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STRATEGI PENENTUAN HARGA DI SISTEM *DUAL CHANNEL SUPPLY CHAIN* DENGAN PERTIMBANGAN PELAYANAN GARANSI

ALDELLA LUTIASARI GINANDA
NRP 2512 100 128

Pembimbing
Erwin Widodo, S. T., M. Eng., Dr. Eng.

JURUSAN TEKNIK INDUSTRI
Fakultas Teknologi Industri
Institut Teknologi Sepuluh Nopember
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PRICING STRATEGY IN A DUAL CHANNEL SUPPLY CHAIN BY CONSIDERING WARRANTY SERVICES

ALDELLA LUTIASARI GINANDA
NRP 2512 100 128

Supervisor
Erwin Widodo, S. T., M. Eng., Dr. Eng.

INDUSTRIAL ENGINEERING DEPARTMENT
Faculty of Industrial Technology
Institut Teknologi Sepuluh Nopember
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AGREEMENT SHEET

FINAL PROJECT PROPOSAL

PRICING STRATEGY IN A DUAL CHANNEL SUPPLY CHAIN BY CONSIDERING WARRANTY SERVICES

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Surabaya

Author:

ALDELLA LUTIASARI GINANDA

NRP 2512 100 128

Approved by Final Project Supervisor:

Erwin Widodo, S.T., M.Eng., Dr. Eng.

NIP. 197405171999031002

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STRATEGI PENENTUAN HARGA DALAM SISTEM DUAL CHANNEL SUPPLY CHAIN DENGAN PERTIMBANGAN PELAYANAN GARANSI

Nama : Aldella Lutiasari Ginanda
NRP : 2512 100 128
Pembimbing : Dr. Eng., Erwin Widodo, S.T., M.Eng.

ABSTRAK

Perkembangan *e-commerce* yang cukup pesat mendorong pelaku usaha untuk memperluas jaringan penjualan hingga sampai ke tangan konsumen. Dengan adanya penambahan *channel* dalam sistem *Supply Chain* yang ada menimbulkan fungsi komplementer dan juga subtitusi. Fungsi komplementer dapat memperluas *market shares* usaha yang dijalankan, sedangkan fungsi subtitusi dapat meningkatkan fleksibilitas *Supply Chain*. Sementara itu, dalam beberapa kasus hal ini tidak selamanya memberikan dampak positif, karena masing-masing *channel* bisa saja mengasumsikan *channel* lainnya sebagai kompetitor mereka. Dalam penelitian ini dilakukan evaluasi efek sensitivitas konsumen terhadap harga dan pelayanan garansi yang ditawarkan terhadap perlakuan konsumen dalam menentukan *channel* tertentu untuk membeli produk yang sama. Dengan pertimbangan efek dari adanya *channel* tambahan dalam *channel* penjualan, adanya perpindahan konsumen dari satu *channel* ke *channel* lain sangat dimungkinkan yang akhirnya menyebabkan adanya kompetisi yang tidak *fair* dalam sistem *Supply Chain* yang sama. Penelitian ini mengembangkan model *Dual Channel Supply Chain* yang sebelumnya hanya mempertimbangkan sensitivitas konsumen terhadap harga, ditambahkan dengan adanya sensitivitas konsumen terhadap pelayanan garansi. *Output* dari penelitian ini adalah penentuan harga yang optimal dan usulan lama periode garansi yang ditawarkan untuk masing-masing *channel*.

Kata kunci: *dual-channel supply chain, game theory,* lama periode garansi, *nonlinear programming,* strategi penentuan harga.

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PRICING STRATEGY IN A DUAL CHANNEL SUPPLY CHAIN BY CONSIDERING WARRANTY SERVICES

Student's Name	: Aldella Lutiasari Ginanda
NRP	: 2512 100 128
Supervisor	: Dr. Eng., Erwin Widodo, S.T., M.Eng.

ABSTRACT

Rapid development of e-commerce had made manufacturers expand their market channels. The additional channel has both complementary and substitution functions. The complementary function is able to widen business market shares, while substitution function is able to increase supply chain flexibility. However, in some case this condition is not always giving a beneficial outcome, since each channel is able to assume that the other channel is its competitor. This research is trying to evaluate the effect of pricing and warranty length sensitivity into customer behavior in selecting a channel to buy a product. Considering the effect of additional channel into a company sales channels, customer shifting between channels may resulting unfair competition under the same supply chain system. In this research a dual-channel supply chain model will be developed to estimate the demand for each channel by considering pricing and warranty length sensitivity, and at the end of the research optimum product prices and acceptable warranty length are suggested based on numerical test experiments. Determining optimum product prices is generated from dual-channel supply chain model developed by the help of *Matlab* software and nonlinear programming approach, while defining best strategy to set acceptable warranty length is using the help of *Gambit* software and game theory approach.

Keywords: dual-channel supply chain, game theory, nonlinear programming, pricing strategy, warranty length.

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CHAPTER 1
INTRODUCTION

The chapter is a preliminary part of the whole research, which is explaining about research background, problem formulation, its objectives and benefits, scope of the research, and also overview of the research outline.

1.1 Background

Rapid development of e-commerce and internet technologies had made manufacturers desiring to expand their market channel. The expansion is on a modification from traditional retail channel into dual-channel, for example direct sales channel by the internet and retail channel (Huang, et al., 2012). Direct channel is added into the supply chain channel in order to trigger performances of a company to be more responsive in delivering their products to their customer (Dumrongsiri, et al., 2008). An additional channel desired to improve services provided by the company is able to lead to an improvement to its sales volume. In other side, a new mode of business and manufacturer direct channel causes new channel competition with traditional retailers in the whole supply chain (Shi, et al., 2015). In the dual-channel system, customers are possible to shift from a particular channel to the other channel because of their preferences in fulfilling their demand process. Due to that condition, the traditional channel and direct channel both have substitute and complementary functions in delivering the products to customers (Peterson, et al., 1997).

Substitution function in dual-channel system let a supply chain flexibility improvement in fulfilling the demand because stock out problems can be solved by inventories supply from another channel (Tsao, 2011). When a customer demand from a particular channel is unable to be fulfilled, then the other channel which still has supplies in their inventory is able to accommodate the demand. This condition makes the inventory management coordination between channels is important, because the uses of inventory management integration for both channel in a dual-

channel system are able to give such benefits into the business players (Bendoly, 2004).

Complementary function in dual-channel system has main aim to gain the company market shares and wider the market targets. However, without a good coordination, such structure modification tends to increase channel competition in term of demand fulfillment. Under a competition, direct channel existence is able to create an internal competition with its own retailers. Retailers may belief that orders placed through a manufacturer's direct channel are supposed to be placed through them, and these conditions appear as direct channel cannibalizes their sales (Chiang, et al., 2003). Competition of each player under the same supply chain system is an individualistic condition where the resources (sales) are contested. These conditions can be avoided by the coordination of whole players under DCSC system, which are manufacturers and retailers. Finally, dual-channel may reach potential customer segments that could not be reached by a single channel (Moriarty & Moran, 1990).

A challenge which is often faced in the implementation of DCSC is the determination of product price for each player in the system, such as the price in traditional channel set by a manufacturer for their retailer or wholesaler, the price in the same channel set by a retailer for the customer, and also the price in direct channel set by a manufacturer for customer. This condition is triggered by an occurrence of pricing sensitivity to the expected demand for each channel (Widodo, et al., 2011). The price set desired to be cooperative enough so that each player in the supply chain system has reached their maximum profit possibility. A good coordination under the cooperative game for each player in the supply chain system definitely has the main aim to achieve maximum profit of the whole supply chain (Tsao & Su, 2012).

Pricing scheme is a general term in the determination of product price offered by manufacturers and retailers to their customers. Generally it depends on the firm average costs and customer perceived value of the products compared to the perceived value of the competitor's products (Business Dictionary, 2016). Customer perceived value of the products indicated by the customer acceptance level of product prices, higher product value allows the customer to pay higher since

the customer acceptance level of product price is higher too. In determining the product prices, enterprises need to be aware with the market segments and customers sensitivity to price (South Western Cengage Learning, 2016). Different customer segments have different product price limit to represent their customer acceptance level of product prices. The gap between customer acceptance level of product price and the real product prices in the market can be defined as customer surplus, while the gap between product price set and the Cost of Goods Sold (COGS) in manufacturer or wholesaler price in retailer can be defined as manufacturer and retailer surplus (Mankiw, 2010). Pricing scheme is easily can be defined as the scheme or determination of proportion division between the customer surplus and manufacturer or retailer surplus.

According to Chen, et al., (2012) the leading home appliances retailers, such as SUNING and GOME studies that price differentiation for the similar products has been insignificant to their customer demand. The competition has become intensified by offering additional warranty to customer. Warranty has become a popular measure to encourage market demand by reducing customer risks, and it is a contractual theory of recovery governed by principle of sales (Kimble & Lesher, 1979). Customer can predict product quality based on warranty length offered. It is claimed as an assurance that the manufacturer provides after evaluating their product's strength and durability. That makes warranty policy enhances customer purchase willingness and increase overall sales channel performance (Tsao & Su, 2012).

Heroine Experience Store is one of the examples of DCSC implementation. They are performing their business by using both traditional and direct channels in delivering their products into customer simultaneously. Currently they are offering apparel products with young male and female as their main market targets. However, as a company who runs their business by implementing DCSC structure, they have not recognized how to implement DCSC as the way it should be. They are implementing DCSC structure in offering products to expand their market targets without realizing other impacts given from the structure.

Offering apparel products for young male and female in both of their sales channels, currently they are selling their products in a same price. They have not

realized the existence of customer shifting possibility due to price sensitivity or other customer preferences. This condition may lead to the inequality demand for each channel, where a channel will has such high demand amount while other has low demand amount. An imbalance demand condition for channels may give disadvantages to the channel who has lower demand than others. That is why; implementing the right DCSC has to consider customer shifting possibility which influence total demand for each channel as well.

As a company who offers apparel products, there is such possibility of customer claim about the product's performances after sales occurred. This condition happens frequently especially for the products bought through direct channel, since the customer is unable to see and evaluate the products directly and clearly. That is why; warranty services and rules have to be developed as well by the company in order to minimize losses possibilities in performing after sales service due to customer claims. Even more the warranty services offered by the company is also able to influence the total customer demand.

Based on the problem explained above, this research has aim to develop a suggestions for the observed object in the determination of optimum product prices offered in each channel by considering warranty services. Besides that, the research also has an aim to suggest the best strategies in offering length of warranty both for traditional and direct channels. In this research price remains fundamental as a basis of market competition estimation, but by the existence of warranty length offered, the warranty also taken as a factor influences customer demand. Product price settings will be tested under the cooperative game to find the best setting for whole supply chain to achieve the maximum profit. Method used in the research is mathematical optimization, especially problem under *Non-linear Programming* case and also the *Game Theory* application to compare the profit achieved by each player.

1.2 Problem Formulation

According to the research background explained above, main idea of the research is to develop an optimum pricing strategy for *Heroine Experience Store* by considering warranty service. Proposed pricing scheme is considered in order to

give a suggestion in terms of calculating an optimum price to achieve maximum profit for the research object. In addition, the research will suggest the optimum length of warranty service offered both for the traditional and direct channels as the player under the same DCSC game.

1.3 Research Objectives

Objectives desired to be achieved in conducting the research are mentioned as the following:

1. Develop *DCSC* model to estimate the demand of each channel by considering product price and warranty length sensitivity of each channel.
2. Determine the optimum product price of each channel to achieve the maximum profit both for each channel and the whole system of supply chain.
3. Determine the acceptable length of warranty service offered both for the traditional and direct channels to achieve the sustainability of player's existence under the same game.

1.4 Research Benefits

Benefits can be achieved for the research development are seen at the following lists:

1. As the additional references for DCSC researches in the future.
2. Suggest an improved strategy for the research object in terms of product pricing scheme.
3. Give scientific suggestions for the research object in determining their products price and warranty length for each channel.

1.5 Research Scopes

Scopes of the research are defined through the limitations and assumptions used as explained at the following parts:

1.5.1 Limitations

Restricting the research scope, the following aspects are defined as limitations of the research:

1. The research is focusing on a DCSC subject consists of traditional channel which is including of offline stores and also direct channel or online stores in form of website and social media accounts.
2. Customer preferences used as the consideration for pricing strategy in this research is customer's acceptance ratio into particular channel, customer's price sensitivity, and also customer's warranty sensitivity.
3. The research is focusing on a type of product offered by the company, which is man t-shirt as the product with the mos
4. Historical data used for the research is along January 2016-May 2016.
5. Traditional channel focuses on a main store of *Heroine Experience Store* and direct channel on their official online website.
6. Business entities which are focused on this research are traditional channel (offline store) and also direct channel (online website and social media accounts services), which means that warehouse and reseller entities are neglected.
7. Other limitations related with the optimization model development will be discussed in the chapter of model development.

1.5.2 Assumptions

Determined assumptions which required for the research are listed as the followings:

1. Customer demand for both channels are determined as deterministic demand.
2. Sales return due to after sales service offered along warranty period is assumed without cashback offers, but performed by product returns.
3. Warranty services performed if defects found in products returned by customers are made due to company's mistakes and have to follow sales return policies set by the company.

4. Direct channel is occurred if only the price offered in online websites is lower than the traditional channel.
5. Other customer preferences in the determination of buying *Heroin Experience Store* products are neglected.
6. Other assumptions required which related to the optimization model development in the model development chapter.

1.6 Research Outline

The research consists of six chapters which following the outline as explained at the following:

CHAPTER I INTRODUCTION

The chapter is a preliminary part of the whole research, which is explaining about research background, problem formulation, its objectives and benefits, scope of the research, and also overview of the research outline.

CHAPTER II LITERATURE REVIEW

The chapter consists of summary according to some references, such as books, journals, articles, or previous researches which are used as basic understanding in the research development.

CHAPTER III RESEARCH METHODOLOGY

The chapter is showing and explaining about detailed framework and procedures followed in conducting the research.

CHAPTER IV MODEL DEVELOPMENT

The chapter is explaining about model development processes using model existed based on previous research, and then adjusting the model with the research real problem.

CHAPTER V NUMERICAL EXPERIMENT

The chapter is showing the numerical experiments using developed model in the research. The experiment is also completed with sensitivity analysis to analyze the model characteristics.

CHAPTER VI CONCLUSIONS AND SUGGESTIONS

The chapter is closing part of the research which is explaining about the conclusion of whole research conducted and also suggestions proposed from the research.

CHAPTER 2
LITERATURE REVIEW

The chapter consists of summary according to some references, such as books, journals, articles, or previous researches which are used as basic understanding in the research development.

2.1 Dual-channel Supply Chain

Supply chain is a network of enterprises which coordinated together in work to develop and deliver a product to end customer. Those enterprises consist of suppliers, manufacturers, distributors, retailers or stores, and also the supporting enterprises like the ones who are responsible to logistic services (Pujawan & ER, 2010). Within an enterprise, the supply chain includes all functions involved in fulfilling the customer requests. For example, in manufacturer organization, its functions such as product development, marketing, operations, distribution, finance, and customer service (Chopra & Meindl, 2001).

Traditional selling systems have changed dramatically with customer use of internet. Manufacturers use both of retail stores and internet to sell their products. This system is called as a two echelons dual-channel distribution system, more generally a multi-channel distribution system (Tsao & Su, 2012). The uses of internet had been effectively broke barriers of time and space for traditional sales models and distribution channels. Thus, amount of money generated through e-commerce has increased since 1991, when the internet uses are started to begin (Kacen, et al., 2002).

Internet and traditional retail channels are parallel channels, as they both have substitute and complementary functions (Peterson, et al., 1997). While a market is not fully covered, then the channels are complementary (Gayer & Shy, 2003). Achieving supply chain flexibility, companies are increasingly using new sales channels alongside the traditional retail channel. However, the substitution functions of dual-channel in a supply chain let the customer are able to shift from a channel into the other channel by their preferences, such as from price and warranty

length offered in different channels (Tsao & Su, 2012). That condition makes the development of a single channel into dual-channel model by considering the substitute effect is essential.

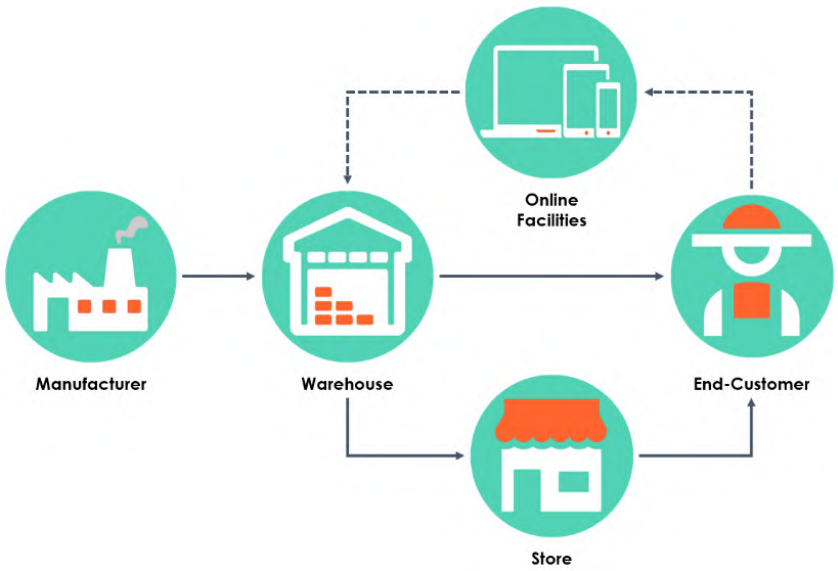

Figure 2. 1 DCSC General Structure Visualization

Figure above is representing general structure of DCSC system, which consists of traditional (offline) and direct (online) channels. According to the structure above, it can be seen that products flow started from manufacturer, then stored in a central warehouse until it is ready to be delivered either to retail store or end-customer directly. If products delivered to retail store, then customer needs to come to the store in order to buy the products, which named as traditional channel. Otherwise, the customer are able to directly order to manufacturer by using online facilities, and later the products will be delivered to customer directly, which named as direct channel.

According to the structure of DCSC system, there has to be a difference between price offered in retail store or traditional channel and price offered in online store or direct channel. The difference is suggested by a consideration of substitution and complementary effect of DCSC system which indicated by the different demand for each channel from customer. Customer demand for each channel has different value influenced by a ratio of customer acceptance into products sold in online store (Widodo, et al., 2011). Customer acceptance ratio for

direct channel is needed to be considered since there are some assurances of products quality or appearance which may different as offered in online facilities. That makes the demand for each channel is also different. Considering different demand fluctuation in both channels of the system that is why; the different price set in each channel is suggested.

In DCSC system, both of channels are working simultaneously. Unlike a single channel system, in DCSC the challenge is to coordinate all the players in whole channels of supply chain system are working together cooperatively and effectively to meet maximum profit. It is desired to achieve the maximum profit both for each player and also for the whole players under the system. According to Steinfield, et al., (2002) evaluating DCSC system can be done by seeing the successes of following benefits:

1. Cost reduction

   Coordinating the whole channel under DCSC system effectively, some of costs such as labor cost, inventory cost, and also distribution cost are able to be reduced.

2. Differentiation through value added services

   Integration existences in the both channels are able to lead an enterprise to develop differentiation by adding pre-purchase (assessment services and online order), purchase, and also post-purchase (installment and maintenance) services.

3. Customer loyalty improvement

   Considering the ratio of customer acceptance in direct channel, customer loyalty to direct channel may lower than to the traditional channel. By a coordination of direct and traditional channels the risks are able to be reduced since the complaints service facilities are existed in traditional store.

4. Market shares development

   Developing a single channel into dual-channel is able to scope wider market segments or targets. Direct channel existence is able to accommodate the customer segments which had been unable to be reached

by the traditional channel. That makes DCSC system development is able to lead to the higher market shares.

2.2 Customer Demand

Demand to products or services are a beginning of every activities in supply chain. Production process, distribution or delivery, product design, and materials procurement need to follow the customer demand. In reverse condition, those activities are performed in order to fulfill the customer demand (Pujawan & ER, 2010). It can be said that customer demand triggers the supply chain activities.

In DCSC system, demand is divided into the demand for each channel, which are conventional customer demand (D_s) and also online customer demand (Do). According to Widodo, et al., (2011) in order to divide the proportions of demand for each channel is can be calculated by following equation formulas below:

1. Conventional customer demand

$$D_s = {d_s}^{max} - \beta \frac{P_s - P_o}{1-\rho} \quad (2.1)$$

2. Online customer demand

$$D_o = \beta \frac{\rho P_s - P_o}{\rho\,(1-\rho)} \quad (2.2)$$

Using the following notation variables:

D_s : Conventional customer demand

D_o : Online customer demand

${d_s}^{max}$: Maximum conventional customer demand

P_s : Price set for traditional channel

P_o : Price set for direct channel

ρ : Ratio of customer acceptance into the online products

In a normal condition, the direct channel is possible to be occurred by the condition that product price offered is lower than the product price offered in traditional channel (Ani, 2014).

Forecasting customer demand is different with managing customer demand. Forecasting demand is the activity to estimate the rate of demand to

products or services in a particular period and region. Inaccurate forecast results are able to lead to some supply chain problems. In order to anticipate fluctuate demand which often unpredictable even it had been forecasted, then the demand management is a solution. Demand management is the effort to make customer demand is easier to be fulfilled by supply chain (Pujawan & ER, 2010). The following are some suggested activities in order to manage the demand according to Pujawan & ER, (2010):

1. Promotion

   Promotion is a way to increase the sales volume in a particular period. The demand pattern is able to be managed by the promotion strategies set, so that the demand will be easier or harder to be fulfilled by supply chain depends on the strategies.

2. Pricing

   Pricing is also included into promotion strategies, but this activity has wider purposes than promotion.

3. Shelf management

   Product shelves layout in retail stores are also able to influence the sales volume. It is suggested to put new products in a place where the customers are able to see it easily.

4. Deal structure

   Deal structure is the sales and purchases agreement consists of payment terms, sales return mechanism, maintenance guarantee, and so on.

2.3 Pricing Scheme

Pricing is a method adapted by firm or enterprise to set their products and services selling price. Generally, it depends on the firm average costs and also customer's perceived value of their products to competitors (Business Dictionary, 2016). Pricing determination is able to be the important decision in a company, which commonly included in pricing strategy to find optimum price for the products consists of marketing objectives, customer demands, product attributes, price set by competitor, and also market trends consideration (Business Dictionary, 2016).

Pricing regulation is also able to be classified to promotion instrument, but actually the main aim of pricing regulation is more than just a promotion strategy. Through pricing regulation, a firm is also able to manage the demand fluctuation, for example the different price set by phone provider for morning and evening calls has aim to anticipate high phone signals load in the morning and low phone signal utilization in the evening (Pujawan & ER, 2010). According to Roth (2007) there are several objectives in pricing determination, as mentioned below:

1. Profit maximization

   It seeks to garner the greatest amount in profits, and it is not necessarily to be tied with the profit margin maximization.

2. Revenue maximization

   It seeks to maximize revenue from the product sales without regard to profit. This objective is useful for introducing a new product into the market.

3. Quantity maximization

   This objective is seeking to maximize the number of products sold and appropriate to be chosen in aiming economies of scales goal.

