the availability of the machine, as well as overtime implemented by the company.

2.3. General Equation

Using logistic regression models, general equations used in this study is the equation with one dependent variable and independent multivariable which can be written as follows:

$$g(x) = (\beta_0 + \beta_1(\text{total man power}) + \beta_2(\text{machine availability}) + \beta_3(\text{over time})$$

2.4. Binary Logistic Regression Methods

According to Hosmer (Page 6: 2000), logistic regression method is a statistical analysis method that describes the relationship between the response variable which has two or more categories with one or more explanatory variables with category or interval scale. The meaning of categorical variables are variables in the form of nominal and ordinal data. The general form of probability logistic regression models are formulated as follows:

$$\pi(x) = \frac{\exp(\beta_0+\beta_{1x1i}+\cdots+\beta_{pxpi})}{1+\exp(\beta_0+\beta_{1x1i}+\cdots+\beta_{pxpi})} \quad (1)$$

with $\pi(x)$ is the probability of success occurrence with probability value 0≤ $\pi(x)$ ≥ 1 and β_i is the parameter value with i = 1,2, ..., p. $\pi(x)$ is a non-linear function, therefore it needs to be transformated to a logit form in order to obtain a linear function so we can see the relationship between independent variables and the dependent variable. By transformating logit $\pi(x)$ then could obtained a simpler equation, namely:

$g(x)=(\beta_0+\beta_1 x_i+...+\beta_p x_p)$ (2)

Several steps to create a mathematical modeling using binary logistic regression method, consist of:

A. Overall significance test

Prior to forming the logistic regression model, we shoud start undertaking parameter significance test. The first test performed is the parameter role test in the comprehensive model with the following hypothesis:
$H_0: \beta_1=\beta_2= \beta_i = 0$ (Model is not significant)
H_1:At least one coefficient $\beta_i \neq 0$ (Model is significant) where i = 1,2, ... p
Test statistic used is:

$$G = -2log\left(\frac{l_0}{l_1}\right)$$
$$= -2log[log(l_0) - log(l_1)]$$
$$= -2(L_0 - L_0) \quad (3)$$

with:
l_0 : The maximum value of the probability function for the model under hypothesis 0
l_1 : The maximum value of the probability function for the model under the alternative hypothesis
L_0 : The maximum value of the log probability function for the model under hypothesis 0
L_0 : The maximum value of the log probability *function* for the model under the alternative hypothesis.
Value -2$(L_0$-$L_1)$ follows the *chi-square* distribution with $df = p$. If using a significance level of α, the test criteria is reject H_0 if -2$(L_0$-$L_1)$ ≥ $X^2_{(p)}$ or *p-value* ≤ α. (Nacrhrowi and Usman, 2002).

B. Test of Significance In the Individual

Significance parameters test was carried out by using an Wald Test with the formulation hypotheses as follows:
$Ho: \beta_i$ = 0 (Logit coefficient is not significant to the model)
$H_1: \beta_i \neq 0$ (logit coefficients significantly to the model)
And the statistic test:

$$W^2 = \left[\frac{\hat{\beta}_i}{SE(\hat{\beta}_i)}\right] \quad (4)$$

The value of the square W follows Chi-square distribution with df = 1. If $W^2 \geq X^2_{(1.\alpha)}$ or p-value ≤ α then H_o rejected and H_1 accepted. B_i is the value of the regression parameter estimates and SE (β_i) is the standard error (Nachrowi and Usman 2002).

C. Suitability Test Model

The instrument used to undertake the suitability test of a logistic regression model is *Hosmer-Lemeshow*s. *Hosmer-Lemeshow* statistic follows *a Chi-square* distribution with *df* = g-2 which is the number of groups, with the equation as follows.

$$X^2_{HL} = \sum_{i=1}^{g} \frac{(Oi - Ni\ i)^2}{Ni\hat{\pi}i\ (1-\hat{\pi}i)} \quad (5)$$

Where Is:
N_i :Total frequency of observation group no.i
O_i: The frequency of observation group no.i
$\hat{\pi}i$: Average estimated probability group
To test the suitability of the model, *Chi-square* values obtained were compared with *chi-square* value in the table *Chi-square,* with *df* =g-2 if $X^2_{HL} \geq X^2_{(g-2)}$ or p-value ≤ α then H_0 rejected and H_1 accepted (Hosmer-Lemeshow, 2000).

