**CAUSAL FORECASTING DURING *IDUL FITRI* CYCLE FOR FUEL DEMAND IN PT. PERTAMINA (PERSERO) TBBM BOYOLALI**

Internship Report

Submitted to International Program
Department of Industrial Engineering
in Partial Fulfillment of Requirement for the degree of
Sarjana Teknik Inudstri
Univeristas Islam Indonesia

By
Gusti Adli Anshari (12522198)

**INTERNATIONAL PROGRAM**
**DEPARTMENT OF INDUSTRIAL ENGINEERING**
**UNIVERSITAS ISLAM INDONESIA**
**YOGYAKARTA**
**2016**

**APPROVAL PAGE**

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PT Pertamina (Persero) Marketing Operation IV TBBM Boyolali
Teras, Boyolali, Jawa Tengah

Start Date of Internship : February 15th, 2016
End Date of Internship : March 15th, 2016
Report Date of Internship : August 15th, 2016

**August 2016**

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Date: August 15th, 2016 Signature of Author: Adli

Certified by:
Date: August 15th, 2016

Muhammad Ridwan Andi Purnomo, ST., M.Sc., Ph.D.,
Supervisor

YOGYAKARTA

Approved by:
Date: August 15th, 2016

Head of International Program
Department of Industrial Engineering

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| | |
|---|---|
| Topic | : Fuel demand forecast during *Idul Fitri* period (10 days before *Idul Fitri* up to 10 days after *Idul Fitri*) |
| Start Date of Internship | : February 15th, 2016 |
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| Submitted by (Student ID) | : Gusti Adli Anshari (12522198) |

Date: March 15th, 2016 Signature of Author: ____________

Approved by (Field Supervisor):
Date: March 15th, 2016

____________
Miftahul Ulum, S.T.
Sr. Supervisor of Receiving, Storage, and Distribution

## PREFACE

***Assalamu'alaikum Warahmatullahi Wabarakatuh***

*Alhamdulillah* and gratitude is presented to Allah SWT, the almighty god who blessed the author with health, passion and spirit to complete Internship Report titled Causal Forecasting during *Idul Fitri* Cycle for Fuel Demand in PT. Pertamina (Persero) TBBM Boyolali which is located in Boyolali. This internship report is arranged as a partial requirement to achieve the degree of Sarjana Teknik Industri at Universitas Islam Indonesia.

The internship at PT. Pertamina (Persero) MOR IV TBBM Boyolali between 15$^{th}$ February and 15$^{th}$ March can be conducted because of the support from many people. Therefore, the author would like to say thanks to:

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Finally, the author realize that there are still shortcomings as well as weakness in this report. Therefore, suggestions and critics are fully appreciated. Hopefully, this report can be a wonderful source of knowledge for everybody who reads it.

***Wassalamu’alaikum Warahmatullahi Wabarakatuh***

Yogyakarta, August
2016

Gusti Adli Anshari

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# CHAPTER I

# INTRODUCTION

## 1.1 Background of Internship

Nowadays, industries have been rapidly growing. In order to sustain, industries require professional labors as the executor of industrial activities whose life differs from students. Almost everyday students receive lecture while professional labors faces various problems in industries. The experience of facing various industrial problems is very important for student’s future who will be professional labor. In order to give this experience, Industrial Engineering Department of Universitas Islam Indonesia accommodates students with Internship as a compulsory requirement for their graduation.

Through internship, students will receive a valuable experience to support their activities in the future. In university, students receive lecture about understanding about the method, tools, and technique to solve problems occurring in industries. Most of the lecture received follows the development of technology and internship is an opportunity for the students to applicate the knowledge they receive from lectures in real industries problem.

Indonesia is known as a rich country with various resources including crude oil managed by PT. Pertamina (Persero). Besides of being owned by the government, PT. Pertamina (Persero) has been vital in the processing of crude oil and gas as a raw material into finished products and distributing it to all regions in Indonesia. As an enormous enterprise, PT Pertamina (Persero) has many units of operation which including Marketing Operation Region Unit and one branch of this unit is Terminal Bahan Bakar Minyak Teras, Boyolali (TBBM Boyolali) which specifically handles the distribution of premium, pertamax, pertalite, and solar (fuel produced by PT. Pertamina (Persero)).

Being a part of PT. Pertamina (Persero)'s downstream, TBBM Boyolali is a great place for students to obtain experience and apply their knowledge related to procurement process, inventory planning, decision making, facility layout planning, etc. which are elements in Supply Chain Management (SCM), a core subject in Industrial Engineering.

## 1.2 Objectives of Internship

Based on the elaborated background, the improvement and development process toward knowledge is becoming important thing to be considered. The objectives of the internship process are defined as follows:

a. Acquiring a media to train the skills, attitudes, and actions pattern which are applied by the people and in the system of the real industry.
b. Building the character of students to always be aware with the knowledge and technology development, specifically in the way of establish the effective, efficient, and innovative thought.
c. Giving the concept, perception, and education as the comprehensive process of study which in in the form of direct observation to the real practices in the industry.
d. Establishing the concept of thought to always be opened toward new knowledge.
e. Training for synchronizing the theoretical knowledge in the university and applied knowledge in the real industry as the preparation for getting in to the real work.
f. Being able to analyze the problems which appear in the industry and establish the problem solving using the knowledge that is already acquired.
g. Being able to create the harmonic condition between the academics and industry/company for developing human resources.

## 1.3 Internship Constraints

In the process of the internship, there are several constraints to follow, which are as follows:

a. The observation and the process of internship are only conducted in PT. Pertamina (Persero) Terminal Bahan Bakar Minyak, Teras, Boyolali.
b. The internship starts from February 15th, 2016 and ends on May 15th, 2016.
c. History of company is only explained in brief and only general information is given.
d. Technology usage is only explained in brief.

## 1.4 Benefit of Internship

The internship was conducted in order to fulfill several purposes as elaborated as follows:

1. For Students

    a. As a self-preparation to enter to a field of work after they finish their study in university.
    b. To extend the knowledge, concept of thought, and idea as well as to understand the tools and technique used in the real work.
    c. As an opportunity to gain experience of applying theoretical concept to the practical aspects of real industry.
    d. To train the concept of thought to be practice, effective, and efficient to face the problems in the real industry.
    e. To understand the role of technology and applicable method used in real industry workplace.
    f. As an opportunity to be familiar with professional work ethics discipline in a strict industry environment.
    g. As a trigger to improve personal quality by learning from professionals in real industry workplace

2. For University

   a. To give an opportunity for its students to know the situation of work in the factual scale.
   b. As the evaluation to improve the quality of existing curriculum in the future.
   c. As the starting point for building relationship and cooperating to the company based on the trust and quality.

3. For Company

   a. Get the problem solving of existing problems which are faced by the company as sufficient as the capacity of related student.
   b. Generate the knowledge of Industrial Technology, especially in the Industrial Engineering field.

## 1.5 Time and Location of Internship

The time and location of where this internship is conducted are as follows:

| | |
|---|---|
| Date | : 15 February – 15 March 2016 |
| Work Time | : 08.00-16.00 WIB |
| Location | : PT. Pertamina (Persero) TBBM Boyolali |
| Department | : Supply, Reception, and Distribution |

# CHAPTER II

# COMPANY PROFILE

## 2.1 Company History

In 1950, the governance of Republik Indonesia started investing in managing the resources available in Indonesia. One of the investment was establishing PT. Permina which is ordered to manage crude oil and gas. At this time, most of the mines are unmanaged and is being controlled by small companies or individuals who keeps on fighting to mine in the mines.

In August $20^{th}$, 1968, PT. Permina was combined with PN. Pertamin which works on marketing and reestablished into PN. Permina. This is done in order to gather capital which was scarce at the time. In 1971, the government announced the approved Undang-Undang No. 8 tahun 1971. This regulation, established PT. Pertamina as the only enterprise managing crude oil and gas starting from mining, production, and distribution all over Indonesia. In September 17th, 2003, the governance announced and approved PP No. 31/2003. This regulation begins the separation of crude and oil gas production in the upstream and downstream.

To support the regulation's goal, TBBM Boyolali is established in October 24th. This branch unit is established to manage the distribution of fuel in for 230 gas stations, industries, PT. KAI,(TNI) Indonesia's National Soldiers, etc. in Central Java and Daerah Istimewa Yogyakarta.

## 2.2 Company Location

Company location of TBBM Boyolali is on Jl Raya Solo-Semarang km. 18, Teras, Boyolali

## 2.3 Company's Vision and Mission

### 2.3.1. Vision

The vision of TBBM Boyolali is as follows:

"Becoming an operational unit with world class quality service"

### 2.3.2. Mission

The mission of TBBM Boyolali are listed below.

a. Accomplish fuel receiving, stockpiling, and distribution with safety, correct quality, correct quantity, and on time, as well as fulfilling the aspect of occupational health, safety, and environment.
b. Support the realization of culture transformation in Pertamina through the culture of clean, competitive, confidence, customer focus, commercial, and capable.

## 2.4. Products

In TBBM Boyolali there are several products processed. The products include premium, pertalite, pertamax, solar, and biosolar.

a. Premium

Premium is fuel for non-diesel engine. The Research Octane Number (RON) for premium is 88. The color of this fuel is yellow. Premium is the cheapest type of fuel for non-diesel engine and has for many years has been the most demanded type of fuel produced by PT. Pertamina. Figure 2.1 below shows the logo of premium.

Figure 2.1 Premium Logo

b. Pertalite

Pertalite is fuel for non-diesel engine. The Research Octane Number (RON) for premium is 90 and several additive including detergency, corrosion inhibitor, and demulsifier. The color of this fuel is green and doesn’t contain lead. Pertalite is the newest product of Pertamina, officially distributed from starting from July 23rd, 2015. Since the launching of pertalite, this fuel gradually changes the demand quantity of each non-diesel engine fuel produced by PT. Pertamina (premium and pertamax) because of the quality and price offered by pertalite. Pertalite is branded as the fuel with slightly lower quality than pertamax but with a more affordable price which most of the time the average price of premium and pertamax. The logo of pertalite is shown in figure 2.2 below.

Figure 2.2 Pertalite Logo

c. Pertamax

Pertamax is fuel for non-diesel engine. The Research Octane Number (RON) for premium is 92 and several additive including detergency, corrosion inhibitor, and demulsifier. The color of this fuel is blue and doesn't contain lead. Figure 2.3 below shows the logo of pertamax.

Figure 2.3 Pertamax Logo

d. Solar

Solar is fuel for diesel engine. This type of fuel is not freely distributed. Figure 2.4 below shows the logo of solar.

Figure 2.4 Solar Logo

e. Biosolar

Biosolar is fuel for diesel engine. This fuel is made based on solar with addition of animal or vegetable fat. The composition of biosolar is 95% solar and 5% Fatty Acid Methyl Ester (FAME). Logo of biosolar is shown in Figure 2.5 below.

Figure 2.5 Biosolar Logo

## 2.5. Human Resources

### 2.5.2 Employee Classification

Employees in TBBM Boyolali are classified into two categories which are as follows.

a. Office Employees

   Employees with contract up to 55 years old and receive salary directly from the company.

b. Outsourcing Labor

   Labor contracted from third party company. These labor are contracted for a particular period of time and salary is given by PT. Pertamina via the company who owns the labor (third party company).

### 2.5.2 Operational Time

The operational time for office employees in TBBM Boyolali are as follows:

a. Monday-Tuesday, start at 07.00 up to 16.00 with one hour break between 12.00 up to 13.00.
b. Friday, begins with sport gymnastics at 06.45 and ends at 16.00 with break between 11.30 up to 13.00.
c. Saturday, Sunday, and holidays are non-operational time for office employees.

### 2.5.3 Organizational Structure

Figure 2.6 below shows the organizational structure in TBBM Boyolali. The function of each department is explained as follows:

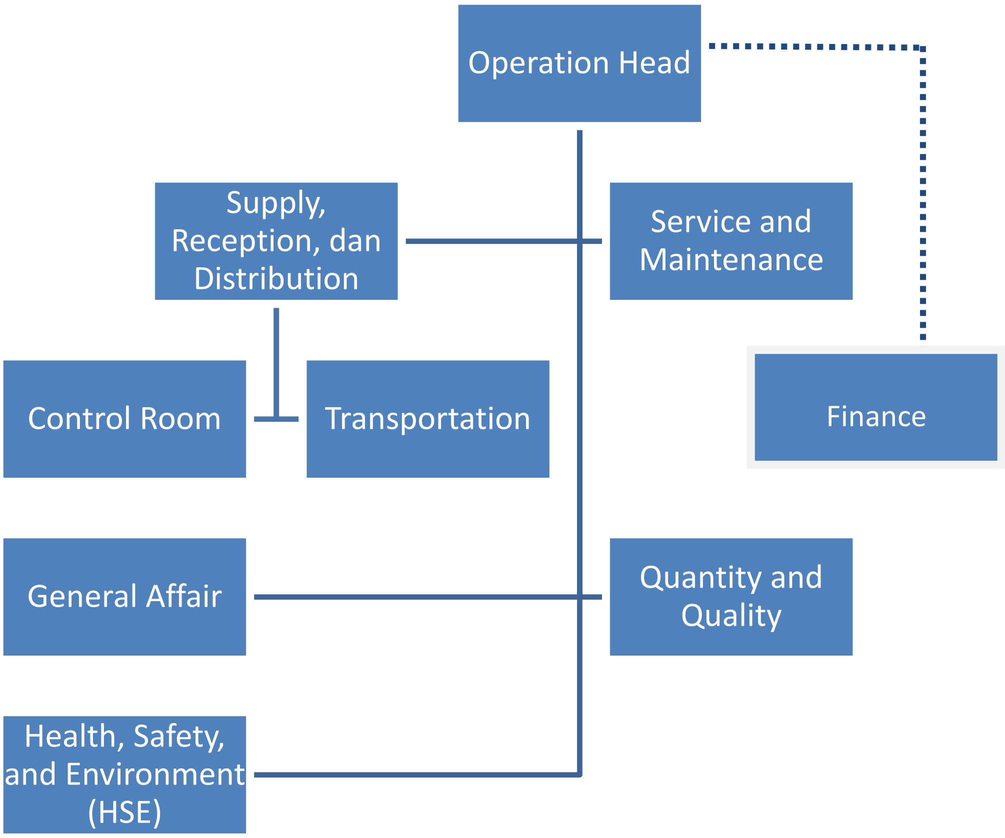



Figure 2.6 Organization Structure of TBBM Boyolali

a. Operation Head

As the main leaders of the highest in Pertamina TBBM Boyolali. Is responsible for coordinating all activities and provide motivation to subordinate and determine the policy for the development for the progress TBBM they lead and have overall responsibility for the continuity of TBBM activities both internally and externally.

b. Supply, Reception, and Distribution

In charge of the control room and to transport to stock fuel depot always awake and distribution to the consumer can run smoothly.

c. Control Room

This department is responsible for the following activities.

1. Carry out preparation pipelines and storage tanks that will be used for reception of fuel.
2. Prepare the path to the storage tank filling shed for fuel distribution
3. Measure the height of the product in the tank
4. Report fuel inventory.
5. Taking samples for quality inspection.
6. Implement the blending process.
7. Monitor filling the fuel into the tank car at filling the shed with the TAS system in the control room.

d. Transportation

Charge of fuel distribution schedule, enter the DO from sales to scheduling delivery of fuel through co-operation with the Patra Niaga, receiving complaints from customers and monitor the tank car at gate-in and gate-out.

e. Service and Maintenance

Responsible for facilities maintenance and vendor selection for productivity and quality improvement in TBBM Boyolali.

f. Finance

Finance is responsible for the following activities

1. Make a payment for taxes, bills and other financial purposes.
2. Make SP3 (Letter of Request for Payment Process)
3. Print and archive the VAT invoice

g. General Affair

Tasked to handle problems that are internal to the company's needs.

h. Quality and Quantity

In charge of controlling / ensure the quality and quantity of fuel received, deposited, distributed. Inspection is done by sampling in the field is then tested in a laboratory through a series of tests that determine the quality and product quality. Parameters measured were density, flashpoint, distillation and other testing.

i. Health, Safety, and Environment (HSE)

HSE department is responsible for the activities below.

1. Duty to keep an eye on the safety aspects of occupational health, and environmental protection.
2. Duty to check the documents of a company that will carry out the procurement of goods and services as well as risk assessment.
3. Monitoring and maintenance of safety equipment such as fire pumps, drainage in the storage tank and the resulting waste handling.

## CHAPTER III

## OPERATION MANAGEMENT

### 3.1 Operation Process

The operation process in TBBM Boyolali is categorized into three operations which includes receiving, stockpiling, and distribution. The products processed in TBBM Boyolali are Premium, Pertamax, Kerosene, and Solar, as well as Solarlite which will be processed in the future. All of the products is received through a pipe from Cilacap and delivered using distribution trucks managed PT. Pertamina Patra Niaga, a subsidiary company of PT. Pertamina (Persero) specializing in delivery trucks maintenance and delivery truck driver preparation. Production flow in TBBM Boyolali is shown in Figure 3.1.