4. Profit margin maximization

   It seeks to maximize the profit margin for each unit product, which is typically applied when the total number of units sold are expected to be low.

5. Quality leadership

   It used to signal the product quality to the customer by placing product prices to convey their quality.

6. Partial cost recovery

   A company that has sources of income other than from the sale of products may decide to implement partial cost recovery as pricing objective. It has benefit to provide the customers with a product at lower cost than the competitors offered in a same value and quality.

7. Firms survival

   Survival pricing means to be used in a short-term or temporary in facing a situation which required to set the price aside in order to make

the business survived. Once the situation ends, product prices are able to be returned.

8. Status quo

   It seeks to keep the product price in line with same or similar products offered by competitors to avoid price war or maintain stable level of profit generated.

In DCSC, product price determination or pricing is very crucial. This condition was leaded by an influence of fluctuate demand according to product price set as one of the factors. Besides that, price is also frequently used as the competitive level between retailers (Chiang, et al., 2003). According to Widodo et al., (2009) there are two schemes generally used in price determination for dual sales channel or DCSC as follow:

1. *Bertrand scheme*

   In this scheme, the price determination in central warehouse, traditional channel store (offline) price, and also direct channel store (online) price is set simultaneously. Since determined simultaneously, the price set depends on each player regulation. According to the scheme, global optimum result is indicated by the total profit of each channel.

2. *Stackelberg scheme*

   Different with the previous scheme, the decision variable for this scheme is set sequentially. Traditional channel (offline) store set as the follower which decided to determine the price first, then followed by central warehouse and direct channel (online) store.

2.4 Warranty Services

Warranty can be defined as a good condition promise of a product and as a statement that the manufacturer is responsible for repairing or replacing the product in a certain period of time after purchase (Merriam-Webster Dictionary, 2016). Customer is able to predict or estimate the product quality based on its warranty service offered by manufacturer, which means warranty period is set after the manufacturer as the main responsible subject in product defects had evaluated

product's strength and durability (Tsao & Su, 2012). Regarding that warranty services are showing product's quality implicitly, then manufacturer offer of warranty service to customer is able to enhance customer willingness to buy. This condition creates an additional influence factor in customer demand expectation, which is warranty services.

Warranty service is one of after sales services offered by the company nowadays. According to Blischke, et al., (1994) in Windiani (2010) warranty service creates two perspectives from customers. First perspective indicates that warranty service offered is a guarantee or assurance given by the manufacturer in fulfilling customer's rights even after sales occurred. In this case, warranty has allowed customer to ask manufacturer's responsibility if products bought are unable to perform as the offers or customer's expectation. The existence of warranty services provided has made the manufacturer to be responsible in repairing or replacing the products in order to achieve customer satisfaction. Second perspective is warranty as the product's quality estimation indicator, since product's reliability can be used as warranty determination consideration. Warranty service offered by manufacturer is able to influence total profit achieved by the company due that performing after sales services during warranty period has incurred warranty cost.

According to Davis, Gestner, & Hagerty (1995), in Desme (2013) stated a theoretical framework about warranty. It is stated that there are two types of warranty services provided by retailer, such as a warranty from manufacturer based on suppliers regulation and money back claim terms and condition, and also option given to the customer to return the products for repair or replacement. However, Heiman, McWilliams, & Zilberman (2001) in Desme (2013) claimed that there are some warranty achievement definition based on warranty services performed as responsibility from manufacturer or retailer. They are exercise (repair, exchange, refund) and activation (ground, duration, cost, condition).

2.4.1 Warranty Services for New Products

According to Blischke et al., (1994) in Windiani (2010) warranty services regulation can be grouped into two main groups which scopes product development process and product non-development process. There are also some factors which

generally used as main factors in determining warranty services given to a product, as explained below.

1. One or two dimensional warranty

   One dimensional warranty is a scheme in warranty offered determination based on period of product usages. However, two dimensional warranty is a scheme in warranty determination based on the length of product's usages and also product usages frequencies.

2. Free Replacement Warranty (FRW), Pro-Rata Warranty (PRW), and Money Back Warranty (MBW)

   FRW policy is when the warranty from manufacturer formed as an assurance to repair or replace broken components during warranty period. On other side, PRW is a service performed as a guarantee from manufacturer to return the products purchasing cost (product's price) and also ask for broken product replacement based on product's price multiplied by failure frequencies into total warranty period. The last policy, which is MBW as an assurance from manufacturer to return the product price to the customer if there are some product failures found during warranty period.

3. Renewing and Non-renewing regulation

   Renewing policy is a warranty from manufacturer by replacing failed products with a new product during warranty period. In every replacement of new product, the warranty period is also being renewed. However, non-renewing warranty is a warranty policy by replacing a new products without renewing its warranty period (continuing excess warranty period from the broken product).

2.4.2 Warranty Management

Warranty existence has the main aim to enhance customer's willingness to buy, which able to lead to the improvement in total sales volume. However, the warranty service performances are also incurring additional cost, which is warranty cost in every service performed. In order to minimize company losses by the

existence of warranty, a good management of warranty services and policies had to be performed. So that, the main aim of giving warranty service period to customer can be achieved to increase competitiveness level of the company without leading the company to big losses.

According to Nuha (2014) there are some aspects which are needed to be integrated in a warranty management of the company, there are technical aspect and also commercial or financial aspect. Technical aspect is an aspect which is more focusing on product's quality and reliability, while commercial aspect is more focusing on product's price and sales. Integrating those aspects in warranty services determination is able to influence the total profit and business performances achieved by the company.

2.5 Non-linear Programming

According Santosa and Willy (2011) optimization is a mathematical and numerical model calculation process with the objective to achieve a best candidate from existed alternatives without requiring to calculate and evaluate entire solution possibilities. Optimization is a tool which frequently used to solve problems with particular objective and constraint. Generally the objective will be set into two directions, which are minimization or maximization, but the important thing is that optimization is a tool to help solving the problem effectively and efficiently (Rahmawati, 2014).

According to Diwekar (2008), optimization grouped into eight categories based on their decision variables, objective functions, and also constraints such as the following:

1. Linear programming
2. Nonlinear programming
3. Integer programming
4. Mixed integer linear programming
5. Mixed integer nonlinear programming
6. Discrete optimization
7. Stochastic programming
8. Multi objective optimization

Non-linear programming is an optimization method which has nonlinear objective function and/or constraints. This method is used in order to accommodate imperfect of linear programming. However, linear programming is focusing on the optimization (maximization or minimization) of a linear function by fulfilling all the constraints set which are also in linear functions (Bazaara & Jarvis, 1997). According to Bazaara & Shetty (1990), nonlinear programming is able to be modeled as below:

$$\textit{Minimize} \quad f(x) \tag{2.3}$$

$$\textit{Subject to} \quad g_i(x) \leq 0 \tag{2.4}$$

$$h_i(x) = 0 \tag{2.5}$$

$$x \in X \tag{2.6}$$

Function (2.3) represents the objective function, while function (2.4) is inequality constraint and function (2.5) is equality constraint. Using *x* as the vector of *n* components $(x_1, x_2, \dots, x_n)$ and *X* is the subset of E_n which consists of $f, g_1, \dots, g_m, h_1, \dots, h_m$. When vector $x \in X$ is satisfying the whole constraints in mathematical model, then the problem is able to be defined as feasible solution problem.

2.5.1 Quadratic Programming

Quadratic programming (QP) involves minimizing or maximizing an objective function subject to bounds, linear equality, and inequality constraints (MathWorks, 2016). According to Taha (2007) quadratic programming can be defined as follows:

$$\textit{Minimize} \quad f(x) \tag{2.7}$$

$$\textit{Subject to} \quad A(x) \leq b \tag{2.8}$$

$$x \geq 0 \tag{2.9}$$

Where:

$$x = (x_1, x_2, \dots, x_n)^T \tag{2.10}$$

$$c = (c_1, c_2, \dots, c_n) \tag{2.11}$$

$$b = (b_1, b_2, \dots, b_m)^T \tag{2.12}$$

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \quad (2.13)$$

$$D = \begin{pmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{m1} & \cdots & d_{mn} \end{pmatrix} \quad (2.14)$$

Based on the equations above, $f(x)$ indicates the objective function, while c is n dimension of vector rows which describes linear coefficient in objective function. D is symmetrical matrix to shows quadratic coefficient and A is a $m\ x\ n$ matrix where m is column vector dimension from right side of the coefficient.

2.5.2 Constrained Optimality Criteria

Regarding that quadratic programming contains of a non-linear objective function and also some linear constraints in its mathematic model, then an approach which can be used to find the optimum solution has to be based on constrained optimality criteria. General optimality approach such as *Cauchy's method*, *Newton's method*, and *Steepest Descent method* are unable to solve since the method was not accommodate the constraints under its mathematical model. There are some methods which can be used namely *Lagrange Multipliers* and *Kuhn-Tucker Condition*.

1. *Lagrange Multipliers*

   Lagrange Multipliers method is essentially giving a set of necessary condition to identify optima candidate points from constrained optimization problems. It can be done by converting constrained problems into unconstrained problems by the help of unspecified parameters known as *Lagrange Multipliers*.

   An example of *Lagrange Multipliers* usages in constrained problem optimization can be seen at the following.

   Minimize $f\ (x_1, x_2, \dots, x_n)$ (2.15)

   Subject to $h_1(x_1, x_2, \dots, x_n) = 0$ (2.16)

   Using *Lagrange Multipliers*, it converts the problem into the following unconstrained optimization problem.

Minimize $L(x, v) = f(x) - vh_1(x)$ (2.17)

After converting constrained problem into unconstrained problem by the help from *Lagrange Multipliers*, next step which need to be conducted is develop a *Hessian Matrix* for *x* and evaluate its value. Then the last process in *Lagrange Multipliers* method is calculate value of x_1^0, x_2^0, and min $f(x)$.

2. *Kuhn-Tucker Condition*

   Kuhn-Tucker Condition is an extension method from *Lagrange Multipliers* which able to be used in solving a constrained problems consists of both equality and inequality constraints.

   An example of non-linear programming problem which can be solved by *Kuhn-Tucker Condition* can be seen as the functions below.

   Minimize $f(x)$ (2.18)

   Subject to $g_j(x) \geq 0$ *for* $j = 1, 2, \dots, J$ (2.19)

   $h_k(x) = 0$ *for* $k = 1, 2, \dots, K$ (2.20)

   $x = (x_1, x_2, \dots, x_n)$ (2.21)

   Constraints in *Kuhn-Tucker Problems* had to be identified whether it was either active or inactive constraint. Recall constraint 2.9, it is said that it is an active constraint at the point of *x* when $g_j(x) = 0$; and contrary said that it is an inactive constraint at the point of *x* when$g_j(x) > 0$. Inactive constraint which had identified then able to be reduced or eliminated from the problem.

   In *Kuhn-Tucker Problem*, the mathematical model which constraints had identified then converted as can be seen at the following form.

   $\nabla f(x) - \sum_{j=1}^{J} u_j \nabla g_j(x) - \sum_{k=1}^{K} v_k \nabla h_k(x) = 0$ (2.22)

   $g_j(x) \geq 0$ *for* $j = 1, 2, \dots, J$ (2.23)

   $h_k(x) = 0$ *for* $k = 1, 2, \dots, K$ (2.24)

   $u_j g_j(x) = 0$ *for* $k = 1, 2, \dots, J$ (2.25)

   $u_j \geq 0$ *for* $k = 1, 2, \dots, J$ (2.26)

   After being converted as above, then the derivation value of each equation had to be found. Implement the equation 2.22 for each

derivation value. Then identify the complementary slackness existence, which is to convert inequality constraint into equality constraint. After that u_j and v_k strictness can be identified.

CHAPTER 3
RESEARCH METHODOLOGY

The chapter is showing and explaining about detailed framework and procedures followed in conducting the research as can be seen at the figure below.

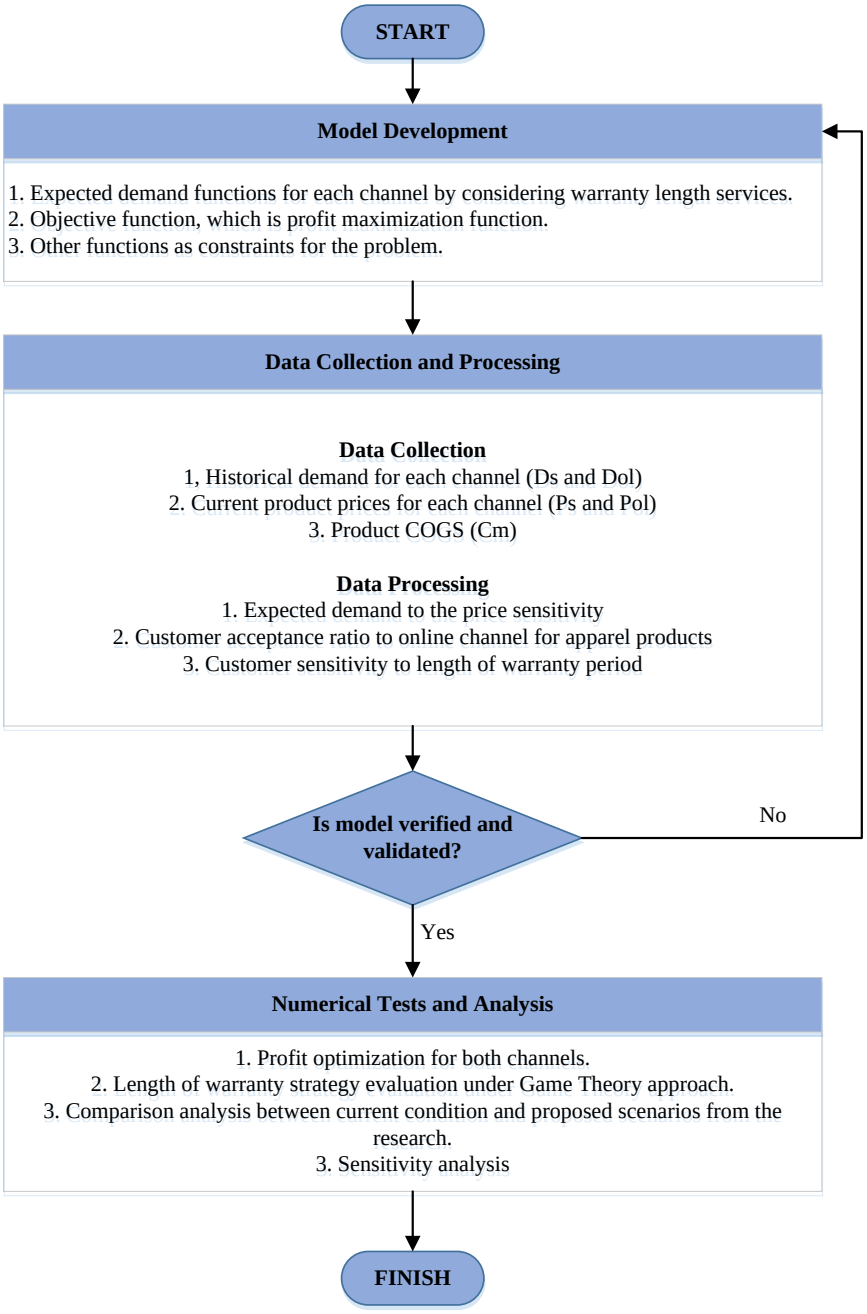

Figure 3. 1 Research Methodology Flowchart

3.1 Model Development Phase

In this research, the first phase which is needed to be conducted is develop the DCSC model. Previous model related to DCSC research can be used as the model references as main source to do the development processes. Those model references will be adjusted according to the real condition at observed system in this research.

Model developed in this research consists of three functions, such as customer demand function for each channel under DCSC system, objective function in the research which is maximizing profit for the whole DCSC system, and to accommodate the company condition constraint functions are developed too. Thus functions later will be used as mathematical model in generating profit optimization.

3.2 Data Collection Phase

In the data collection phase, data required as input for the next phases are identified and collected. Mainly, the data which needed to be collected is to evaluate the market and company condition. Market condition can be evaluated from voice of customers which accommodated by questionnaires. However the company condition can be evaluated from historical data which had been collected by the company. Data collected from the voice of customers questionnaires are related to customer preferences according to pricing and warranty sensitivity, while historical data collected from the company are related to manufacturing costs and historical demand for each channel.

3.3 Data Processing Phase

It is obvious that after data collection process, the next phase is data processing, especially in order to convert raw data from the market and company condition evaluation into parameters values which will be inputted into the model. Questionnaires which collected are processed in order to find the most approximate values of parameters in order to indicate the market condition.

3.4 Verification and Validation Phase

In order to eliminate error in the implementation of the model developed into the real system, verification and validation tests are required to be followed. Verification test is required to compare the model developed with the basic approach used for the research in order to evaluate error level in the model. The verification test can be performed by using *MATLAB* software to be the tool for model correction process. However validation is the test to compare model developed with the real system observed for the research. Validation test process has the aim to check whether the model developed had represented the real condition of the system or not. If there are some error found in the model by verification and validation check, then the model developed is required to be evaluated and model development process has to be conducted again.

3.5 Numerical Tests and Analysis

There are several processes in the numerical tests and analysis phase for the research. First numerical test which is conducted is to find the optimum product price for each channel by the use of *MATLAB* software. The tests are conducted in several times by changing the values of warranty periods in each channel. This process is done in order to get profit possibility by changing value of warranty period in each channel. Resulting some values of profit in each channel by different warranty periods inputted, later those values are used as an input in generating pay off matrix to evaluate DCSC game.

Generating payoff matrix can be done by assuming that each channel are the players under the same DCSC game, while different warranty period set as the strategy which can be chosen by each player, and profit achieved are the resources or values which contested by the players. Finding *nash equilibria* of the game will be a best method to find most acceptable warranty period for each channel to let all the players sustain in the game.

Resulting optimum product price and acceptable warranty period, then the last numerical tests which needed to be done is sensitivity analysis to evaluate which parameters are the most sensitive into profit achieved by the company. This sensitivity analysis is important for the implementation later in the company.

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CHAPTER 4
MODEL DEVELOPMENT

The chapter is explaining about model development processes using model existed based on previous research, and then adjusting the model with the research real problem.

4.1 Reference Model

Reference models used for the research are related to traditional channel demand (offline store), direct channel demand (online store), and demand functions by considering length of warranty offered on each channel. Following models are the reference demand functions model according to Widodo et al., (2011)

- In store demand function

$$d_s = D_s - \frac{P_s - P_{ol}}{1-\rho} \quad (4.1)$$

- Online demand function

$$d_{ol} = \frac{\rho P_s - P_{ol}}{\rho\,(1-\rho)} \quad (4.2)$$

When,

$$P_s > \frac{P_{ol}}{\rho} \text{ or } P_{ol} < \rho P_s \quad (4.3)$$

Variable notation description:

d_s : In store demand

d_{ol} : Online demand

D_s : Maximum demand in store

β : Price elasticity ratio into customer demand

P_s : Product's price in store

P_{ol} : Product's price in online facilities

ρ : Customer's preference ratio into online channel rather than offline channel

According to Chen, et al., (2012) when price differentiation between channels considered as an insignificant factor to the amount of customer demand but warranty as the significant factors. Then the following is a model indicates that

customer demand influenced by warranty periods offered. In this function, warranty period is defined as a dependent variable.

- Demand function under length of warranty period competition

$$D = \alpha + \lambda t_i - \gamma t_j \quad (4.4)$$

Variables notation description:

D : Expected demand

α : Primary demand of channel i

λ : Customer sensitivity to warranty period offered in channel i

t_i : Warranty period promised by channel i

γ : Customer sensitivity warranty period offered in channel j

t_j : Warranty period promised by channel j

4.2 System Description

DCSC system under observation for the research is an enterprise works in apparel industry field, who distributes their products in stores and online facilities such as website and social media accounts. DCSC system of the observed object consists of manufacturer, central warehouse, retail stores, online facilities, and end-customer. Online facilities existence into the system has the aim in order to make the market scopes to distribute their products in a wider scope. Figure below shows an illustration about DCSC system in observed object for the research.

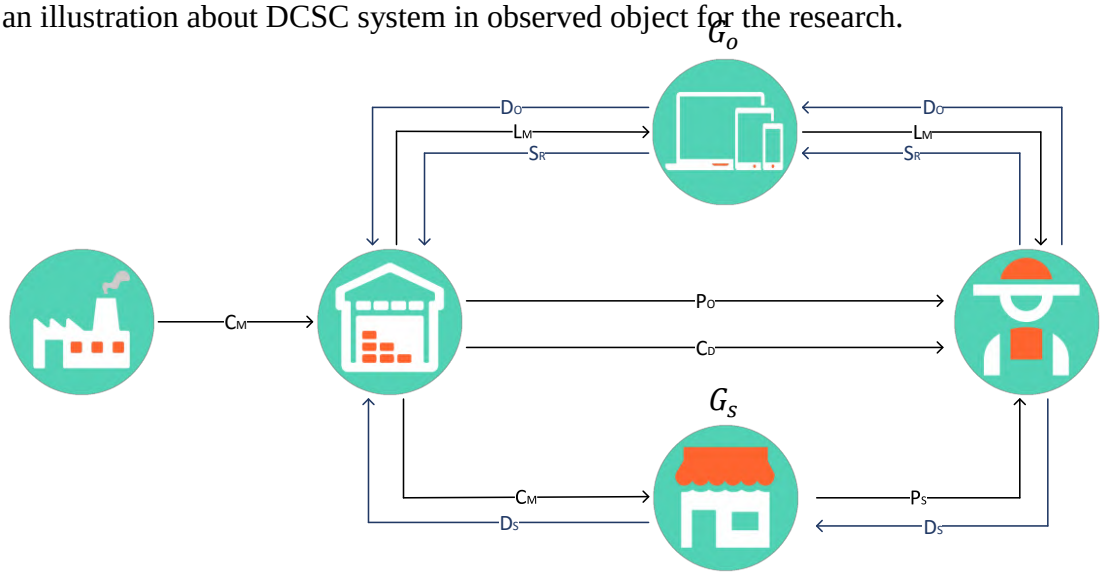

Figure 4. 1 Conceptual Model of *Heroine Experience Store* System

Heroine Experience Store is a company who runs business by offering apparel products for young male and female. In delivering the products to customer they were using multi channels, which are traditional channel or offline stores and direct channel which performed in online website and social media accounts. Those channels are operated by the company simultaneously, in order to expand their market targets. Customers are able to buy the products either from offline stores by visiting directly or using online facilities but need to wait the products to be delivered in a particular of time. Product's details and pictures are shown in their official website, and the order can be done by using particular features in the website or reaching admin by using social media accounts, such as *Whatsapp* and *Line*.

Setting product's prices, *Heroine Experience Store* has not considered the possibility of customer shifting through channels and also customer's price sensitivity. It is proven by the strategy of the company to set their product's price in a same price both in traditional and direct channels, even though for direct channel the price shown has not been included of transportation cost. Currently the company was using intuitive approach in setting the product's price. They were only consider product's COGS and some other competitor's prices in the market.

As an apparel company, they frequently faced sales return claim from customer after sales occurred, especially direct channel's customers. This condition is aggravated since the company has not set an appropriate warranty claim rules in their official website. However, in some cases after sales claim caused by the mistakes from company, such as product's defect which means that sales return has to be performed in order to increase the customer's satisfaction.

