

# **Developing a Reverse Logistics Model for Raya Brewery**

Addis Ababa University  
Addis Ababa Institute of Technology



School of Mechanical and Industrial Engineering  
(Industrial Engineering)

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Addis Ababa, Ethiopia

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## **Developing a Reverse Logistics Model for Raya Brewery**

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This is to certify that the thesis prepared by Berhe Syum, entitled: Developing a Reverse logistics model for Raya Brewery and submitted in partial fulfillments of the requirements for the degree of Master of Science (Mechanical and Industrial Engineering) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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### **Declaration**

I, Berhe Syum, declare that the Masters Research thesis entitled “**Developing a Reverse Logistics Model for Raya Brewery**” is my original research work and no material has been submitted previously for the award of any other academic degree. The research work was done under the guidance of Dr. Ir. Kassahun Yimer and Fitsum Getachew (PhD Candidate), at Addis Ababa University, Addis Ababa Institute of Technology in School of Mechanical and Industrial Engineering.

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Date\_\_\_\_\_

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**List of Acronyms and Abbreviations**

|        |  |
|--------|--|
| AHP    | Analytical Hierarchy Process   |
| BGI    | Baelen Gaillard Industries   |
| CONE   | Conic Program  |
| EC     | Ethiopian Calendar   |
| EDI    | Electronic Data Interchange  |
| EFT    | Electronic Fund Transfer   |
| EOL    | End of Life  |
| FGP    | Fuzzy Goal Programming   |
| GCF    | Global competitiveness main factor   |
| HL     | Hecto-Litter   |
| ICT    | Information Communication Technology                                       |
| LAN    | Local Area Network   |
| LINDO  | Linear Interactive and Discrete Optimizer                                  |
| LINGO  | Linear Interactive and Goal Optimizer                                      |
| LP     | Linear Programming   |
| MICMAC | Modelling and Cross Impact Matrix Multiplication Applied to Classification |
| MILP   | Mixed Integer Linear Program   |
| MINLP  | Mixed Integer Nonlinear Program  |
| MIQP   | Mixed Integer Quadratic Program  |
| MLP    | Multi-Layer Perceptron   |
| MVT    | Marginal Value of Time   |
| NLP    | Nonlinear Program  |
| PC     | Pearson Correlation  |
| PICONE | Pure Integer Conic (Second-Order Cone) Program                             |
| PILP   | Pure Integer Linear Program  |
| PINLP  | Pure Integer Nonlinear Program   |
| PIQ    | Pure Integer Quadratic   |
| QP     | Quadratic Program  |
| RL     | Reverse Logistics  |
| S      | Significant Two Tailed Correlation   |
| SPSS   | Statistical Package for Social Science                                     |
| TOPSIS | Technique for Order Preference by Similarity to Ideal Solution             |
| UAE    | United Arabia Emirates   |
| VAN    | Value Added Network  |
| WAN    | Wide Area Network  |

### **Abstract**

*Reverse logistics can be defined as the way of returning products or others from the customer /end user to the producers. Nowadays, the field of reverse logistics is an important activity due to the expansion of different number of industries. Previous studies on reverse logistics focused on hazardous management programmes, asset recovery and obsolete material disposition. Studying reverse logistic has great advantage to Companies for resource conservation and addressing environmental sustainability thereby reducing costs from purchasing a new product. Raya Brewery Share Company, a case company in this study, has been challenged to return empty beer bottles and steel kegs while it distributes high amount of beer product per day.*