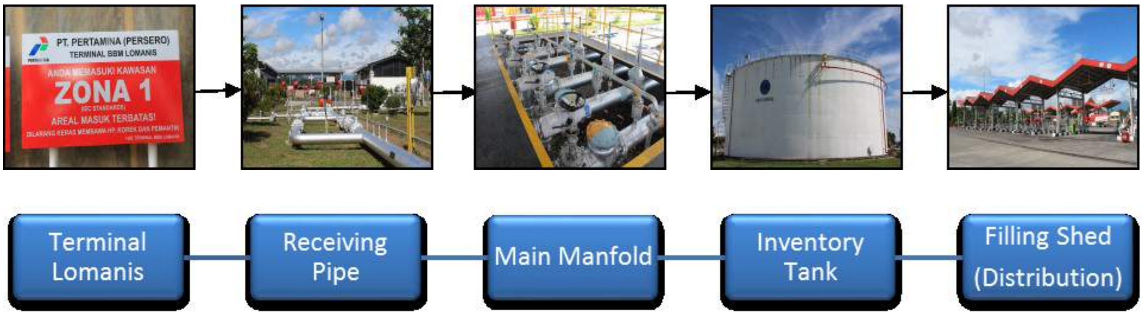



Figure 3.1 Production Flow in TBBM Boyolali

### 3.1.1 Receiving Operation

The production process in TBBM Boyolali begins with receiving fuel from Refinery Unit IV Cilacap as the main supply point. Beside of receiving from Refinery Unit IV Cilacap, TBBM Boyolali is also the consignment point for TBBM Madiun in East Java. The supply pipe route in TBBM Boyolali is shown in Figure 3.2.

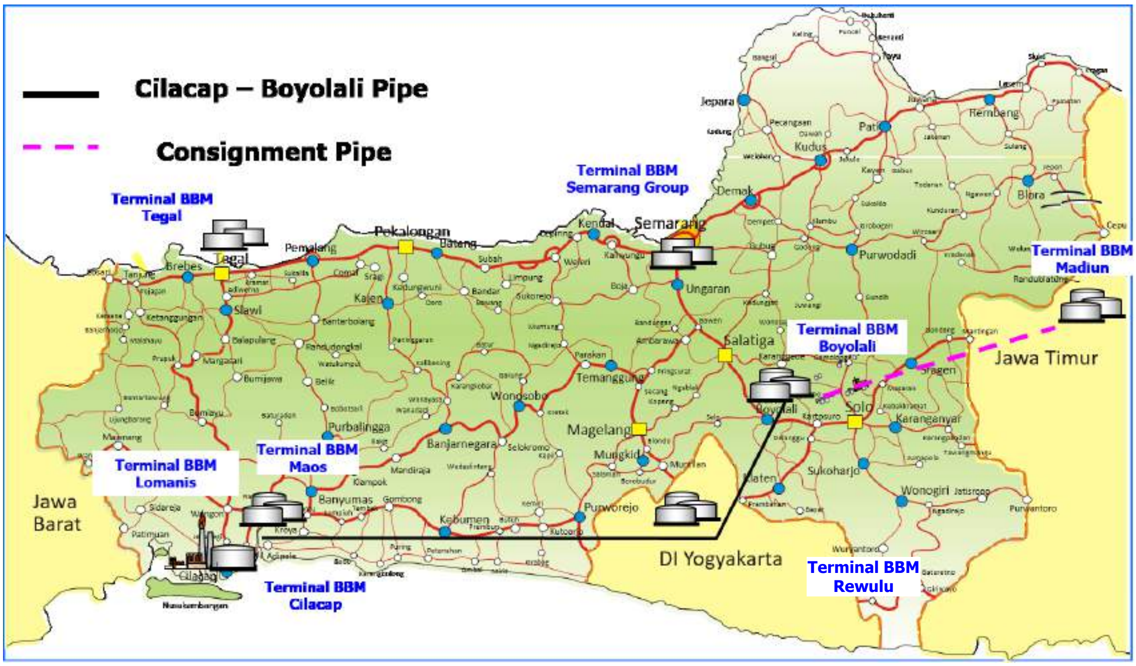



Figure 3.2 Supply Pipe Route for TBBM Boyolali

The main pipe from Cilacap is named Pipe CY 2. This pipe is 246 km long with diameter 12" and can deliver around 18,098 kL. The products received by TBBM Boyolali is separated by the main manifold. TBBM Boyolali receives around 137.427 kL/month.

### 3.1.2 Stockpiling Operation

The inventory tanks owned by TBBM Boyolali accommodates around 10.000 kL. TBBM Boyolali owns 11 inventory tanks. Figure 3.3 shows the inventory tanks available in TBBM Boyolali, the detail of the tanks is shown in Table 3.1

Table 3.1 Inventory Tanks Available in TBBM Boyolali

| Tank | Quantity | Capacity |
|---|---|---|
| Premium | 3 tanks | 13.000 kL |
| Pertamax | 2 tanks | 5.000 kL |
| Pertalite | 1 tanks | 5.000 kL |
| Solar | 3 tanks | 15.000 kL |
| Feed Stock | 1 tanks | 500 kL |
| FAME | 1 tanks | 126 kL |
| **Total** | **11 tanks** | **99,626 kL** |


Figure 3.3 Inventory Tanks in TBBM Boyolali

### 3.1.3 Distribution Operation

The distribution TBBM Boyolali distributes around 133.793 kL/month. The distribution point of TBBM Boyolali includes 230 fuel station, PT. KAI, and TNI/POLRI in Boyolali, Surakarta, Klaten, Wonogiri, Sukoharjo, Karanganyar, Salatiga, South Semarang (Ungaran, Ambarawa, Banyubiru), Purwodadi and the West region of East Java (Pacitan, Ngawi dan Magetan). Out of 230 fuel station 83 of them are less than 30 km from TBBM Boyolali, 64 fuel station in radius between 30 km to 60 km, and leaving 83 fuel station in radius more than 60 km. The distribution area covered by TBBM Boyolali is shown in Figure 3.4


Figure 3.4 Distribution area for TBBM Boyolali

### 3.1.4 Delivery Trucks

PT. Pertamina Patra Niaga, a subsidiary company of PT. Pertamina (Persero) manages the delivery trucks maintenance and delivery truck driver preparation. In total there are 96 delivery trucks used in 1 batch at TBBM Boyolali. The details of trucks used in a batch is shown in Table 3.2.

Table 3.2 Delivery Trucks for 1 Batch in TBBM Boyolali

| **Maximum Capacity** | **Quantity** |
|---|---|
| 8 kL | 1 Unit |
| 16 kL | 36 Unit |
| 24 kL | 41 Unit |
| 32 kL | 18 Unit |
| **Total** | **96 Unit** |

The delivery trucks in TBBM Boyolali must follow delivery truck flow which respectively are queue, truck registration, gate in, filling sheds, gate out, and fuel fill. The flow is shown in the Figure 3.5 with detail of area shown in Table 3.3

a. Queue Area

Every delivery truck driver must park their trucks in this area. After parking their truck, the driver must go to PT. Pertamina Patra Niaga office.

b. PT. Pertamina Patra Niaga Office

This is the area where every driver register for the filling scheduling and filling preparation. In this driver is given medical checkup and reminded about the safety regulations. In this area the driver waits to be called by TBBM Boyolali to fill their trucks in the rest area which is also available in this area. There is also a cafeteria in this area for driver’s food supply in this area.

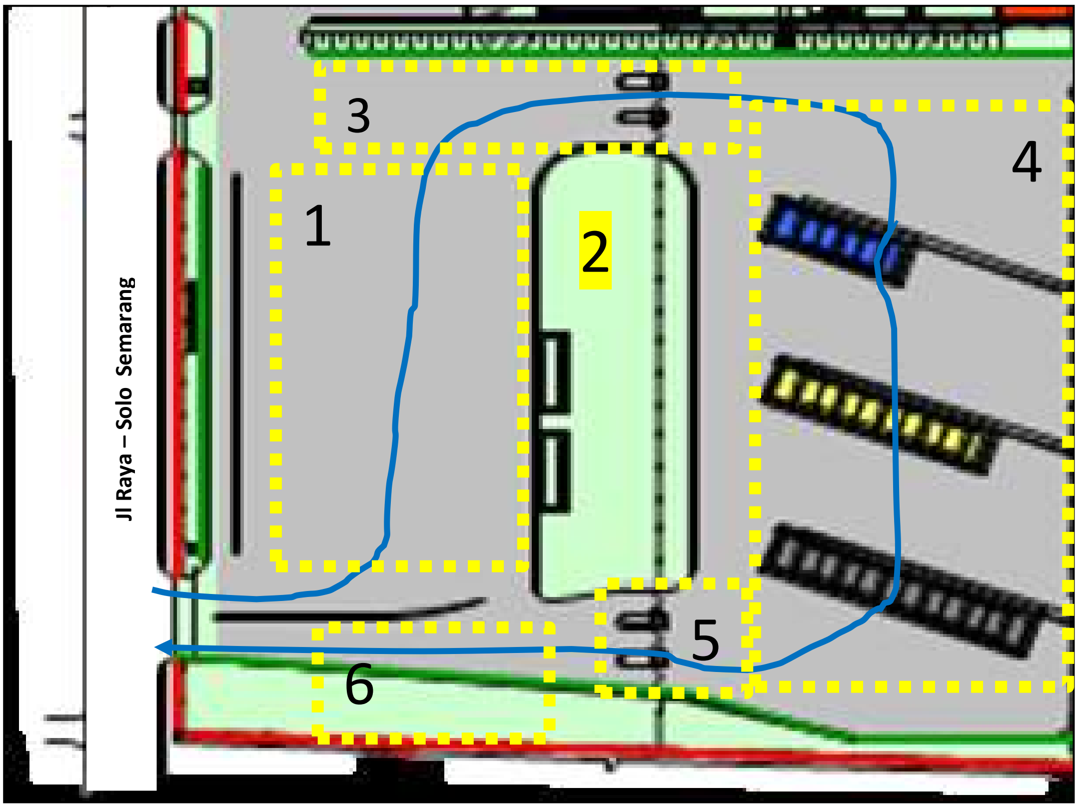



Figure 3.5 Distribution Truck Flow in TBBM Boyolali (Blue Line)

Table 3.3 Area Passed by Delivery Truck in TBBM Boyolali

| Area Number | Area Name |
|---|---|
| 1 | Queue Area |
| 2 | PT. Pertamina Patra Niaga Office |
| 3 | Gate in Area |
| 4 | Filling Sheds Area |
| 5 | Gate Out Area |
| 6 | Fuel Fill Area |

c. Gate in Area

Once called to fill their delivery trucks, drivers will drive their truck to this area before entering the filling sheds. In this area the driver will take an order check which shows what type of fuel to fill and where to drive their truck. The condition of the truck is also checked when entering this area.

The occupational safety regulations in the filling sheds are very strict. Therefore, in the gate in area the item that the drivers bring are thoroughly checked and borrowed a safety velvet and helmet. A delivery truck in the gate in area is shown in Figure 3.6

Figure 3.6 Delivery Truck in The “Gate in” Area

d. Filling Sheds

This is the area where the delivery trucks are filled. There are 29 filling sheds available in TBBM Boyolali with detail shown in Table 3.4. A delivery truck filling it's delivery tank in the filling shed is shown in Figure 3.7

Table 3.4 Quantity of Filling Sheds in TBBM Boyolali

| Input | Quantity |
|---|---|
| Premium | 12 |
| Pertamax | 4 |
| Solar | 11 |
| Pertalite | 2 |
| **Total** | **29** |


Figure 3.7 Delivery Truck in Filling Sheds Area

e. Gate out Area

Once finished filling the trucks, the trucks will enter this area and Quality and Quantity physical check of product is done. At this the area Quality and Quantity will check the storage tank fuel and ensure it is tightly closed.

f. Fuel Fill Area

Before leaving TBBM Boyolali, normally a truck will fill their fuel for distribution. The fuel tank in every truck is separated with storage tank.

## 3.2 Monitoring and Control

All of the operation in TBBM Boyolali is monitored and controlled in the control room. This is one of the area in TBBM Boyolali which operates non-stop, 24 hours a day, 7 days a week, and no holidays. The monitor and control system in TBBM Boyolali is partially automated and named Terminal Automation System (TAS). TAS includes monitoring and controlling receiving pipes, inventory tanks, and fuel station (customer). The view in TBBM Boyolali's control room is shown in Figure 3.8

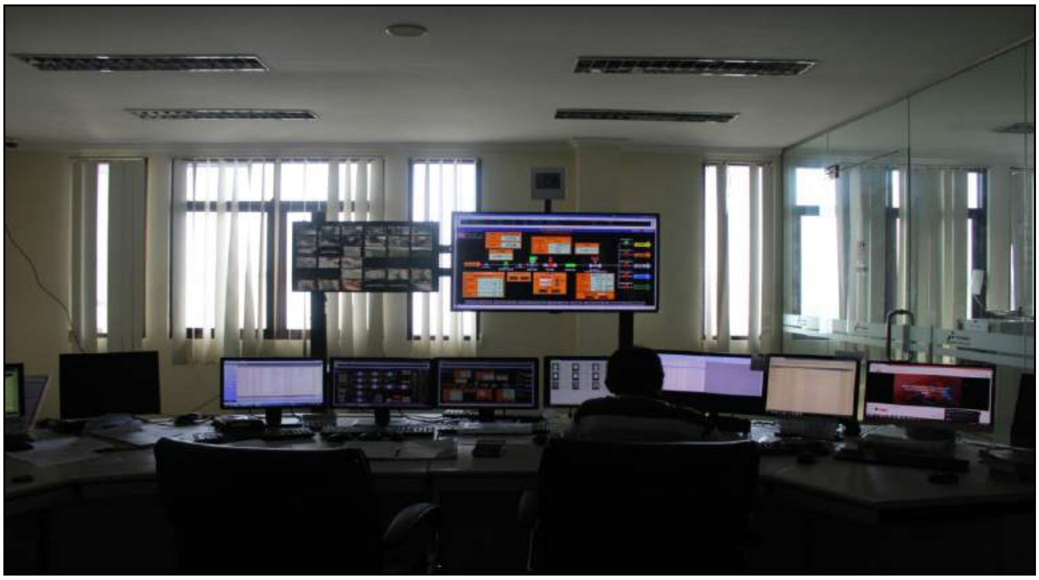


Figure 3.8 Control Room in TBBM Boyolali

### 3.2.1 Pipe Line Batch Tracking System (PBTS)

Pipe Line Batch Tracking System (PBTS) is a system which controls the receiving activities and is directly involved with the inventory tanks in TBBM Boyolali. From Refinery Unit IV Cilacap fuel is delivered through a pipe which also passes through TBBM Rewulu. Fuel is delivered based on production quantity and schedule in Refinery Unit IV Cilacap and this system will help TBBM Boyolali in separating the fuels in main manifold, closing and opening the inventory tank.

The only non-automated process in this system is opening some of the Pressure Control Valve (PCV) (some of them are already automated). If not done correctly the inventory tank will worn out and cause big loss for TBBM Boyolali

### 3.2.2 Fuel Sales & Distribution Management System (FSDMS)

Fuel Sales & Distribution Management System (FSDMS) is a system to control the product inventory in fuel stations. With this system TBBM Boyolali is able to reduce customer dissatisfaction by refilling the inventory of fuel in the fuel station before it becomes scarce in the region. The FSDMS screenshot is shown in Figure 3.9

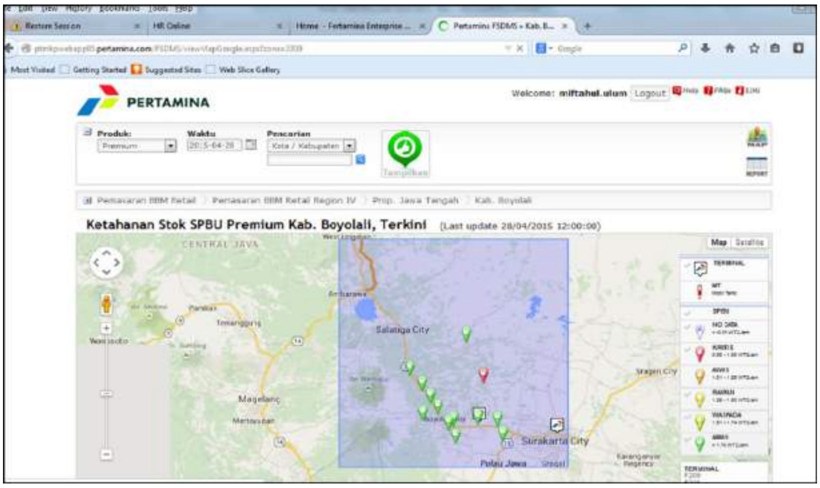



Figure 3.9 Fuel Sales & Distribution Management System (FSDMS)

# CHAPTER IV

# CAUSAL FORECASTING DURING IDUL FITRI CYCLE FOR FUEL DEMAND IN PT. PERTAMINA (PERSERO) TBBM BOYOLALI

## 4.1 Background

The last part of a downstream in a supply chain is the most crucial part in forecasting because they directly knows the customer's demand (Synestos, et al., 2015). Understanding their position in the supply chain, TBBM Boyolali always try to develop the best demand forecast periodically.