In this research there are some limitations and assumptions used to limit and simplify the research scope. Details of limitations and assumptions used in the research development are listed below.

4.2.1 System's Limitations

Limitations used are mentioned below:

1. Traditional channels under discussion for the research are 2 (two) offline stores owned and operated by *Heroine Experience Store*.

2. Online facilities under discussion is limited to *Heroine Experience Store*'s official website and also social media accounts which used to process customer's order.

4.2.2 System's Assumptions

Assumptions used can be seen at the following lists:

1. COGS for each unit of the product consists of manufacturing cost, inventory cost, and also distribution costs into stores.
2. Primary data collected related to questionnaire results are assumed to be able represent the most of customer behavior and preferences for *Heroine Experience Store*.
3. Secondary data collected related to demand and COGS calculation from *Heroine Experience Store* are assumed to be sufficient enough to represent the condition of observed object.

4.3 Research Model

Research model which is developed in this part will be discussed from an explanation of used variables notation or definition, then adjusted demand model based on modified reference model, and also the mathematical models of the problem consists of its objective function and constraint equations. Further explanation can be seen at the following.

4.3.1 Variables Notation

Followings are variables used in the mathematical model development which divided into each type of the variables. Notation of the variables later will be used in model developed.

- Decision Variables

  P_s : Product's price in traditional channel

  P_{ol} : Product's price in direct channel

  t_s : Length of warranty offered in traditional channel

  t_{ol} : Length of warranty offered in direct channel

- Dependent Variables
  - d_s : Expected demand in traditional channel
  - d_{ol} : Expected demand in direct channel
  - G_s : Total profit in traditional channel
  - G_{ol} : Total profit in direct channel
  - G_T : Total profit in whole supply chain
- Parameters
  - ρ : Customer's preference ratio to direct channel
  - β : Customer's sensitivity ratio into price
  - λ : Customer's acceptance ratio to length of warranty offered in direct channel
  - γ : Customer's acceptance ratio to length of warranty offered in traditional channel
  - d_s^{max} : Demand maximum from historical data in traditional channel
  - C_M : Manufacturing costs spent by manufacturer for each unit of the products (COGS)

4.3.2 Demand Function

Demand functions were developed by considering the existence of two channels which may lead to different pricing determination in traditional and direct channels under the same supply chain system. Recall that a study in China mention that in some particular problems price is no longer has been the significant factor to customer demand. Customer starts to attract by the existence of product warranty to reduce customer risks in selecting a product in the market.

Demand functions developed for both traditional and direct channels were using demand function according to Widodo, et al., (2011) and Chen, et al., (2012) as the references and main bases. Developed demand function for traditional and direct channels can be seen at the following.

- Traditional channel demand (offline store)

  According to Chen and Simchi Levi, (2004) traditional channel demand is commonly modeled by:

  $$d_s = D_s^{max} - \beta P_s \quad (4.5)$$

  Under the condition:

  D_s^{max} : Largest amount of expected demand in store channel

  β : Demand elasticity ratio on price

  P_s : Product price in store channel

  As can be seen at the function above, there is not any influence from product price differences between traditional (P_s) and direct (P_o) channels. Recall the equation 4.1 according to Widodo, et al., (2011) the problem in order to overcome product price differentiation between channels is solved. However the equation still unable to overcome the different warranty period in the channels under the same supply chain system. In other hand, the equation 4.3 according to Chen, et al., (2012) has been considering length of warranty period offered, but the product price considered as insignificant factors to customer demand. That is why, to overcome the problem in accommodating customer demand sensitivity to product price and also length of warranty period offered between channels those model are combined as seen at the equation below.

  $$d_s = \left(D_s^{max} - \beta \frac{P_s - P_{ol}}{1-\rho}\right) + \lambda t_s - \gamma t_{ol} \quad (4.6)$$

  Graphical representation to develop direct channel function using the previous traditional channel function can be seen as the following.

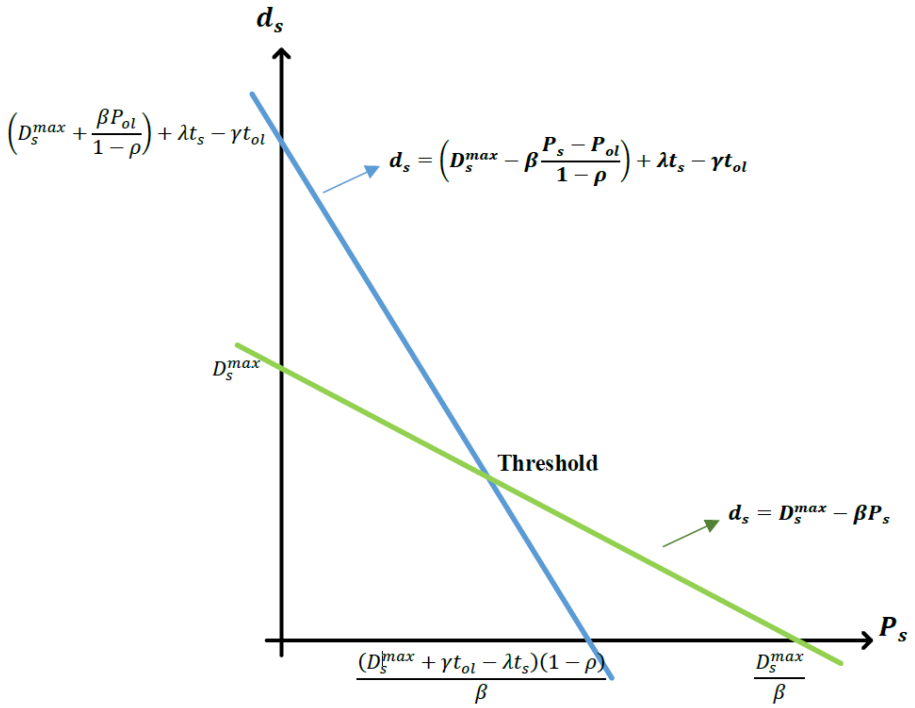

Figure 4. 2 Traditional Channel Demand Function Graphical Representation

- Direct channel demand (online store)

  Direct channel demand function is also using the model reference according to Widodo, et al., (2011). However, since the traditional channel demand was modified and adjusted to accommodate length of warranty period consideration, then direct channel demand is also required an adjustment based on the procedure of providing direct channel demand from Widodo, et al., (2011) as follow.

  1. Online facility is only can make sales under the normal condition, which is:

     $P_s > \frac{P_{ol}}{\rho}$ or $P_{ol} < \rho P_s$

  2. Online facility sales can be represented by a space shift from d_s^{lt} to d_s^{ut}, explained at the calculation below.

     $d_s^{lt} = D_s^{max} - \beta P_s$ (4.7)

     $d_s^{ut} = \left(D_s^{max} - \beta \frac{P_s - P_{ol}}{1-\rho}\right) + \lambda t_s - \gamma t_{ol}$ (4.8)

     So that,

     $d_{ol} = d_s^{lt} - d_s^{ut}$ (4.9)

$$d_{ol} = (D_s^{max} - \beta P_s) - \left[\left(D_s^{max} - \beta \frac{P_s - P_{ol}}{1-\rho}\right) + \lambda t_s - \gamma t_{ol}\right] \quad (4.10)$$

Following the equation above, then the expected demand for direct channel by considering length of warranty period and price sensitivity can be seen below.

$$d_{ol} = \frac{\beta\rho P_s - \beta P_{ol} + (\gamma t_{ol} - \lambda t_s)(1-\rho)}{(1-\rho)}$$

$$d_{ol} = \frac{\beta(\rho P_s - P_{ol}) + (\gamma t_{ol} - \lambda t_s)(1-\rho)}{(1-\rho)} \quad (4.11)$$

Since originally, online demand is also influenced by acceptance ratio of customer into online channel rather than offline channel, then the equation updated as follow.

$$\rho d_{ol} = \frac{\beta(\rho P_s - P_{ol}) + (\gamma t_{ol} - \lambda t_s)(1-\rho)}{(1-\rho)}$$

$$d_{ol} = \frac{\beta(\rho P_s - P_{ol}) + (\gamma t_{ol} - \lambda t_s)(1-\rho)}{\rho(1-\rho)} \quad (4.12)$$

Graphical representation for direct channel after the formula derivation can be seen on the figure below.

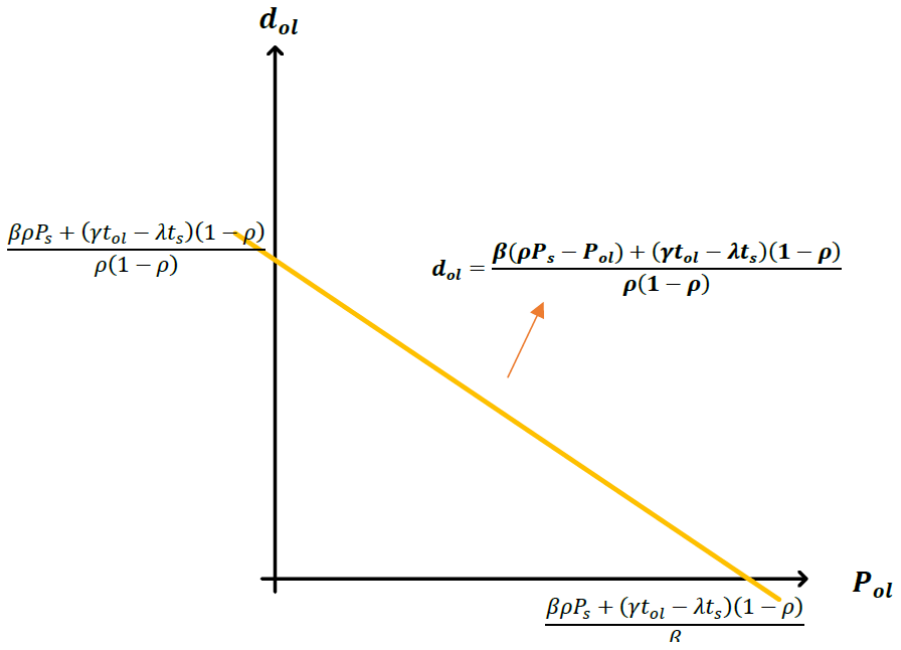

Figure 4. 3 Direct Channel Demand Function Graphical Representation

4.3.3 Mathematical Model of the Problem

In order to solve an optimization problem, the mathematical model which is able to be used as a representative model indicates the real problem has to be made. Generally mathematical model developed consists of objective function and also constraints which influence the decision variable required to be found.

1. Objective Function

   In this research, the objective function for mathematical model developed is a profit maximization to be achieved by the whole players under same supply chain system. So that, objective functions for the problem is divided into two, such as:

   - Profit maximization function for traditional channel.
   - Profit maximization function for direct channel.

   Using those profit maximization functions, the whole supply chain profit maximization can be achieved (G_{so}). Generally, profit calculation used in this research is using the following equation:

   $$Total\ Profit = (Selling\ Price - COGS)\ x\ Demand \quad (4.13)$$

   Then, the following equations are developed for profit maximization function of each channel in DCSC system under observation.

   - Traditional channel profit

     $$G_s = (P_s - C_M)\ x\ d_s$$

     $$G_s = (P_s - C_M)\ x\ \left[\left(D_s^{max} - \beta\frac{P_s - P_{ol}}{1-\rho}\right) + \lambda t_s - \gamma t_{ol}\right] \quad (4.14)$$

   - Direct channel profit

     $$G_o = (P_o - C_M)\ x\ d_{ol}$$

     $$G_o = (P_o - C_M)\ x\ \left[\frac{P_s(\beta - 1 + \rho) - \beta P_{ol} + (\gamma t_{ol} - \lambda t_s)(1-\rho)}{\rho(1-\rho)}\right] \quad (4.15)$$

   - Total profit for DCSC

     $$G_{so} = G_s + G_o \quad (4.16)$$

2. Constraint Equations

   Following equations are constraints used for the research.

- $P_s > C_M$ (4.17)

  Constraint indicates that the price set in traditional channel has to be higher than manufacturing costs (COGS).
- $P_{ol} > C_M$ (4.18)

  Constraint to indicate the price set in direct channel is also has to be higher than manufacturing costs (COGS).
- $\frac{P_{ol}}{\rho} \leq P_s$ (4.19)

  Constraint to assure the existence of direct channel occurrences.
- $P_s \geq P_{ol}$ (4.20)

  Constraint to define a price leadership condition, where product price in traditional channel has to be larger than product price in direct channel.
- $D_s \geq 0$ (4.21)

  Constraint to let the demand possibility is never be in negativity values.
- $D_{ol} \geq 0$ (4.22)

  Constraint to let the demand possibility is never be in negativity values.

4.4 Parameter Data Collection and Processing

In this sub chapter parameters required for the formulation as explained at the previous sub chapter will be discussed. Parameters are collected both from questionnaires and historical data from observed object. These following parameters which shown will be explained as listed below.

4.4.1 β Parameter

β is a parameter to indicate customer's sensitivity ratio into price changes in the market. This parameter is collected from questionnaire which fulfilled by correspondences as samples to accommodate their preference into price sensitivity.

Table 4. 1 β Parameter Data Collection based on Questionnaires

No.	β Indicator	β	No.	β Indicator	β
1	Rp 1,000.00	0.00100000	32	Rp 30,000.00	0.00003333
2	Rp 5,000.00	0.00020000	33	Rp 30,000.00	0.00003333
3	Rp 5,000.00	0.00020000	34	Rp 40,000.00	0.00002500
4	Rp 5,000.00	0.00020000	35	Rp 50,000.00	0.00002000
5	Rp 10,000.00	0.00010000	36	Rp 50,000.00	0.00002000
6	Rp 10,000.00	0.00010000	37	Rp 50,000.00	0.00002000
7	Rp 10,000.00	0.00010000	38	Rp 50,000.00	0.00002000
8	Rp 15,000.00	0.00006667	39	Rp 50,000.00	0.00002000
9	Rp 15,000.00	0.00006667	40	Rp 50,000.00	0.00002000
10	Rp 15,000.00	0.00006667	41	Rp 50,000.00	0.00002000
11	Rp 15,000.00	0.00006667	42	Rp 50,000.00	0.00002000
12	Rp 15,000.00	0.00006667	43	Rp 50,000.00	0.00002000
13	Rp 15,000.00	0.00006667	44	Rp 50,000.00	0.00002000
14	Rp 20,000.00	0.00005000	45	Rp 50,000.00	0.00002000
15	Rp 20,000.00	0.00005000	46	Rp 50,000.00	0.00002000
16	Rp 20,000.00	0.00005000	47	Rp 50,000.00	0.00002000
17	Rp 20,000.00	0.00005000	48	Rp 50,000.00	0.00002000
18	Rp 20,000.00	0.00005000	49	Rp 50,000.00	0.00002000
19	Rp 20,000.00	0.00005000	50	Rp 50,000.00	0.00002000
20	Rp 20,000.00	0.00005000	51	Rp 50,000.00	0.00002000
21	Rp 20,000.00	0.00005000	52	Rp 50,000.00	0.00002000
22	Rp 20,000.00	0.00005000	53	Rp 50,000.00	0.00002000
23	Rp 20,000.00	0.00005000	54	Rp 50,000.00	0.00002000
24	Rp 20,000.00	0.00005000	55	Rp 70,000.00	0.00001429
25	Rp 20,000.00	0.00005000	56	Rp 100,000.00	0.00001000
26	Rp 20,000.00	0.00005000	57	Rp 100,000.00	0.00001000
27	Rp 25,000.00	0.00004000	58	Rp 100,000.00	0.00001000
28	Rp 25,000.00	0.00004000	59	Rp 100,000.00	0.00001000
29	Rp 25,000.00	0.00004000	60	Rp 100,000.00	0.00001000
30	Rp 30,000.00	0.00003333	61	Rp 100,000.00	0.00001000
31	Rp 30,000.00	0.00003333	62	Rp 100,000.00	0.00001000
			Mean		0.00005988
			Mode		0.00002

β parameter means that in every price changes offered by the manufacturer to their customer, there will be a differences in total customer demand achieved by the company. At the table 4.1, it can be seen that β indicator was collected based on customer preference in giving a tolerance for price differences between

traditional and direct channel for the same product. Recall the equation (4.1) according to Widodo et al., (2011), by neglecting other parameter values (D_s and ρ), then:

$$d_s = \beta\ (P_s - P_{ol}) \tag{4.23}$$

Regarding that each questionnaire to accommodate 1 sample of demand, then it can be assumed that every price tolerance is influence 1 value into total demand achieved by the company. Then, to convert β indicator from questionnaire into β value can be seen as the following.

$$\beta = \frac{1}{(Ps - Pol)} \tag{4.24}$$

An example calculation in converting β indicator from questionnaire into β value:

$$\beta = \frac{1}{50000}$$
$$= 0.00002$$

Based on the questionnaires, it is seen that the mean of β parameter is 0.00005988. While the most respondents are sensitive at the price Rp50,000.00 then the mode of β parameter is 0.00002. Considering the frequencies of suggested values from the respondents, then frequency distribution table is developed as can be seen at the table below.

Table 4. 2 Frequency Distribution Table of β parameter

No.	β Indicator		X_i	F_i
1	Rp 1,000.00	Rp 15,315.93	Rp 8,157.96	13
2	Rp 15,316.93	Rp 29,632.85	Rp 22,474.89	16
3	Rp 29,633.85	Rp 43,949.78	Rp 36,791.81	5
4	Rp 43,950.78	Rp 58,266.70	Rp 51,108.74	20
5	Rp 58,267.70	Rp 72,583.63	Rp 65,425.66	1
6	Rp 72,584.63	Rp 86,900.55	Rp 79,742.59	0
7	Rp 86,901.55	Rp 101,217.48	Rp 94,059.51	7
Total				**62**

According to the table above, it is seen that the highest frequency shown in the class of Rp 43,950.78 – Rp 58,266.70 with the total frequencies selected 20. While the other class with quite high values of frequencies selected are 2nd and 1st class. These 3 classes will be used as an input for the β parameter in numerical test processes.

4.4.2 ρ Parameter

ρ is a parameter to indicate customer's preference ratio into direct channel instead of traditional channel. The following is recapped of collected questionnaire answers related to customer's preference ratio into direct channel.

Table 4. 3 ρ Parameter Data Collection based on Questionnaires

No.	ρ Indicator	ρ	No.	ρ Indicator	ρ
1	Rp 50,000.00	0.40	32	Rp 100,000.00	0.80
2	Rp 60,000.00	0.48	33	Rp 100,000.00	0.80
3	Rp 70,000.00	0.56	34	Rp 100,000.00	0.80
4	Rp 70,000.00	0.56	35	Rp 100,000.00	0.80
5	Rp 75,000.00	0.60	36	Rp 100,000.00	0.80
6	Rp 75,000.00	0.60	37	Rp 100,000.00	0.80
7	Rp 75,000.00	0.60	38	Rp 100,000.00	0.80
8	Rp 75,000.00	0.60	39	Rp 100,000.00	0.80
9	Rp 75,000.00	0.60	40	Rp 100,000.00	0.80
10	Rp 75,000.00	0.60	41	Rp 100,000.00	0.80
11	Rp 75,000.00	0.60	42	Rp 100,000.00	0.80
12	Rp 75,000.00	0.60	43	Rp 100,000.00	0.80
13	Rp 80,000.00	0.64	44	Rp 100,000.00	0.80
14	Rp 80,000.00	0.64	45	Rp 100,000.00	0.80
15	Rp 80,000.00	0.64	46	Rp 100,000.00	0.80
16	Rp 85,000.00	0.68	47	Rp 100,000.00	0.80
17	Rp 85,000.00	0.68	48	Rp 105,000.00	0.84
18	Rp 90,000.00	0.72	49	Rp 110,000.00	0.88
19	Rp 90,000.00	0.72	50	Rp 110,000.00	0.88
20	Rp 90,000.00	0.72	51	Rp 110,000.00	0.88
21	Rp 90,000.00	0.72	52	Rp 110,000.00	0.88
22	Rp 90,000.00	0.72	53	Rp 110,000.00	0.88
23	Rp 90,000.00	0.72	54	Rp 112,500.00	0.90
24	Rp 90,000.00	0.72	55	Rp 115,000.00	0.92
25	Rp 95,000.00	0.76	56	Rp 115,000.00	0.92
26	Rp 100,000.00	0.80	57	Rp 115,000.00	0.92
27	Rp 100,000.00	0.80	58	Rp 120,000.00	0.96
28	Rp 100,000.00	0.80	59	Rp 120,000.00	0.96
29	Rp 100,000.00	0.80	60	Rp 122,000.00	0.98
30	Rp 100,000.00	0.80	61	Rp 125,000.00	1.00
31	Rp 100,000.00	0.80	62	Rp 125,000.00	1.00
			Mean		0.66709677
			Mode		0.6

ρ indicator values shown at table 4.2 is collected from the questionnaire based on customer preference in suggesting the current product price for direct channel, since ρ parameter indicates the customer acceptance ratio into direct channel by the existence of traditional channel. Converting ρ indicator into ρ values as can be seen at the table above is following the equation as seen below.

$$\rho = \frac{Suggested\ Price\ by\ Customer}{Current\ Product\ Price\ in\ Traditional\ Channel}$$

An example to convert ρ indicator into ρ value as the parameter in this research:

$$\rho = \frac{100000}{125000}$$
$$= 0.8$$

Based on the questionnaires, it can be seen that ρ mean value is 0.6671. While mode value for this parameter is 0.6. Considering frequencies of respondent's suggestions into the value of this parameter, frequency distribution table is developed as can be seen at the table below.

Table 4. 4 Frequency Distribution Table for ρ Parameter

No.	ρ Indicator		X_i	F_i
1	Rp 50,000.00	Rp 60,845.16	Rp 55,422.58	2
2	Rp 60,846.16	Rp 71,691.31	Rp 66,268.73	2
3	Rp 71,692.31	Rp 82,537.47	Rp 77,114.89	11
4	Rp 82,538.47	Rp 93,383.62	Rp 87,961.04	9
5	Rp 93,384.62	Rp 104,229.78	Rp 98,807.20	23
6	Rp 104,230.78	Rp 115,075.93	Rp 109,653.36	10
7	Rp 115,076.93	Rp 125,922.09	Rp 120,499.51	5
Total				**62**

As can be seen at the table above, the highest frequency of ρ indicator suggested is at the 5th class which resulting ρ parameter at the value of 0.7905. This value will be used as an input parameter for ρ.

4.4.3 λ Parameter

λ is a parameter to indicate the customer's acceptance ratio into length of warranty service period offered by traditional channel. The value of acceptance ratio into length of warranty service offered by traditional channel also needed to

be evaluated since generally, traditional channel is offering shorter warranty period. This condition is due to customer has an opportunity to check the products instead of only seeing in picture as direct channel customer.

