THE USE OF REGRESSION ANALYSIS TO DETERMINE THE ORDER OF DELAYS IN THE MANUFACTURING PROCESSES

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Abstract
The effect of Supply Chain Management is very important on the performance of companies their life cycle. The paper tries to investigate the role of Supply Chain Management on company performance. Companies in order to be successful in the manufacturing sector of industries, they need to manage the data order and the performance of the company. Therefore, this paper tries to emphasize that the order parameters help in estimation of the order implementation during deadlines. Thus, the obtained results will provide insights to companies on manufacturing industries and to decision makers. The results will also help decision makers to be more accurate on their decisions about orders and reaching the results by the model.

Key words: *Logistic Regression, Supply Chain Management, Order Manufacturing, Hosmer & Lemeshow Goodness of Fit Test.*

JEL Classification: M19

I.   INTRODUCTION

The role of economic parameters in valuation calculations increases its importance more and more every day. For this reason, all decision makers at macro and micro level have to make great effort to keep their economic and monetary variables at appropriate levels in order to increase the value of their organizations. When the correct decisions taken at the micro level are combined with the right policies carried out at the macro level, the level of social welfare reaches the upper levels. This situation in the form of a cycle again micro organizations, as well as all members of the community positively affects. Nevertheless, it has been experienced many times during the history of humanity that the other cases occurred. The only thing that does not change, albeit positively but negatively, is that these developments are manifested as the effect of domino stone or butterfly effect with the term popular. This is the case when external factors are kept constant. However, in today's global economy, the effects of external factors have increased and this has made the decision-makers more difficult to make the right decisions and carry out the right policies. Increasing the importance of the decisions made today has led the organizations to increase productivity. In this respect, the level of information that organizations have is of great importance. In addition to the organizational knowledge, the information sharing must be available to the maximum extent as well as keeping the non-organizational information at the maximum level. This situation made the organizations obliged to develop methods in this direction and even the advancement of the technology and the methods of sharing information in the software dimension were developed and made available to the organizations.

It is one of the success parameters of the firm that it can meet the order it has received for a manufacturer. Because the manufacturer can meet the order on time, the company has the opportunity to supply the maximum value. The value of an order that cannot be carried out on time decreases every time it is delayed and loses its economy. In addition to the financial losses, there are also spiritual losses, all these losses negatively affecting the future expectations of the company.

II.   SUPPLY CHAIN MANAGEMENT

Optimization, which is one of the basic principles of decision making process in business administration, necessitated the harmonization of many fields of study and new principles with decision making models. In this area, where the aim is to maximize value, resource and cost minimization necessitates optimization in many working methods. Supply chain management is one of these fields of study and it makes a great contribution to enterprises in the direction of benefit maximization which is the common goal of enterprises. This type of management, which was discovered by planning the inputs of the product in the production processes in the 1960s, has expanded its field today and reached an inter-organizational structure.

Supply chain management is a process management that is born in modern times and is considered to be an essential part of the development of the organization. This process is the process until the product or service

reaches the user from the raw material supplier. Supply chain management can be defined briefly as product, service, money and information flow between each intermediary involved in this process.

The supply chain can be defined as the supply of raw materials, production and assembly, storage, stock control, order management, distribution, activities involving the delivery of the product to the customer and the information systems required to monitor all these activities. (Lummus, Krumwide, & Vokurka, 2001) It is called supply chain management to keep every step of the process from the supply of raw material to the end-user presentation of the product. In this process, the elements under control are material and non-material elements, services and information. There are three types of flow in the supply chain. These are material flow, information flow and financial flow. Material flow consists of physical product flow from suppliers to customers, and reverse flow consisting of return, service, recycling and disposal. Here, spare parts come from suppliers of raw materials and intermediates.