However, TBBM Boyolali mostly finds difficulties in developing the accurate forecast during special occasions such as *Idul Fitri*, New Year eve, long holidays, etc. During special occasions TBBM Boyolali tends to keep the fuel inventory at safety level based on the highest level of forecasted demand in order to avoid backlog. For example, the predicted demand of premium for New Year eve is forecasted to be maximum at 3000 kL and with this forecast, TBBM Boyolali will keep the premium stock at 3000 kL. Doing this very costly for every part of the supply chain and causes a direct bullwhip effect to the whole supply chain which ends up in big loss for PT. Pertamina's supply chain.

In order to overcome this problem, researcher is given special task to develop a model, identify causes of demand, and forecast demand for the nearest special occasion which is *Idul Fitri* based on the last 2 years historical data between 10 days before and after the event. Hopefully with this research the loss and bullwhip in PT. Pertamina's supply chain can be minimized while also maintaining the ability to fulfill the customer's demand.

## 4.2 Problem Formulation

From the explanation above, the problem to be solved are as follows:

a. How can PT. Pertamina (Persero) TBBM Boyolali forecast fuel demand during 10 days before up to 10 days after *Idul Fitri*?
b. What are the factors influencing fuel demand between 10 days before and after *Idul Fitri*?
c. How much is the forecasted demand during 10 days before and after *Idul Fitri* in 2016?

## 4.3 Research Objective

The objective of this research are as follows:

a. To develop a fuel demand forecasting model for 10 days before up to 10 days after *Idul Fitri*
b. To identify the factors influencing fuel demand between 10 days before and after *Idul Fitri*?
c. To find the forecasted demand during 10 days before and after *Idul Fitri* in 2016?

## 4.4 Research Limitations

The limitations of this research are as follows:

a. The data used for this research is daily demand for the last 2 years during 10 days before and after Idul Fitri
b. Influencing factors are based on observation or experiment
c. Confidence level is 95% ($\alpha = 0.05$)
d. Product Family (Fuel) Decomposition is not done

## 4.5 Research Methodology

### 4.5.1 Basic Theory

Demand is uncertain and it needs to be forecasted (Syntetos, et. al., 2015). In order to support the decision making in a production planning, forecasting has been a necessity reference.

In forecasting there are 4 components to consider (Montgomery, et. al., 1989). The components are as follows:

a. Trend
   The smooth long-term direction of a time series
b. Cycle
   A component of time which is the point where a pattern tends to repeat
c. Seasonal Variation
   Patterns of change in a time series within a cycle. These patterns. Tend to repeat themselves each cycle
d. Irregular Variation
   A variation obtained by observing the demand pattern cause. The cause may be observation or experimental based

Based on these components, many method has been developed to obtain the best forecasting result and each not all components is considered in a particular method (Makridakis & Wheelwright, 1989). In general, the methods of forecasting is categorized as time-series and causal forecasting method. Time-series forecasting main weakness is the inability to predict irregular variation (Farizal, et. al., 2014). Thus, in this research, causal forecasting is used.

Figure 4.1 and Figure 4.2 shows example of components to consider in forecasting.

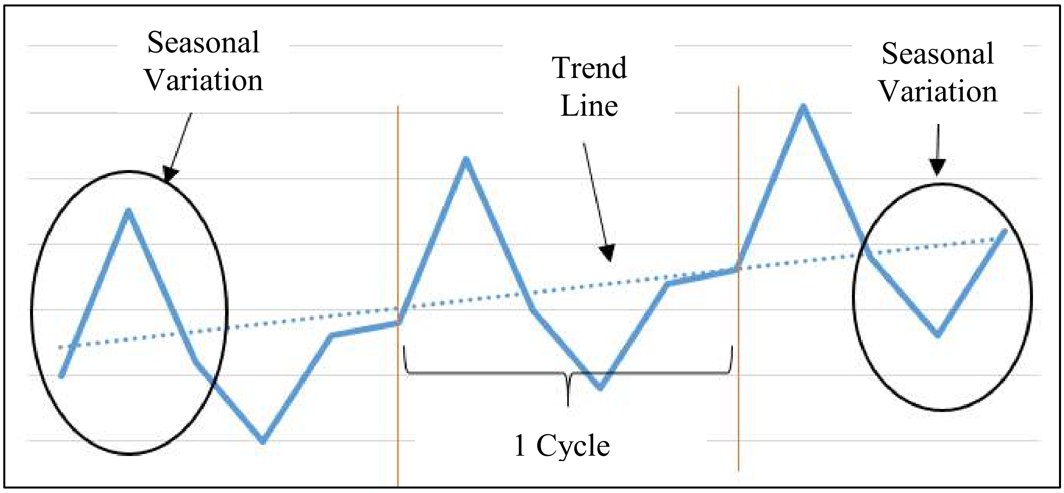



Figure 4.1 Demand Pattern with Increasing Trend and Seasonal Variation

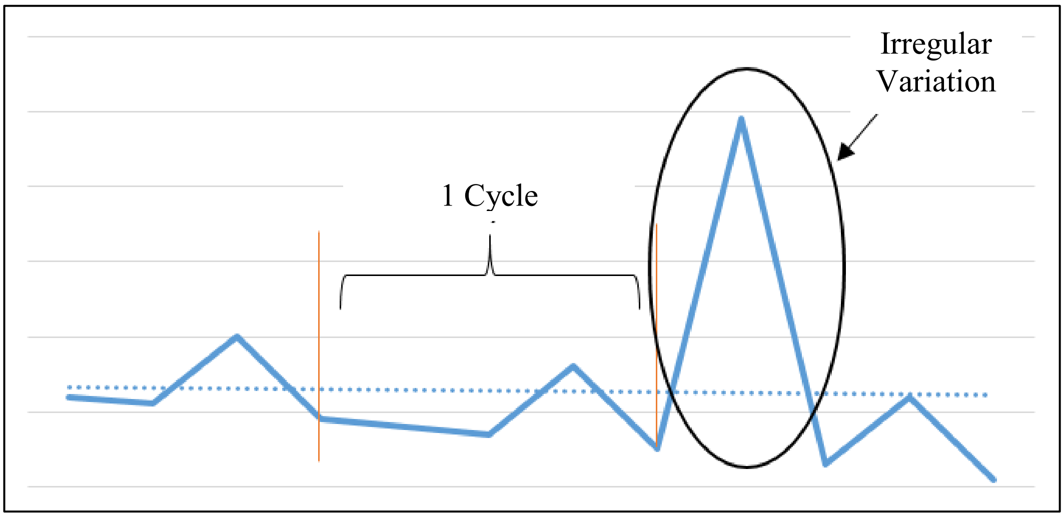



Figure 4.2 Demand Pattern with Decreasing Trend and Irregular Variation

One of the most popular method in causal forecasting is regression. From various types of regression, the most common method used is Multi-Linear Regression (MLR) (Choi & Abdullah, 2016). In forecasting, MLR is able to model the relation between a dependent variable and two or more predictor variables (Vining, 1998; Walpole, et. al., 2007). MLR is represented by Equation 4.1.

$$Y = a + \sum_{i=1}^{n} b_i x_i + e \qquad (4.1)$$

where:

$Y$ : predicted value

$a$ : intercept value

$b_i$: predictor variable weight for factor $i$

$x_i$: predictor variable constant for factor $i$

$e$ : error factor

In regression there are 3 assumptions to consider (Rawlings, et. al., 1998). The assumptions are listed below.

a. Severe multicollinearity (correlation among predictors) must not occur in regression

   In regression, multicollinearity refers to predictors that are correlated with other predictors. Moderate multicollinearity may not be problematic. However, severe multicollinearity is problematic because it can increase the variance of the regression coefficients, making them unstable and difficult to interpret.

   Multicollinearity can be founded by examining the correlation structure of the predictor variables or reviewing the variance inflation factor (VIF), which measures how much the variance of an estimated regression coefficient increases if your predictors are correlated. If the VIF = 1, there is no multicollinearity but if the VIF is > 1, predictors may be moderately correlated. When the VIF is 5 - 10, the regression coefficients are poorly estimated. The equation to find VIF is available in the Equation 4.2.

$VIF = \frac{1}{1-R_j^2}$ .......................................................................................... (4.2)

where:

$VIF$ : variance inflation factor

$R^2$ : coefficient of determination

When using VIF, the solution for severe multicollinearity is by removing highly correlated predictors in the model. Because they supply redundant information, removing them often does not drastically reduce the $R^2$

b. All predictor variables must have significant impact to the MLR model

Analyzing the significance of predictor variables in a regression line is handled by an analysis-of-variance (ANOVA) approach: a procedure whereby the total variation in the dependent variable is subdivided into meaningful components that are then observed and treated in a systematic fashion. In this research, ANOVA is done simultaneously and individually

1. Simultaneous ANOVA test

Simultaneous ANOVA test in this research is done by conducting simultaneous *F* test. In this test the significance level of each predictor variables ($\beta_i$) are compared. The test follows Equation 4.3.

$H_0 : \beta_1 = \beta_2 = \beta_3 = \cdots = \beta_k = 0$ versus $H_1 : \beta_1, \beta_2, \beta_{3,} \ldots \beta_k \neq 0$ ...... (4.3)

where:

$\beta_k$ : significance level of predictor $k$

To test the hypothesis, we use Minitab to calculate $f$. $H_0$ is rejected at the α-level of significance when $f_{computation} > f_{\alpha}(k, n-k-1)$ where n stands for number of observation and k stands for number of predictors. Once the regression model pass this test, each of the predictors must be tested

2. Individual ANOVA test

Individual ANOVA test in this research is done by analyzing each predictor's p-value. A predictor can only pass this test if the p-value is lower than α-value. In this research we allow Minitab to calculate the p-value

c. No outliers is identified in the regression model

In order to reduce ambiguity in a model, outliers must be identified. A clear model consist of no outliers. In this research outliers is identified when the standardized residual of an observation is lower than -2 or higher than 2. To solve outliers problem, removing a factor or adding an unidentified factor based on demand pattern is needed.

After developing a forecasting model, knowing the forecasting quality is important. By knowing the forecast quality, a forecaster can make adjustments based on his/her experience to keep expenses at minimum level. Forecast quality in MLR can be defined by checking the Coefficient of Determination ($R^2$) and Mean Absolute Error (MAE).

a. Coefficient of Determination ($R^2$)

$R^2$ is a measure that shows how similar is the forecast developed compared to the original demand. $R^2$ value ranges from 0 up to 1, the higher the value the higher similarity of the developed model has with the original condition. Therefore, when $R^2 = 1$ the developed model is identical with the original condition. In this research, $R^2$ is calculated using Minitab

b. Mean Absolute Error (MAE)

When forecasting, expecting an error in forecast is a must. One of the most common method to determine error is by calculating the Mean Absolute Error (MAE). MAE can directly shows how much error is developed by the forecast in average. MAE is computed using Equation 4.4.

$$MAE = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n} \qquad (4.4)$$

where:

$MAE$ : mean absolute error

$A_t$ : actual demand at period t

$F_t$ : forecasted demand at period t

$n$ : number of observations

### 4.5.2 Research Flow

Figure 4.3 shows the steps required to conduct this research.

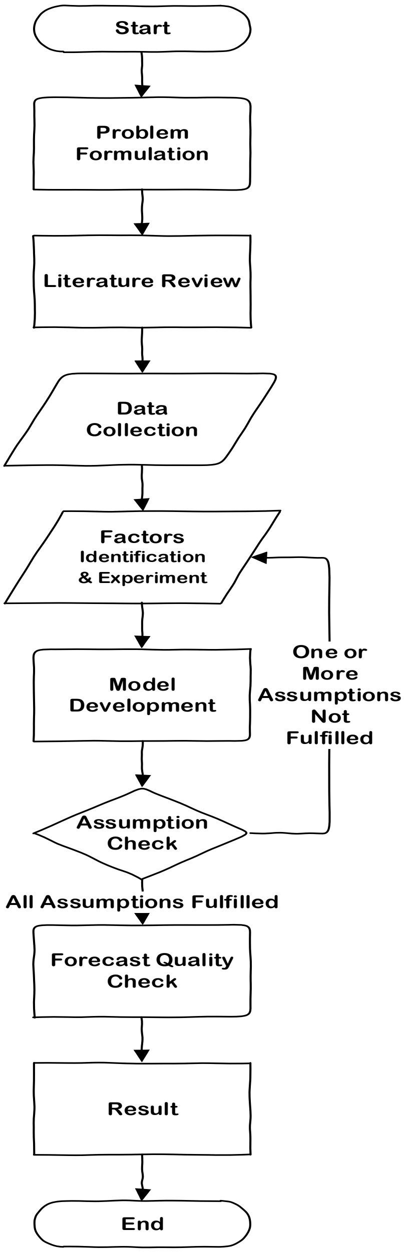



Figure 4.3 Research Flowchart

The explanation of each steps are as follows:

1. Problem Formulation

The research begins by formulating the problem to solve. The main problem to solve in this research is demand forecasting between 10 days before and after *Idul Fitri*.

2. Literature Review

   In order to overcome the research problem, literature review is done. The literature review in this research is limited to literatures about forecasting and regression.

3. Data Collection

   Data collection in this research is the daily historical demand data. The historical data given is the demand historical data between 10 days before and after *Idul Fitri* for 2014 and 2015. At this stage the historical demand data is observed and an interview with the expert to identify all possible factors is done.

4. Factors Identification & Experiment

   At this stage, all factors are identified and experimented. Initially all factors are quantitatively identified based on observation and then experimented. Experiment on the factors is done in order to fulfill all assumptions and obtain the best forecast model.

5. Model Development

   Once the data is collected and factors are identified, all of them is inputted into Minitab. Minitab will develop the model for the regression line.

6. Assumptions Check

   At this point, all assumptions must be satisfied. If one of them is not satisfied, factors need to be adjusted. It would need several iterations to pass the assumptions check.

7. Forecast Quality Check

   Before obtaining the forecast result, model (forecast) quality check is conducted. The quality check in this research is done by determining the Coefficient of Determination ($R^2$) and Mean Absolute Error (MAE).

8. Result

   Based on the model developed in Minitab and identified factors, the future demand can be predicted. The forecast quality is determined by the Coefficient of Determination ($R^2$) while Mean Absolute Error (MAE) is a references for expert judgement adjustments. Product family (fuel) is not decomposed in this research because of the recent product of Pertamina, Pertalite is new in 2016's forecast and may cause decomposition of the product family using historical data unreliable.

## 4.6 Data Collection

In this research the data is collected from the historical data demand. The historical data demand used is the daily demand from 10 days before *Idul Fitri* up to 10 days after *Idul Fitri*. In this case, 1 cycle consist of 21 days in a year (10 days before *Idul Fitri*, *Idul Fitri* day, and 10 days after *Idul Fitri*). The historical demand data are shown in Table 4.1 for the 1st cycle (2014) data and Table 4.2 for the 2nd cycle (2015) data and the pattern developed by these data is shown in Figure 4.4

Table 4.1 Historical Demand Data 1st Cycle (2014)

| **Period** | **Days from/to *Idul Fitri*** | **Day** | **Date** | **Historical Demand** | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Premium** | **Pertamax** | **Solar/Biosolar** | **Total** |
| 1 | -10 | Friday | 18 July 2014 | 2928 | 44 | 1584 | 4556 |
| 2 | -9 | Saturday | 19 July 2014 | 3320 | 32 | 1984 | 5336 |
| 3 | -8 | Sunday | 20 July 2014 | 2952 | 16 | 1480 | 4448 |
| 4 | -7 | Monday | 21 July 2014 | 2320 | 16 | 1088 | 3424 |
| 5 | -6 | Tuesday | 22 July 2014 | 4136 | 60 | 1944 | 6140 |
| 6 | -5 | Wednesday | 23 July 2014 | 3464 | 28 | 1456 | 4948 |
| 7 | -4 | Thursday | 24 July 2014 | 3584 | 24 | 1408 | 5016 |
| 8 | -3 | Friday | 25 July 2014 | 3864 | 76 | 984 | 4924 |
| 9 | -2 | Saturday | 26 July 2014 | 4552 | 96 | 1192 | 5840 |
| 10 | -1 | Sunday | 27 July 2014 | 4456 | 24 | 784 | 5264 |
| 11 | *Idul Fitri* | Monday | 28 July 2014 | 4280 | 76 | 592 | 4948 |
| 12 | +1 | Tuesday | 29 July 2014 | 3848 | 48 | 376 | 4272 |
| 13 | +2 | Wednesday | 30 July 2014 | 4608 | 64 | 704 | 5376 |
| 14 | +3 | Thursday | 31 July 2014 | 4360 | 20 | 592 | 4972 |
| 15 | +4 | Friday | 01 August 2014 | 4888 | 56 | 928 | 5872 |
| 16 | +5 | Saturday | 02 August 2014 | 4496 | 80 | 1160 | 5736 |
| 17 | +6 | Sunday | 03 August 2014 | 4128 | 48 | 1208 | 5384 |

| Period | Days from/to *Idul Fitri* | Day | Date | Historical Demand | | | |
|---|---|---|---|---|---|---|---|
| | | | | Premium | Pertamax | Solar/Biosolar | Total |
| 18 | +7 | Monday | 04 August 2014 | 3024 | 76 | 728 | 3828 |
| 19 | +8 | Tuesday | 05 August 2014 | 3768 | 64 | 1928 | 5760 |
| 20 | +9 | Wednesday | 06 August 2014 | 3552 | 52 | 1696 | 5300 |
| 21 | +10 | Thursday | 07 August 2014 | 3528 | 40 | 2080 | 5648 |