Table 4. 5 λ Parameter Data Collection based on Questionnaires

No.	λ Indicator	λ	No.	λ Indicator	λ
1	1	0.047619048	32	10	0.476190476
2	1	0.047619048	33	10	0.476190476
3	1	0.047619048	34	10	0.476190476
4	2	0.095238095	35	10	0.476190476
5	2	0.095238095	36	10	0.476190476
6	2	0.095238095	37	10	0.476190476
7	3	0.142857143	38	11	0.523809524
8	3	0.142857143	39	11	0.523809524
9	3	0.142857143	40	14	0.666666667
10	3	0.142857143	41	14	0.666666667
11	5	0.238095238	42	14	0.666666667
12	7	0.333333333	43	14	0.666666667
13	7	0.333333333	44	14	0.666666667
14	7	0.333333333	45	14	0.666666667
15	7	0.333333333	46	14	0.666666667
16	7	0.333333333	47	14	0.666666667
17	7	0.333333333	48	15	0.714285714
18	7	0.333333333	49	15	0.714285714
19	7	0.333333333	50	15	0.714285714
20	7	0.333333333	51	15	0.714285714
21	7	0.333333333	52	15	0.714285714
22	7	0.333333333	53	15	0.714285714
23	7	0.333333333	54	18	0.857142857
24	7	0.333333333	55	21	1
25	7	0.333333333	56	21	1
26	7	0.333333333	57	21	1
27	7	0.333333333	58	21	1
28	7	0.333333333	59	21	1
29	7	0.333333333	60	21	1
30	7	0.333333333	61	21	1
31	7	0.333333333	62	21	1
			Mean		0.25499232
			Mode		0.333333333

Since λ parameter indicates customer acceptance ratio into length of warranty service offered in traditional channel, then this parameter is able to influence the demand in traditional channel regarding length of warranty offered in the channel. Regarding it is an acceptance ratio based on customer preferences, it can be evaluated as the following.

$$\lambda = \frac{Suggested\ Warranty\ Period}{Maximum\ Period\ Offered\ in\ Questionnaires}$$

For example,

$$\lambda = \frac{1}{21}$$

$$\lambda = 0.047619048$$

Similar with other parameter which the value is collected based on questionnaire, then the consideration of frequency distribution to evaluate preferences among respondents can be seen through the following frequency distribution table.

Table 4. 6 Frequency Distribution Table for λ Parameter

No.	λ Indicator		X_i	F_i
1	1	3	2	10
2	4	6	5	1
3	7	9	8	20
4	10	12	11	8
5	13	15	14	14
6	16	18	17	1
7	19	21	20	8
Total				**62**

It can be seen from the table above that the value of λ indicator from the questionnaires which most frequent selected is at the 3rd class. The value of bin at this class which is 8 will be used as the main λ indicator as an input at the numerical test.

4.4.4 γ Parameter

γ is the parameter value to indicate the acceptance ratio of customer into warranty length offered in direct channel. The value of acceptance ratio into warranty length offered in direct channel also need to be considered, since the

customer in direct channel is unable to check the products as traditional channel's customer did. They need some assurance about product's performance and quality through the warranty service offered in direct channel. The following table is showing lists of length of warranty suggested by respondents from questionnaire collected.

Table 4. 7 γ Parameter Data Collected based on Questionnaires

No.	γ Indicator	γ	No.	γ Indicator	γ
1	1	0.035714	32	14	0.500000
2	2	0.071429	33	14	0.500000
3	4	0.142857	34	14	0.500000
4	5	0.178571	35	14	0.500000
5	5	0.178571	36	15	0.535714
6	5	0.178571	37	15	0.535714
7	7	0.250000	38	15	0.535714
8	7	0.250000	39	15	0.535714
9	7	0.250000	40	20	0.714286
10	7	0.250000	41	20	0.714286
11	7	0.250000	42	21	0.750000
12	7	0.250000	43	21	0.750000
13	7	0.250000	44	25	0.892857
14	7	0.250000	45	28	1.000000
15	7	0.250000	46	28	1.000000
16	7	0.250000	47	28	1.000000
17	7	0.250000	48	28	1.000000
18	7	0.250000	49	28	1.000000
19	10	0.357143	50	28	1.000000
20	14	0.500000	51	28	1.000000
21	14	0.500000	52	28	1.000000
22	14	0.500000	53	28	1.000000
23	14	0.500000	54	28	1.000000
24	14	0.500000	55	28	1.000000
25	14	0.500000	56	28	1.000000
26	14	0.500000	57	28	1.000000
27	14	0.500000	58	28	1.000000
28	14	0.500000	59	28	1.000000
29	14	0.500000	60	28	1.000000
30	14	0.500000	61	28	1.000000
31	14	0.500000	62	28	1.000000
			Mean		0.58237327
			Mode		1

Similar with λ parameter, γ indicator is collected by the suggestion from respondents about length of warranty service offered in direct channel based on their preferences. Since it is an acceptance ratio, then the value of γ parameter can be done as seen at the following.

$$\gamma = \frac{Suggested\ Warranty\ Period}{Maximum\ Length\ of\ Warranty\ Offered\ in\ Questionnaires}$$

Equation above based on the consideration of acceptance by the mean how far the warranty period expected by customer if they are able to choose a value in the range of 1-28 days for the direct channel. That is why; the following is an example of the calculation for γ.

$$\gamma = \frac{1}{28}$$

$$\gamma = 0.035714$$

As the other previous parameters, the existence of frequency suggested by respondents in determining γ value is also considered. The following is a frequency distribution table for γ parameter.

Table 4. 8 Frequency Distribution Table for γ Parameter

No.	γ Indicator		X_i	F_i
1	1	4	3	3
2	5	8	7	15
3	9	12	11	1
4	13	16	15	20
5	17	20	19	2
6	21	24	23	2
7	25	28	27	19
Total				**62**

According to the table, it can be seen that the bin which are most selected by the respondents are at 4th class. Then the value of γ indicator which used in numerical test is 0.535714.

4.4.5 D_s^{max} Parameter

D_s^{max} parameter represents estimated total demand from customer when the products offered as the same value of its manufacturing cost (COGS). Value of

D_s^{max} can be estimated by considering historical demand in the observed object. Table below is showing total demand in traditional channel, then followed by table which is showing total demand in direct channel, especially man t-shirt product.

Table 4. 9 Historical Demand of Man T-shirt during January-May 2016 in Traditional Channel

No	Month	Total Demand	Tees Demand	Total Sales	Shirt Sales
1	January	216	30	Rp 33,263,900.00	Rp 3,750,000.00
2	February	228	34	Rp 32,684,250.00	Rp 4,250,000.00
3	March	275	28	Rp 38,172,700.00	Rp 3,500,000.00
4	April	222	34	Rp 31,863,100.00	Rp 4,250,000.00
5	May	278	29	Rp 45,367,000.00	Rp 3,625,000.00
Total		1219	155	Rp 181,350,950.00	Rp 19,375,000.00
Mean		243.8	31	Rp 36,270,190.00	Rp 3,875,000.00
Max		278	34	Rp 45,367,000.00	Rp 4,250,000.00

Table 4. 10 Historical Demand of Man T-shirt during January-May 2016 in Direct Channel

No.	Month	Total Demand	Tees Demand	Total Sales	Shirt Sales
1	January	6	1	Rp 1,288,000.00	Rp 125,000.00
2	February	5	1	Rp 1,059,000.00	Rp 125,000.00
3	March	8	2	Rp 1,392,000.00	Rp 250,000.00
4	April	11	1	Rp 1,979,000.00	Rp 125,000.00
5	May	7	2	Rp 1,678,000.00	Rp 250,000.00
Total		37	7	Rp 7,396,000.00	Rp 875,000.00
Mean		7	1	Rp 1,479,200.00	Rp 175,000.00
Max		11	2	Rp 1,979,000.00	Rp 250,000.00

Regarding D_s^{max} parameter is a demand value which is only in traditional channel when the product is offered at the same price with COGS, then the value of D_s^{max} has to be greater than 34. Because, from the historical data at table 4.5, it can be seen that the maximum demand based on history is 39. However, based on expert experiences, the total demand during sales and expo which is eventually the demand could be more than 100 shirt, even it was on sale not reaching the product price as the same value with COGS. That is why; in this research the D_s^{max} used has to be greater than 100, and the test used at 110.

4.4.6 t_s Parameter

t_s is the parameter used to represent length of warranty services offered by traditional channel to their customer. Since currently the observed object has not set an appropriate procedural and rules related to warranty services provided by the company as an after sales service, then this parameter is also collected from questionnaires. The following table is showing collected data for t_s parameter based on respondent's suggestions.

Table 4. 11 Suggested Length of Warranty Service for Traditional Channel from Questionnaires

No.	t_s Suggestions	Definition	No.	t_s Suggestions	Definition
1	Short period	1-7 days	26	Long period	15-21 days
2	Medium period	8-14 days	27	Long period	15-21 days
3	Medium period	8-14 days	28	Medium period	8-14 days
4	Medium period	8-14 days	29	Short period	1-7 days
5	Short period	1-7 days	30	Short period	1-7 days
6	Long period	15-21 days	31	Short period	1-7 days
7	Medium period	8-14 days	32	Short period	1-7 days
8	Short period	1-7 days	33	Short period	1-7 days
9	Medium period	8-14 days	34	Short period	1-7 days
10	Short period	1-7 days	35	Short period	1-7 days
11	Short period	1-7 days	36	Short period	1-7 days
12	Short period	1-7 days	37	Long period	15-21 days
13	Short period	1-7 days	38	Short period	1-7 days
14	Medium period	8-14 days	39	Medium period	8-14 days
15	Medium period	8-14 days	40	Short period	1-7 days
16	Short period	1-7 days	41	Short period	1-7 days
17	Medium period	8-14 days	42	Short period	1-7 days
18	Long period	15-21 days	43	Short period	1-7 days
19	Medium period	8-14 days	44	Short period	1-7 days
20	Medium period	8-14 days	45	Short period	1-7 days
21	Short period	1-7 days	46	Long period	15-21 days
22	Medium period	8-14 days	47	Medium period	8-14 days
23	Short period	1-7 days	48	Short period	1-7 days
24	Medium period	8-14 days	49	Long period	15-21 days
25	Short period	1-7 days	50	Short period	1-7 days

According to the table 4.7 above, the conclusion of respondent's suggestions about length of warranty services should be offered by the observed object for its traditional channel is can be seen at the pie chart below.

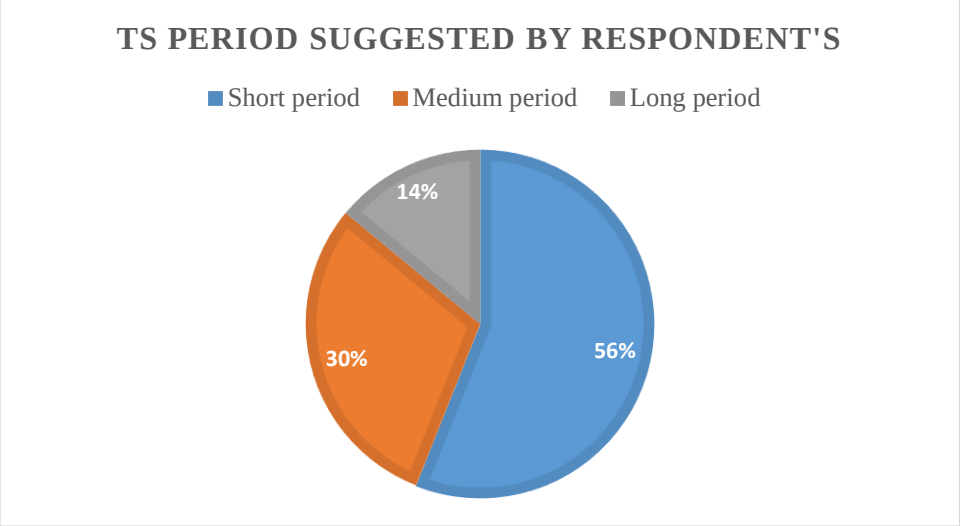

Figure 4. 4 ts Suggested by Respondents based on Questionnaire Proportions

Based on the figure 4.2 above, it can be seen that the most suggested length of warranty service which should be offered by company for its traditional channel is in short period. However, since the number of respondents who suggest medium period and long period is still worth considering by the value of 30% and 14%, then all possibilities of period group will be tested in optimization stage by using the maximum period of each group, which are 7, 14, and also 21 days.

4.4.7 t_{ol} Parameter

Contrary with t_s, t_{ol} parameter is representing length of warranty services offered in direct channel. This parameter accommodated by suggestions from respondents related to length of warranty service to accommodate the claim after sales service in direct channel based on their preferences. The data collected for this parameter can be seen at the following table.

Table 4. 12 Suggested Length of Warranty Service for Direct Channel from Questionnaires

No.	t_{ol} Suggestions	Definition	No.	t_{ol} Suggestions	Definition
1	Short period	1-7 days	26	Long period	15-21 days

No.	t_{ol} Suggestions	Definition	No.	t_{ol} Suggestions	Definition
2	Medium period	8-14 days	27	Very long period	22-28 days
3	Medium period	8-14 days	28	Short period	1-7 days
4	Very long period	22-28 days	29	Medium period	8-14 days
5	Medium period	8-14 days	30	Short period	1-7 days
6	Very long period	22-28 days	31	Very long period	22-28 days
7	Medium period	8-14 days	32	Short period	1-7 days
8	Medium period	8-14 days	33	Short period	1-7 days
9	Long period	15-21 days	34	Short period	1-7 days
10	Short period	1-7 days	35	Short period	1-7 days
11	Short period	1-7 days	36	Short period	1-7 days
12	Long period	15-21 days	37	Very long period	22-28 days
13	Short period	1-7 days	38	Medium period	8-14 days
14	Very long period	22-28 days	39	Medium period	8-14 days
15	Long period	15-21 days	40	Medium period	8-14 days
16	Medium period	8-14 days	41	Short period	1-7 days
17	Very long period	22-28 days	42	Long period	15-21 days
18	Medium period	8-14 days	43	Short period	1-7 days
19	Very long period	22-28 days	44	Medium period	8-14 days
20	Short period	1-7 days	45	Short period	1-7 days
21	Medium period	8-14 days	46	Medium period	8-14 days
22	Medium period	8-14 days	47	Very long period	22-28 days
23	Short period	1-7 days	48	Very long period	22-28 days
24	Short period	1-7 days	49	Short period	1-7 days
25	Long period	15-21 days	50	Short period	1-7 days

According to the table 4.7 above, the conclusion of respondent's suggestions about length of warranty services should be offered by the observed object for its traditional channel is can be seen at the pie chart below.

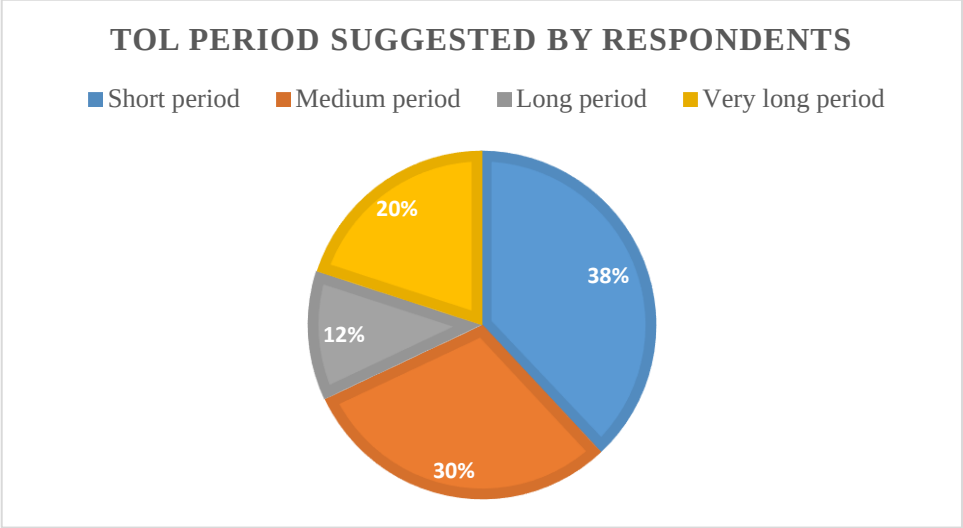

Figure 4. 5 ts Suggested by Respondents based on Questionnaire Proportions

Based on the figure 4.3 above, it can be seen that all the length of warranty service period asked in questionnaire are worth considering in optimization stage. The results from questionnaires are biased, it can be seen that the proportions value of each option is insignificant different, except long period which only 12%. That is why; all the options of suggested length of warranty which should be offered by the company will be tested in optimization stage to find the optimum value of length of warranty service should be offered for direct channel.

4.4.8 C_M Parameter

C_M indicates the total manufacturing cost spent by the company in order to develop each unit product before ready to be sold. This parameter is also accommodated by the historical data from company in production process. Manufacturing cost defined as the whole costs required in producing a product, includes of materials procurement, production process, packaging process, inventory management, until transportation cost.

Based on interview with the employee of *Heroine Experience Store* it is said that the total manufacturing cost for a man t-shirt product is around Rp65.000,00.

4.5 Recapped Parameters Value

Concluding all parameters had been collected in data collection and also processed in previous sub chapter, then the following is a table to show all the recapitulation parameter values which will be used in the optimization stage.

Table 4. 13 Recapped Parameters used for Numerical Test

No.	Parameters	Highest Frequency Sequence						
		1st	2nd	3rd	4th	5th	6th	7th
1	β	0.000019566	0.000044494	0.000122580	0.000010632	0.000027180	0.000015285	0.000012540
2	ρ	0.790457597	0.616919110	0.877226841	0.703688353	0.963996085	0.443380622	0.530149866
3	λ	0.380952381	0.666666667	0.095238095	0.523809524	0.952380952	0.238095238	0.809523810
4	γ	0.517857143	0.946428571	0.232142857	0.089285714	0.660714286	0.803571429	0.375000000

Those parameters which shown at the table 4.13 are mentioned in a sequence based on their selected frequencies, since the consideration of central tendency (mode, median, mean) are important for the generation of parameters value based on the data collected. However for C_M and D_s^{max} which are from the historical data is not requiring this step, so that the value of C_M and D_s^{max} will be used are at Rp 65,000.00 and 110 for the numerical tests.

However for other parameters, which are t_s and t_{ol} is not recapped in this parameter recapitulation, because those parameters later will be tested in numerical tests which later can also be used as an important decision variable. Due that determination of t_s and t_{ol} are also can be the strategies of observed company in keeping the business sustainability.

CHAPTER 5
NUMERICAL EXPERIMENTS

The chapter is showing the numerical experiments using developed model in the research. The experiment is also completed with sensitivity analysis to analyze the model characteristics.

5.1 Model Verification and Validation

Verification and validation processes are important processes in this research, regarding that the model developed in this research has to be evaluated. These processes both are evaluating the model developed, whether it is able to represent the real system condition or not.

5.1.1 Model Verification

Verification is a process to compare and evaluate the model developed with the conceptual model which had been built previously. This process can be done by checking the input algorithm into *MATLAB* software, whether it contains of error or not in the *m-file* which had been made. The verification processes for this research are done in three times, since the model developed into *MATLAB* algorithm which will be used in numerical experiments are three model, consist of objective function, demand function, and also matrix development in order to make the pricing optimization processes become easier and faster. These following figures are showing the verification processes in *MATLAB* software to evaluate the algorithm.

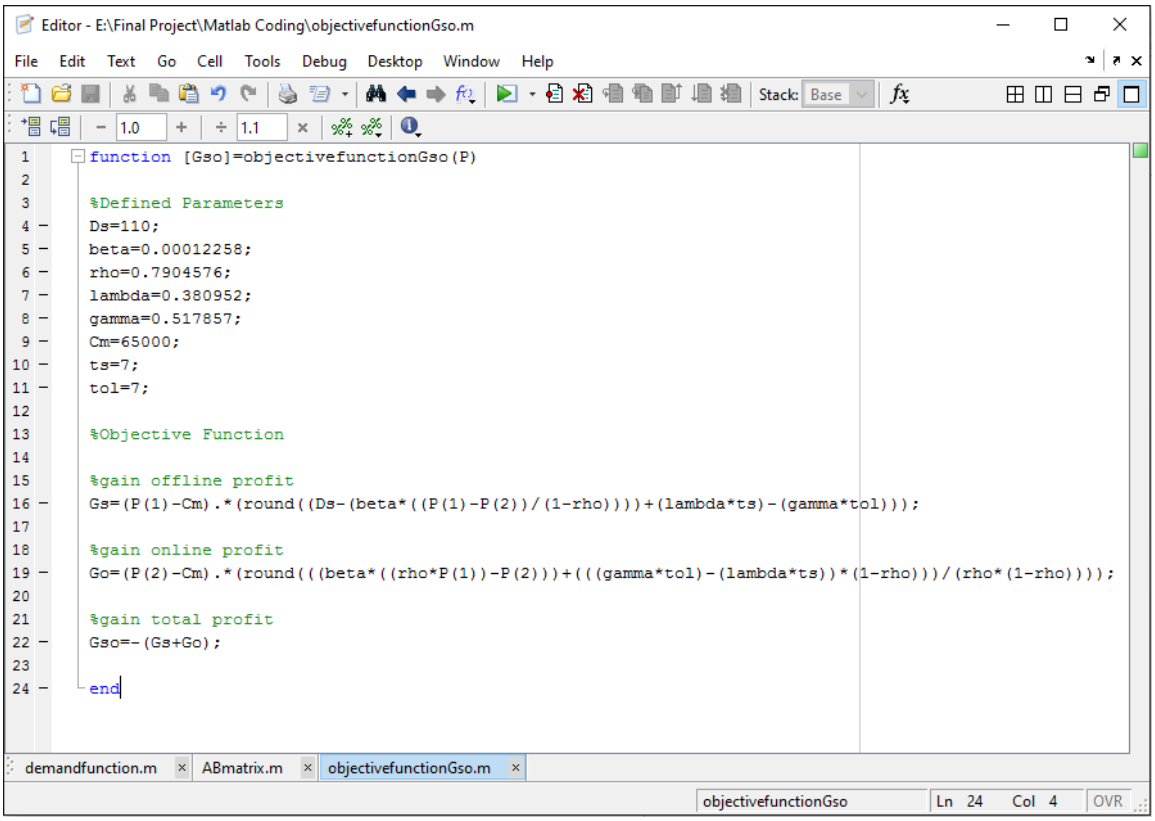

Figure 5. 1 Verification Process for Total Profit Maximization Objective Function (Gso) Algorithm

As can be seen at the figure 5.1 above, algorithm to accommodate total profit maximization objective function has been verified. At the top-right corner of *MATLAB* software it is seen that there is a green box which indicates that *m-file* which had been made has no contain any error. The file can be run in *MATLAB* software smoothly later if recalled by using *command window* or *optimtool* options.