D. Interpretation of the Model

The best model based on the criteria of testing parameters which have been obtained, further interpretated its coefficients based on the parameters. Odds ratio can be used to simplify the interpretation of the model. Odds ratio is a measure that estimates how predictor variable could influence the response variables (Hosmer-Lemeshow 2000). Odds ratio for Y = i against Y = k, calculated at two values (eg, x = a and x = b) as follows:

$$\psi(a, b) = \frac{(Y=I)|x=a)/(Y=k|x=a)}{(Y=i|x=a)(Y=k|x=b)} \quad (6)$$

if a-b = 1 so ψ = exp(βi)
ψ is always positive and usually used as a relative risk approach (relative risk). For ψ = 1 means that x = a has the same risk with x = b resulting Y = i. 1 <ψ <∞ means that x = a has higher risk ψ times than x = b, and otherwise for 0<ψ<1. If predictor variable is continuous, the interpretation of coefficient estimation depends on the particular unit of predictor variables. Continuous predictor variables requires change units "c", then the odds ratio is obtained by exp$(c\beta_i)$ (Hosmer-Lemeshow, 2000).

2.5. Order Fulfillment Analysis by Using Opportunity Regression Logistics Model

As the result of data collection and its processing, it can be obtained a mathematical model, furthermore can be used as an analysis by input the value of the predictor variables to result probabilities using logistic regression opportunities models.

3. RESULTS AND DISCUSSION

3.1 Data Processing with Binary Logistic Regression Methods

A. Early Model Parameters Significance Tests

Table 1. Value Odds Ratio *(Log Like Lihood)*

Product Name	*Value Logs*	Df	Sig	Decision
Apparel	63*. 965*	3	7.**815**	Reject Ho

Thus it can be seen that the value of *the log lik lihood* $_{apparel,}$ ≥ value of Chi square table = 7815 with α = 0.05 and df = p = 3 so that H_0 is rejected. This means that at least one of the logistic regression coefficient significant at α = 0:05.

B. Individual Significance Test

The Wald statistic test has Chi-square distribution with degrees of freedom 1 or W_i $X^2_{1,}$ α in common. Ho is rejected if Wi>$X^2_{1,}$ α. If H_0 is rejected, meaning that the parameters are statistically significant at a signifycance level α. The results of the value Wald statistic test of production with α = 0.05 and df = 1 obtained from calculations using *the software* SPSS are shown in Table 2 below:

Table 2. Value Test Wald

Predictors	Wald	P-value	Decision	B
Contans	8,207	0.004		-132.06
Man power (X_1)	7,860	0.005	Reject H_0	0.029
Availibility machine (X_2)	16,520	0.000	Reject H_0	4,251
Over time (X_3)	6,569	0,01	Reject H_0	-3886

C. Model Suitability Test

To test the suitability of the model, *chi-square* values obtained were compared with *chi-square* value in the table *Chi-square,* with *df* = g-2 if $X^2_{HL} \geq X^2_{(g-2)}$ or p-value ≤ α then H_0 is rejected and H_1 accepted. The recapitulation *Chi-square* statistical to test *Hosmer-Lemeshow* models suitability of apparel products obtained from calculations is using *the software* SPSS is shown in Table 3 below:

Table 3. Value of *Hosmer-Lemeshow* models suitability test

Product Name	*Chi-Square*	Df	Sig	Decision
Apparel	6. 541	8	0.590	Accepted H_0

D. Model Interpretation

After testing the suitability model, the logistic regression models can be formed using the estimated parameter values or odds ratios. The resulting mathematical model is:

g(x)= -132,063+0.029(x₁)+4.251(x₂)+2,598 (x₃)

$$g(x) = -132{,}063 + 0.029(x_1) + 4.251(x_2) + 2{,}598\,(x_3)$$

With the interpretation of odds ratios as follows:

a) For variable X_1, *odds ratio* values obtained is 1.029, means that any one person man power increases, it will increase the probability of achieving production targets at 1,029 times higher, which means the possibility of achieving the target (y=1) getting higher if the number of man power is increased.

b) For variable X_2, *odds ratio* values obtained is 70.154, means that the opportunity to achieve production targets if the machine is capable to operate at 70.154 times higher than the machine is not capable for operate.

c) For variable X_3, *odds ratio* values obtained is 13.437, means that the opportunity to achieve production targets if there is *overtime* at 13.437 times higher compared without *overtime.*

3.2 Production Target Achievement Opportunity Analysis

From the results of the data collection and processing, it can be obtained a mathematical model which further can be used as an analysis by input the value of the predictor variables to generate a probability or production target achieved using equation (1), as seen on chart as follows:

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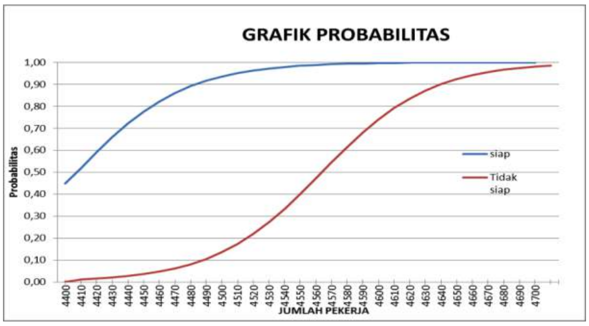

Figure 1. Chart of Achievement Production Target Opportunity Model with Machine Availability Without Overtime

Figure 1. illustrates that the probability of achieving the production target without overtime and machine is available to operate, then the probability are optimal when the number of labor is equal to or more than 4.550 personnel.

Meanwhile the probability of achieving the production target without overtime and machine is not available to operate, then probability are optimal when the number of labor is equal to or more than 4.700 personnel.

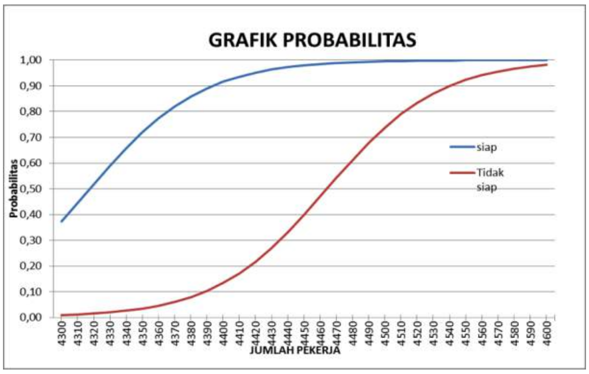

Figure 2. Chart of Achievement Production Target Opportunity Model with Machine Availability and Overtime

Figure 2. illustrates that the probability of achieving the production target and machine is available to operate with overtime, then the probability are optimal when the number of labor is equal to or more than 4.470 personnel.

Meanwhile for the probability of achieving the production target with machine is not available and overtime, then the probability are optimal when the number of labor is equal to or more than 4.620 personnel.

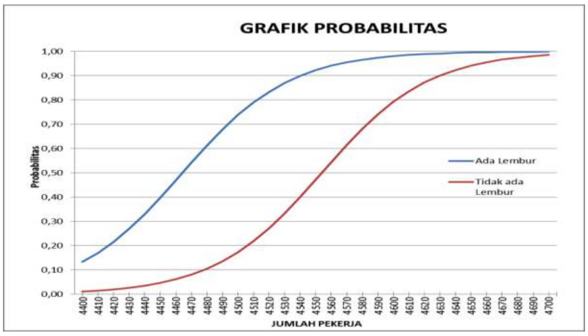

Figure 3. Chart of Achievement Production Target Opportunity Model with Overtime without Machine Availability

From the calculation of the previous table and see the chart above, it can be concluded that the probability of achieving the target with overtime and machine is not available to operate, then probability are optimal when the number of labor is equal to or more than 4.600 personnel.

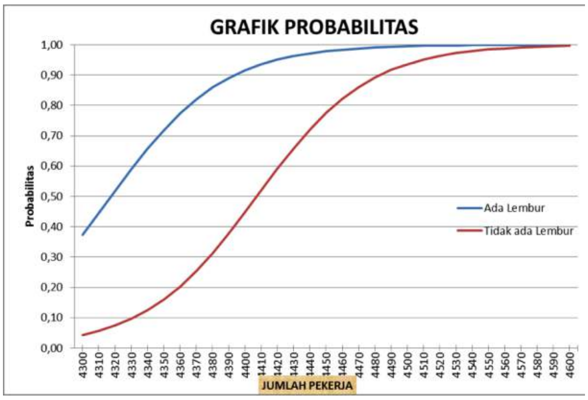

Figure 4. Chart of Achievement Production Target Opportunity Model with Overtime and Machine Availability

From the chart above, we can conclude that the probability of achieving the production targets with overtime and machine is available to operate, then the probability are optimal when the number of labor is equal to or more than 4.470 personnel.

Meanwhile the probability of achieving production target without overtime and machine is available to operate, then the probability are optimal when the number of labor is equal to or more than 4.560 personnel. And if machine is not available to operate, the probability would be optimal if the number of labor is more than 4.700 personnel.