From the supply of raw materials, we can define the supply chain which is composed of the elements that are related to the other elements that are involved in the process until the final consumer reaches to the product and the two products are related. The success of supply chain management depends on ensuring that all these elements are shared with each other and that all rings in the chain work in a coordinated manner. Therefore, it is of great importance that the rings forming the supply chain act in a coordinated manner. For this reason, the most important reason for the failure of the supply chain is that all of the rings forming the chain cannot be kept under control. No matter how much effort is given to control the rings, it is almost impossible to be in a position to rule them all. Organizations that can be successful in this regard are advantageous in the market. Moreover, even the organizations that set up the supply chain system cannot provide 100% control over the chain and face the disadvantages of the supply chain. Elements such as order quantity, order time, demand forecast, production capacity, storage capacity, transportation, product and service quality are all part of the supply chain. It is very difficult to keep control over all these elements at the desired level. Because the many chains of the supply chain, non-organizational elements constitute. For example, what is the product quality produced no matter how low the production costs are, the product will not be able to reach the final consumer (quantity, quality, pricing etc.) if the performance of the steps required for the product to reach its final consumer is not at the desired level. Therefore, the satisfaction of the end consumer will not be achieved, the consumer's feedback will not reach the company, medium and long-term product hold in the market and the company profitability and longevity will be taken into consideration.

It is not enough to evaluate the situation only for the manufacturer and the final consumer. The strength of the chain, the link between the rings and the fit affect all the rings directly or indirectly. In this respect, the elements between the producer and the consumer and the suppliers for production will be affected by the negativity in the chain.

It is possible to evaluate the factors affecting the chain in many respects. While these factors may originate from the chain, some external factors may also affect the strength and performance of the chain. The most important external factors are; general economic conditions, political situation, social factors and natural factors. The effect of the factors in the chain is directly proportional to the linkage of the chain to these factors and its sensitivity to changes in factors. The negative effects of external factors on the chain can be considered as the risk of external factors in the supply chain.

Naturally, the elements that directly and more affect the chain stem from the chain. For example, the risks associated with suppliers are mainly due to the difficulties in supplying raw materials. One of the biggest risks in the chain is that the required materials cannot be supplied in the desired quality, quantity and time. The problems in the procurement stage are of the kind that can affect the chain through domino stone effect.

We can face many problems that we can consider as a risk during the production phase. Factors affecting production and causing problems in the transition of products to the next stage also pose risks directly or indirectly because they affect the chain. The financial situation, production capacity and production elements (workers, fixed capital investments, maintenance and repair etc.) are the internal factors affecting the production of the enterprise.

After the production stage, the rings that are made up of more wholesalers and retailers, which enable the product to reach its final consumers, may face the risk factors affecting their performance both inside and outside, just like the manufacturer. These troubles also risk the products to reach the final consumer as desired. All these risks also impede the success of the product and the transfer of mutual benefits.

Even if it is very difficult to eliminate the risks in the supply chain, it is possible to minimize the risks. The most important issue to achieve this is communication. Particularly important is Tracing, which means inden traceability of the product from the raw material procurement process until it reaches the end consumer ana. The stronger the relationship and communication between the rings and the greater the traceability, the less the risks on the success of the chain. In order to establish this communication in the healthiest way and to reduce the risks, many manufacturers try to integrate the rings in the supply chain as much as possible or to create them within their own structure. For example, in the name of keeping the products in the food and fast-moving sectors, the final consumers are able to control the transportation of their products through the firms or units of activity they

have established within themselves. Because transportation costs, transportation capacity and route are the factors affecting the product cost. In terms of cost management, many companies aim to make transportation control first hand by considering transportation.

After-sales support is also an important consideration. The openness of the feedback channels, increasing the service periods to be minimized, but trying to minimize the supply chain in this regard is very important in terms of eliminating the risks.

Exceeding storage-related issues also undergoes successful management. Inventory management and inventory cost management are the most important tools to minimize the risks that the supply chain may face in terms of storage. Depending on the nature of the product, the extra costs that may be incurred for special protection conditions and the transportation of the warehouses in certain centers taking into account the transportation costs are the risks that can be encountered and can be solved by a successful inventory management as previously stated.

Outsourcing, called outsourcing, is a method used by enterprises today, but plays an important role in increasing the efficiency of supply chain management. The fact that the enterprises leave their activities outside the main activity areas to the organizations that have determined this work as the main activity area is called external welding. The provision of services such as accounting, human resources and R & D in this way as a service, increases its focus on the core business of the business and positively affects the dynamism of the enterprise. It has been observed that such enterprises are more effective in supply chain management.