Table 4.2 Historical Demand Data 2nd cycle (2015)

| Period | Days from/to *Idul Fitri* | Day | Date | Historical Demand | | | |
|---|---|---|---|---|---|---|---|
| | | | | Premium | Pertamax | Solar/Biosolar | Total |
| 22 | -10 | Tuesday | 07 July 2015 | 3736 | 340 | 1352 | 5428 |
| 23 | -9 | Wednesday | 08 July 2015 | 2832 | 176 | 1364 | 4372 |
| 24 | -8 | Thursday | 09 July 2015 | 3000 | 284 | 1360 | 4644 |
| 25 | -7 | Friday | 10 July 2015 | 3016 | 196 | 1320 | 4532 |
| 26 | -6 | Saturday | 11 July 2015 | 3408 | 256 | 1476 | 5140 |
| 27 | -5 | Sunday | 12 July 2015 | 3160 | 232 | 1064 | 4456 |
| 28 | -4 | Monday | 13 July 2015 | 2832 | 288 | 648 | 3768 |
| 29 | -3 | Tuesday | 14 July 2015 | 4272 | 360 | 1168 | 5800 |
| 30 | -2 | Wednesday | 15 July 2015 | 4168 | 364 | 952 | 5484 |
| 31 | -1 | Thursday | 16 July 2015 | 4744 | 448 | 1016 | 6208 |

| Period | Days from/to *Idul Fitri* | Day | Date | Historical Demand | | | |
|---|---|---|---|---|---|---|---|
| | | | | Premium | Pertamax | Solar/Biosolar | Total |
| 32 | *Idul Fitri* | Friday | 17 July 2015 | 4080 | 320 | 520 | 4920 |
| 33 | +1 | Saturday | 18 July 2015 | 3440 | 224 | 288 | 3952 |
| 34 | +2 | Sunday | 19 July 2015 | 4224 | 156 | 608 | 4988 |
| 35 | +3 | Monday | 20 July 2015 | 4008 | 220 | 520 | 4748 |
| 36 | +4 | Tuesday | 21 July 2015 | 4616 | 388 | 1104 | 6108 |
| 37 | +5 | Wednesday | 22 July 2015 | 3808 | 372 | 968 | 5148 |
| 38 | +6 | Thursday | 23 July 2015 | 3560 | 356 | 1144 | 5060 |
| 39 | +7 | Friday | 24 July 2015 | 2928 | 272 | 1104 | 4304 |
| 40 | +8 | Saturday | 25 July 2015 | 3344 | 320 | 1384 | 5048 |
| 41 | +9 | Sunday | 26 July 2015 | 2976 | 280 | 920 | 4176 |
| 42 | +10 | Monday | 27 July 2015 | 2416 | 108 | 840 | 3364 |

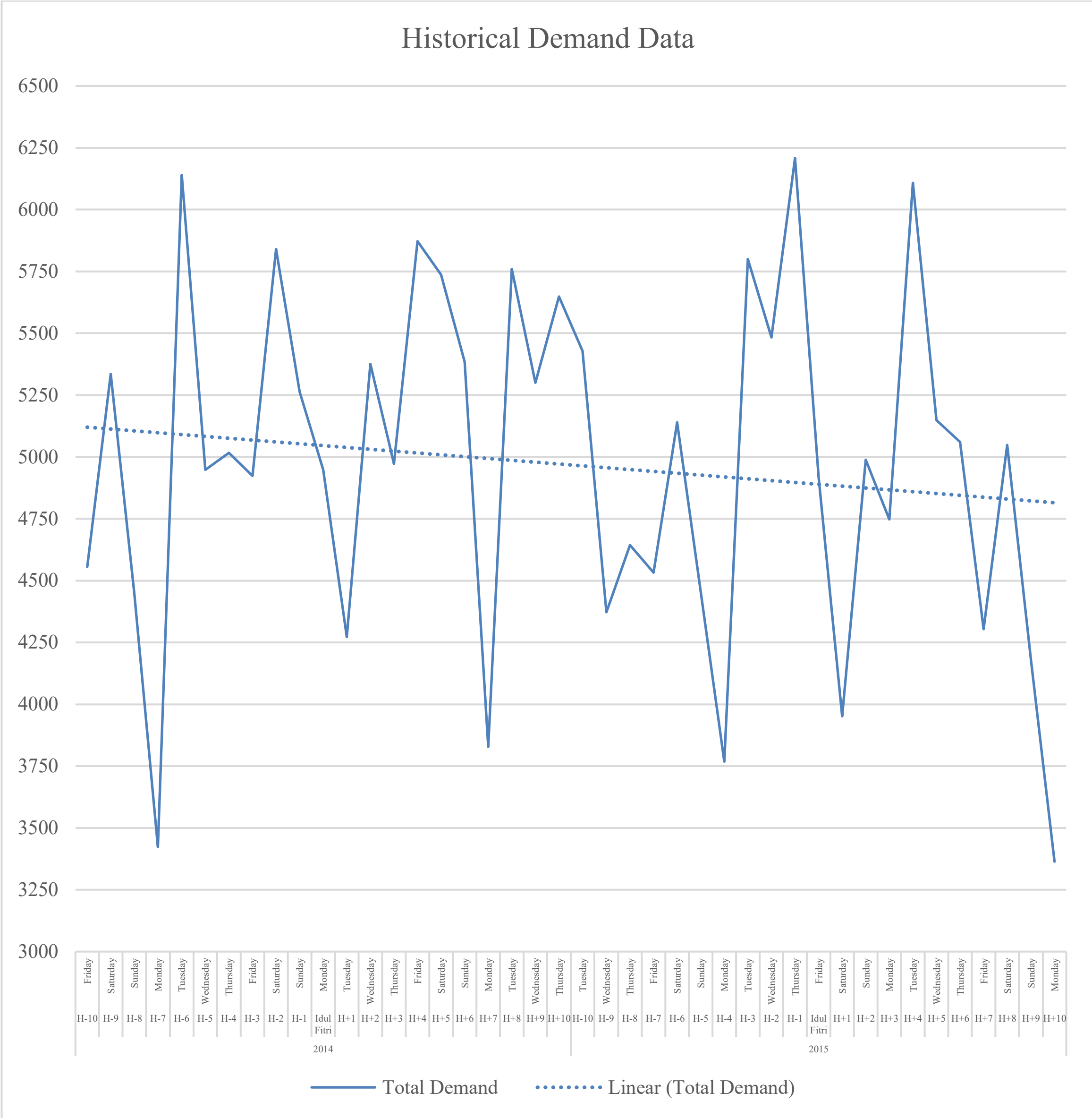



Figure 4.4 Historical Data Demand Pattern

By comparing the data in each cycle, there are several information which can be inferred. The comparison and information obtained are as follows:

a. The trend in the pattern tends to decrease

Based on the demand pattern in figure 4.4, it can be inferred that the demand pattern tends to decrease every year. This is shown by the Linear (Total Demand) line

b. The demand tends to follow a seasonal pattern based on daily basis

Figure 4.5 below shows the demand pattern comparison of each cycle based on the day of demand occurrence

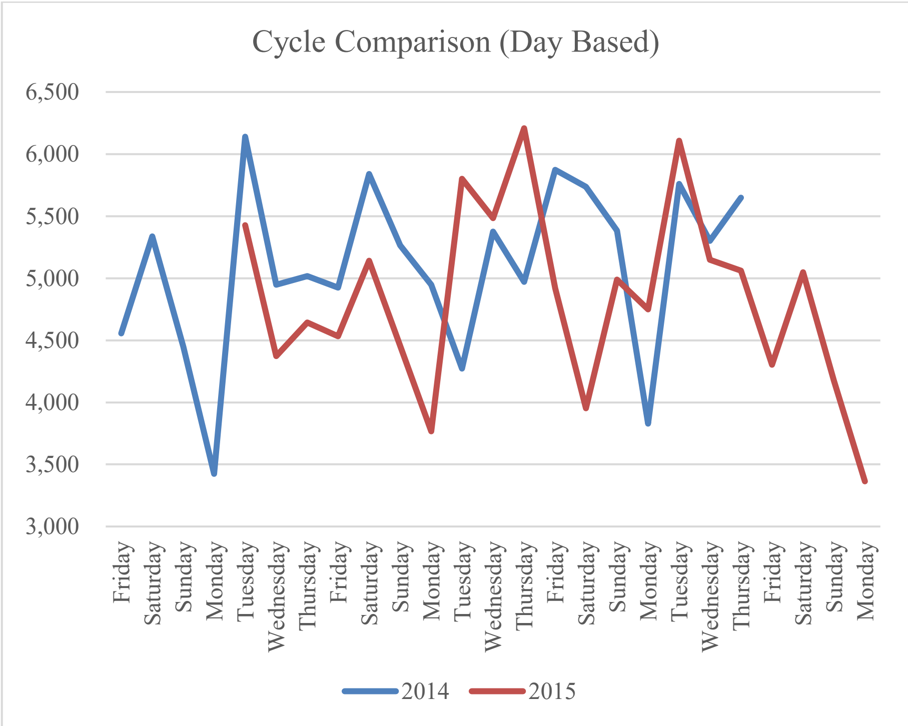



Figure 4.5 Demand Pattern Cycle Comparison (Day Based)

From the comparison we can infer that fuel demand tends to follow a daily pattern, although on some occasion irregular variations occurs instead of seasonal variations. The daily demand pattern identified are as follows:

1. On Tuesday, the demand tends to increase except for the second Tuesday of 2014 (1 day after *Idul Fitri*)
2. On Wednesday, the demand tends to decrease except for the second Wednesday of 2014 (2 day after *Idul Fitri*)
3. On Thursday, the demand movement varies with increasing pattern on the first Thursday of each year and varying on the next Thursdays.

4. On Friday, the demand tends to decrease except for the second Friday on 2014 (4 day after *Idul Fitri*)
5. On Saturday, the demand tends to increase except for the third Saturday of 2014 (5 day after *Idul Fitri*) where it decreases slightly and second Saturday of 2015 where it drastically decreases (1 day after *Idul Fitri*)
6. On Sunday, the demand tends to decrease except for the second Sunday of 2014 (2 day after *Idul Fitri*)
7. On Monday, the demand tends to decrease

c. The demand tends to follow a seasonal pattern based on periods in the cycle

Figure 4.6 below shows the demand pattern comparison of each cycle on a 21 day period. The pattern shows that demand tends to repeat in every cycle and this may explain irregularity in the first cycle comparison

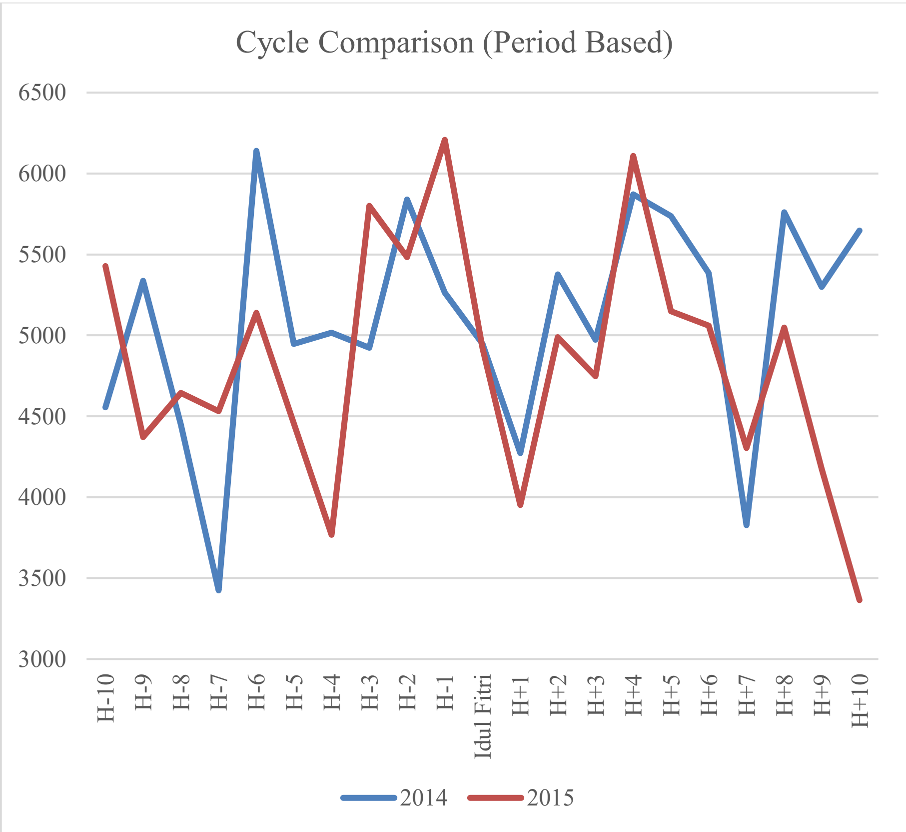



Figure 4.6 Demand Pattern Cycle Comparison (Period Based)

The seasonal variations identified in the comparison above are as follows:

1. The demand tends to decrease on *Idul Fitri*
2. The demand tends to decrease 1 day after *Idul Fitri*
3. The demand tends to increase 2 day after *Idul Fitri*
4. The demand tends to decrease 3 day after *Idul Fitri*
5. The demand tends to increase 4 day after *Idul Fitri*

d. Irregular variations occurs before and after *Idul Fitri*

By comparing the seasonal variations obtained in daily based cycle and period based cycle, irregular variation can be identified. In this case the irregular variation is identified before and after *Idul Fitri*. After discussing with expert, these variations is referred as homecoming stream and return stream respectively for the irregular variations which occurs before and after *Idul Fitri*.

## 4.7 Data Processing

The data processing in this research may consist of several iterations. Each iteration will start with factors identification and experiments, continued with model development, Minitab input, Minitab processing, Minitab output, and ends with assumptions check. The iterations will stop once all of the assumptions is fulfilled.

### 4.7.1 1st Iteration

a. Factors Identification and Experiment

The first iteration will follow the data collection initial factors. The factors at this stage will not be experimented.

b. Model Development

All of the factors previously identified must be weighted. The weighting will be determined in Table 4.3, Table 4.4, and Table 4.5

Table 4.3 Weighting Factor Table of 1st Iteration for Mathematical Model (Factor 1 -6)

| Period $j$ | Factors ($i = 1, 2, 3, \dots 6$) | | | | | |
|---|---|---|---|---|---|---|
| | **Period** $i = 1$ | **Monday** $i = 2$ | **Tuesday** $i = 3$ | **Thursday** $i = 4$ | **Wednesday** $i = 5$ | **Friday** $i = 6$ |
| 1 | $b_{1,1}$ | $b_{2,1}$ | $b_{3,1}$ | $b_{4,1}$ | $b_{5,1}$ | $b_{5,1}$ |
| 2 | $b_{1,2}$ | $b_{2,2}$ | $b_{3,2}$ | $b_{4,2}$ | $b_{5,2}$ | $b_{5,2}$ |
| 3 | $b_{1,3}$ | $b_{2,3}$ | $b_{3,3}$ | $b_{4,3}$ | $b_{5,3}$ | $b_{5,3}$ |
| $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ |
| 42 | $b_{1,42}$ | $b_{2,42}$ | $b_{3,42}$ | $b_{4,42}$ | $b_{5,42}$ | $b_{5,42}$ |

Table 4. 4 Weighting Factor Table of 1st Iteration for Mathematical Model (Factor 7 -10)

| Period $j$ | Factors ($i = 7, 8, 9, 10$) | | | |
|---|---|---|---|---|
| | **Saturday** $i = 7$ | **Sunday** $i = 8$ | ***Idul Fitri* day** $i = 9$ | **1 day after *Idul Fitri*** $i = 10$ |
| 1 | $b_{7,1}$ | $b_{8,1}$ | $b_{9,1}$ | $b_{10,1}$ |
| 2 | $b_{7,2}$ | $b_{8,2}$ | $b_{9,2}$ | $b_{10,2}$ |
| 3 | $b_{7,3}$ | $b_{8,3}$ | $b_{9,3}$ | $b_{10,3}$ |
| $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ |
| 42 | $b_{7,42}$ | $b_{8,42}$ | $b_{9,42}$ | $b_{10,42}$ |

Table 4.5 Weighting Factor Table of 1st Iteration for Mathematical Model (Factor 12 -15)

| Period $j$ | Factors ($i = 11, 12, 13, \ldots 15$) | | | | |
|---|---|---|---|---|---|
| | 2 day after *Idul Fitri* $i = 11$ | 3 day after *Idul Fitri* $i = 12$ | 4 day after *Idul Fitri* $i = 13$ | Homecoming Stream $i = 14$ | Return Stream $i = 15$ |
| 1 | $b_{11,1}$ | $b_{12,1}$ | $b_{13,1}$ | $b_{14,1}$ | $b_{15,1}$ |
| 2 | $b_{11,2}$ | $b_{12,2}$ | $b_{13,2}$ | $b_{14,2}$ | $b_{15,2}$ |
| 3 | $b_{11,3}$ | $b_{12,3}$ | $b_{13,3}$ | $b_{15,3}$ | $b_{15,3}$ |
| $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ |
| 42 | $b_{11,42}$ | $b_{12,42}$ | $b_{13,42}$ | $b_{15,42}$ | $b_{15,42}$ |