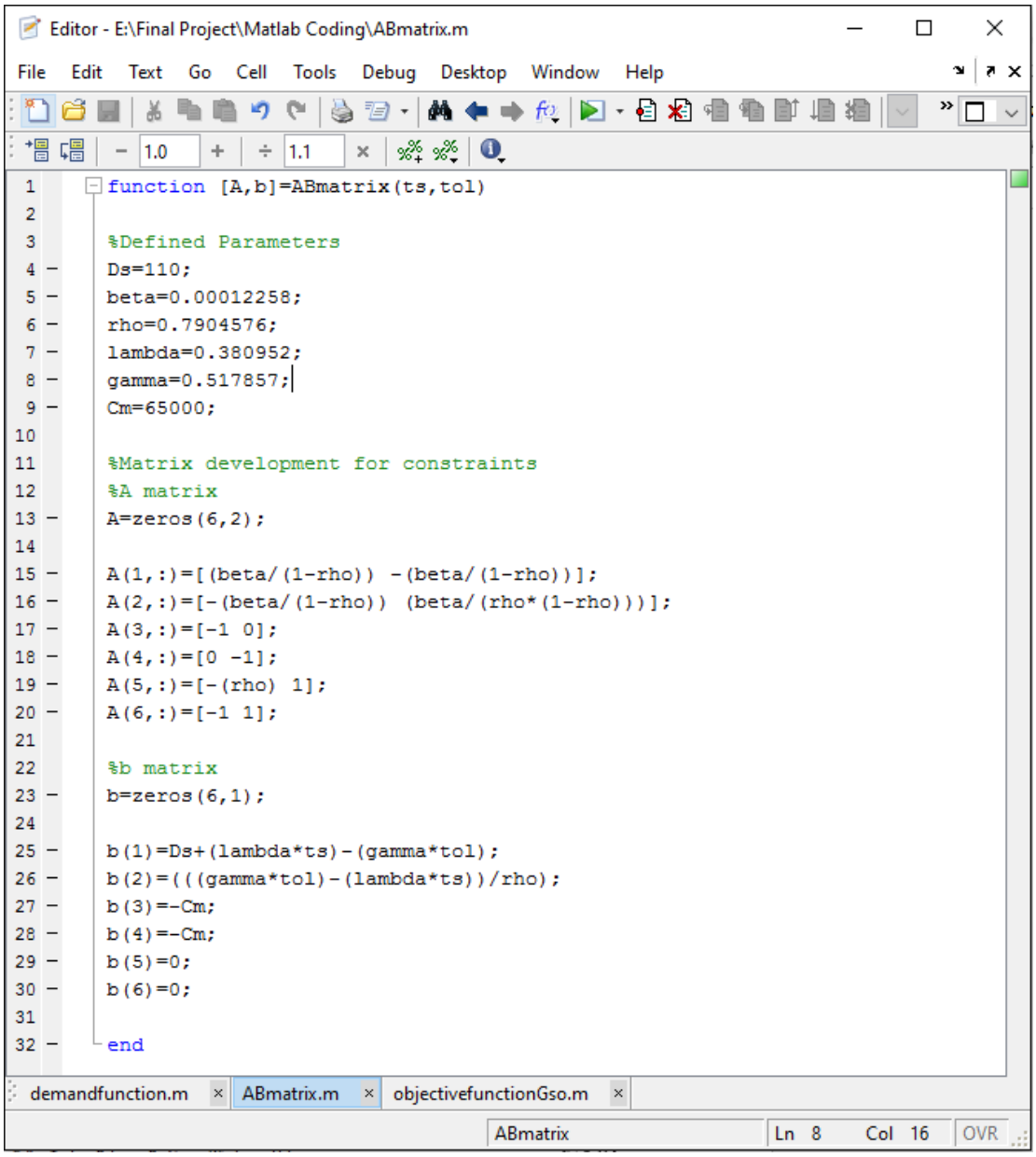

Figure 5. 2 Verification Process for Constraints Matrix Development Algorithm

Constraint matrix development algorithm will help the numerical tests processes, regarding that the tests will be conducted frequently. The tests will be done by using the help from *optimtool* function in *MATLAB* software, and it will be much easier and faster when the inequality constraints of the mathematical model developed being recalled by calling a single variable, without inputting and calculating manually.

It is seen from the figure 5.2 above that the algorithm for matrix development is also verified, by the sign of green box at the top-right corner of the window. There is no such error in its *m-file*, and this algorithm is ready to being recalled for optimization process.

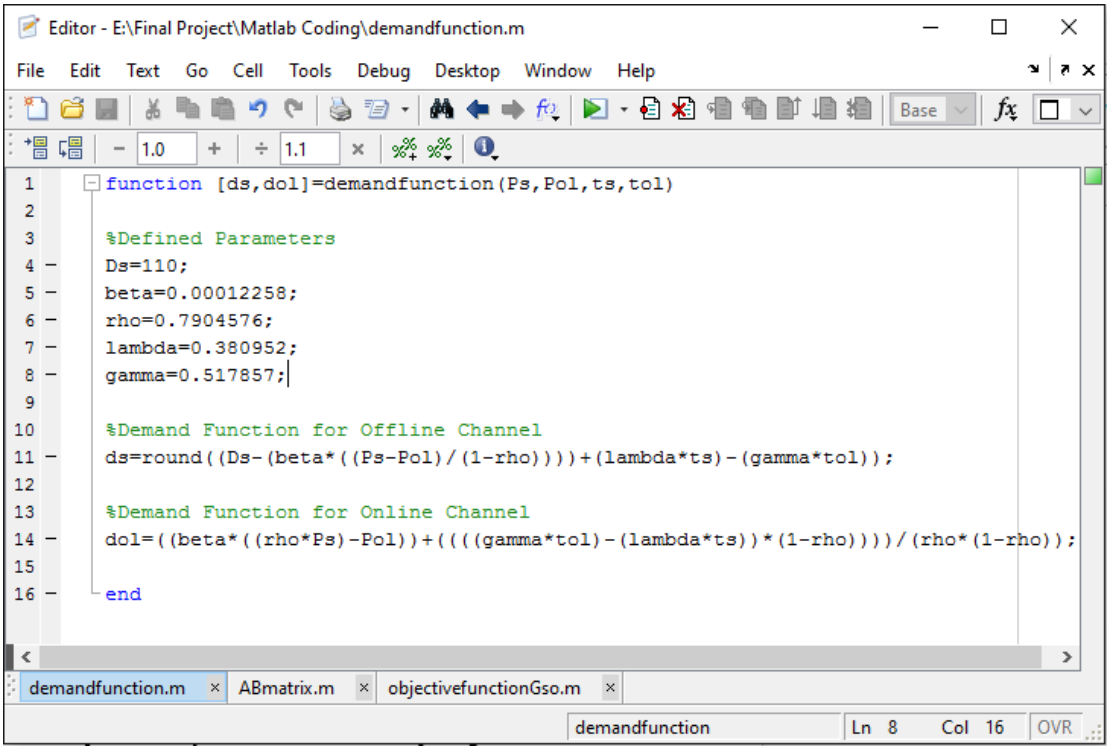

Figure 5. 3 Verification Process of Demand Function Algorithm

Demand function algorithm is developed in order to utilize *MATLAB* software in estimating the demand in traditional channel and direct channel in order to estimate the profit for whole supply chain system.

Based on the figure 5.3 above, it can be seen that the algorithm for demand function is also being verified. It is proven by an existence of green box in the top-right corner which indicate there is no error found in *m-file* developed.

According to those figures which shown before, it is said that all the algorithm developed in *m-file* are verified. Besides that, the other thing which can be done for verifying process is by checking the mathematical model developed before and

comparing it with *m-file* developed manually to make sure that the input algorithm is similar as model developed.

In this research, the main function in *Matlab* used to find optimum prices both for traditional and direct channels is *optimtool*. Verifying the results of this function can be done by seeing the result as shown at the figures below.

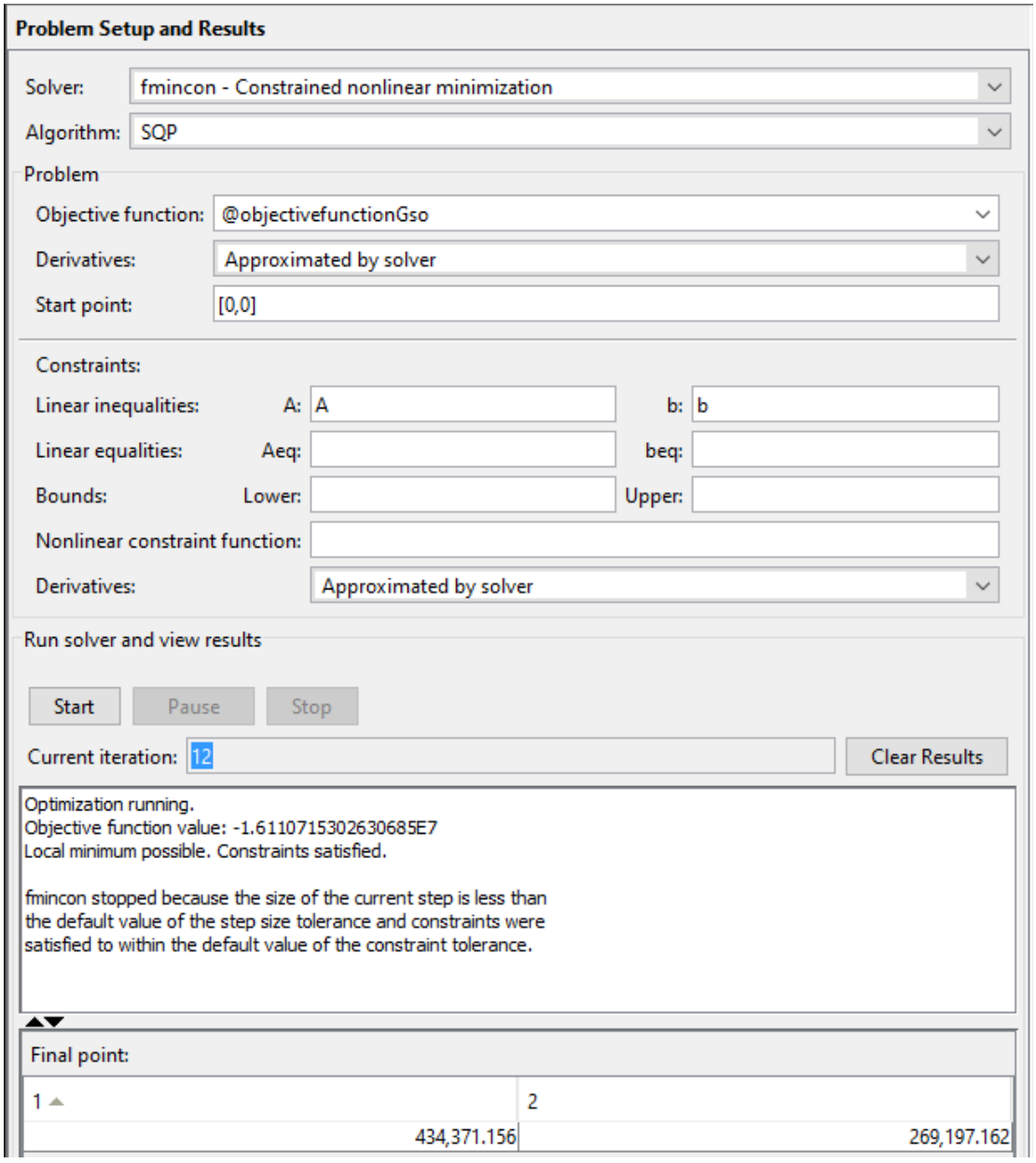

Figure 5. 4 *Optimtool* Window in Matlab Software

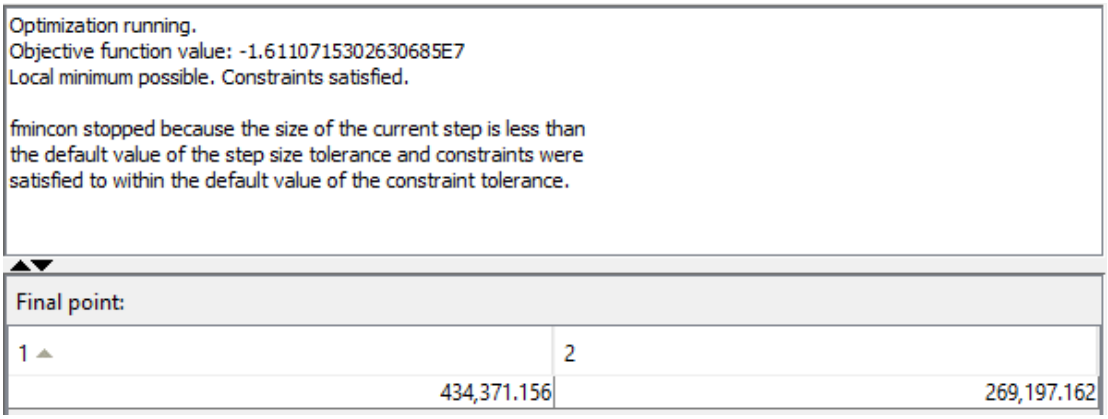

Figure 5. 5 Verification Process of *Optimtool* Prices Result

According to the figure 5.5 above, it is seen that the output from finding optimum prices using objective function algorithm by considering constraints (AB matrix development algorithm) as mentioned before, has reached the local minimum result. Based on the description at the window, it can be concluded that the results are verified since the optimum value is in a feasible region and also all the constraints are satisfied.

5.1.2 Model Validation

Validation processes are conducted to check and evaluate the model developed by comparing it with the real system condition. It has done by inputting existing data into profit and demand function which had been developed. This validation process is to check the influence of parameters tested in the model into system behavior, which evaluated from profit and demand of the system.

These validation processes are also done frequently, since there are some parameters are used in the model developed. Recall the parameters will be used in this research, such as β, ρ, λ, γ, t_s, t_{ol}, C_M, and also D_s^{max}. However, not all the parameter tests result will be shown in this sub-chapter, only some parameters which have some significant influence in the system behavior and comparing its behavior to the real condition of the current system observed. The following parts are showing all the

validation tests conducted with the parameters test results which have significant influence into the system behavior.

- Prices Influence into Demand Behavior

Currently, in the observed DCSC system for this research prices offered both in traditional and direct channels are similar, or even exactly the same before any additional transportation or delivery cost. In this test, the other parameter will be tested at the same values and only changing the value of P_s and P_{ol}. These following parameters are the values definition for each parameter tested in this validation processes.

Table 5. 1 Data Input for Parameters Value in Pricing Influence Tests

D_s^{max}	β	ρ	λ	t_s	γ	t_{ol}
110	0.000019566	0.790457597	0.380952381	0	0.517857143	0

a. Offline Price Influences into Traditional Channel (Offline Demand) Behavior

In offline price influence tests into demand behavior, the parameters values mentioned above remain the same, while offline price (P_s) will be changed in different values until reaching the current COGS. System behavior tests for this validation process result can be seen at the following figure.

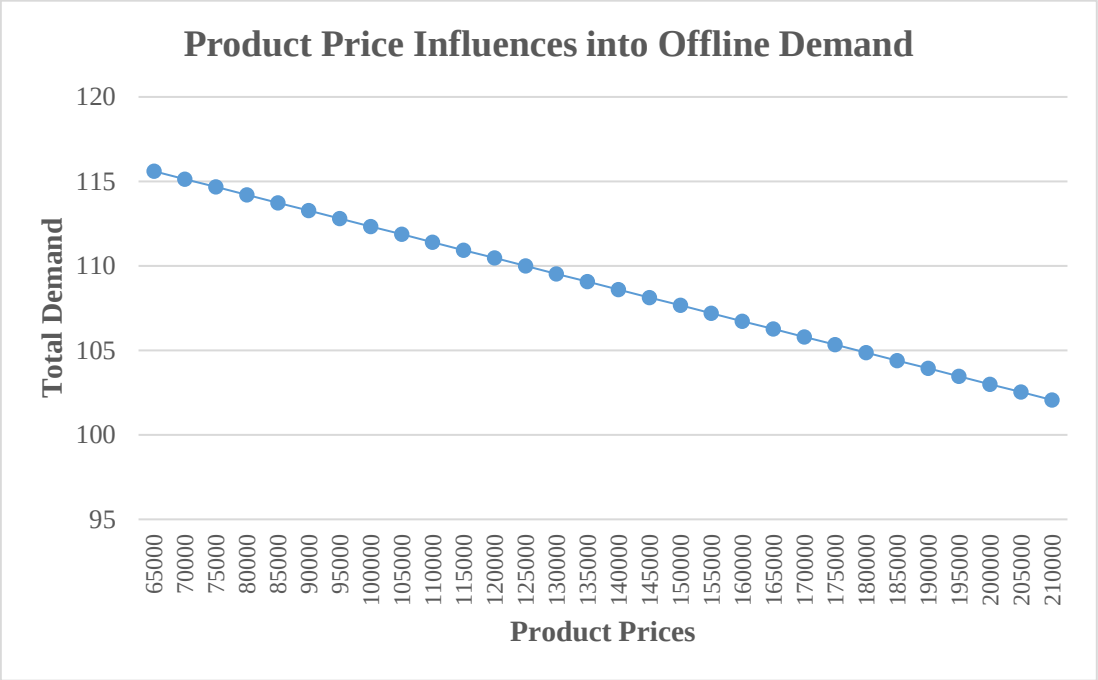

Figure 5. 6 Ps Validation Process into Total Offline Demand Influences

As can be seen at the figure 5.6 above, pricing scheme strategy is really influence the demand. It can be seen that the higher price set for P_s value, then the lower demand in traditional channel will be achieved. This model behavior is similar with the current condition. When the product is offered in higher price, then the total demand in that channel will decrease. It can be concluded that the traditional channel's (offline) demand function is valid.

b. Online Price Influences into Direct Channel (Online Demand) Behavior

Similar with the validation process at the previous part, regarding that the research is also developing a direct channel's (online) demand function, then that function is also needed to be tested. The tests are keeping the values of other parameters as mentioned previously, but the values of P_{ol} or online price will be changed until reaching the current COGS. The result of this test can be seen at the following figure.

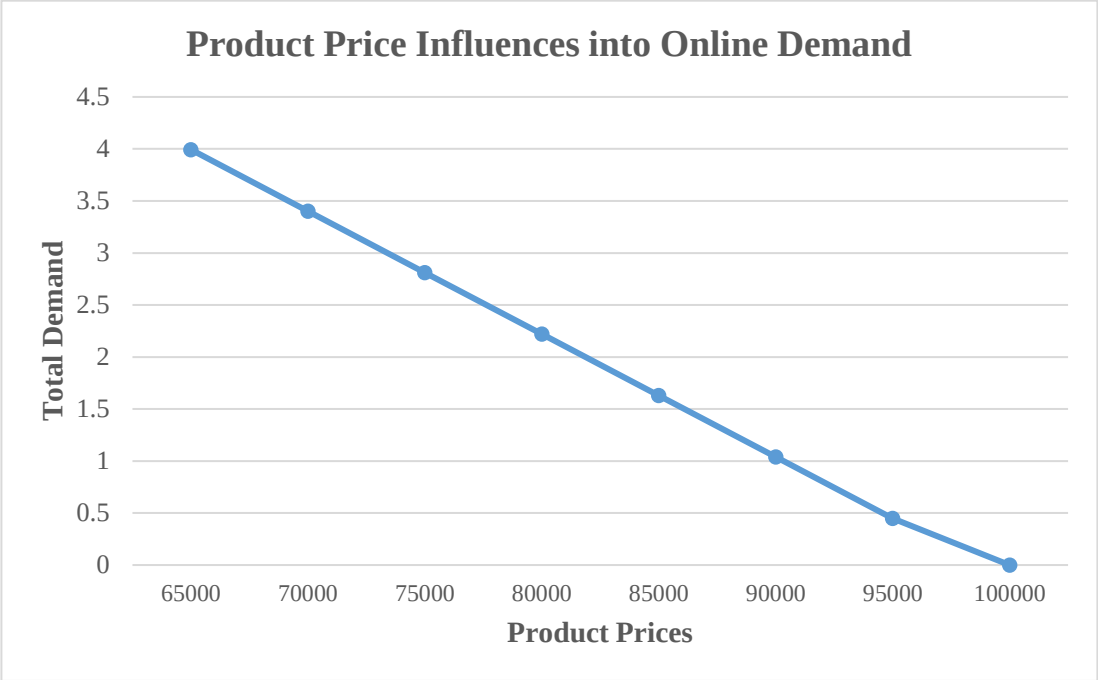

Figure 5. 7 Pol Validation Process into Total Online Demand Influences

According to the figure 5.7 above, it can be seen that by the increment value of P_{ol} value, the total demand in direct channel is decreasing. Even though at some point the demand remains the same, however the pattern of the system indicates that by increasing P_{ol} values, then the demand in direct channel will be decreasing. It is similar with the real condition of the system observed, that is why; this direct channel demand function is valid enough.

- Length of Warranty Influences into Demand Behavior

Regarding that currently the observed object for this research has not implement any general procedures and rules related to warranty services performed by the company if there is any complaints from customer, then in this test, the validation check to see demand influence by the changes in length of warranty services period for each channel. While test the traditional channel, length of warranty service period for traditional channel will be changed in several times, while direct channel length of warranty period remains the same, which is 0 day, and vice versa. However for the other parameters in this test will be shown at the following table.

Table 5. 2 Data Input Parameters for Length of Warranty Influence Tests

γ	λ	β	ρ	P_s	P_{ol}
0.517857143	0.3809524	0.00001957	0.790457597	Rp 125,000.00	Rp 125,000.00

a. Length of Warranty in Offline Channel Influences into Offline Demand

In this length of warranty tests, the value of length of warranty period for traditional channel will be changed in a range of 7-30 days. The result of the tests can be seen at the following figure.

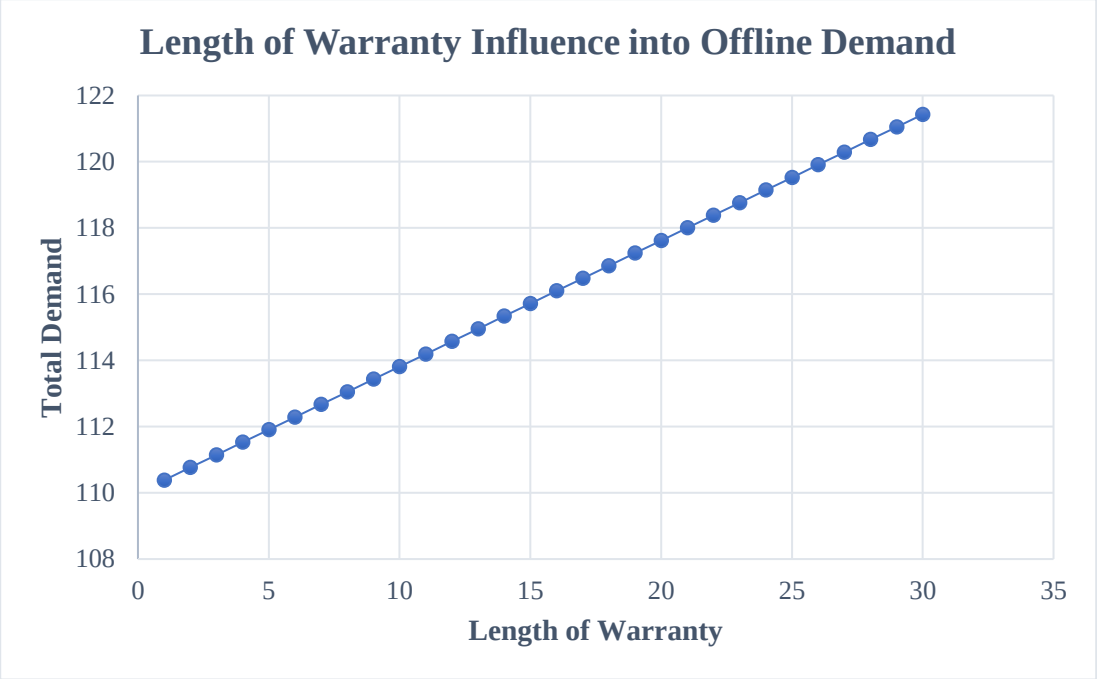

Figure 5. 8 Length of Warranty in Offline Channel Influences into Demand Validation Test

According to the figure 5.8 above, it seen that demand in offline channel will increase when the length of warranty period in traditional channel is increasing. Even though at some points the value of demand remains the same, but overall behavior of the system shows that length of warranty period has influence into demand for its channel. This condition shows that model built was valid enough.

b. Length of Warranty in Online Channel Influences into Online Demand

Similar with the previous tests, but the difference is that the changes values are on length of warranty period for direct channel while the length of warranty period of traditional channel remains the same, which is 7 days. Length of warranty period in direct channel for this tests were changed from 7-30 days, and the result of the tests can be seen at the following figure.