4. CONCLUSION

Mathematical modeling using binary logistic regression to see the production target achievement in PT. Hansae Karawang based on production factor, generating mathematical model, as follows:

Table 4. Results of Target Production Mathematical Model in PT. Hansae Karawang

Constants	Total Man Power (X_1)	Machine Availability (X_2)	Over time (X_3)
-132.063	0,029	4.251	2,598

Based on the mathematical model, it can be obtained *probability* with different condition. The optimal probability of achieving production target considering the following factor i.e. machine availability, working overtime and man power (personnel), results as follows:

Table 5. Optimal Probability of Target Production Achievement

Availability Machines	Probability	
	Over Time	Not Overtime
Available	4470 ≥ man power	≥ 4,560 man power
Not Available	≥ 4600 man power	≥ 4,700 man power

5. REFERENCES

(a) Agresti, A, 1990, *Categorical Data Analysis*, New York: John Wiley & Sons, Inc.

(b) Arsyad, Lincoln*,* 1999, *Ekonomi Manajerial,* Yogyakarta: Penerbit BPFE.

(c) Assauri, Sofjan, 1993, *Manajemen Produksi dan Operasi*, Edisi Keempat, Jakarta : BPFE.

(d) Biegel, J. E., 1992, *Pengendalian Produksi Suatu Pendekatan Kuantitatif*, Jakarta: Akademika Pressindo.

(e) Cristina, Widya, Utami, 2006, *Manajemen Ritel (Strategi dan Implementasi Ritel Modern)*, Jakarta: Salemba Empat.

(f) Gaspersz, Vincent, 2012 *Production Planning And Inventory Control For Supply Chain Professionals Srategi Menuju World Class Manufacturing*, Bogor: Vinchristo Publication.

(g) Haloho Oktani et. all, *Penerapan Analisis Regresi Logistik Pada Pemakaian Alat Kontrasepsi Wanita,* Jurnal Saintia Matematika Universitas Sumatera Utara*,* Volume 1, No.1 51-61.

(h) Heizen Jay, Render Barry, 2004, *Operation Management*, Edisi Tujuh, Jakarta: Salemba Empat.

(i) Herjanto, Eddy, 1999, *Manajemen Produksi dan Operasi*, Edisi Kedua, Jakarta: PT. Gramedia Widiasarana Indonesia.

(j) Hosmer, D.W., Lemeshow, S., 2000, *Applied Logistic Regression*, New York: John Wiley & Sons, Inc.

(k) Joesron, Tati Suhartati dan Fathorozi, 2003, *Teori Ekonomi Mikro*, Jakarta: Salemba Empat.

(l) Jaenudin, Asep, *Analisis Dampak Penerapan Sistem Lembur (Overtime) Terhadap* Karyawan *oleh Perusahaan di Kota Batam.* [http://www.slideshare.net/asepjaenudinupb12/analisis-dampak-penerapan-sistem-kerja-lembur-overtime] diakses pada 6 Desember 2013.

(m) Kleinbaum, D.G, 1994, *Logistic Regression*, New York : A Self Learning Text.

(n) Kutner, M.H., Nachtsheim, C.J. dan Neter, J, *Applied Linear Regression Models Fourth,* 2004.

(o) Mudrajad Kuncoro, 2001, *Metode Penelitian Kuantitatif*. Yogyakarta : UPP AMP YKPM,

(p) Nachrowi, D., Usman, H., 2002., Penggunaan Teknik Ekonometri. Jakarta: PT. Raja Grafindo Persada.

(q) Nur Afidah Layli, 2011, *Pola Tingkat Keparahan Korban Kecelakaan Lalu Lintas Dengan Menggunakan Regresi Logistik Multinomial (Studi Kasus: Kecelakaan Lalu* Lintas *Di Surabaya),* Tugas Akhir jurusan Statistika ITS, Surabaya,

(r) Sudjana, 1989, *Metoda Statistika Edisi ke 5*, Bandung: Tarsito.

(s) Sugiyono, 2000, *Statistik Untuk Penelitian.* Bandung: CV. Alfabeta,

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AUTHOR BIOGRAPHIES

Ade Momon S. is lecturer in Department of Industrial Engineering, Faculty of Engineering, Singaperbangsa Karawang University, Karawang.

Ikbal Wijaya has graduated from Department of Industrial Engineering, Faculty of Engineering, Singaperbangsa Karawang University, Karawang in 2014