*This research focuses on developing a reverse logistics model for Raya Brewery Share Company. Studying the reverse logistics of this company helps to increases the flow of the empty bottles and steel kegs from the end users of customer to the company itself. In order to apply a good flow of empty bottles and steel kegs to the company; a theoretical holistic model and a proper collection centre is considered with optimum location facility that minimizes the transportation cost of returning empty beer bottles and steel kegs. In order to achieve the stated objectives of the study, different data gathering techniques including literature review of different published articles related to the concept of reverse logistics was carried out. The SPSS and LINGO 17 tools were used in this study. From the finding of this study the barriers and the drivers influence the reverse logistics process of Raya Brewery internally and externally and gating the products in the required period of time is the challenging and dynamic behaviour due to unpermitted sharing of bottles and steel kegs by the other beer producer. These factors hinder the company in returning empty beer bottles and steel kegs. The barriers and drivers of reverse logistics are analysed using SPSS factor analysis method. The result from the SPSS shows that the factors have direct and indirect impact in the reverse logistics of Raya Brewery. The collection centre is computed by using LINGO 17 and centre of gravity to determine the optimal collection centre with respect to transportation cost by formulating a transportation model. The result indicates that 20.941% of improvement by minimizing transportation cost compared to the total transportation expenses of the company. Therefore, assigning a proper collection centres helps to return the products easily and reduces a cost related to transportation and managing properly the barriers and drivers can make the company more successful. To improve the return of bottles and kegs of Raya Brewery, the study recommends implementing the developed reverse logistics holistic model and the proposed collection centre.*

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## CHAPTER ONE

### 1. INTRODUCTION

#### 1.1 Background of the Study

This research focuses on, developing a reverse logistics model for Raya Brewery Share Company to return effectively the empty beer bottles and steel kegs. Studying a reverse logistics helps for the management of material flow and the chance of reusing for both used product and material which helps to increase the flow of material from the end user to the origin of the producers by providing helpful information (Vlachos, 2004). In reverse logistics the most important motivation for bottle recycling for the producers, distributors and wholesalers, is to ensure that the products are sold through intended channel. On the other hand, restaurant may sell its product to their neighborhood convenient store who acquires beers from the same wholesaler in order to reach sales goal (Jiangang, 2008).

(Rogers, 1998) defines reverse logistics as a process of planning, efficient controlling, and the transformation of raw materials with respect of cost effective, implementing, finished goods, in-process inventory with integrated information from the end users of customers to the manufacturer company in order to fulfill customers need and to reuse or to dispose in proper way. (Surendra et al., 2013). According to (Rogers, 1998) reverse logistics also includes processing where products returned by customers or merchandise due to damage, seasonal inventory, end of life, repair, end of lease, and warranty, restock, salvage, recalls, and excess inventory (Micheal, 2011). Most of times reverse logistics focuses on hazardous material and recycling products, asset recovery and obsolete equipment disposition (Dhananjaya, 2011). Reverse logistics most of time concern with transportation, production planning, and inventory management where the transportation flow is many-to-one (Surendra et al., 2013) however, reverse supply chain is the way of returning different kinds products or materials to the producers which includes due to repair or service, recyclable containers, customer return, leased and worn out returns (Surendra et al., 2013).

The configuration of the logistics network in supply chain management is one of the most important strategic issues with a significant effect in the whole performance of the supply chain. As they share a number of resources, the configuration of the reverse logistics network has a strong influence on the performance of the forward logistics network, and vice versa. (Ehsan, 2015).The

way of return in the reverse logistics process does not considered by assuming all the returns are reusable and usually “as good as new”. The process of supporting classical material flow from producer to final user is carried out still now only using logistics system. In nowadays Logistics system supports recapturing of values from used goods that has a remarkable growth of interest in optimizing logistics processes (Jodejko, 2012).

According to (Jiangang, 2008) the activity of bottle return has very low profit than beer distribution which is often carried out by low cost. However; from world the china government encourages recycling of bottle for the purpose of material management and resource conservation.

According the (Bart-hass, 2017) annual report, from 2008-2017 the world shows a 10-year growth rate of beer bottles consumption by 2.3% and Africa beer bottle consumption increases by 6.5%. However, Ethiopia shows high beer bottle consumption by 7.3%. Ethiopia importing a beer bottle glass standard size (330 ml) from Saudi Arabia, Egypt, Tanzania and UAE international companies and from the domestic producers of Addis Glass Company and Daylight Applied Technology with annually estimated 12,000 tons (Atlas Ethiopia, 2017).