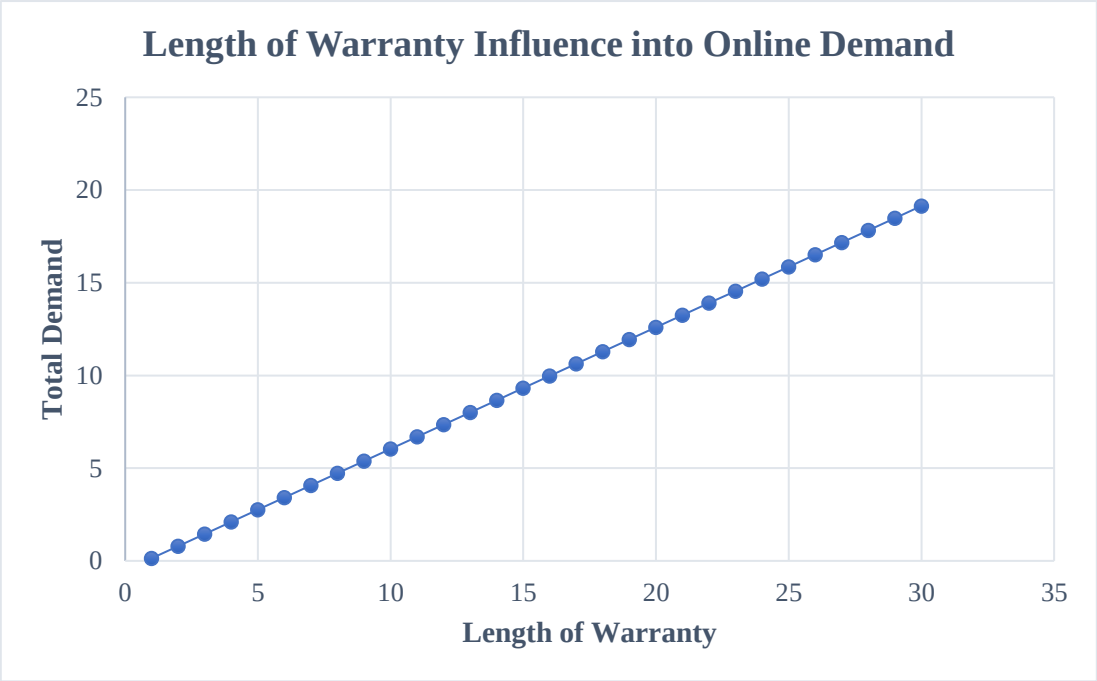

Figure 5. 9 Length of Warranty in Online Channel Influences into Demand Validation Test

As can be seen at the figure 5.9, length of warranty period in direct channel has some influence into total demand in that channel. Even though at some points the demand remains at the same values, however with the longer period of warranty services the demand is started to increase. It is said that this demand function with the influence of length of warranty service period is valid enough.

- COGS Influences into Total Profit Achieved Behavior

The other function which developed in this research is the function in order to gain profit in traditional and direct channel, which will gain the total profit achieved by DCSC system itself. The only parameter which influence total profit is COGS, while the other is influenced by the total demand. That makes in this test, the changes values are on COGS parameter. Result of the tests can be seen at the following figure.

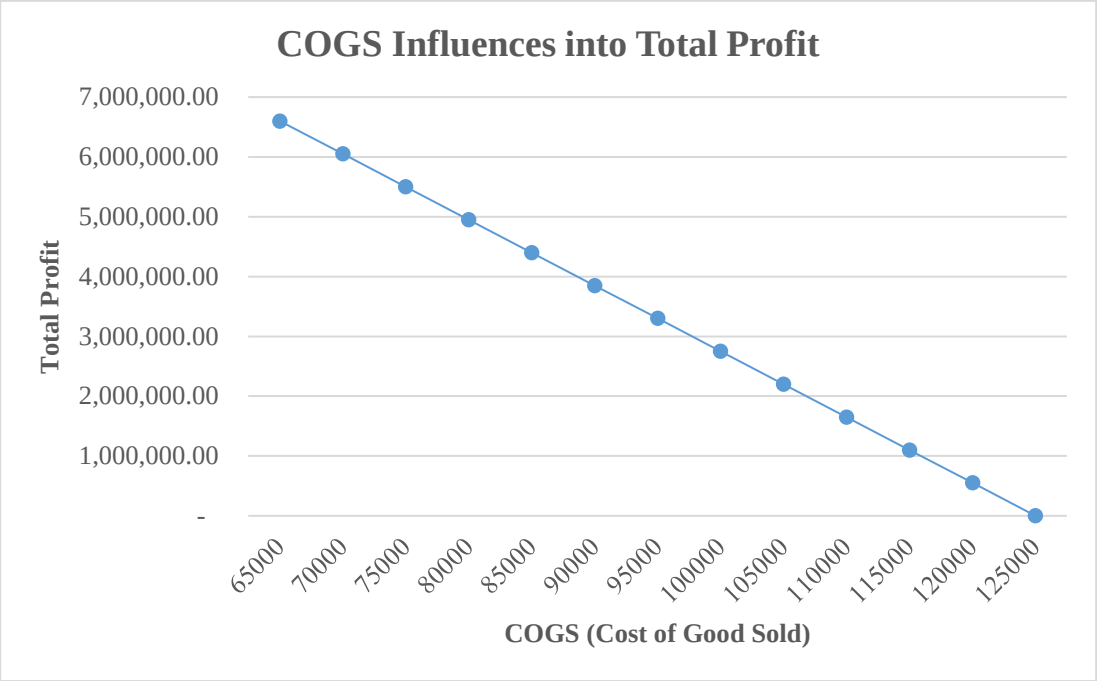

Figure 5. 10 COGS Influences into Total Profit Tests

From the figure 5.8 it is seen that COGS value has significant influence into total profit achieved by the company. The higher COGS spent for production, the lower profit can be achieved, while the lower COGS spent for production, the higher profit can be achieved. From this result it is said that the model is valid enough since the result is able to represent real condition of the current system.

5.2 Numerical Experiment

Recall from the objectives of this research, there are several decision variables which will be discussed in this sub-chapter, such as optimum price for traditional

channel (P_s), optimum price for direct channel (P_{ol}), length of warranty period for traditional channel (t_s), and also length of warranty period for direct channel (t_{ol}). In order to find the optimum prices, both for traditional and direct channels the method will be used is *Nonlinear Programming*, while in finding optimum length of warranty services period is using *Game Theory* approach. In finding optimum price, the tool used is *MATLAB* by the help of *optimtool* function, while finding optimum length of warranty service period is using *Gambit* software. The details of each part of optimization will be discussed at these following parts.

5.2.1 Numerical Experiment to find Optimum Price

Numerical experiment in finding optimum prices both for traditional and direct channels is done by maximizing the total profit as objective function by considering characteristic of implemented DCSC, which figured out by the constraints defined. Finding the optimum price for both traditional and direct channels are conducted simultaneously, since the current condition both traditional and direct channels were managed under the same management system. It means that the coordination between traditional and direct channels are cooperative enough and the game between channels are fair.

Finding optimum prices simultaneously by using *optimtool* function requiring some definition to convert the developed model for this research into default language in *MATLAB* software. This following table is showing conclusion of constraints used to define the characteristic of observed DCSC system converted into *MATLAB* language.

Table 5. 3 Constraints in Finding Optimum Prices

No.	A		b	Definition
1.	$\left(\frac{\beta}{1-\rho}\right)P_s + \left(\frac{-\beta}{1-\rho}\right)P_{ol}$	$\leq$	$D_s^{max} + \lambda t_s - \gamma t_{ol}$	$d_s \geq 0$
2.	$\left(\frac{-\beta}{1-\rho}\right)P_s + \left(\frac{\beta}{\rho(1-\rho)}\right)P_{ol}$	$\leq$	$\frac{(\gamma t_{ol} - \lambda t_s)}{\rho}$	$d_{ol} \geq 0$

No.	A		b	Definition
3.	$-P_s$	$\leq$	$-C_M$	$P_s \geq C_M$
4.	$-P_{ol}$	$\leq$	$-C_M$	$P_{ol} \geq C_M$
5.	$(-\rho)P_s + P_{ol}$	$\leq$	0	Direct channel existence general condition
6.	$-P_s + P_{ol}$	$\leq$	0	Price leadership

According to those several constraints and also objective function which had been mentioned at the previous part, then optimization processes in finding optimum value for product price can be done. The optimization processes are done in several times in order to find not only the optimum but also it is a logical solution. The tests were done in three times, and each result of the test will be discussed further at the following parts.

a. Optimum solution using parameter based on questionnaire results

Recall recapped parameters mentioned at previous chapter resulting several values which may have significant influence into the optimized result later, then several tests are conducted. According to the recapped parameters, the following are details about several tests conducted in order to find the optimum, logical, and also appropriate results.

- Highest frequency suggested by the respondents parameters (mode)
- Average results of all parameters influenced in the model (mean)
- Considering frequency distribution table of β parameter, by changing value of β with the top 3 highest frequency, combined with the highest frequency selected for other parameters.
- Considering frequency distribution table, combining top 3 highest suggested of β parameter, with the average results of other parameter in a model.

According to those details, there are 8 tests which had been conducted and resulting different decision of optimum product price for each channel. Regarding that this research has the aim to find not only optimum result but also logical and most appropriate result, then the selected result which considered as the most appropriate and logical can be seen as following.

Table 5. 4 Recapped Parameters

β	ρ	λ	γ	D_s^{max}	C_M
0.00012258	0.7904576	0.380952	0.517857	110	Rp 65,000.00

Inputting those values as mentioned at table 5.4, then result of optimum price can be seen at the table below by changing the values of warranty period in each channel.

Table 5. 5 Numerical Tests Result based on Questionnaires Parameter Values

No.	Length of Warranty		Decision Variables		Number of Iterations	ds	dol	Total Profit		
	ts	tol	Ps	Pol				Gs	Gol	Total
1	7	7	IDR 432,312.36	IDR 263,861.96	11	11	59	IDR 4,040,436.00	IDR 11,732,855.56	IDR 15,773,291.55
2	7	14	IDR 612,740.64	IDR 484,345.49	21	30	6	IDR 16,432,219.21	IDR 2,516,072.97	IDR 18,948,292.18
3	7	21	IDR 610,414.55	IDR 436,408.43	20	0	45	IDR -	IDR 16,713,379.46	IDR 16,713,379.46
4	7	28	IDR 603,966.18	IDR 436,156.76	18	0	46	IDR -	IDR 17,073,210.80	IDR 17,073,210.80
5	14	7	IDR 385,708.27	IDR 228,084.31	14	20	55	IDR 6,414,165.36	IDR 8,969,637.25	IDR 15,383,802.61
6	14	14	IDR 431,957.26	IDR 265,145.03	12	11	59	IDR 4,036,529.82	IDR 11,808,557.03	IDR 15,845,086.85
7	14	21	IDR 616,203.36	IDR 440,479.47	20	2	42	IDR 1,102,406.71	IDR 15,770,137.67	IDR 16,872,544.38
8	14	28	IDR 591,069.18	IDR 418,701.27	17	0	48	IDR -	IDR 16,977,660.86	IDR 16,977,660.86

No.	Length of Warranty		Decision Variables		Number of Iterations	ds	dol	Total Profit		
	ts	tol	Ps	Pol				Gs	Gol	Total
9	21	7	IDR 350,422.71	IDR 198,496.80	10	26	53	IDR 7,420,990.59	IDR 7,075,330.65	IDR 14,496,321.24
10	21	14	IDR 391,731.66	IDR 235,745.95	12	20	54	IDR 6,534,633.29	IDR 9,220,281.44	IDR 15,754,914.73
11	21	21	IDR 434,371.17	IDR 269,197.17	12	11	59	IDR 4,063,082.91	IDR 12,047,633.13	IDR 16,110,716.04
12	21	28	IDR 82,230.85	IDR 65,000.00	3	93	8	IDR 1,602,469.04	IDR -	IDR 1,602,469.04
								Profit Mean		**IDR 15,129,307.48**

5.2.2 *Numerical Experiment to find Optimum Length of Warranty Services*

Using game theory approach in finding optimum length of warranty service period for each channel requires profit achieved by each channel with different length of warranty service period as input data. Those profit achieved with different length of warranty service period will be used as an input variable for payoff matrix development, while length of warranty service period set as the strategies which could be chosen by each player. In this game, the players who compete in getting resources are traditional and direct channel.

Gambit software is the tool used in this research to find an equilibria point of the game. The tests conducted by using *Gambit* software is as many as the total numerical tests conducted in finding optimum product price as mentioned at the previous parts. However, since the selected decision is when the result as seen at the table 5.5, then the following are figures shown of *Gambit* software output.

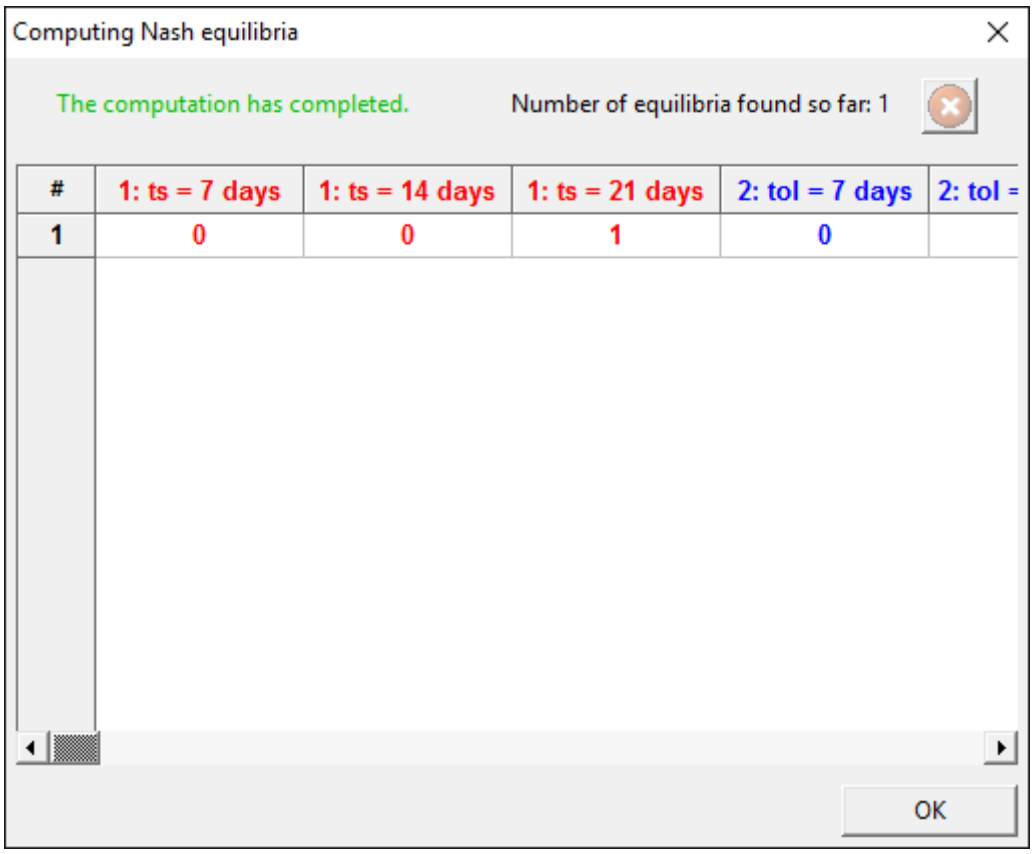

Figure 5. 11 Gambit Output in Finding Nash Equilibria

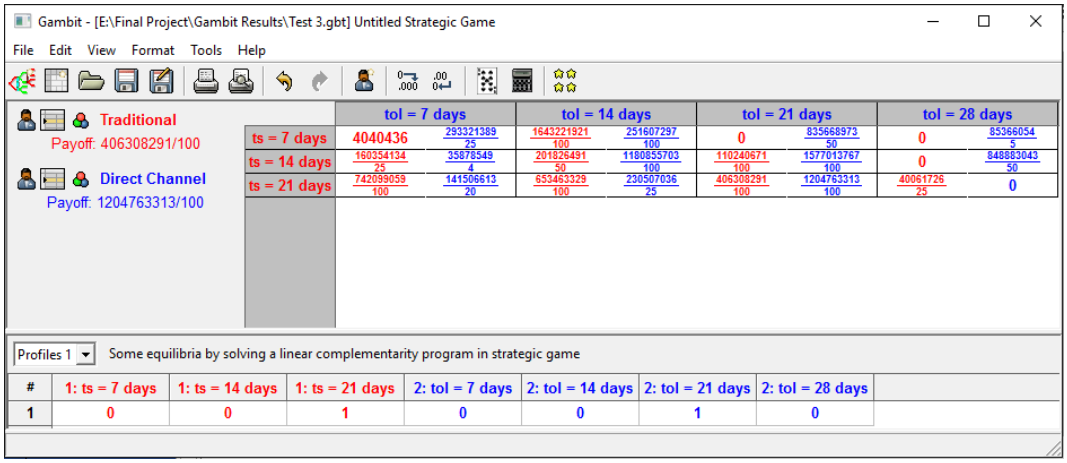

Figure 5. 12 Gambit Software Display in Generating Result of Warranty Period

According to the software, it is seen that the game is included in a pure strategy game, since the selection probability of warranty period by each channel is at the value of 1. The conclusion of probability of each channel in selecting the most acceptable warranty period can be seen at the following table.

Table 5. 6 Probability of Warranty Selection by Each Channel

Traditional Channel		Direct Channel	
Strategies	**Probability**	**Strategies**	**Probability**
ts = 7 days	0	tol = 7 days	0
ts = 14 days	0	tol = 14 days	0
ts = 21 days	**1**	**tol = 21 days**	**1**
		tol = 28 days	0

5.2.3 Comparison Analysis between Existing Condition and Optimized Results

Even though the at the previous parts are discussing two options, which are initial result based on questionnaire recapitulation and also adjusted parameter value in order finding more logical and appropriate price, in this part the only result which will be discussed is the adjusted one. It was caused that the main aim of this research is finding optimum, logical, and also appropriate result to be implemented in real system.

Comparing the current system condition and optimization result as mentioned before, then the following is recapitulation table to make the comparison process easier.

Table 5. 7 Comparison Table between Existing Condition and Numerical Test Results

No	Parameter	Existing	Result
1	P_s	IDR 125,000.00	IDR 434,371.17
2	P_{ol}	IDR 125,000.00	IDR 269,197.17
3	d_s	31	11
4	d_{ol}	1	59
5	t_s	-	21 days
6	t_{ol}	-	21 days
7	G_s	IDR 1,860,000.00	IDR 4,063,082.91
8	G_{ol}	IDR 60,000.00	IDR 12,047,633.13
G_{so}		**IDR 1,920,000.00**	**IDR 16,110,716.04**

According to the table, it is seen that the price proposed based on the several processes in numerical tests are suggested higher than the existing condition. It is also seen that the decision related to warranty period are also suggested at 21 days for both channels. Suggesting higher product price, it is estimated that total demand in traditional channel decreased while direct channel is increased. However, the total profit achieved by implementing results suggested by this research estimated to gain higher profit than the existing condition.

Values shown at the table can be changed by the adjustment of parameters used, due that result from optimization process is really influenced by the parameters inputted. Sensitivity of each parameter can be different, and the differences will be explained further at the next sub-chapter.

5.3 Sensitivity Analysis

Sensitivity analysis conducted in order to evaluate which parameter has significant or critically influence to the total profit achieved by the system. Sensitivity analysis is conducted by changing evaluated parameters in different value while the other parameter values remain the same. After that, the effect or its behavior into total profit can be evaluated through a graphic. Parameters which

evaluated in this sensitivity analysis are C_M, D_s^{max}, β, ρ, λ, and γ. Each evaluation for the parameter can be seen at the following parts.

5.3.1 C_M Parameter Sensitivity Test

In this part the sensitivity test will be focused on C_M parameter, which means only C_M parameter values will be changes while other at the same values. In order to evaluate the effect of C_M parameter into total profit achieved, the test is resulting as recapped below.

Table 5. 8 Sensitivity Analysis Result for C_M Parameter

C_M	Proposed Result	Existing
IDR 45,000.00	IDR 17,510,716.04	IDR 2,560,000.00
IDR 50,000.00	IDR 17,160,716.04	IDR 2,400,000.00
IDR 55,000.00	IDR 16,810,716.04	IDR 2,240,000.00
IDR 60,000.00	IDR 16,460,716.04	IDR 2,080,000.00
IDR 65,000.00	**IDR 16,110,716.04**	**IDR 1,920,000.00**
IDR 70,000.00	IDR 15,760,716.04	IDR 1,760,000.00
IDR 75,000.00	IDR 15,410,716.04	IDR 1,600,000.00
IDR 80,000.00	IDR 15,060,716.04	IDR 1,440,000.00
IDR 85,000.00	IDR 14,710,716.04	IDR 1,280,000.00
IDR 90,000.00	IDR 14,360,716.04	IDR 1,120,000.00
IDR 95,000.00	IDR 14,010,716.04	IDR 960,000.00
IDR 100,000.00	IDR 13,660,716.04	IDR 800,000.00
IDR 105,000.00	IDR 13,310,716.04	IDR 640,000.00
IDR 110,000.00	IDR 12,960,716.04	IDR 480,000.00
IDR 115,000.00	IDR 12,610,716.04	IDR 320,000.00
IDR 120,000.00	IDR 12,260,716.04	IDR 160,000.00
IDR 125,000.00	IDR 11,910,716.04	IDR -
Profit Mean	**IDR 14,710,716.04**	**IDR 1,280,000.00**

In order to make the comparison between existing and proposed result is more attractive and easier, then the following is graphic illustration for the sensitivity analysis result of C_M parameter.