For effective supply chain management, information sharing is crucial. The ability to share information completely, quickly provides advantages for the organization. Especially in an environment where information technology renews itself day by day, organizations need to renew themselves in this regard. Failure to share or transmit information sufficiently raises various problems. Since it is known that the rings in the chain act in line with their purposes, it is also possible to predict that the deficiencies in the information flow can lead to conflicts of these aims. On the contrary, in environments where information can be shared, the rings will give them an advantage and avoid the occurrence of the whole system and thus their own existence and the negative effects. In other words, as the members of the supply chain, such as the functions of a common organization, conducting their activities by considering the interests of the whole, will advance the whole organization positively with both themselves and the other members they are in contact with.

Information sharing is a key element in the management of the supply chain. The members of the supply chain should be able to reach the necessary information in a timely manner in order to coordinate their activities. With the development of information technologies, it has been observed that the information sharing among enterprises is made much easier and the enterprises that realize the information sharing effectively have achieved significant success in the integration of the supply chain. (*Davis, T. 1993*)

In Supply Chain Management, it is vital for a company to deliver the orders received in a timely manner. However, firms cannot deliver the orders to their customers on time due to the problems they face during the production process or different problems. This leads to disruptions in supply chain management. In order to minimize these disruptions, it is beneficial to determine the ability of these orders to be timely in order to be determined at the beginning of the process. The aim of the study is to calculate the probability of realization of this order in time by logistic regression analysis by examining the order variables in a company operating in manufacturing industry.

The study aims to prove that the order parameters can be used to calculate the likelihood of the order. In this way, it will be possible for manufacturing industry enterprises and business decision makers to be more accurate in making decisions and taking decisions on these orders. An enterprise that can make predictions about the future of the orders it receives will be able to make more dynamic decisions, thus strengthening both its own and its supply chain. In this study, the applicability of the model will be discussed in many rings of supply chain management. Not only the manufacturing phase, but also all the other methods used in the study will be proved by the statistical method used in the study.

2.1 Factors Affecting Supply Chain Management

There are many factors that affect supply chain management. One of them, and perhaps most importantly, is the conditions of today's competition. The many tools and strategies that businesses establish superior to each other are very important in shaping the competition conditions of the market. In this respect, the structure of the supply chain, in which the enterprises are members, is also important in giving them an advantage in the market. Because the speed of communication and reactions between bodies of a body, such as the rate at which the body gains speed, the information sharing within the supply chain will give the enterprise and organization the ability to react quickly to changes in the market and help it to establish a superiority over its competitors. Nowadays, the speed of reacting to market conditions increases the importance of product life processes.

One of the important factors affecting supply chain management is technological developments. The rapid development of technology reveals the necessity of enterprises to renew themselves. The change in the

technology field affects the rings of the chain in the positive and negative aspects. The proliferation of technological facilities and it accelerates the flow of products, services, information and money and makes the supply chain a more dynamic structure. On the other hand, rapid change in information technologies, in particular, pushes the members of the chain to keep up with the technological developments and sometimes cause them to remain behind. In addition to this, technological developments increase diversity in terms of customers and suppliers, but also make competition conditions more difficult for businesses.

2.2 Cost Elements in Supply Chain Management

The basic philosophy in supply chain management is to minimize the total supply chain cost in line with the desired fixed demand. This total cost includes the following cost elements:
- Raw materials and other procurement costs
- Inbound transport and transportation costs
- Facility investment cost
- Direct and indirect production costs
- Direct and indirect distribution center costs
- Stock retention cost
- In-investment and transportation costs
- Outbound transportation and transport costs (Shapiro, 2001)

III.   LOGISTIC REGRESSION

Logistic Regression calculates the effects of independent variables on outcome variables and determines these risk factors as probabilistic. Logistic Regression is a method that interrogates the relationship between the result variable and the independent variables in binary and multiple stages. Based on numerical data, statistical analysis is done for the solution or interpretation of the problem. As a result of these analyzes, some models are being developed about the problem.