The factor weighting table will be filled with quantitative data. The algorithm to fulfill the table follows Equation 4.5 – 4.19.

$$b_{1,j} = j \quad (4.5)$$

$$b_{2,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Monday} \\ 0, & \text{otherwise} \end{cases} \quad (4.6)$$

$$b_{3,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Tuesday} \\ 0, & \text{otherwise} \end{cases} \quad (4.7)$$

$$b_{4,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Wedenesday} \\ 0, & \text{otherwise} \end{cases} \quad (4.8)$$

$$b_{5,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Thurday} \\ 0, & \text{otherwise} \end{cases} \quad (4.9)$$

$$b_{6,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Friday} \\ 0, & \text{otherwise} \end{cases} \quad (4.10)$$

$$b_{7,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Saturday} \\ 0, & \text{otherwise} \end{cases} \quad (4.11)$$

$$b_{8,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Sunday} \\ 0, & \text{otherwise} \end{cases} \quad (4.12)$$

$$b_{9,j} = \begin{cases} 1, & \text{period } j \text{ occurs on } Idul\ Fitri \text{ day} \\ 0, & \text{otherwise} \end{cases} \quad (4.13)$$

$$b_{10,j} = \begin{cases} 1, & \text{period } j \text{ occurs on 1 day after } Idul\ Fitri \\ 0, & \text{otherwise} \end{cases} \quad (4.14)$$

$$b_{11,j} = \begin{cases} 1, & \text{period } j \text{ occurs on 2 day after } Idul\ Fitri \\ 0, & \text{otherwise} \end{cases} \quad (4.15)$$

$$b_{12,j} = \begin{cases} 1, & period\ j\ occurs\ on\ 3\ day\ after\ Idul\ Fitri \\ 0, & otherwise \end{cases} \quad \text{.........(4.16)}$$

$$b_{13,j} = \begin{cases} 1, & period\ j\ occurs\ on\ 4\ day\ after\ Idul\ Fitri \\ 0, & otherwise \end{cases} \quad \text{.........(4.17)}$$

$$b_{14,j} = \begin{cases} 1, & period\ j\ occurs\ on\ homecoming\ stream \\ 2, & period\ j\ occurs\ on\ homecoming\ stream\ peak \\ 3, & period\ j\ occurs\ on\ homecoming\ stream\ peak \\ & and\ 1\ day\ before\ Idul\ Fitri \\ 0, & otherwise \end{cases} \quad (4.18)$$

$$b_{15,j} = \begin{cases} 1, & \text{Period } j \text{ occurs on return stream} \\ 2, & \text{Period } j \text{ occurs on return stream peak} \\ 0, & \text{otherwise} \end{cases} \quad \text{...............(4.19)}$$

where :

$b_{i,j}$ : weighting for factor $i$ on period $j$

The mathematical model above is developed based on observation and experiment. Weighting factor 1 up to 13 is fulfilled based on observation while weighting factor 14 and 15 is fulfilled by experiment based on expert judgement. The fulfilled weighting is available in Table 4.6 and Table 4.7.

With 15 factor identified, the forecasting model result will follow Equation 4.20.

$$F_j = a + \sum_{i=1}^{15} b_{i,j} x_{i,j} \quad \text{..............................................................(4.20)}$$

where :

$F_j$ : forecast of period $j$

$a$ : intercept value

$b_{i,j}$ : weighting for factor $i$ on period $j$

$x_{i,j}$ : constant for factor $i$ on period $j$

Table 4.6 Weighting Factor Table of 1st Iteration for Regression (Factor 1 – 8)

| Period | Days from/to *Idul Fitri* | Day | Factors ($i = 1, 2, 3, 4, 5, 6, 7, 8$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Period** | **Monday** | **Tuesday** | **Wednesday** | **Thursday** | **Friday** | **Saturday** | **Sunday** |
| 1 | -10 | Friday | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2 | -9 | Saturday | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 3 | -8 | Sunday | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 4 | -7 | Monday | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | -6 | Tuesday | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6 | -5 | Wednesday | 6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 7 | -4 | Thursday | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 8 | -3 | Friday | 8 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 9 | -2 | Saturday | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10 | -1 | Sunday | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11 | *Idul Fitri* | Monday | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | +1 | Tuesday | 12 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 13 | +2 | Wednesday | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 14 | +3 | Thursday | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 15 | +4 | Friday | 15 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 16 | +5 | Saturday | 16 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 17 | +6 | Sunday | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| Period | Days from/to *Idul Fitri* | Day | Factors ($i = 1, 2, 3, 4, 5, 6, 7, 8$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Period | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| 18 | +7 | Monday | 18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | +8 | Tuesday | 19 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 20 | +9 | Wednesday | 20 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 21 | +10 | Thursday | 21 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 22 | -10 | Tuesday | 22 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 23 | -9 | Wednesday | 23 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 24 | -8 | Thursday | 24 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 25 | -7 | Friday | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 26 | -6 | Saturday | 26 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 27 | -5 | Sunday | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 28 | -4 | Monday | 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | -3 | Tuesday | 29 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 30 | -2 | Wednesday | 30 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 31 | -1 | Thursday | 31 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 32 | *Idul Fitri* | Friday | 32 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 33 | +1 | Saturday | 33 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 34 | +2 | Sunday | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 35 | +3 | Monday | 35 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| Period | Days from/to *Idul Fitri* | Day | Factors ($i = 1, 2, 3, 4, 5, 6, 7, 8$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Period | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| 36 | +4 | Tuesday | 36 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 37 | +5 | Wednesday | 37 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 38 | +6 | Thursday | 38 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 39 | +7 | Friday | 39 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 40 | +8 | Saturday | 40 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 41 | +9 | Sunday | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 42 | +10 | Monday | 42 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 4.7 Weighting Factor Table of 1st Iteration for Regression (Factor 9 - 15)

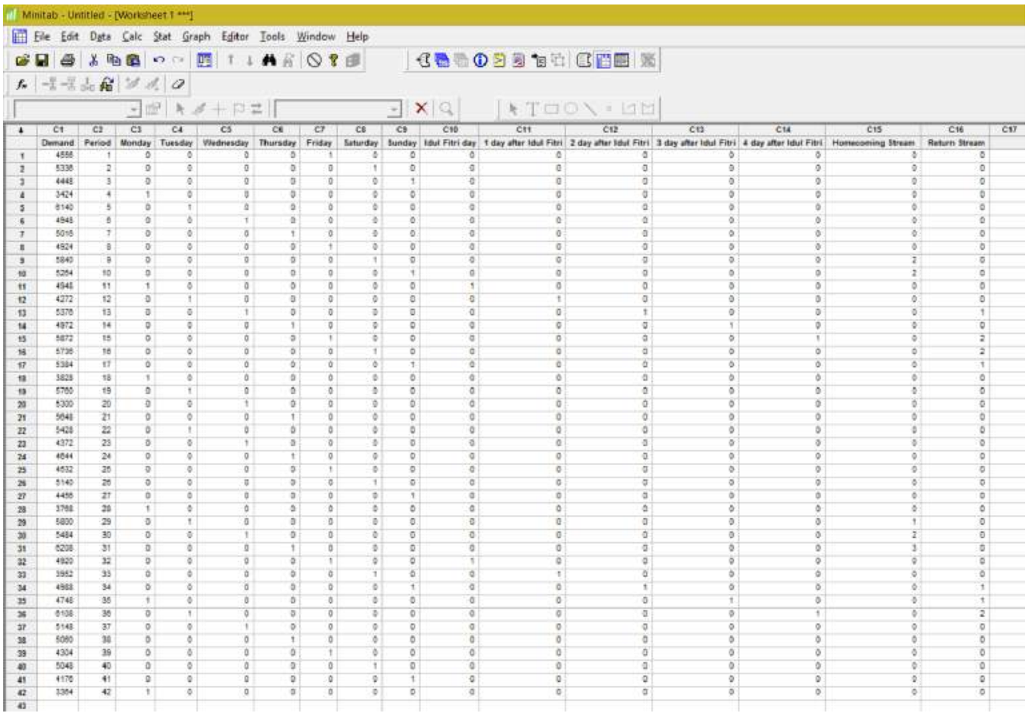
| **Period** | **Days from/to *Idul Fitri*** | **Day** | **Factors ($i = 9, 10, 11, 12, 13, 14, 15$)** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | ***Idul Fitri* day** | **1 day after *Idul Fitri*** | **2 day after *Idul Fitri*** | **3 day after *Idul Fitri*** | **4 day after *Idul Fitri*** | **Homecoming Stream** | **Return Stream** |
| 1 | -10 | Friday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | -9 | Saturday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | -8 | Sunday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | -7 | Monday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | -6 | Tuesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | -5 | Wednesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | -4 | Thursday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | -3 | Friday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | -2 | Saturday | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 10 | -1 | Sunday | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 11 | *Idul Fitri* | Monday | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | +1 | Tuesday | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 13 | +2 | Wednesday | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 14 | +3 | Thursday | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 15 | +4 | Friday | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| 16 | +5 | Saturday | 0 | 0 | 0 | 0 | 0 | 0 | 2 |

| Period | Days from/to *Idul Fitri* | Day | Factors ($i = 9, 10, 11, 12, 13, 14, 15$) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Idul Fitri* day | 1 day after *Idul Fitri* | 2 day after *Idul Fitri* | 3 day after *Idul Fitri* | 4 day after *Idul Fitri* | Homecoming Stream | Return Stream |
| 17 | +6 | Sunday | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 18 | +7 | Monday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | +8 | Tuesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | +9 | Wednesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | +10 | Thursday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | -10 | Tuesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | -9 | Wednesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | -8 | Thursday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | -7 | Friday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | -6 | Saturday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | -5 | Sunday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | -4 | Monday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | -3 | Tuesday | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 30 | -2 | Wednesday | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 31 | -1 | Thursday | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| 32 | *Idul Fitri* | Friday | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | +1 | Saturday | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

| Period | Days from/to *Idul Fitri* | Day | Factors ($i = 9, 10, 11, 12, 13, 14, 15$) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Idul Fitri* day | 1 day after *Idul Fitri* | 2 day after *Idul Fitri* | 3 day after *Idul Fitri* | 4 day after *Idul Fitri* | Homecoming Stream | Return Stream |
| 34 | +2 | Sunday | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 35 | +3 | Monday | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 36 | +4 | Tuesday | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| 37 | +5 | Wednesday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | +6 | Thursday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | +7 | Friday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | +8 | Saturday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | +9 | Sunday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | +10 | Monday | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

c. Minitab Software Processing

All of the data obtained is inputted and processed in Minitab. Minitab software used is Minitab 16.0. The image of data inputting in Minitab 16.0 is shown in the Figure 4.7




| ↓ | C1 Demand | C2 Period | C3 Monday | C4 Tuesday | C5 Wednesday | C6 Thursday | C7 Friday | C8 Saturday | C9 Sunday | C10 Idul Fitri day | C11 1 day after Idul Fitri | C12 2 day after Idul Fitri | C13 3 day after Idul Fitri | C14 4 day after Idul Fitri | C15 Homecoming Stream | C16 Return Stream | C17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4556 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 2 | 5336 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 4448 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 4 | 3424 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 5 | 6140 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 6 | 4948 | 6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 5016 | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 8 | 4924 | 8 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 5840 | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | |
| 10 | 5264 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | |
| 11 | 4948 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 12 | 4272 | 12 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 5376 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| 14 | 4972 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | |
| 15 | 5872 | 15 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | |
| 16 | 5736 | 16 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 17 | 5384 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 18 | 3828 | 18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 19 | 5760 | 19 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 20 | 5300 | 20 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 21 | 5648 | 21 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 22 | 5428 | 22 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 23 | 4372 | 23 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 24 | 4644 | 24 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 25 | 4632 | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 26 | 5140 | 26 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 27 | 4456 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 28 | 3768 | 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 29 | 5800 | 29 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | |
| 30 | 5484 | 30 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | |
| 31 | 6208 | 31 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | |
| 32 | 4920 | 32 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 33 | 3952 | 33 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 34 | 4988 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| 35 | 4748 | 35 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | |
| 36 | 6108 | 36 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | |
| 37 | 5148 | 37 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 38 | 5080 | 38 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 39 | 4304 | 39 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 40 | 5048 | 40 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 41 | 4176 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 42 | 3364 | 42 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 43 | | | | | | | | | | | | | | | | | |

Figure 4.7 Minitab Data Input ($1^{st}$ Iteration)

Once all of the data is inputted, the process is followed by generating the regression line (shown in Figure 4.8). In the regression window select "Demand" as Response and "Period" up to "Return Stream" as Predictors (shown in Figure 4.9). Before clicking "OK" ensure that the "Variance Inflation Factor" checkbox is checked (shown in Figure 4.10) in order to check the multicollinearity assumption. The output generated by Minitab is shown in Figure 4.11 and Figure 4.12

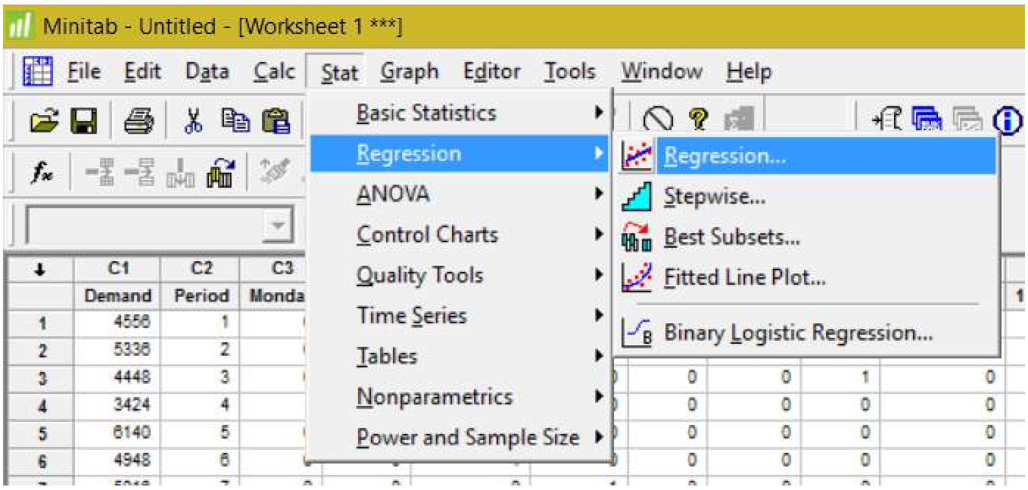



Figure 4.8 Regression Line Generating

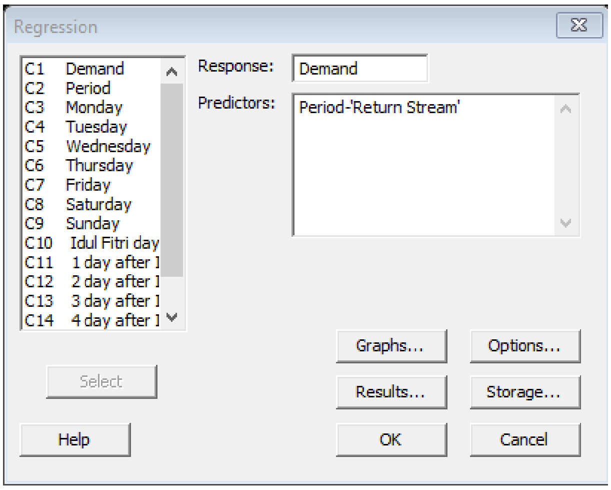



Figure 4.9 Regression Line Data Inputting (1st Iteration)