### **1.2 Problem Statement**

Ethiopia is one of the rapidly growing economies in the world with high beer production. The International companies are importing glass bottles standard size (330ml) from Saudi Arabia, Egypt, Tanzania, and UAE for Ethiopia. According the report of (Atlas Ethiopia, 2017) the growth rate of beer consumption of Ethiopia is increased rapidly with 14.5% from 2002 up to 2017. The Raya Brewery Share Company which produces 600,000 HL needs 181,818,182 number of beer bottles annually that shows high bottle consumption. This company starts by 8,354,390 bottles and 1,500 steel kegs in 2007 E.C. The Raya Brewery Share Company in nowadays is challenged in the reverse logistics process even they distribute on average 600,000 beer of bottles and 200 steel kegs per day for different grocery and hotels and it returns 550,000bottels and 150 steel kegs per day. According the Raya Brewery annual report of 2009 E.C, due to delays, it bought beer bottle of 2,789,068 and steel kegs of 2,000 in 2008 and 2,782,891beer bottles and 1,500 steel kegs in 2009 E.C. Raya Brewery consumes an average over 2.7 million beer bottles per year due to lack of proper collecting system of the beer bottles and steel kegs which challenges it to be competitive within the different beer brands of Ethiopia. To return the bottles, delaying is one problem that affects to forecast the availability of bottles and steel kegs due to lack of collection center and this leads high transportation cost expenses. For this reason, Raya Brewery registered a consecutive

loss of \$4.6 million for the same period of 2016 and 2017. The latter is currently in discussion with BGI over a majority share transfer (Atlas Ethiopia, 2017). Because of these barrier and driver problems, the Raya Brewery is not distributed still now in most of Ethiopian markets.

### **1.3 Research Questions**

1. What are the critical obstacles that hinder the reverse logistics of Raya Brewery Share Company?
2. What kind of reverse logistics model can address for the existing problem of Raya Brewery Share Company?

### **1.4 Objectives**

#### **1.4.1 General objective**

The main objective of this research is to develop a reverse logistics model for Raya Brewery Share Company to return empty bottles and steel kegs with effective and efficient way.

#### **1.4.2 Specific objectives**

To achieve the general objective of the study, the following specific objectives are addressed:

- To study the existing status of reverses logistics of Raya Brewery.
- To develop a conceptual reverse logistics model
- To propose a proper collection centers to return the empty beer bottles and steel kegs.
- To identify the existing critical reverse logistics problem of Raya Brewery.
- To develop a transportation minimization model.

### **1.5 Significance of the study**

The first benefit of this study is for achievement of academically purpose as research guide line. The second purpose of this study is to develop a reverse logistics model for Raya Brewery Share Company since there is no any study before this. Then the Raya Brewery Share Company can be benefit from this reverse logistics study to improve its logistic process beginning from production to delivering to the customer and reversely.

### **1.6 Scope of the Study**

The scope of this study is focuses on developing a reverse logistics model for Raya Brewery Share Company which is located in the southern Tigray. The developed model is dealing only the Tigray towns; this is because of the beer bottles and steel kegs are distributed mostly to Tigray Region.

This study helps to create a good understanding the effect of drivers and barriers on reverse logistics in order to minimize the expense of transportation cost in the reverse process for Raya Brewery Share Company.

### **1.7 Limitation of the study**

Reverse logistics is a complex and dynamic in nature to return the products from the users. The barriers and drivers have great impact not only the company but also to the returners. The limitation of this study is it focuses one region only especially the transportation model developed. That's why no more location was included except region one. The other limitation of this study is it focuses only one industry. Therefore, the barriers and drivers may be varying from one region to another region.

### **1.8 Organization of the Thesis**

This thesis is organized into five chapters. The first chapter includes background of the study, justification of the problem, objective, significance, scope, limitation and organization of the study. The second chapter focus on literature review concepts related to reverse logistics, components, basic activities challenges, common algorithms and optimization tools of reverse logistic, literature gap and summery. The third chapter discusses all about research design and methodology of the study. The fourth Chapter is all about data analysis and interpretation of the study. The analysis is all about the reverse logistics barriers, drivers, formulation of the model and major finding of the research study. The fifth Chapter includes conclusion, recommendation and future research direction according to the result of the study.