The first use of the logistic model was proposed by Berkson (1944, 1953, 1955) for the analysis of biological experiments. Cox (1970) developed the logistics model, has made various applications, Halpering et al. also argued that logistic regression in 1971 could be shown as an alternative to discriminant analysis when the assumption of normal distribution of independent variables is not fulfilled.

After the first use of logistic regression, Finney has signed one of the studies comparing the logistic regression with other analysis methods in the literature in 1971. Gordon (1974) in his study on the removal of problems caused by multiple inter-relationships has made some suggestions. Belsley et al. (1980) proposed ideas for the use of linkage analysis similar to those in linear regression in logistic regression. Andersson summarized the progress of the method in his studies in 1979 and 1983.

In the study conducted by Albert and Anderson (1984) about the estimation methods in logistic regression, they explained the theoretical basis for the estimation of logistic regression coefficients with the most likelihood method in different data sets. In addition, studies have been done to adapt the data to the predicted logistic regression model. The works by Aranda-Ordaz (1981) and Johnson (1985) are the most important ones. In addition, Pregibon (1981) conducted a study on the determination of effective and contradictory observations in the logistic models where the response variable takes binary value. In a study by Hosmer and Lemeshow (1980), the criterion of goodness of fit was developed. Then, Hosmer and Lemeshow (2000) examined logistic regression model in detail, maximum likelihood estimation method, goodness of fit measures, studies on determining effective and contradictory observations were summarized and various sample applications were done. In addition, Roy and Guria (2008), in their study, used the technique based on the observation of observations and examined the effective and contradictory observations for logistic regression.

The widespread use of logistic regression models has led to the development of coefficient estimation methods and a more detailed analysis of logistic regression models. Cornfield (1962) popularized the discriminant function approach for the first time in coefficient estimation operations in logistic regression. Lee (1984) focused on linear logistic models for simple cross-over trial plans. Bonney (1987) studied the use and development of logistic regression model. Robert et al. (1987) carried out studies on logistic regression standard Kikere, likelihood ratio (G2), "pseudo se maximum likelihood estimations, compliance excellence and hypothesis tests. Duffy (1990) examined the distribution of error terms in logistic regression and the approach of parameter values to real values. Basarir (1990) studied multivariate logistic regression analysis and

differentiation problems in clinical data. Hsu and Leonard (1995) have studied the logistic regression functions of Bayesian estimation and showed that Monte Carlo transformation can be used in logistic regression.

3.1 Linear Regression Model

Simple linear (linear) regression is a method used to explain the relationship between an independent and a dependent variable. The method allows modeling of the relationship between variables. By simple linear regression analysis, the dependent variable is estimated. As a result of the analysis, the relationship between the variables is revealed. In cases where the number of independent variables is more than one, it becomes multiple linear regression. The equations of the simple and multiple linear regression models are as follows:

$$y = \beta_0 + \beta_1 X + \varepsilon$$
$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon$$

*y = **Dependent** or **response variable** (variable to be modeled)*
*x = **Independent** or **predictor variable** (variable used as a predictor of y)*
$E(y) = \square_0 + \square_1 x = Deterministic component$
$\square$ (epsilon) = Random error component
*$\square_0$ (beta zero) = **y-intercept of the line**, that is, the point at which the line intercepts or cuts through the y-axis,*
*$\square_1$ (beta one) = **slope of the line**, that is, the change (amount of increase or decrease) in the deterministic component of y for every 1-unit increase in x.*

3.2 Logistic Regression Model

Linear regression is a method commonly used to examine the effect of independent variables on the response variable when the response variable (y) does not have a categorical structure. In the logit analysis method, both independent variables and dependent variable (y) may have a categorical structure. For example; logit analysis is a useful method in investigations related to the types of responders generated by situations such as the survival or death of the patient, the presence or absence of a traffic accident, the acquisition or loss of a match.

In order to use m discriminant ant analysis, which is an alternative to the least squares method, all variables must be continuous. In the olm Log-linear k analysis, all of the variables must be categorical. The reason of using logistic regression method is that the data set has both categorical and continuous variables. The application of the study with SPSS package program is the ability to automatically generate the dummy variables and necessary conversion procedures required by the analysis method of the program. In logistic regression, the dependent variable is a binary and has a bovine distribution and consists of qualitative variables, generally not as a successful / unsuccessful patient / patient. Logit provides an estimate of whether or not a model event exists by using a set of arguments with binary probability. Logit model is a nonlinear regression model that forces the result to fall between 1 and 0.