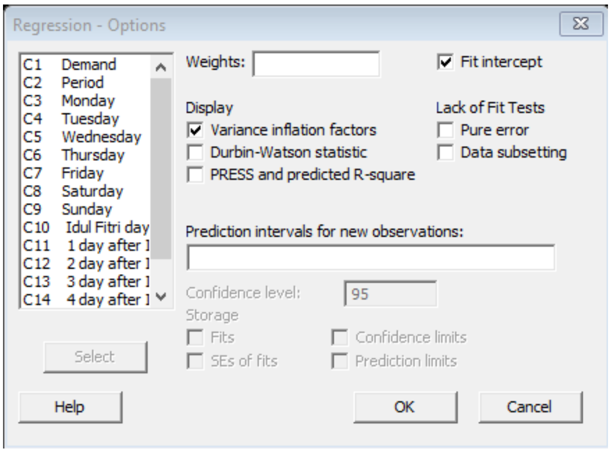



Figure 4.10 “Variance Inflation Factor” checkbox must be checked

**Regression Analysis: Demand versus Period, Monday, ...**

```
* Sunday is highly correlated with other X variables
* Sunday has been removed from the equation.


The regression equation is
Demand = 4659 - 7.07 Period - 730 Monday + 1051 Tuesday + 396
Wednesday
         + 540 Thursday + 45 Friday + 585 Saturday + 769 Idul Fitri
day
         - 1206 1 day after Idul Fitri + 9 2 day after Idul Fitri
         + 228 3 day after Idul Fitri - 1 4 day after Idul Fitri
         + 361 Homecoming Stream + 482 Return Stream


Predictor                    Coef  SE Coef      T      P    VIF
Constant                   4659.1    172.7  26.98  0.000
Period                     -7.074    4.209  -1.68  0.104  1.024
Monday                     -729.7    205.8  -3.55  0.001  2.040
Tuesday                    1050.8    205.5   5.11  0.000  2.033
Wednesday                   395.5    190.5   2.08  0.047  1.747
Thursday                    539.7    202.3   2.67  0.013  1.970
Friday                       44.9    207.9   0.22  0.831  2.081
Saturday                    584.7    200.0   2.92  0.007  1.926
Idul Fitri day              769.4    255.9   3.01  0.006  1.168
1 day after Idul Fitri    -1205.7    258.1  -4.67  0.000  1.188
2 day after Idul Fitri        9.0    289.4   0.03  0.975  1.494
3 day after Idul Fitri      228.0    266.3   0.86  0.399  1.265
4 day after Idul Fitri       -1.3    399.5  -0.00  0.998  2.847
Homecoming Stream          360.66    78.04   4.62  0.000  1.119
Return Stream               482.3    155.0   3.11  0.004  3.064

S = 326.808   R-Sq = 86.3%   R-Sq(adj) = 79.2%


Analysis of Variance

Source          DF        SS       MS      F      P
Regression      14  18193802  1299557  12.17  0.000
Residual Error  27   2883696   106804
Total           41  21077498

Source                  DF   Seq SS
Period                   1   342505
Monday                   1  6242132
Tuesday                  1  1482521
Wednesday                1    36902
Thursday                 1   486767
Friday                   1    76346
Saturday                 1   441169
Idul Fitri day           1   604007
1 day after Idul Fitri   1  3802227
2 day after Idul Fitri   1   144512
3 day after Idul Fitri   1   194893
4 day after Idul Fitri   1  1309269
Homecoming Stream        1  1996476
Return Stream            1  1034077
```

Figure 4.11 1st Iteration Minitab Output (Page 1)

```
Unusual Observations

Obs  Period  Demand     Fit  SE Fit  Residual  St Resid
 16    16.0  5736.0  6095.3   288.4    -359.3     -2.34R
 21    21.0  5648.0  5050.3   146.7     597.7      2.05R

R denotes an observation with a large standardized residual.
```

Figure 4.12 1st Iteration Minitab Output (Page 2)

d. Assumptions Check

The output of Minitab for the 1st iteration indicates that there are some assumptions that are not satisfied. The assumptions check details are as follows:

1. Multicollinearity occurs on Sunday factor which causes Minitab directly removing the factor from the model. According to Minitab the factor is already represented by other factors. This is shown in Figure 4.11

2. Even though the model passes the simultaneous ANOVA test, this model fails to pass the individual ANOVA test. The predictors which fail to pass are predictor with p-value larger than 0.05 (Period, Wednesday, Thursday, Friday, Saturday, *Idul Fitri* Day, 2 day after *Idul Fitri*, 3 day after *Idul Fitri*, and 4 day after *Idul Fitri*). The evidence of this assumption check is shown in Equation 4.21 computation below for the simultaneous test and p-values in Figure 4.11

$$f_{computation} > f_{\alpha}(k, n-k-1) \quad (4.21)$$

$$f_{computation} > f_{0.05}(14,27)$$

$$12.17 > 2.08$$

3. Based on Minitab output on Figure 4.12, there are outliers on observation 16 and 21.

### 4.7.2 2nd Iteration

a. Factors Identification and Experiment

Based on the assumptions check in the 1st iteration the repair needed in the model are as follows:

1. Removing predictor 1 (Period)
2. Removing predictor 4 (Wednesday)
3. Removing predictor 5 (Thursday)
4. Removing predictor 6 (Friday)
5. Removing predictor 7 (Saturday)
6. Removing predictor 8 (Sunday)
7. Removing predictor 9 (*Idul Fitri* Day)
8. Removing predictor 11 (2 day after *Idul Fitri*)
9. Removing predictor 12 (3 day after *Idul Fitri*)
10. Removing predictor 13 (4 day after *Idul Fitri*)

b. Model Development

All of the factors previously identified follows the same weighting as in the 1st iteration. By excluding predictor 1, 4, 5, 6, 7, 8, 9, 11, 12, and 13, the forecasting follows Equation 4.22

$$F_j = a + \sum_{i=1}^{15} b_{i,j} x_{i,j} \qquad , i \in N: 2,3,10,14,15 \quad \text{.............}(4.22)$$

where :

$F_j$ : forecast of period *j*

$a$ : intercept value

$b_{i,j}$ : weighting for factor $i$ on period *j*

$x_{i,j}$ : constant for factor $i$ on period *j*

c. Minitab Software Processing

Since we are only removing unwanted predictors, in Minitab 16.0 the data doesn't need to be changed. However, the predictors in developing the regression line will change as shown in Figure 4.13. Output of this model is available in Figure 4.14 and Figure 4.15

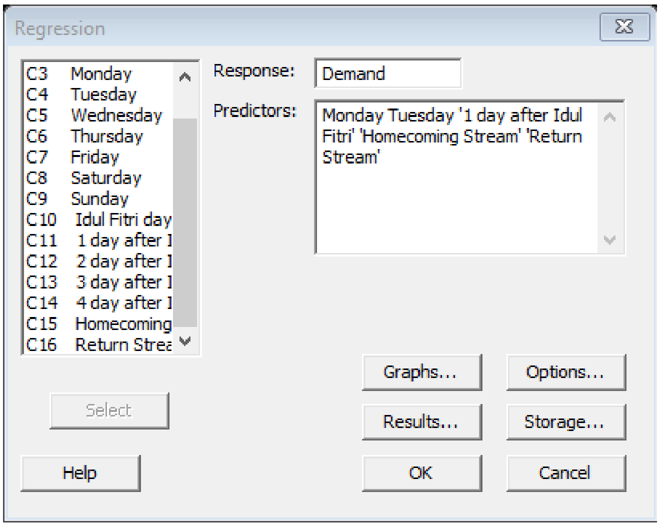



Figure 4.13 Regression Line Data Inputting ($2^{nd}$ Iteration)

**Regression Analysis: Demand versus Monday, Tuesday, ...**

```
The regression equation is
Demand = 4858 - 916 Monday + 704 Tuesday - 1098 1 day after Idul
Fitri
         + 378 Homecoming Stream + 428 Return Stream


Predictor                   Coef  SE Coef      T      P    VIF
Constant                 4858.37    84.44  57.54  0.000
Monday                    -916.4    180.5  -5.08  0.000  1.063
Tuesday                    703.6    182.7   3.85  0.000  1.089
1 day after Idul Fitri    -1098.1    299.3  -3.67  0.001  1.083
Homecoming Stream         377.85    92.27   4.10  0.000  1.060
Return Stream              428.4    110.1   3.89  0.000  1.047


S = 397.013   R-Sq = 73.1%   R-Sq(adj) = 69.3%

Analysis of Variance

Source          DF        SS       MS      F      P
Regression       5  15403193  3080639  19.54  0.000
Residual Error  36   5674305   157620
Total           41  21077498
```

Figure 4.14 $2^{nd}$ Iteration Minitab Output ($1^{st}$ page)

```
Source                   DF    Seq SS
Monday                    1   6374629
Tuesday                   1   1510301
1 day after Idul Fitri    1   3188632
Homecoming Stream         1   1943452
Return Stream             1   2386179


Unusual Observations

Obs  Monday  Demand     Fit  SE Fit  Residual  St Resid
 11    1.00  4948.0  3941.9   163.1    1006.1     2.78R
 12    0.00  4272.0  4463.8   295.2    -191.8    -0.72 X
 21    0.00  5648.0  4858.4    84.4     789.6     2.04R
 33    0.00  3952.0  3760.2   295.2     191.8     0.72 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Figure 4.15 2nd Iteration Minitab Output (2nd page)

d. Assumptions Check

The output of Minitab for the 2nd iteration indicates that there are some assumptions that are not satisfied. The assumptions check are as follows:

1. Multicollinearity doesn't occur. Shown by the VIF values in Figure 4.14

2. Both variances ANOVA test are satisfied. The evidence that the 2nd iterations passes the simultaneous ANOVA test is shown in the Equation 4.23 below and the individual test evidence is shown by the p-values in Figure 4.14

$$f_{computation} > f_{\alpha}(,n-k-1) \quad (4.23)$$

$$f_{computation} > f_{0.05}(5,36)$$

$$19.54 > 2.48$$

3. Based on Minitab output on Figure 4.15, there are outliers on observation 11 and 21.

### 4.7.3 3rd Iteration

a. Factors Identification and Experiment

By observing the outliers in the previous iteration (observation 11 and 21), it can be inferred that observation 11 occurs on Idul Fitri day on the first cycle while observation 21 the last day in the first cycle. After discussion with expert, the problem in observation 11 may be caused due to predictor weight overlap between daily predictors and *Idul Fitri* day predictor. Thus, the researcher decided to re-add the Idul Fitri day factor while also adjusting daily predictors to 0 when it overlaps.

b. Model Development

Based on the previous factor identification a new model is developed. The model follows the weighting table factor (shown in Table 4.8), mathematical model, and forecasting equations below.

Table 4.8 Weighting Factor Table of 3rd Iteration for Mathematical Model

| **Period** $j$ | **Factors ($i = 1, 2, 3, \ldots 6$)** | | | | | |
|---|---|---|---|---|---|---|
| | **Mon day** $i = 1$ | **Tues day** $i = 2$ | ***Idul Fitri* day** $i = 3$ | **1 day after *Idul Fitri*** $i = 4$ | **Homecoming Stream** $i = 5$ | **Return Stream** $i = 6$ |
| 1 | $b_{1,1}$ | $b_{2,1}$ | $b_{3,1}$ | $b_{4,1}$ | $b_{5,1}$ | $b_{5,1}$ |
| 2 | $b_{1,2}$ | $b_{2,2}$ | $b_{3,2}$ | $b_{4,2}$ | $b_{5,2}$ | $b_{5,2}$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 42 | $b_{1,42}$ | $b_{2,42}$ | $b_{3,42}$ | $b_{4,42}$ | $b_{5,42}$ | $b_{5,42}$ |

The factor weighting table will be filled with quantitative data based on mathematical model below in Equation 4.24 – 4.29.

$$b_{1,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Monday and } b_{3,j} \neq 1 \\ 0, & \text{otherwise} \end{cases} \quad \text{..............(4.24)}$$

$$b_{2,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Tuesday and } b_{3,j} \neq 1 \\ 0, & \text{otherwise} \end{cases} \quad \text{.............(4.25)}$$

$$b_{3,j} = \begin{cases} 1, & \text{period } j \text{ occurs on } Idul\ Fitri \text{ day} \\ 0, & \text{otherwise} \end{cases} \quad \text{.........................(4.26)}$$

$$b_{4,j} = \begin{cases} 1, & \text{period } j \text{ occurs on 1 day after } Idul\ Fitri \\ 0, & \text{otherwise} \end{cases} \quad \text{.............(4.27)}$$

$$b_{5,j} = \begin{cases} 1, & \text{period } j \text{ occurs on homecoming stream} \\ 2, & \text{period } j \text{ occurs on homecoming stream peak} \\ 3, & \text{period } j \text{ occurs on homecoming stream peak} \\ & \text{and 1 day before Idul Fitri} \\ 0, & \text{otherwise} \end{cases} \quad \text{....(4.28)}$$

$$b_{6,j} = \begin{cases} 1, & \text{Period } j \text{ occurs on return stream} \\ 2, & \text{Period } j \text{ occurs on return stream peak} \\ 0, & \text{otherwise} \end{cases} \quad \text{................(4.29)}$$

where :

$b_{i,j}$ : weighting for factor $i$ on period $j$

The forecasting result will be calculated using Equation 4.30.

$$F_j = a + \sum_{i=1}^{6} b_{i,j} x_{i,j} \quad \text{..............................................................(4.30)}$$

where :

$F_j$ : forecast of period $j$

$a$ : intercept value

$b_{i,j}$ : weighting for factor $i$ on period $j$

$x_{i,j}$ : constant for factor $i$ on period $j$

Based on the mathematical model above, a newly filled weighting factors table is developed. The table is shown in Table 4.9

Table 4.9 Weighting Factor Table of 3rd Iteration for Regression

| **Period** | **Factors ($i = 1, 2, 3, \dots 6$)** | | | | | |
|---|---|---|---|---|---|---|
| | **Mon day** | **Tues day** | ***Idul Fitri* day** | **1 day after *Idul Fitri*** | **Homecoming Stream** | **Return Stream** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 2 | 0 |
| 10 | 0 | 0 | 0 | 0 | 2 | 0 |
| 11 | 0 | 0 | 1 | 0 | 0 | 0 |
| 12 | 0 | 1 | 0 | 1 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 1 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 2 |
| 16 | 0 | 0 | 0 | 0 | 0 | 2 |
| 17 | 0 | 0 | 0 | 0 | 0 | 1 |
| 18 | 1 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 1 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 1 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 |

| Period | Factors ($i = 1, 2, 3, \dots 6$) | | | | | |
|---|---|---|---|---|---|---|
| | **Mon day** | **Tues day** | ***Idul Fitri* day** | **1 day after *Idul Fitri*** | **Homecoming Stream** | **Return Stream** |
| 29 | 0 | 1 | 0 | 0 | 1 | 0 |
| 30 | 0 | 0 | 0 | 0 | 2 | 0 |
| 31 | 0 | 0 | 0 | 0 | 3 | 0 |
| 32 | 0 | 0 | 1 | 0 | 0 | 0 |
| 33 | 0 | 0 | 0 | 1 | 0 | 0 |
| 34 | 0 | 0 | 0 | 0 | 0 | 1 |
| 35 | 1 | 0 | 0 | 0 | 0 | 1 |
| 36 | 0 | 1 | 0 | 0 | 0 | 2 |
| 37 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | 1 | 0 | 0 | 0 | 0 | 0 |

c. Minitab Software Processing

Since some predictors are re-added and adjusted, rewriting the data in Minitab 16.0 will reduce confusion (shown in Figure 4.16). The inputting process to generate the Minitab output is shown in Figure 4.17. Output of this model is shown in Figure 4.18 and Figure 4.19.

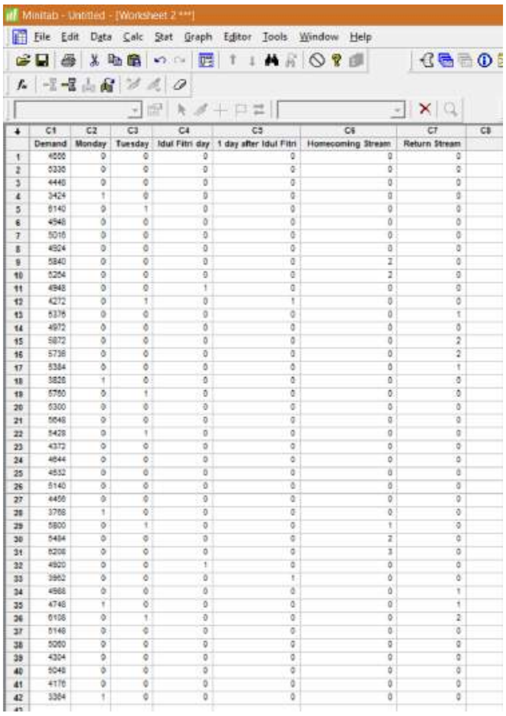



Figure 4.16 Minitab Data Input (3rd Iteration)

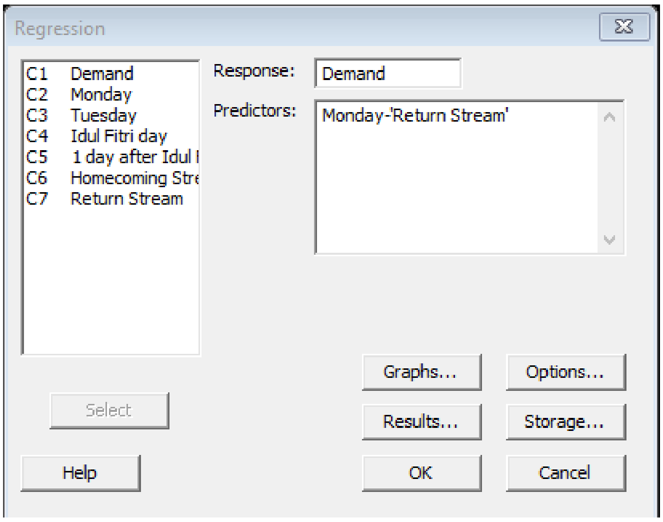



Figure 4.17 Regression Line Data Inputting (3rd Iteration)

**Regression Analysis: Demand versus Monday, Tuesday, ...**

```
The regression equation is
Demand = 4851 - 1113 Monday + 704 Tuesday + 83 Idul Fitri day
         - 1091 1 day after Idul Fitri + 381 Homecoming Stream
         + 445 Return Stream
```

Figure 4.18 3rd Iteration Minitab Output (1st Page)

```
Predictor                    Coef  SE Coef      T      P    VIF
Constant                  4850.80    77.65  62.47  0.000
Monday                    -1113.5    175.2  -6.36  0.000  1.063
Tuesday                     703.6    164.4   4.28  0.000  1.093
Idul Fitri day               83.2    263.9   0.32  0.754  1.043
1 day after Idul Fitri    -1090.6    269.2  -4.05  0.000  1.085
Homecoming Stream          381.29    83.19   4.58  0.000  1.067
Return Stream              445.39    99.36   4.48  0.000  1.057


S = 356.668   R-Sq = 78.9%   R-Sq(adj) = 75.3%


Analysis of Variance

Source          DF        SS       MS      F      P
Regression       6  16625078  2770846  21.78  0.000
Residual Error  35   4452420   127212
Total           41  21077498

Source                  DF   Seq SS
Monday                   1  7391892
Tuesday                  1  1534024
Idul Fitri day           1    20641
1 day after Idul Fitri   1  3201247
Homecoming Stream        1  1920981
Return Stream            1  2556294

Unusual Observations

Obs  Monday  Demand     Fit  SE Fit  Residual  St Resid
 12    0.00  4272.0  4463.8   265.3    -191.8     -0.80 X
 21    0.00  5648.0  4850.8    77.7     797.2      2.29R
 33    0.00  3952.0  3760.2   265.3     191.8      0.80 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Figure 4.19 3rd Iteration Minitab Output

a. Assumptions Check

The output of Minitab for the 3rd iteration indicates that there are some assumptions that are not satisfied. The assumptions check are as follows:

1. Multicollinearity doesn't occur. Shown by the VIF values in Figure 4.19

2. Even though the model passes the simultaneous ANOVA test, this model fails to pass the individual ANOVA test. The predictors which fail to pass is *Idul Fitri* due to having p-value larger than 0.05 which is shown in Figure 4.19. The evidence that this model passes the simultaneous ANOVA test is shown by the computation of Equation 4.31 below.