## CHAPTER TWO

### 2. LITERATURE REVIEW

#### 2.1 Reverse Logistics

Nowadays, the field of reverse logistics is very important due to the expansion of different a number of industries. The system of reversing and directly reusing of products have an advantage for the manufacturing industries, resource conservation and environmental sustainability which helps to reduce costs related to acquiring new component by recycling or recovering instead of purchasing an expensive raw material (Jodejko, 2012).

Reverse logistics is a reverse process of logistics which traditionally viewed as a process of recycling products (Rogers, 1998). However; the definition of the reverse logistics is varied from one system to others depending on the company or industry what they attempt. The retailers define reverse logistics as a way of gating product that has been returned by the end users or customers back to the vendor (Surendra et al., 2013). Manufacturers also define the term reverse logistics as the process of receiving defective products or reusable materials from the users (Benaissa et al., 2011). Nowadays, most of the companies are thinking different issues to improve their operation due to the enforcement of globalization such as competitiveness, productivity, quality, equity, and sustainability. For this reason, different companies are implementing practically a new strategy for survival purpose to increase the competitive market. This reverse logistics issue emerges the consequence of competitiveness by the competitive forces (Juan, 2005). To collect the used plastic bottles effectively and efficiently the separation, collection, transportation and recycling processes must be given emphasis by the different stakeholders (Hagos, 2016). In reverse logistics responsive reverse is used for products with high marginal value time (MVT), whereas the efficient reverse is appropriate for products with low MVT (Joseph et al., 2004).

#### 2.2 Reverse Logistics Basic Activities

According (Rogers, 1998) Recovery Process, Collection of end of usability products, Inspection and Classification are the main common basic activities of reverse logistics. Recovery process can be considered as the key element of a reverse logistics network due to, in this phase, the economic value of the returned product being recovered through the options of reuse, remanufacturing and recycling. (Surendra et al., 2013) The inspection and classification activities will determine the

condition of the returned products, so an analysis of the locations and capacities of sorting centers is required (Rogers, 1998). One of the main characteristics of the product recovery management is the uncertainty associated to recover products, in terms of quantity, quality and time. Collection of end of usability products can be considered the starting point of the system, and three different collection options can be observed depending on whether the collection is made directly by the manufacturer or remanufacturer, third-party logistics providers, or through a network of distributors and retailers (Sergio, 2014).

### **2.3 Components of Logistics System**

According (Yungyu, 2005) logistic system has three main components which are closely integrated each other (Logistics services, information systems and logistics infrastructure and resources). Logistics service helps for movement of materials and products from the producer to deliver to the customers and by collecting wastes by flowing reversely (Dhananjaya, 2011). Logistics service is an activity that basically performed internally at the manufacturing plant in the process of storage or inventory control and providing an external operational service. Logistics service activities are most of time bi-directional. The logistic service it may include physical activity and non-physical activities like selection of contractors, freightage and negotiations. (Yungyu, 2005). Information system helps to gather important data to avoid uncertainty in each logistics service interactions and the target group in order to tack and trace issues by using decision (Sergio, 2014). Resource is also another blueprint component of logistics system which includes human resources, warehouse, communication, financial resources, transport and packaging materials (Yungyu, 2005).