In discriminant analysis, independent variables must have a continuous structure and normal distribution as well as dependent variable. If the independent variables do not have this structure, discriminant analysis cannot be used. These conditions are not needed for the logistic regression model.

There are three basic elements that differentiate logistic regression from linear regression analysis:

1. While the dependent variable is numerical in regression analysis, logistic regression analysis should be a discrete value.

2. In the regression analysis, the value of the dependent variable and the logistic regression are estimated to be one of the values that the dependent variable can take.

3. In the regression analysis, when there is a need for multiple normal distribution of independent variables, there is no requirement for the distribution of independent variables in order to apply logistic regression. (Hosmer & Lemeshow, 2000)

The logistic regression model is created as follows:

$$L = \ln\left(\frac{p_1}{1 - p_1}\right) = \beta_0 + \beta_i X_i + \varepsilon_i$$

On the basis of logistic regression model, odds ratios are available. The superiority ratio compares the probability of occurrence of an event and the probability of not occurring. Logistic regression is obtained by

taking the natural logarithm of superiority ratio. In the estimation of the parameters of the model, the maximum likelihood method is often used. Logistic regression model parameters, analytically it is estimated by the maximum likelihood (ML) technique which is an iterative method.

The odds ratios (OR) and probabilities (P) (probabilities) evaluate the same situations from different angles. P (X = 1) is the likelihood of an event and is called likelihood P. OR is the ratio of a situation to the likelihood of not occurring. OR is used in the Logit model. The relationship between OR and P is as follows:

$$P(X) = \frac{OR(X)}{1 - OR(X)}$$

$$OR(X) = \frac{P(X)}{1 - P(X)}$$

P (X) refers to the probability of occurrence of an event and the values it can take are 0 to 1. OR (X) is the ratio between the probability of not having the same event and 0 and ise. When P (X) is 0.5, OR (X) takes 1. When P (X) takes 1, OR (X) goes to infinity. The natural logarithm of OR (LnOR) eliminates this asymmetry in the distribution. The term logit is the expression of LnOR.

Table 1 The Relationship Between P (X), OR (X) and LnOR (X)

P(X)	OR(X)	LnOR(X)
0	0	$-\infty$
0.5	1	0
1	$+\infty$	$+\infty$

Therefore, in logistic regression model, OR is used by taking natural logarithm.

$$ln[OR(VF = 1|X_1, X_2, \ldots\ldots X_n)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$
VF = value of forcaste

$$L = ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

When it is desired to reach the probability of P (X) from this equation, the following equations are reached.

$$p = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}}$$

$$p = \frac{e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}}{1 + e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}}$$

The theoretical part can be concretized by addressing the relationship between the success of an exam and gender. In Table 2, the distribution of the students who are successful and cannot pass the exam is presented in gender discrimination.

Table 2 Exam Results by Gender

Gender	Exam result Successful	Exam result Unsuccessful	Total
M	41	22	63
F	35	16	51
Total	76	38	114

The situation in the distribution shows that 41/22 = 1.86 of according to the failure of the success rate of a woman in the class. A man has a superiority ratio of 35/16 = 2.19. The result is 0.85 (1.86 / 2.19 = 0.85). This result shows that the probability of a woman being successful is 0.85 times the probability of a man to be successful. When the ratio of superiority of a man was compared to the share of success ratio of the ratio, the result was 1.18 (2.19 / 1.86 = 1.18). This result shows that a man's success rate is 1.18 times more likely than the success of a woman.