$f_{computation} > f_{\alpha}(, n - k - 1)$ ..................................................... (4.31)

$f_{computation} > f_{0.05}(6{,}35)$

$19.54 > 2.37$

3. There is an outlier on observation 21 as shown in Figure 4.19.

### 4.7.4 4th Iteration

a. Factors Identification and Experiment

On this iteration predictor 3 (*Idul Fitri* day) will be excluded. It is excluded because in the previous iteration it failed to pass the individual ANOVA test.

b. Model Development

All of the factors previously identified follows the same weighting as in the 3rd iteration. By excluding predictor 3, the forecasting follows Equation 4.32 below.

$F_j = a + \sum_{i=1}^{6} b_{i,j} x_{i,j}$ $\quad , i \in N: 1,2,4,5,6$ .................... (4.32)

where :

$F_j$ : forecast of period *j*

$a$ : intercept value

$b_{i,j}$ : weighting for factor $i$ on period *j*

$x_{i,j}$ : constant for factor $i$ on period *j*

c. Minitab Software Processing

Since we are only removing unwanted predictors, in Minitab 16.0 the data doesn't need to be changed. However, the predictors in developing the regression line will change (shown in Figure 4.20). Output of this model is available in Figure 4.21 and Figure 4.22

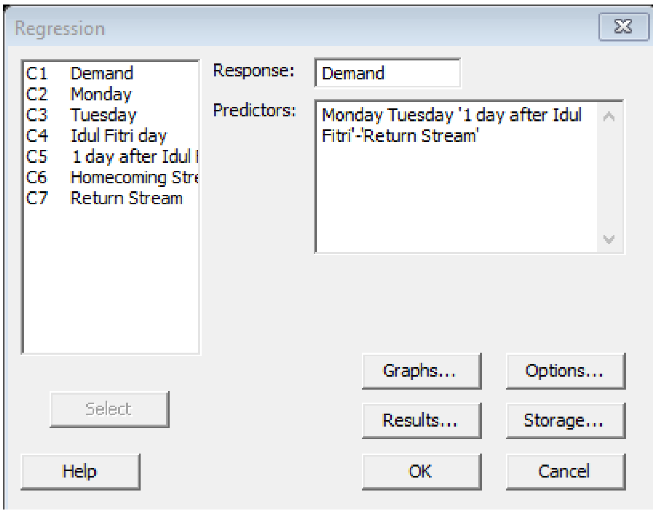



Figure 4.20 Regression Line Data Inputting ($4^{th}$ Iteration)

**Regression Analysis: Demand versus Monday, Tuesday, ...**

```
The regression equation is
Demand = 4858 - 1120 Monday + 699 Tuesday - 1095 1 day after Idul
Fitri
         + 378 Homecoming Stream + 442 Return Stream


Predictor                 Coef  SE Coef      T      P    VIF
Constant               4858.01    73.28  66.29  0.000
Monday                 -1120.0    171.8  -6.52  0.000  1.048
Tuesday                  698.9    161.7   4.32  0.000  1.084
1 day after Idul Fitri -1095.5    265.3  -4.13  0.000  1.081
Homecoming Stream       378.23    81.58   4.64  0.000  1.053
Return Stream           441.88    97.49   4.53  0.000  1.044


S = 352.178   R-Sq = 78.8%   R-Sq(adj) = 75.9%

Analysis of Variance

Source          DF        SS       MS      F      P
Regression       5  16612434  3322487  26.79  0.000
Residual Error  36   4465064   124030
Total           41  21077498
```

Figure 4.21 $4^{th}$ Iteration Minitab Output ($1^{st}$ Page)

```
Source                  DF   Seq SS
Monday                   1  7391892
Tuesday                  1  1534024
1 day after Idul Fitri   1  3179261
Homecoming Stream        1  1959127
Return Stream            1  2548130


Unusual Observations

Obs  Monday  Demand     Fit  SE Fit  Residual  St Resid
 12    0.00  4272.0  4461.5   261.8    -189.5     -0.80 X
 21    0.00  5648.0  4858.0    73.3     790.0      2.29R
 33    0.00  3952.0  3762.5   261.8     189.5      0.80 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Figure 4.22 4th Iteration Minitab Output (2nd Page)

d. Assumptions Check

The output of Minitab for the 4th iteration indicates that there are some assumptions that are not satisfied. The assumptions check are as follows:

1. Multicollinearity doesn't occur. Shown by the VIF values in Figure 4.21.

2. Both variances ANOVA test are satisfied. The individual ANOVA test evidence is shown by the p-values in Figure 4.21, while the simultaneous ANOVA test is shown in Equation 4.33 computation below.

$f_{computation} > f_{\alpha}(, n - k - 1)$ ........................................................(4.33)

$f_{computation} > f_{0.05}(5{,}36)$

$26.79 > 2.48$

3. There is an outlier on observation 21 as shown in Figure 4.22.

### 4.7.5 5th Iteration

a. Factors Identification and Experiment

From the previous iteration it can be inferred that observation number 21 is an outlier. Observation 21 occurs on the final day of the cycle, but with period factor failing to pass the ANOVA test (in 1st iteration) adding period or last day in a cycle as factor is irrelevant.

If we observe the end of return stream in 1st cycle (which occurs on observation 17), observation 21 occurs 4 day after the final return stream and on the 2nd cycle the same occurrence can be observed on period 40 (return stream ends on period 36). This is not periodically based, therefore in this iteration 4 days after final return stream factor is added while also removing *Idul Fitri* day factor.

b. Model Development

Based on the previous factor identification a new model is developed. The model follows the weighting table factor (shown in Table 4.10 and 4.11), mathematical model, and forecasting equations below.

Table 4.10 Weighting Factor Table of 5th Iteration for Mathematical Model

| **Period $j$** | **Factors ($i = 1, 2, 3$)** | | |
|---|---|---|---|
| | **Monday $i = 1$** | **Tuesday $i = 2$** | **4 day after final Return Stream $i = 3$** |
| 1 | $b_{1,1}$ | $b_{2,1}$ | $b_{3,1}$ |
| 2 | $b_{1,2}$ | $b_{2,2}$ | $b_{3,2}$ |
| ⋮ | ⋮ | ⋮ | ⋮ |
| 42 | $b_{1,42}$ | $b_{2,42}$ | $b_{3,42}$ |

Table 4.11 Weighting Factor Table of 5th Iteration for Mathematical Model

| **Period $j$** | **Factors ($i = 4, 5, 6$)** | | |
|---|---|---|---|
| | **1 day after *Idul Fitri*** $i = 4$ | **Homecoming Stream** $i = 5$ | **Return Stream** $i = 6$ |
| 1 | $b_{4,1}$ | $b_{5,1}$ | $b_{5,1}$ |
| 2 | $b_{4,2}$ | $b_{5,2}$ | $b_{5,2}$ |
| ⋮ | ⋮ | ⋮ | ⋮ |
| 42 | $b_{4,42}$ | $b_{5,42}$ | $b_{5,42}$ |

The factor weighting table will be filled with quantitative data based on mathematical model in Equations 4.34 – 4.39.

$$b_{1,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Monday and } b_{3,j} \neq 1 \\ 0, & \text{otherwise} \end{cases} \quad \text{..............(4.34)}$$

$$b_{2,j} = \begin{cases} 1, & \text{period } j \text{ occurs on Tuesday and } b_{3,j} \neq 1 \\ 0, & \text{otherwise} \end{cases} \quad \text{.............(4.35)}$$

$$b_{3,j} = \begin{cases} 1, & \text{period } j \text{ occurs 4 day after final return stream} \\ 0, & \text{otherwise} \end{cases} \quad \text{...(4.36)}$$

$$b_{4,j} = \begin{cases} 1, & \text{period } j \text{ occurs on 1 day after } \mathit{Idul\ Fitri} \\ 0, & \text{otherwise} \end{cases} \quad \text{.............(4.37)}$$

$$b_{5,j} = \begin{cases} 1, & \text{period } j \text{ occurs on homecoming stream} \\ 2, & \text{period } j \text{ occurs on homecoming stream peak} \\ 3, & \text{period } j \text{ occurs on homecoming stream peak and 1 day before Idul Fitri} \\ 0, & \text{otherwise} \end{cases} \quad \text{....(4.38)}$$

$$b_{6,j} = \begin{cases} 1, & \text{Period } j \text{ occurs on return stream} \\ 2, & \text{Period } j \text{ occurs on return stream peak} \\ 0, & \text{otherwise} \end{cases} \quad \text{................(4.39)}$$

where :

$b_{i,j}$ : weighting for factor $i$ on period $j$

The forecasting result will be calculated using the Equation 4.40

$F_j = a + \sum_{i=1}^{6} b_{i,j} x_{i,j}$ ..............................................................(4.40)

where :

$F_j$ : forecast of period $j$

$a$ : intercept value

$b_{i,j}$ : weighting for factor $i$ on period $j$

$x_{i,j}$ : constant for factor $i$ on period $j$

Based on the mathematical model above, a newly filled weighting factors table is developed. The table is shown in Table 4.12 and 4.13

Table 4.12 Weighting Factor Table of 5th Iteration for Regression

| **Period** | **Factors ($i = 1, 2, 3$)** | | |
|---|---|---|---|
| | **Monday** | **Tuesday** | **4 day after final Return Stream** |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 4 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 |
| 6 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 1 | 0 |
| 13 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 |

| Period | Factors ($\boldsymbol{i = 1, 2, 3}$) | | |
|---|---|---|---|
| | **Monday** | **Tuesday** | **4 day after final Return Stream** |
| 18 | 1 | 0 | 0 |
| 19 | 0 | 1 | 0 |
| 20 | 0 | 0 | 0 |
| 21 | 0 | 0 | 1 |
| 22 | 0 | 1 | 0 |
| 23 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 |
| 27 | 0 | 0 | 0 |
| 28 | 1 | 0 | 0 |
| 29 | 0 | 1 | 0 |
| 30 | 0 | 0 | 0 |
| 31 | 0 | 0 | 0 |
| 32 | 0 | 0 | 0 |
| 33 | 0 | 0 | 0 |
| 34 | 0 | 0 | 0 |
| 35 | 1 | 0 | 0 |
| 36 | 0 | 1 | 0 |
| 37 | 0 | 0 | 0 |
| 38 | 0 | 0 | 0 |
| 39 | 0 | 0 | 0 |
| 40 | 0 | 0 | 1 |
| 41 | 0 | 0 | 0 |
| 42 | 1 | 0 | 0 |

Table 4.13 Weighting Factor Table of 5th Iteration for Regression

| Period | Factors ($i = 4, 5, 6$) | | |
|---|---|---|---|
| | **1 day after *Idul Fitri*** | **Homecoming Stream** | **Return Stream** |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 |
| 9 | 0 | 2 | 0 |
| 10 | 0 | 2 | 0 |
| 11 | 0 | 0 | 0 |
| 12 | 1 | 0 | 0 |
| 13 | 0 | 0 | 1 |
| 14 | 0 | 0 | 0 |
| 15 | 0 | 0 | 2 |
| 16 | 0 | 0 | 2 |
| 17 | 0 | 0 | 1 |
| 18 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 |
| 22 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 |
| 27 | 0 | 0 | 0 |
| 28 | 0 | 0 | 0 |
| 29 | 0 | 1 | 0 |

| Period | Factors ($i = 4, 5, 6$) | | |
|---|---|---|---|
| | **1 day after *Idul Fitri*** | **Homecoming Stream** | **Return Stream** |
| 30 | 0 | 2 | 0 |
| 31 | 0 | 3 | 0 |
| 32 | 0 | 0 | 0 |
| 33 | 1 | 0 | 0 |
| 34 | 0 | 0 | 1 |
| 35 | 0 | 0 | 1 |
| 36 | 0 | 0 | 2 |
| 37 | 0 | 0 | 0 |
| 38 | 0 | 0 | 0 |
| 39 | 0 | 0 | 0 |
| 40 | 0 | 0 | 0 |
| 41 | 0 | 0 | 0 |
| 42 | 0 | 0 | 0 |

c. Minitab Software Processing

Since some predictors are re-added and adjusted, rewriting the data in Minitab 16.0 will reduce confusion. The Minitab data inputting is shown in Figure 4.23, regression data inputting is shown in Figure 4.24, and output of this model is available in Figure 4.25

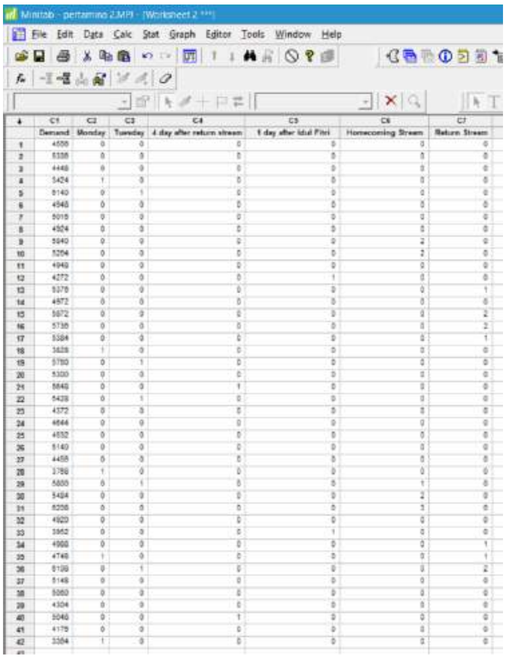


Figure 4.23 Minitab Data Input (5th Iteration)

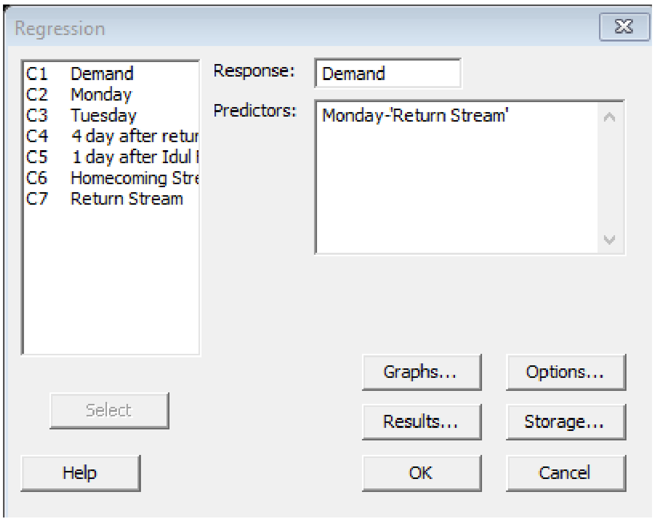



Figure 4.24 Regression Line Data Inputting (5th Iteration)

```
Regression Analysis: Demand versus Monday, Tuesday, ...