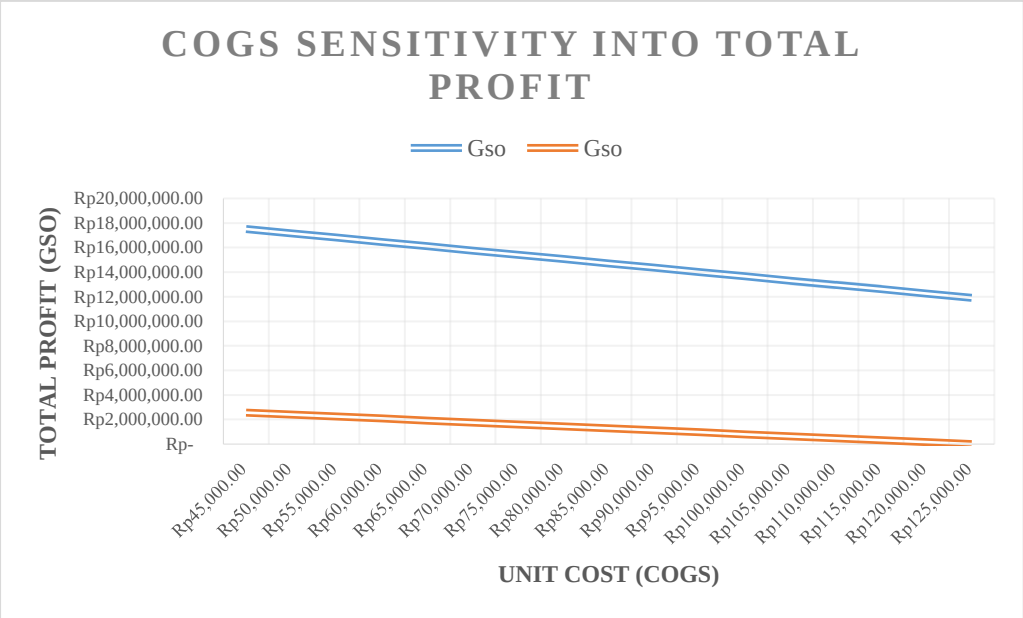

Figure 5. 13 Graphic Illustration for C_M Parameter Sensitivity

According to the figure 5.15, it is seen that the higher C_M values, the lower profit can be achieved. As can be seen at the figure too, the proposed result is achieving profit which is quite higher than the existing profit. Even it is only slightly different, and there is a point where the proposed result is achieving lower profit, but overall proposed result is achieving higher profit than the existing. It is proven by the average from proposed result profit by the changes of C_M parameter is still higher than the average from existing profit.

Based on the figure 5.15, it can be concluded that the higher C_M parameter value, then the lower profit can be achieved. This condition happens since profit achieved by the system, both for traditional and direct channels, were generated from the differences values between price set by the company multiplies by total demand at that period. That is why; the smaller gap between price set and COGS of a product, the lower profit can be achieved and vice versa.

5.3.2 D_s^{max} Parameter Sensitivity Test

In this part, the parameter which will be evaluated is D_s^{max}. Since this research has monthly as its planning horizon, then the value of D_s^{max} defined in this part is the maximum total demand estimated when product price reaches as same

as its COGS for each month. The following table is showing recapped result of the sensitivity test for D_s^{max} parameter.

Table 5. 9 Sensitivity Analysis Result for D_s^{max} Parameter

Desc.	D_s^{max}	Proposed Result	Existing
-10%	99	IDR 12,047,633.13	IDR 1,320,000.00
0%	**110**	**IDR 16,110,716.04**	**IDR 1,920,000.00**
10%	121	IDR 20,173,798.94	IDR 2,520,000.00
20%	132	IDR 24,236,881.85	IDR 3,120,000.00
30%	143	IDR 28,299,964.75	IDR 3,720,000.00
40%	154	IDR 32,363,047.66	IDR 4,320,000.00
Profit Mean		**IDR 22,205,340.39**	**IDR 2,820,000.00**

In order to make the comparison between existing and proposed result is more attractive and easier, then the following is graphic illustration for the sensitivity analysis result of D_s^{max} parameter.

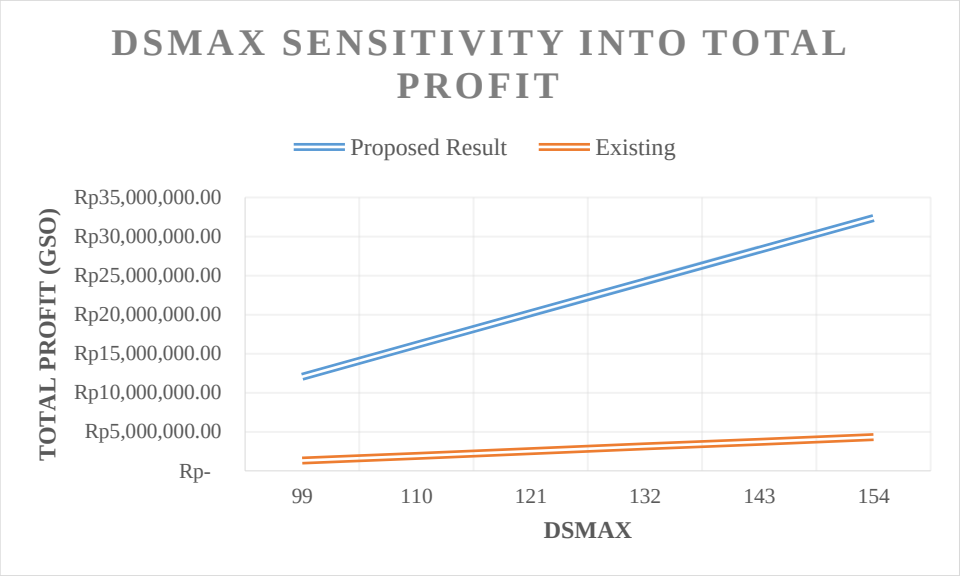

Figure 5. 14 Graphic Illustration for D_s^{max} Sensitivity

According to the table and figure above, it can be seen that D_s^{max} parameter has significant influence to the total profit achieved by the system. However, from this sensitivity test can be concluded that the lower D_s^{max} parameter, the lower profit can be achieved by the system. It creates a problem when D_s^{max} value is starting to decrease at the value lower than 110, because at the smaller value than 110, proposed result is not becoming the optimum result anymore, since

existing profit achieves higher than proposed result profit. By the addition of D_s^{max} values, proposed result profit achieved can be significantly higher than existing profit. That is why; in the changes of D_s^{max} parameter during implementation to the real system requires frequently evaluation to keep the sustainability of both channels in business processes.

While C_M parameter has contribution directly into total profit achieved by the system, D_s^{max} parameter has direct influence into total demand achieved in traditional or offline channel. The higher D_s^{max} parameter, the higher demand can be achieved in that channel. Generally, D_s^{max} parameter has no significant influence to the total demand achieved in direct or online channel. However, by the difference of total demand achieved in traditional channel, the profit achieved by the system also can be resulted in different value. That is why; the higher D_s^{max} parameter value, the higher demand in traditional channel, and then the higher profit can be achieved. While the lower D_s^{max} parameter value, the smaller amount demand in traditional channel, and then the lower profit can be achieved.

5.3.3 β Parameter Sensitivity Test

As another parameter which has contribution to this model development, then β sensitivity into profit also need to be evaluated. In this test, the value of β parameter will be changed not in a really extreme values, since in some extreme points are resulting non feasible solution.

Table 5. 10 Sensitivity Analysis Result for β Parameter

Desc.	β Values	Proposed Result		Existing	
-80%	2.45159E-05	IDR	35,567,620.82	IDR	1,980,000.00
-60%	4.90319E-05	IDR	30,426,366.25	IDR	1,980,000.00
-40%	7.35478E-05	IDR	25,654,482.84	IDR	1,980,000.00
-20%	9.80637E-05	IDR	20,882,599.44	IDR	1,920,000.00
0%	**0.00012258**	**IDR**	**16,110,716.04**	IDR	1,920,000.00
20%	0.000147096	IDR	14,089,604.85	IDR	1,860,000.00
Profit Mean		**IDR**	**23,788,565.04**	**IDR**	**3,440,000.00**

In order to make the comparison between existing and proposed result is more attractive and easier, then the following is graphic illustration for the sensitivity analysis result of β parameter.

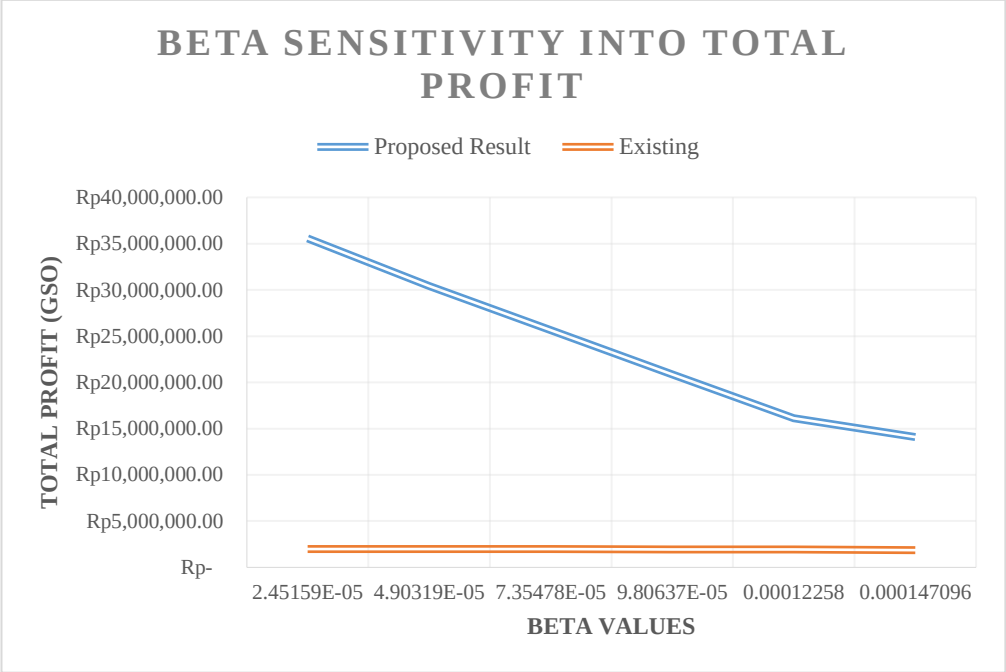

Figure 5. 15 Graphic Illustration for β Sensitivity

As can be seen at the figure 5.17, β parameter has significant effect in generating profit achieved for proposed result, but it has no significant effect in generating profit achieved for the existing condition. In proposed result, the higher β parameter, the lower profit which can be achieved by the system. Differently in existing condition, which even the β parameter has become higher or lower total profit achieved remains at a constant value.

Recall the definition of β parameter, it is a parameter which showing the acceptance ratio of product price sensitivity. While in existing condition there is no such difference or gap between product price offered in traditional and direct channel. This price difference between channels are leading to the different value of total demand when the value of β parameter is changed. When the β parameter set in a high value, then customer sensitivity into price is higher, and then if product price is set too pricey, it is leading to the lower demand achieved. Lower demand

achieved means lower profit gained for the whole system. That is why; when there is no such difference for product prices between channels, then there is no fluctuated demand amount which will lead to constant profit even though the value of β parameter changed.

5.3.4 ρ Parameter Sensitivity Test

Another sensitivity test is conducted by the changes of ρ values, in order to evaluate and conclude the effect of this parameter into whole profit gained by the system. Recapped result of sensitivity test for this parameter shown at the table below.

Table 5. 11 Sensitivity Analysis Result for ρ Parameter

Desc.	ρ Values	Proposed Result	Existing
-20%	0.632366078	IDR 12,047,633.13	IDR 3,060,000.00
0%	**0.790457597**	**IDR 14,293,802.02**	**IDR 1,920,000.00**
20%	0.948549117	IDR 73,919,376.15	IDR 600,000.00
Profit Mean		**IDR 33,420,270.43**	**IDR 1,860,000.00**

In order to make the comparison between existing and proposed result is more attractive and easier, then the following is graphic illustration for the sensitivity analysis result of ρ parameter.

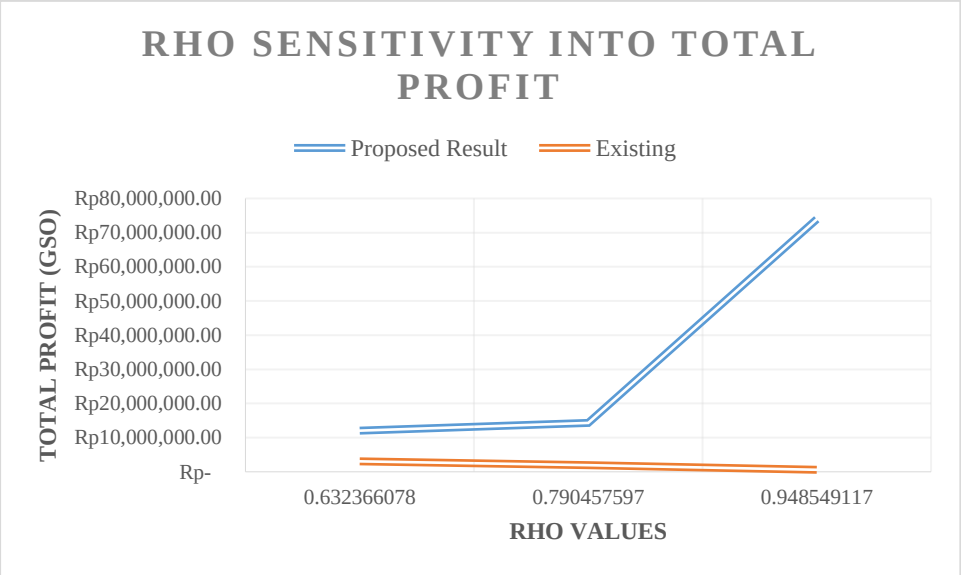

Figure 5. 16 Graphic Illustration for ρ Sensitivity

Based on the figure 5.18 above, it can be seen that ρ parameter value has very slight significant effect for the existing condition, but ρ parameter value has significant effect to profit gained for the optimized result. Comparing profit gained from existing condition and based on the optimized result total profit gained for the system is higher when implementing result from the proposed model. Overall the profit gained by optimized results are higher than the profit gained in existing condition.

The cause of ρ is more significantly giving influence to the total profit gained in optimized result is due to the difference between price offered in traditional and direct channel. By these price difference, demand in traditional channel becomes more fluctuated than the existing condition. With the same value of product price for both channels, demand in traditional channel remains at a constant value. However for the demand in direct channel, by the existence of different value of ρ parameter, online demand becomes more fluctuated. But, in the lower value of ρ parameter online demand may become in negative value, this condition leads to no profit gained for direct channel. That is the additional cause why the existing condition has profit which more constant than the optimized result gained.

5.3.5 λ Parameter Sensitivity Test

As the parameter which has strong relation with the length of warranty period offered in traditional channel, it is important to evaluate λ parameter too. In this sensitivity test, only λ which will be changed in different value to check it influence to the total profit gained for the system. Recapped result of sensitivity test for this parameter can be seen at the following table.

Table 5. 12 Sensitivity Analysis Result for λ Parameter

Desc.	λ Values	Proposed Result	Existing
-80%	0.014628571	IDR 14,993,521.19	IDR 1,920,000.00
-60%	0.073142857	IDR 15,158,695.20	IDR 1,920,000.00
-40%	0.182857143	IDR 15,284,846.03	IDR 1,920,000.00
-20%	0.304761905	IDR 15,780,368.03	IDR 1,920,000.00
0%	**0.380952381**	**IDR 16,110,716.04**	**IDR 1,920,000.00**
20%	0.457142857	IDR 15,867,495.69	IDR 1,920,000.00
40%	0.64	IDR 16,528,191.70	IDR 1,920,000.00
Profit Mean		**IDR 15,674,833.41**	**IDR 1,920,000.00**

In order to make the comparison between existing and proposed result is more attractive and easier, then the following is graphic illustration for the sensitivity analysis result of λ parameter.

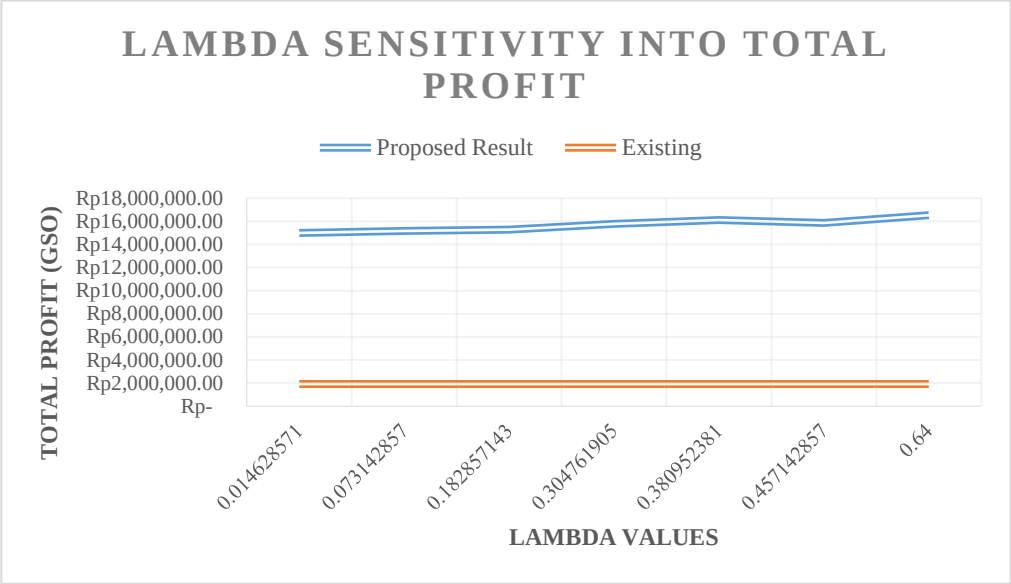

Figure 5. 17 Graphic Illustration for λ Sensitivity

According to the figure 5.19, it is seen that λ parameter has no significant effect to the existing condition, since the existing condition was not implement any policy related to warranty service along such period. It is different with the result from proposed model. The higher value of λ parameter, the higher profit achieved. It is proven by the overall profit achieved in implementing result from proposed model is higher than overall profit achieved in existing condition.

λ parameter is only influencing the profit achieved when system is implementing result from proposed model, since the λ parameter has close relation with length of warranty period in traditional channel. This condition has no effect when the channel is not offering any warranty period services as the existing condition. That is why; by the changes of λ parameter values, there is no significant effect to the profit achieved. Contrary with the implementation of result from proposed model, by changing value of λ parameter, the demand in traditional channel becomes fluctuated and lead to the fluctuated profit achieved depends on the value of λ parameter. The higher value of λ, the higher demand achieved in traditional channel, and then the higher profit can be achieved by its whole system.

5.3.6 γ Parameter Sensitivity Test

Last parameter which will be tested in this several sensitivity test is γ parameter. This sensitivity test has aim to find the effect of γ parameter into profit gained by the system. Recapped result of sensitivity tests for this parameter can be seen at the table below.

Table 5. 13 Sensitivity Analysis Result for γ Parameter

Desc.	γ Values	Proposed Result	Existing
-40%	0.248571429	IDR 16,323,994.53	IDR 1,920,000.00
-20%	0.414285714	IDR 16,236,866.87	IDR 1,920,000.00
0%	**0.517857143**	**IDR 16,110,716.04**	**IDR 1,920,000.00**
20%	0.621428571	IDR 15,410,996.86	IDR 1,920,000.00
40%	0.87	IDR 14,993,521.19	IDR 1,920,000.00
60%	0.994285714	IDR 14,497,999.19	IDR 1,920,000.00
Profit Mean		**IDR 15,595,682.45**	**IDR 1,920,000.00**

In order to make the comparison between existing and proposed result is more attractive and easier, then the following is graphic illustration for the sensitivity analysis result of γ parameter.

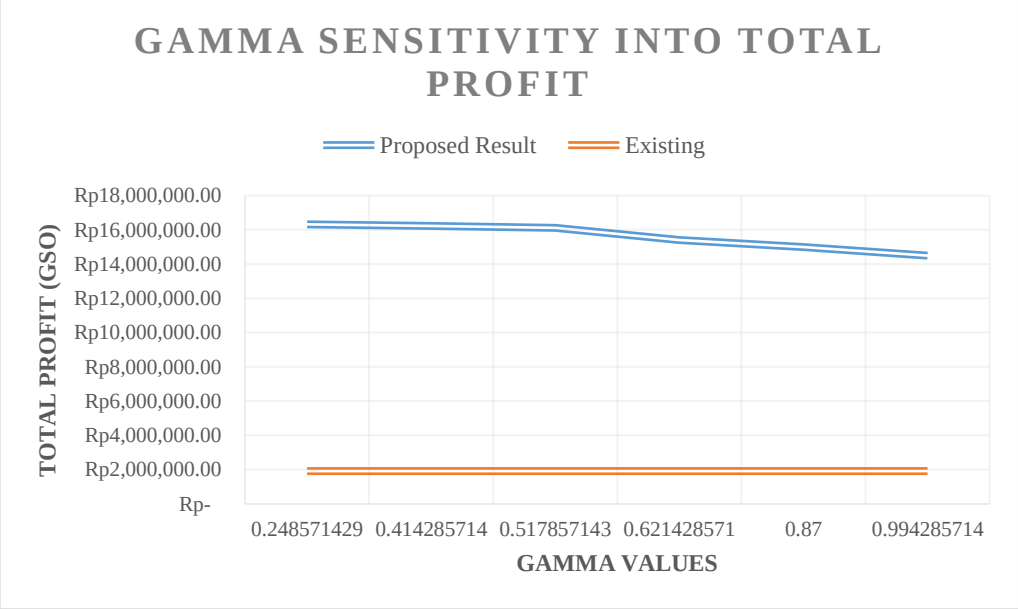

Figure 5. 18 Graphic Illustration for γ Sensitivity

Based on the figure 5.20, it is seen that γ parameter is only giving significant influence to the implementation of result from proposed model. It is seen from the graphic that the profit achieved in existing condition remains constant even though the value of γ is changed between 0 until 1. The graphic is also showing that higher value of γ makes lower profit achieved by the system, if it is implementing result from proposed model. It is aggravated by the condition of average profit achieved in existing condition is still higher than average profit achieved in implementing result from proposed model if the value of γ changed.

Similar with λ parameter, γ parameter has close relation with length of warranty period policy too. If λ parameter has strong relation with the length of warranty period offered in traditional channel, γ parameter has strong relation with length of warranty period offered in direct channel. That is why; in existing condition this parameter has no influence with total profit achieved by the system. It was caused by the existing condition was not implementing any warranty policy along particular period. It is different when implementing warranty policy as resulted from proposed model.

Profit achieved in implementing result from proposed model is keep decreasing because by the additional value of γ parameter, it has significant influence to the total demand achieved in direct channel. Higher γ parameter value, the higher demand in direct channel while demand in traditional channel keep decreasing. Therefore, in the result from proposed model product price for direct channel is lower than the existing. That is why; profit achieved in implementing result from proposed model keeps decreasing and still lower than existing profit. It can be concluded that by the changes of γ value, there should be frequent evaluation to make sure that the current suggestion is still the best strategy for sustainability of the company.

5.4 Managerial Implication for Observed Object

Regarding that this research is aiming to improve the current real system, then in this sub-chapter details of managerial implications into observed object will

be explained. Each managerial implication is explained in details as seen at the parts below.