In the model where the reference group considered to be Male, the value that will be taken is 0 when the gender variable is male. If the variable is female, this value is 1. The model is created as follows:

One-variable logistics regression equation:

$$p = \frac{e^{(\beta_0 + \beta_1 X_1)}}{1 + e^{(\beta_0 + \beta_1 X_1)}}$$

Since the reference group is Male, β_0 coefficient is the natural logarithm of the superiority ratio of being successful in the male group.

$$\beta_0 = \ln 2,19 = 078$$

β_1 Coefficient is equal to the natural logarithm of the superiority ratio of female to male.

$$\beta_1 = \ln 0,85 = -0,16$$

In this case, one-variable logistic regression model is formed as follows:

$$p = \frac{e^{(0,78 - 0,16 X_1)}}{1 + e^{(0,78 - 0,16 X_1)}}$$

3.3 Probit Model

Probit analysis is a model used as an alternative to logistic regression. In order to analyze binominal response variable, Probit analysis is usually used in Regression. Both analyzes are very similar. And the probability estimates obtained by both methods are close to each other. While superiority ratios are used in probit cumulative normal distribution analysis. *The* logit model uses something called the cumulative distribution *function of the* logistic distribution. The probit model uses something called the cumulative distribution *function of the* standard normal distribution *to define f (*). Both functions will take any number and rescale it to fall between 0 and 1.*

3.4 Tobin Model

The Tobit model is a statistical model proposed by James Tobin (1958) to describe the relationship between a non-negative dependent variable and an independent variable (or vector) . The term Tobit was derived from Tobin's name by truncating and adding -it by analogy with the probit model.

3.5 Deviance

Deviance is a statistical model that is used in statistics for testing the hypothesis. İt generally uses the sum of squares of residuals in ordinary least squares where the model fitting is analyzed. Thus, deviance can be used to test the significance of a particular predictors as variables in the model. Therefore, deviance as a statistical model plays in dispersion models, which is equal to the chi-square distribution and the number of p-slope coefficients, is obtained and it is decided to accept or reject the H_0 hypothesis by comparing it with the table value.

$$H_0 = The\ matched\ model\ is\ meaningless.$$

$$H_1 = The\ matched\ model\ is\ significant.$$

$$G = Deviance = -2 \ln \left[\frac{L\ (fitted\ model)}{L\ (saturated\ model)} \right]$$ is written.

$G > x_{a,p}^2$ is accepted at the level of materiality and the model is inadequate. (Hosmer & Lemeshow, 2000) This demonstrates that no explanatory variable contributes statistically to the model.In the logistic regression models, the Hosmer-Lemeshow test as a test is used to test the goodness of fit. Therefore, it used for predicting risk models. So, this test specifies the subgroups on the risk values.. (Hosmer & Lemeshow, 2000).

$$H_0: \beta_j = 0 \ (x_j \text{ there is no significant contribution to the model })$$

$$H_1: \beta_j \neq 0 \ (x_j \text{ has a significant contribution in the model })$$

There are several methods for testing the significance of the coefficients in the model:

LR (Likelihood Ratio) Test: $D\{\beta_j|\beta_1, \beta_2, \dots, \beta_{j-1}, \beta_{j+1}, \dots, \beta_k\}$

W (Wald Test): $W_j = \dfrac{\bar{\beta_J}}{se(\hat{\beta_J})}$

ST (Score Test): $ST = \dfrac{\sum_{i=1}^{n} x_i(y_i - \bar{y})}{\sqrt{\bar{y}(1-\bar{y})\sum_{i=1}^{n}(x_1 - \bar{x})^2}}$

In this study wald test was used.

Rule of Decision: If the above statistics, $> x_{\alpha,1}^2$, H_0 is rejected at the significance level α. This situation x_j shows that it has an important contribution in the model.

The important thing to note is that, in some cases, a descriptive variable can be included in the model even if it is not statistically significant in the model. (Hosmer & Lemeshow, 2000)

IV. CONCLUSION

In this study, firstly supply chain management is examined in terms of general principles. In accordance with the purpose of the study, the connection between supply chain management and the findings of the method and data set is emphasized. In the next section, the logistic regression method is presented with the basics. However, model building, significance and compatibility tests, deviation and residual analyzes are described in this section. With regard to supply chain management and logistic regression cases, the data set was implemented after these sections based on previous studies. First of all, a general information about the structure of the data set is given and then the analyzes are explained in detail with SPSS applications. With the application of step-by-step analyzes, meaningful variables have been reached for various situations, and individual models were created for each case and significance and compatibility tests were performed. After this section, the analysis method was used to analyze the variables.

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