The regression equation is
Demand = 4804 - 1071 Monday + 778 Tuesday + 544 4 day after return
stream
         - 692 1 day after Idul Fitri + 399 Homecoming Stream
         + 462 Return Stream


Predictor                      Coef  SE Coef      T      P    VIF
Constant                    4804.45    73.06  65.76  0.000
Monday                      -1070.5    164.1  -6.52  0.000  1.065
Tuesday                       778.0    162.7   4.78  0.000  1.048
4 day after return stream     543.6    247.0   2.20  0.034  1.044
1 day after Idul Fitri       -692.4    247.0  -2.80  0.008  1.044
Homecoming Stream            398.98    77.84   5.13  0.000  1.068
Return Stream                462.38    92.98   4.97  0.000  1.057


S = 333.673   R-Sq = 81.5%   R-Sq(adj) = 78.3%


Analysis of Variance

Source          DF        SS       MS      F      P
Regression       6  17180676  2863446  25.72  0.000
Residual Error  35   3896822   111338
Total           41  21077498


Source                     DF   Seq SS
Monday                      1  7391892
Tuesday                     1  3041806
4 day after return stream   1   245889
1 day after Idul Fitri      1  1636378
Homecoming Stream           1  2111372
Return Stream               1  2753339
```

Figure 4.25 5$^{th}$ Iteration Minitab Output

d. Assumptions Check

The output of Minitab for the 5$^{th}$ iteration indicates that all assumptions are satisfied. The details are as follows:

1. Multicollinearity doesn’t occur. Shown by the VIF values in Figure 4.25

2. Both variances ANOVA test are satisfied. Individual ANOVA test pass evidence is shown by the p-values in Figure 4.25 while the simultaneous test result is shown by the Equation 4.41 computation below.

$f_{computation} > f_{\alpha}(, n - k - 1)$ ....................................................(4.41)

$f_{computation} > f_{0.05}(6{,}35)$

$19.54 > 2.37$

3. There is no outlier in the model as shown in Figure 4.25.

## 4.8 Forecasting Model Quality

After all assumptions are fulfilled, we can develop the forecasting model. The model is available in the Equation 4.42. Before calculating the results, quality check is needed. The quality check includes checking the Coefficient of Determination ($R^2$) and Mean Absolute Error (MAE).

$F_j = a + \sum_{i=1}^{6} b_{i,j} x_{i,j}$ ..........................................................................(4.42)

$F_j = 4804 - 1071 b_{1,j} + 778 b_{2,j} + 544 b_{3,j} - 692 b_{4,j} + 399 b_{5,j} + 462 b_{6,j}$

where :

$F_j$ : forecast of period $j$

$a$ : intercept value

$b_{i,j}$ : weighting for factor $i$ on period $j$

$x_{i,j}$ : constant for factor $i$ on period $j$

a. Coefficient of Determination ($R^2$)

The Coefficient of Determination ($R^2$) on this model is represented by the Minitab output (shown in Figure 4.25). Coefficient of Determination ($R^2$) in Minitab is shown by the R-Sq value (in Figure 4.26) which is 81.5%. This shows that the model is able to represent 81.5% of the actual demand.

```
S = 333.673   R-Sq = 81.5%   R-Sq(adj) = 78.3%
```

Figure 4.26 Coefficient of Determination ($R^2$) in Minitab

b. Mean Absolute Error (MAE)

The Mean Absolute Error (MAE) calculation is done in Table 4.14 below. From the calculation the MAE for this forecasting model is 275.69 kL of fuel.

Table 4.14 Mean Absolute Error (MAE) Calculation

| Period | Actual | Factors Weight | | | | | | Forecast | Absolute Error |
|---|---|---|---|---|---|---|---|---|---|
| | | b1 | b2 | b3 | b4 | b5 | b6 | | |
| 1 | 4556 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 248 |
| 2 | 5336 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 532 |
| 3 | 4448 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 356 |
| 4 | 3424 | 1 | 0 | 0 | 0 | 0 | 0 | 3733 | 309 |
| 5 | 6140 | 0 | 1 | 0 | 0 | 0 | 0 | 5582 | 558 |
| 6 | 4948 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 144 |
| 7 | 5016 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 212 |
| 8 | 4924 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 120 |
| 9 | 5840 | 0 | 0 | 0 | 0 | 2 | 0 | 5602 | 238 |
| 10 | 5264 | 0 | 0 | 0 | 0 | 2 | 0 | 5602 | 338 |
| 11 | 4948 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 144 |
| 12 | 4272 | 0 | 1 | 0 | 1 | 0 | 0 | 4890 | 618 |
| 13 | 5376 | 0 | 0 | 0 | 0 | 0 | 1 | 5266 | 110 |
| 14 | 4972 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 168 |
| 15 | 5872 | 0 | 0 | 0 | 0 | 0 | 2 | 5728 | 144 |
| 16 | 5736 | 0 | 0 | 0 | 0 | 0 | 2 | 5728 | 8 |
| 17 | 5384 | 0 | 0 | 0 | 0 | 0 | 1 | 5266 | 118 |
| 18 | 3828 | 1 | 0 | 0 | 0 | 0 | 0 | 3733 | 95 |
| 19 | 5760 | 0 | 1 | 0 | 0 | 0 | 0 | 5582 | 178 |
| 20 | 5300 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 496 |
| 21 | 5648 | 0 | 0 | 1 | 0 | 0 | 0 | 5348 | 300 |
| 22 | 5428 | 0 | 1 | 0 | 0 | 0 | 0 | 5582 | 154 |
| 23 | 4372 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 432 |
| 24 | 4644 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 160 |
| 25 | 4532 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 272 |
| 26 | 5140 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 336 |
| 27 | 4456 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 348 |
| 28 | 3768 | 1 | 0 | 0 | 0 | 0 | 0 | 3733 | 35 |
| 29 | 5800 | 0 | 1 | 0 | 0 | 1 | 0 | 5981 | 181 |
| 30 | 5484 | 0 | 0 | 0 | 0 | 2 | 0 | 5602 | 118 |
| 31 | 6208 | 0 | 0 | 0 | 0 | 3 | 0 | 6001 | 207 |
| 32 | 4920 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 116 |

| Period | Actual | Factors Weight | | | | | | Forecast | Absolute Error |
|---|---|---|---|---|---|---|---|---|---|
| | | b1 | b2 | b3 | b4 | b5 | b6 | | |
| 38 | 5060 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 256 |
| 39 | 4304 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 500 |
| 40 | 5048 | 0 | 0 | 1 | 0 | 0 | 0 | 5348 | 300 |
| 41 | 4176 | 0 | 0 | 0 | 0 | 0 | 0 | 4804 | 628 |
| 42 | 3364 | 1 | 0 | 0 | 0 | 0 | 0 | 3733 | 369 |
| | | | | | | | | **Mean Absolute Error** | **275.69** |

Figure 4.27 shows the comparison of actual demand and forecast result in line graph.

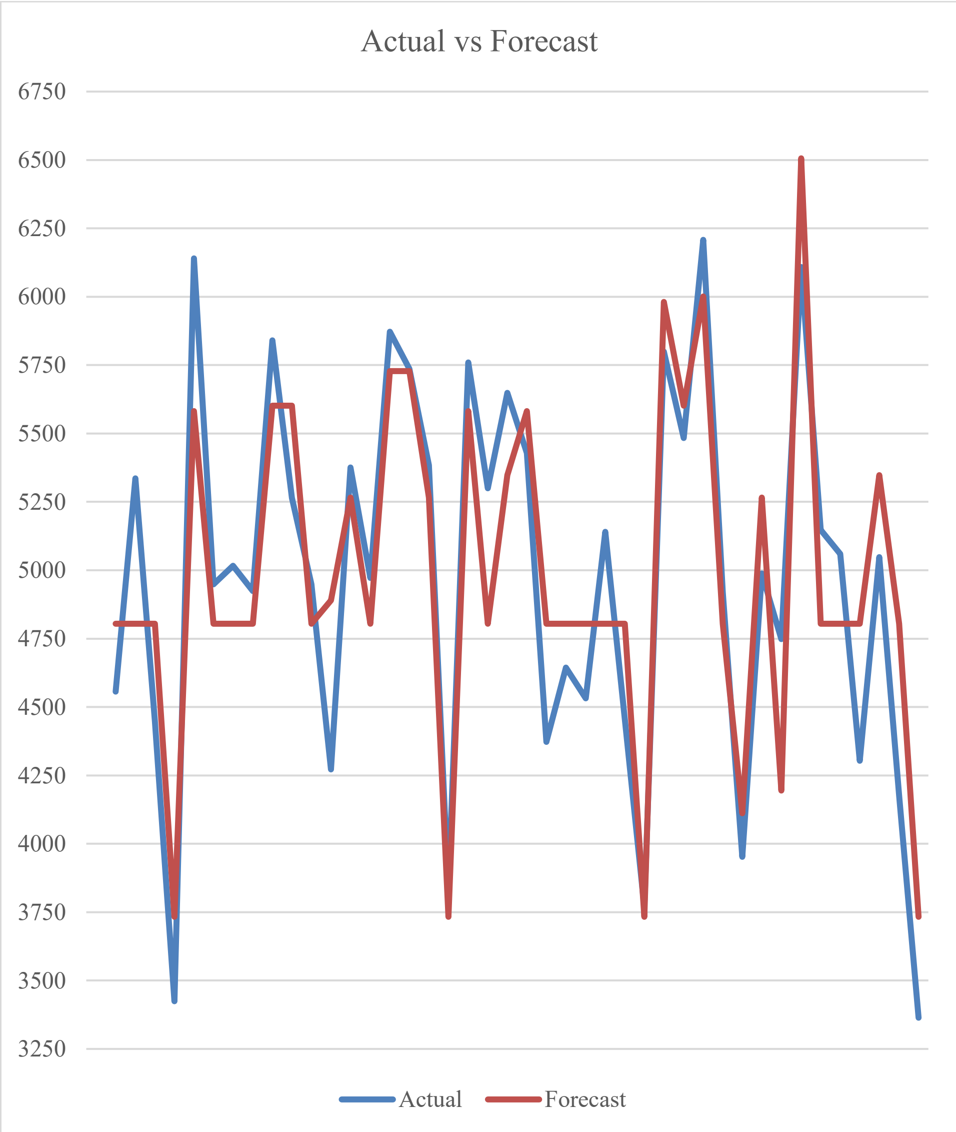



Figure 4.27 Actual and Forecast Demand Comparison

## 4.9 Forecasting Result

Forecast for fuel demand (kL) during 10 days before up to 10 days after *Idul Fitri* is available in Table 4.15 below. The weighting for predictor 5 and 6 is based on the expert's judgement by considering the holiday date on Indonesia National Calendar. The graphical result of the forecast is shown in Figure 4.28

Table 4.15 Forecasting Result and Calculation

| Days from/to *Idul Fitri* | Day | Date | Factors Weight | | | | | | Forecast |
|---|---|---|---|---|---|---|---|---|---|
| | | | b1 | b2 | b3 | b4 | b5 | b6 | |
| -10 | Sunday | 26 June | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| -9 | Monday | 27 June | 1 | 0 | 0 | 0 | 0 | 0 | 3733 |
| -8 | Tuesday | 28 June | 0 | 1 | 0 | 0 | 0 | 0 | 5582 |
| -7 | Wednesday | 29 June | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| -6 | Thursday | 30 June | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| -5 | Friday | 01 July | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| -4 | Saturday | 02 July | 0 | 0 | 0 | 0 | 1 | 0 | 5203 |
| -3 | Sunday | 03 July | 0 | 0 | 0 | 0 | 1 | 0 | 5203 |
| -2 | Monday | 04 July | 1 | 0 | 0 | 0 | 2 | 0 | 4531 |
| -1 | Tuesday | 05 July | 0 | 1 | 0 | 0 | 1 | 0 | 5981 |
| *Idul Fitri* | Wednesday | 06 July | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| 1 | Thursday | 07 July | 0 | 0 | 0 | 1 | 0 | 0 | 4112 |
| 2 | Friday | 08 July | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| 3 | Saturday | 09 July | 0 | 0 | 0 | 0 | 0 | 2 | 5728 |
| 4 | Sunday | 10 July | 0 | 0 | 0 | 0 | 0 | 1 | 5266 |
| 5 | Monday | 11 July | 1 | 0 | 0 | 0 | 0 | 0 | 3733 |
| 6 | Tuesday | 12 July | 0 | 1 | 0 | 0 | 0 | 0 | 5582 |
| 7 | Wednesday | 13 July | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| 8 | Thursday | 14 July | 0 | 0 | 1 | 0 | 0 | 0 | 5348 |
| 9 | Friday | 15 July | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |
| 10 | Saturday | 16 July | 0 | 0 | 0 | 0 | 0 | 0 | 4804 |

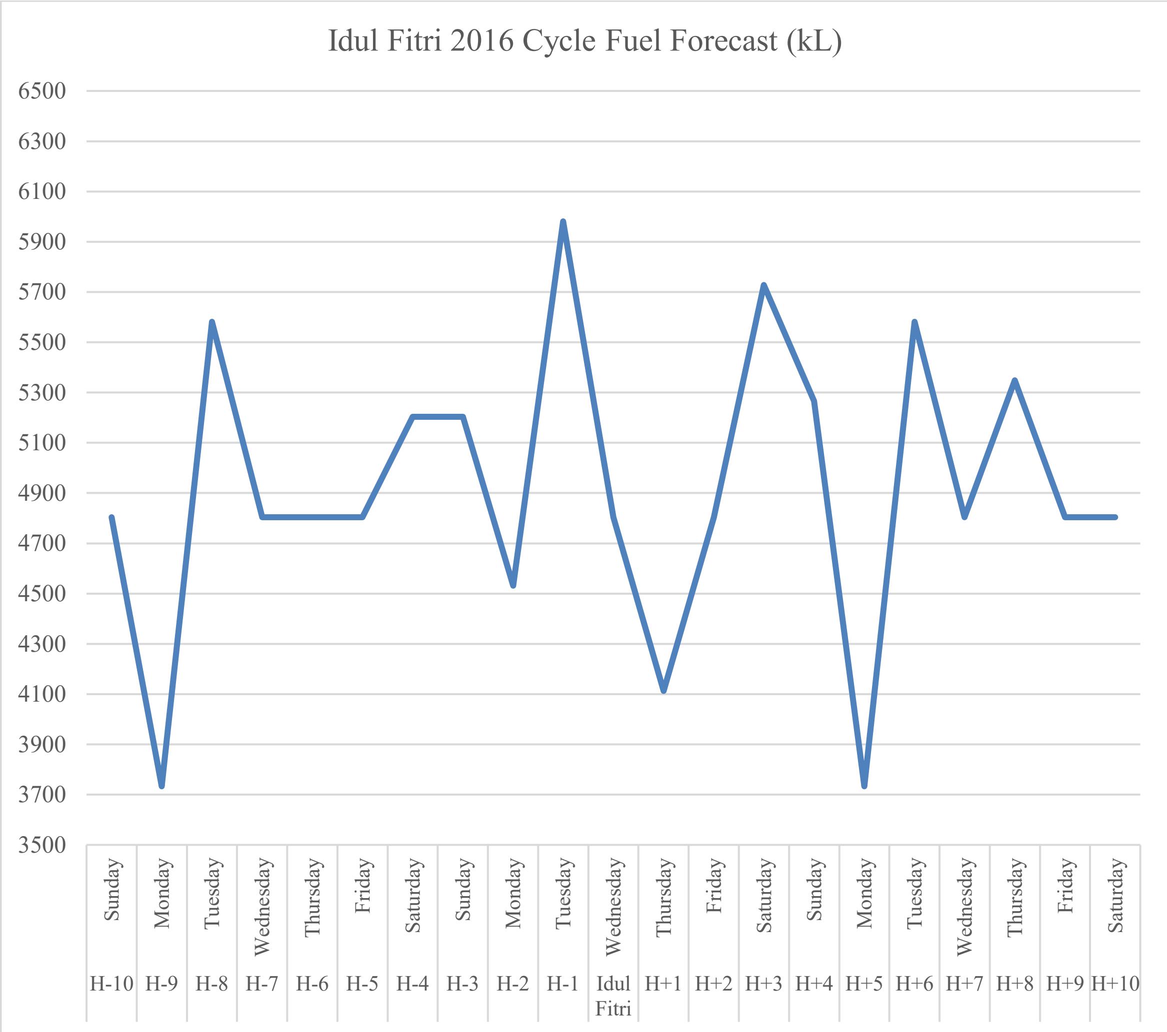



Figure 4.28 Fuel Forecast (kL) for *Idul Fitri* 2016 Cycle

The forecast developed in this research is not fully correct. This result may still change depending on the upcoming condition occurring on 2016's *Idul Fitri* and it may change the weighting factors used in this model.

# CHAPTER V

# CONCLUSION AND SUGGESTION

## 5.1 Conclusion

The conclusion of this research are as follows:

a. PT. Pertamina (Persero) TBBM Boyolali can forecast fuel demand during 10 days before up to *Idul Fitri* by considering 6 factors in their forecasting model.

b. The factors influencing demand between 10 days before and after *Idul Fitri* include Mondays, Tuesdays, the day after *Idul Fitri*, 4 days after *Idul Fitri*'s return stream, *Idul Fitri*'s homecoming stream, and *Idul Fitri*'s return stream.

c. The demand forecast result from 10 days before up to 10 days after *Idul Fitri* for 2016 respectively are 4804 kL, 3733 kL, 5582 kL, 4804 kL, 4804 kL, 4804 kL, 4804 kL, 4804, kL, 4132 kL, 6380 kL, 4804 kL, 4112 kL, 4804 kL, 5728 kL, 5266 kL, 3733 kL, 5582 kL, 4804 kL, 5348 kL, 4804 kL, and 4804 kL

## 5.2 Suggestion

After conducting this research, the suggestions for the company are as follows:

a. PT. Pertamina (Persero) TBBM Boyolali current forecasting method for *Idul Fitri* demand period may be quite risky especially on 1 day after *Idul* Fitri because the company keeps inventory at very high level while the demand is very low.

b. Consider using the model developed in this research with expert judgement's adjustment in order to reduce supply chain expenses.

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