1. The decision of product price setting has to be evaluated frequently, regarding the different values of parameter or condition at the company and their customer preferences behavior are leading to the different optimum price setting strategy.
2. Parameters which are influencing the total profit gained by the system in sequence based on their criticality are COGS (C_M), maximum demand amount at traditional channel (D_s^{max}), customer price sensitivity (β), customer acceptance ratio into direct channel instead of traditional channel (ρ), customer acceptance ratio into length of warranty in traditional channel (λ), and the last is customer acceptance ratio into length of warranty in direct channel (γ). Parameters D_s^{max}, β, ρ, λ, and γ are having direct influence to the total demand for each channel, while C_M is having direct influence to the total profit gained by the system.
3. In this research the product prices are proposed to be set at the value of IDR 434,371.17 for the product offered in traditional channel, while for direct channel product price is proposed to be set at IDR 269,197.17. There are some implications which may be as the additional consideration for the company as described below.
    a. According to the numerical tests in this research, demand in traditional channel is estimated to be lower than the existing condition by the set of product price as mentioned before. However, by the proposed product prices as mentioned before too, total demand in direct channel keep increasing compared with the existing condition. That is why; if the company is trying to widen its market size by increasing total demand in direct channel, proposed model is suggested.
    b. However, if the company is focusing on profit achievement, then the product price setting in the proposed model can be re-evaluated

by considering the value of β. This parameter has strong relation with the product price set in optimum value, which will be leading to the total demand achieved and also total profit gained by the company. It is not a wrong suggestion too, if the company is re-evaluating C_M values too, since it has critical influence to the total profit gained by the company.

4. In developing length of warranty for traditional channel (t_s) and length of warranty for direct channel (t_{ol}), it is also needing a regular evaluation to the values of the parameter. Regarding at the decision of selecting t_s and t_{ol}, total profit gained has been the main factor of developing payoff matrix in game theory setting. Different values of profit gained could change the different decision for t_s and t_{ol} strategies.

5.5 Model Weakness for Future Research Improvement Analysis

In this part, the weaknesses of model developed in this research will be discussed. Hopefully this part can be a useful consideration in developing a research model under DCSC topic in the future. This analysis will show the aspects which have to be developed for the next research. These following parts are weaknesses of this research.

1. Parameters used in this research are pricing sensitivity, direct channel acceptance sensitivity, and also length of warranty period sensitivity as the customer preference to estimate total demand for each channel. For the next research it is better if other customer preferences are also used as the consideration in the optimization processes.
2. The development of parameter values in this research are based on questionnaires and also historical data from observed object, it is better that parameter values development for the research is coming from the observed object customer segments to make the model becomes more representative.

3. In this research the development of optimum prices were using nonlinear programming, while finding acceptable length of warranty services were using game theory approach, for the next research if these methods were unable to accommodate anymore, the other methodology or approach is acceptable.
4. Other customer preferences could be the additional factors in developing DCSC model to widen the scope of demand function developed for the next research.

ATTACHMENTS

Attachment 1 – Questionnaire Screenshot

Link of the questionnaire: https://aldellalg.typeform.com/to/VhZFXq

Attachment 2 – List of Questions in the Questionnaire

1. Jenis kelamin:
   a. Pria b. Wanita
2. Usia:
   a. 15-18 tahun c. 23-26 tahun
   b. 19-22 tahun d. Other
3. Apakah Anda pernah membeli produk pakaian melalui fasilitas Online?
   a. Ya b. Tidak
4. Jika harga menjadi pertimbangan Anda dalam melakukan pembelian melalui Online atau toko Offline, maka pada selisih harga berapakah Anda lebih memilih berbelanja melalui toko Offline daripada melalui Online?
   * Isi dengan nilai yang Anda anggap pantas.
5. Berdasarkan preferensi Anda berapakah nilai yang menurut Anda pantas untuk produk yang dijual secara Online, jika produk yang sama dijual secara Offline pada harga Rp125.000,00?
6. Apakah sebelum melakukan pembelian, lama garansi yang ditawarkan merupakan salah satu pertimbangan Anda dalam membeli suatu produk?
   a. Ya b. Tidak
7. Jika Anda tidak mempertimbangkan garansi sebelum melakukan pembelian, apa alasan yang menjadikan garansi kurang penting menurut preferensi Anda?
   a. Kualitas produk sudah pasti bagus
   b. Loyalitas konsumen yang cukup tinggi terhadap produsen
   c. Deskripsi dan gambar yang ditunjukkan sudah mampu menjelaskan produk secara detil
   d. Other
8. Menurut Anda seberapa pentingkah lama periode garansi yang ditawarkan sebagai bahan pertimbangan dalam melakukan pembelian suatu produk?
   * Isi dengan nilai pada rentang skala 0-100.
9. Menurut Anda pentingkah adanya perbedaan lama garansi yang ditawarkan antara produk yang dijual secara Online dan Offline?

a. Ya b. Tidak

10. Menurut Anda, berapakah jangka waktu yang Anda sarankan untuk diberikan oleh produsen dalam memberikan allowance periode klaim setelah pembelian melalui toko Offline untuk produk pakaian?
    a. Jangka waktu pendek (1-7 hari)
    b. Jangka waktu menengah (8-14 hari)
    c. Jangka waktu panjang (15-21 hari)
11. Menurut Anda, berapakah jangka waktu yang Anda sarankan untuk diberikan oleh produsen dalam memberikan allowance periode klaim setelah pembelian melalui Online untuk produk pakaian?
    a. Jangka waktu pendek (1-7 hari)
    b. Jangka waktu menengah (8-14 hari)
    c. Jangka waktu panjang (15-21 hari)
    d. Jangka waktu lebih panjang (22-28 hari)
12. Semisal, keputusan Anda berbelanja di channel Offline dipengaruhi oleh panjang pendeknya periode garansi yang ditawarkan. Untuk membuat Anda memutuskan berbelanja di channel Offline sebuah produk kaos berapakah periode garansi yang seharusnya ditawarkan oleh toko Offline?
    * Isi dengan nilai angka pasti dalam satuan hari pada rentang 1-21 hari.
13. Semisal, keputusan Anda berbelanja di channel Online dipengaruhi oleh panjang pendeknya periode garansi yang ditawarkan. Untuk membuat Anda memutuskan berbelanja di channel Online sebuah produk kaos berapakah periode garansi yang seharusnya ditawarkan oleh toko Online?
    * Isi dengan nilai angka pasti dalam satuan hari pada rentang 1-28 hari.

Attachment 3 – Recapped Questionnaire Results

No	Gender	Age	Online Buyers Experience	Beta	rho Indicator	Warranty Importance Opinion	Reason Why Warranty is Unimportant	Length of Warranty Differences Importance Opinion	Lambda Indicator	Gamma Indicator	ts	tol
1	Woman	19-22	Yes	Rp 5,000.00	Rp 100,000.00	Yes		Yes	15	5	Short period	Short period
2	Woman	19-22	Yes	Rp 20,000.00	Rp 135,000.00	No	Good description and picture.	No	21	28	Short period	Long period
3	Woman	19-22	Yes	Rp 50,000.00	Rp 100,000.00	No	Good description and picture.	Yes	1	4	Short period	Short period
4	Woman	19-22	Yes	Rp 30,000.00	Rp 150,000.00	No	Quality trust.	No	3	16	Short period	Short period
5	Man	19-22	Yes	Rp 50,000.00	Rp 100,000.00	Yes		Yes	21	28	Short period	Short period
6	Woman	19-22	Yes	Rp 50,000.00	Rp 120,000.00	Yes		No	10	15	Medium period	Medium period
7	Woman	19-22	Yes	Rp 100,000.00	Rp 70,000.00	Yes		No	14	14	Medium period	Medium period
8	Woman	19-22	Yes	Rp 30,000.00	Rp 120,000.00	No	Good description and picture.	Yes	3	14	Short period	Medium period
9	Man	19-22	Yes	Rp 50,000.00	Rp 100,000.00	No	Good description and picture.	No	15	28	Medium period	Very long period
10	Woman	19-22	Yes	Rp 100,000.00	Rp 75,000.00	Yes		Yes	10	28	Short period	Medium period
11	Man	19-22	Yes	Rp 100,000.00	Rp 110,000.00	Yes		No	21	28	Long period	Very long period
12	Woman	19-22	Yes	Rp 5,000.00	Rp 85,000.00	No	Customer's loyalty.	No	3	25	Short period	Short period
13	Woman	19-22	Yes	Rp 50,000.00	Rp 150,000.00	Yes		Yes	14	21	Short period	Medium period
14	Woman	19-22	Yes	Rp 25,000.00	Rp 90,000.00	No	Good description and picture.	No	7	14	Medium period	Medium period
15	Woman	19-22	No	Rp 20,000.00	Rp 145,000.00	Yes		No	7	7	Short period	Short period
16	Woman	19-22	No	Rp 10,000.00	Rp 130,000.00	Yes		Yes	7	20	Short period	Long period
17	Man	19-22	Yes	Rp 50,000.00	Rp 112,500.00	Yes		No	7	14	Short period	Medium period
18	Man	19-22	Yes	Rp 30,000.00	Rp 100,000.00	Yes		Yes	1	7	Short period	Short period
19	Woman	19-22	Yes	Rp 100,000.00	Rp 145,000.00	Yes		Yes	14	28	Short period	Medium period
20	Woman	19-22	Yes	Rp 50,000.00	Rp 100,000.00	Yes		No	14	14	Medium period	Long period
21	Woman	19-22	Yes	Rp 100,000.00	Rp 75,000.00	Yes		Yes	7	14	Short period	Short period

No	Gender	Age	Online Buyers Experience	Beta	rho Indicator	Warranty Importance Opinion	Reason Why Warranty is Unimportant	Length of Warranty Differences Importance Opinion	Lambda Indicator	Gamma Indicator	ts	tol
22	Woman	19-22	Yes	Rp 20,000.00	Rp 100,000.00	No	Quality trust.	No	5	7	Short period	Short period
23	Woman	19-22	Yes	Rp 50,000.00	Rp 90,000.00	Yes		No	7	28	Short period	Long period
24	Woman	19-22	No	Rp 50,000.00	Rp 80,000.00	No	Good description and picture.	No	18	7	Short period	Short period
25	Man	19-22	Yes	Rp 1,000.00	Rp 50,000.00	Yes		No	1	1	Short period	Long period
26	Woman	19-22	Yes	Rp 20,000.00	Rp 100,000.00	Yes		Yes	15	15	Medium period	Very long period
27	Man	19-22	Yes	Rp 20,000.00	Rp 100,000.00	No	Quality trust.	Yes	10	10	Medium period	Long period
28	Man	19-22	Yes	Rp 100,000.00	Rp 135,000.00	Yes		Yes	14	21	Medium period	Long period
29	Man	19-22	Yes	Rp 20,000.00	Rp 100,000.00	Yes		No	21	28	Short period	Medium period
30	Man	23-26	No	Rp 15,000.00	Rp 125,000.00	Yes		Yes	21	28	Medium period	Very long period
31	Woman	19-22	Yes	Rp 20,000.00	Rp 100,000.00	Yes		Yes	3	5	Short period	Short period
32	Woman	23-26	Yes	Rp 10,000.00	Rp 140,000.00	Yes		Yes	7	6	Long period	Short period
33	Woman	19-22	Yes	Rp 50,000.00	Rp 90,000.00	No	Good description and picture.	No	7	28	Long period	Medium period
34	Woman	19-22	Yes	Rp 50,000.00	Rp 60,000.00	Yes		Yes	14	28	Medium period	Very long period
35	Woman	19-22	Yes	Rp 10,000.00	Rp 100,000.00	Yes		No	7	14	Medium period	Short period
36	Woman	19-22	Yes	Rp 20,000.00	Rp 110,000.00	Yes		No	7	7	Short period	Medium period
37	Woman	19-22	Yes	Rp 25,000.00	Rp 95,000.00	No	Good description and picture.	No	7	14	Medium period	Medium period
38	Man	19-22	Yes	Rp 20,000.00	Rp 75,000.00	Yes		Yes	7	7	Short period	Short period
39	Woman	19-22	Yes	Rp 50,000.00	Rp 75,000.00	Yes		No	21	14	Medium period	Short period
40	Man	19-22	No	Rp 20,000.00	Rp 145,000.00	No	Quality trust.	Yes	21	28	Short period	Medium period
41	Woman	19-22	Yes	Rp 50,000.00	Rp 70,000.00	Yes		Yes	7	15	Short period	Long period
42	Woman	19-22	Yes	Rp 10,000.00	Rp 110,000.00	Yes		Yes	14	20	Long period	Long period
43	Woman	19-22	No	Rp 20,000.00	Rp 100,000.00	Yes		Yes	21	28	Long period	Very long period

No	Gender	Age	Online Buyers Experience	Beta	rho Indicator	Warranty Importance Opinion	Reason Why Warranty is Unimportant	Length of Warranty Differences Importance Opinion	Lambda Indicator	Gamma Indicator	ts	tol
44	Man	19-22	No	Rp 20,000.00	Rp 130,000.00	Yes		Yes	4	7	Medium period	Medium period
45	Man	23-26	Yes	Rp 50,000.00	Rp 115,000.00	Yes		Yes	2	7	Medium period	Medium period
46	Woman	23-26	Yes	Rp 70,000.00	Rp 85,000.00	Yes		Yes	10	28	Medium period	Short period
47	Man	19-22	No	Rp 100,000.00	Rp 130,000.00	Yes		Yes	14	7	Medium period	Short period
48	Woman	19-22	No	Rp 10,000.00	Rp 115,000.00	No	Other	Yes	7	14	Short period	Medium period
49	Man	19-22	Yes	Rp 20,000.00	Rp 130,000.00	Yes		Yes	7	28	Short period	Very long period
50	Woman	23-26	Yes	Rp 20,000.00	Rp 100,000.00	Yes		Yes	14	14	Short period	Short period
51	Woman	19-22	Yes	Rp 100,000.00	Rp 80,000.00	Yes		Yes	10	15	Short period	Very long period
52	Man	19-22	Yes	Rp 20,000.00	Rp 100,000.00	No	Other	No	7	7	Short period	Short period
53	Man	19-22	No	Rp 20,000.00	Rp 100,000.00	Yes		Yes	14	28	Short period	Short period
54	Woman	19-22	Yes	Rp 20,000.00	Rp 100,000.00	Yes		Yes	3	7	Short period	Medium period
55	Woman	19-22	Yes	Rp 20,000.00	Rp 100,000.00	Yes		Yes	10	14	Short period	Short period
56	Woman	19-22	Yes	Rp 50,000.00	Rp 75,000.00	No	Other	No	7	7	Short period	Short period
57	Woman	19-22	Yes	Rp 50,000.00	Rp 80,000.00	Yes		Yes	2	2	Medium period	Medium period
58	Woman	19-22	Yes	Rp 15,000.00	Rp 90,000.00	No	Customer's loyalty.	Yes	7	7	Short period	Short period
59	Woman	19-22	Yes	Rp 40,000.00	Rp 90,000.00	Yes		Yes	21	28	Long period	Very long period
60	Woman	19-22	Yes	Rp 50,000.00	Rp 110,000.00	No	Good description and picture.	Yes	21	28	Short period	Medium period
61	Woman	19-22	Yes	Rp 15,000.00	Rp 90,000.00	Yes		No	11	28	Medium period	Medium period
62	Woman	19-22	Yes	Rp 50,000.00	Rp 75,000.00	No	Customer's loyalty.	Yes	7	21	Short period	Medium period
63	Man	23-26	Yes	Rp 15,000.00	Rp 140,000.00	Yes		Yes	14	21	Medium period	Medium period
64	Man	19-22	Yes	Rp 100,000.00	Rp 100,000.00	No	Good description and picture.	No	7	7	Short period	Short period
65	Man	19-22	Yes	Rp 15,000.00	Rp 100,000.00	No	Customer's loyalty.	Yes	15	28	Short period	Long period

No	Gender	Age	Online Buyers Experience	Beta	rho Indicator	Warranty Importance Opinion	Reason Why Warranty is Unimportant	Length of Warranty Differences Importance Opinion	Lambda Indicator	Gamma Indicator	ts	tol
66	Man	19-22	Yes	Rp 25,000.00	Rp 150,000.00	No	Good description and picture.	Yes	7	14	Short period	Medium period
67	Man	19-22	Yes	Rp 5,000.00	Rp 122,000.00	Yes		Yes	15	20	Short period	Long period
68	Man	23-26	Yes	Rp 15,000.00	Rp 110,000.00	Yes		Yes	7	14	Short period	Short period
69	Man	19-22	No	Rp 20,000.00	Rp 135,000.00	Yes		Yes	15	14	Short period	Short period
70	Man	23-26	Yes	Rp 50,000.00	Rp 105,000.00	Yes		Yes	7	14	Short period	Medium period
71	Woman	19-22	Yes	Rp 15,000.00	Rp 100,000.00	No	Quality trust.	No	2	5	Short period	Short period
72	Woman	19-22	Yes	Rp 30,000.00	Rp 90,000.00	No	Quality trust.	Yes	11	14	Short period	Short period
73	Man	19-22	No	Rp 20,000.00	Rp 145,000.00	Yes		Yes	2	2	Short period	Short period
74	Man	19-22	Yes	Rp 25,000.00	Rp 115,000.00	Yes		Yes	14	14	Long period	Medium period
75	Man	19-22	Yes	Rp 100,000.00	Rp 75,000.00	Yes		Yes	15	28	Medium period	Very long period
76	Man	19-22	Yes	Rp 50,000.00	Rp 150,000.00	Yes		Yes	7	14	Medium period	Medium period
77	Man	23-26	No	Rp 30,000.00	Rp 100,000.00	No	Quality trust.	Yes	7	28	Short period	Very long period
78	Man	23-26	Yes	Rp 20,000.00	Rp 135,000.00	Yes		Yes	20	28	Short period	Short period
79	Man	19-22	No	Rp 50,000.00	Rp 75,000.00	Yes		Yes	14	21	Long period	Short period
80	Man	19-22	No	Rp 50,000.00	Rp 125,000.00	Yes		Yes	7	7	Short period	Short period

Attachment 4 – Script Objective Function Algorithm in *m-file*

```
function [Gso]=objectivefunctionGso(P)

%Defined Parameters
Ds=110;
beta=0.00012258;
rho=0.7904576;
lambda=0.380952;
gamma=0.517857;
Cm=65000;
ts=0;
tol=0;

%Objective Function

%gain offline profit
Gs=(P(1)-Cm).*(round((Ds-(beta*((P(1)-P(2))/(1-
rho))))+(lambda*ts)-(gamma*tol)));

%gain online profit
Go=(P(2)-Cm).*(round(((beta*((rho*P(1))-
P(2)))+(((gamma*tol)-(lambda*ts))*(1-
rho)))/(rho*(1-rho))));

%gain total profit
Gso=-(Gs+Go);

end
```

Attachment 5 – Script Constraint Matrix Development in *m-file*

```
function [A,b]=ABmatrix(ts,tol)

%Defined Parameters
Ds=110;
beta=0.00012258;
rho=0.7904576;
lambda=0.380952;
gamma=0.517857;
Cm=65000;

%Matrix development for constraints
%A matrix
A=zeros(6,2);

A(1,:)=[(beta/(1-rho)) -(beta/(1-rho))];
A(2,:)=[-(beta/(1-rho)) (beta/(rho*(1-rho)))];
A(3,:)=[-1 0];
A(4,:)=[0 -1];
A(5,:)=[-(rho) 1];
A(6,:)=[-1 1];

%b matrix
b=zeros(6,1);

b(1)=Ds+(lambda*ts)-(gamma*tol);
b(2)=(((gamma*tol)-(lambda*ts))/rho);
b(3)=-Cm;
b(4)=-Cm;
b(5)=0;
b(6)=0;

end
```

Attachment 6 – Script Demand Function Algorithm in *m-file*

```
function [ds,dol]=demandfunction(Ps,Pol,ts,tol)

%Defined Parameters
Ds=110;
beta=0.00012258;
rho=0.7904576;
lambda=0.380952;
gamma=0.517857;

%Demand Function for Offline Channel
ds=round((Ds-(beta*((Ps-Pol)/(1-
rho))))+(lambda*ts)-(gamma*tol));

%Demand Function for Online Channel
dol=((beta*((rho*Ps)-Pol))+((((gamma*tol)-
(lambda*ts))*(1-rho))))/(rho*(1-rho));

end
```

CHAPTER 6
CONCLUSIONS AND SUGGESTIONS

The chapter is closing part of the research which is explaining about the conclusion of whole research conducted and also suggestions proposed from the research.

6.1 Conclusions

A dual channel supply chain model has been developed in this research. The model considered customer sensitivity to price, customer acceptance ratio between direct channel and traditional channel, and also customer sensitivity to length of warranty service period offered in the channel. All these parameters have shown significant influence to the demand level in the system.

Optimum product prices suggested in this research are IDR 434,371.17 for product offered in traditional channel, while for product offered in direct channel is set to be lower at a value of IDR 269,197.17. Based on the result of the numerical tests, the total demand in traditional channel is decreased compared to the existing while total demand in direct channel increased. However, overall total profit gained by this setting is still higher than the current profit.

The acceptable length of warranty services offered in traditional channel is proposed at maximum 21 days, while optimum length of warranty services for direct channel is offered in 21 days. However, the optimum length of warranty services needs to be evaluated regularly as the profit in both channels changed.

6.2 Suggestions

The suggestions proposed from this research are mentioned at the points below.

1. Length of warranty service offered in particular channel contributes to the total demand in the channel. It makes the warranty services important to be considered to maximize the business performance of the company.

2. Price setting and warranty length decision suggested in this research is unable to be implemented in all periods, it has to be regularly evaluated for the current market and company conditions. Different parameter values in the system changes the decision both for product price setting and also length of warranty services.
3. Resellers of *Heroine Experience Store* existence are considered too in the model development.
4. Other warranty services performed such as cash back policy could also be considered. Since cash back policy is also influenced total profit gained by the company.
5. The scope of customer preferences are expected to be wider than current research, due to customer preferences are not only price sensitivity, warranty sensitivity, and also direct channel acceptance ratio.

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AUTHOR'S BIOGRAPHY

Aldella Lutiasari Ginanda – the author, was born in Malang on 6 June 1994 as the first child of Lulut Prabudi and Titik Kiswari. Her educational background is started from SD Islam Sabillah Malang (2000-2006) for the elementary, then MTs Negeri Malang 1 (2006-2009), continued to SMA Negeri 3 Malang (2009-2012), and the recently she finished her study at Industrial Engineering Department of ITS Surabaya (2012-2016).

In her college life, she was very active in big event organization under the supervision of HMTI ITS Surabaya, named as IE Fair. She has the experience in managing event for about three years, especially in field of financial and administration management. Besides improving her soft skills by actively involved in big event management, she also joined an academic organization in Industrial Computation and Optimization Laboratory or KOI Laboratory of TI ITS Surabaya. In this laboratory, she also has an experience as secretary in that organization.

Joined KOI Laboratory let the author to improve her hard skills especially in statistics, optimization, and also simulation courses. As one of the assistants in the laboratory, makes her gets such lecturer's assistant in those courses and has the responsibility to help the lecturers in guiding students for their projects under the course assignments. Besides that, the author also has improved her ability in operating *Lingo*, *Matlab*, *Arena*, and *Minitab* softwares by joined the laboratory organization, since all the assistants conducted trainings and skills upgrading regularly.

In the very last year of her study in Industrial Engineering Department, she still involved in one of big event committee, named Inchall 2016. As steering committee, together with other representative from different laboratories created concepts, responsible with the questions and assessment of the competition. It was challenging yet unforgettable since the competition was held in ASEAN scale and the furthest participants were from Thailand.