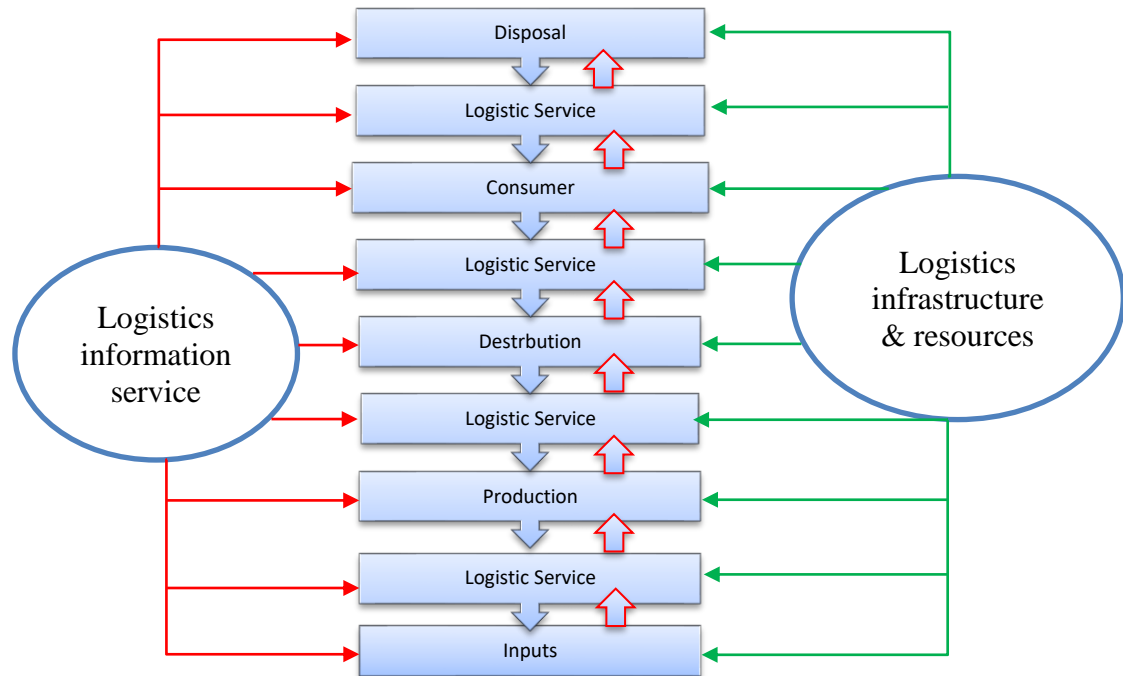


Figure 1: Overview of Logistics System (Yungyu, 2005)

A generalized logistics system composes two main business process loops which are inbound logistic (material management) and outbound logistic (physical distribution) (Meysam et al., 2014). Inbound logistics deals with acquisition and storage of raw material, parts and suppliers. logistics loop is composed of all activities related to producing customer service, order (receptions and processing), storage, transportation, inventory control, pricing, and consolidation, and promotional support, life cycle support, handling and returned products. (Hatem, 2007).

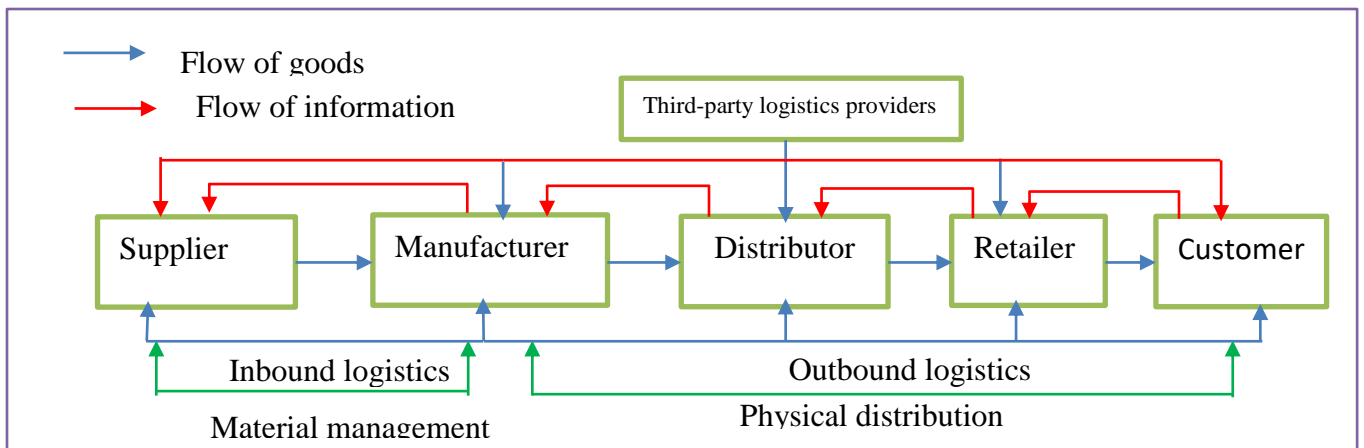


Figure 2: Generalized logistics system (Shigeki., 2013)

Based on (Muthusamy, 2014) and (Vikram, 2004) reverse logistics drivers are classified in to two categories as logistic drivers and cross-sectional drivers. The common logistics drivers are marketing, economic, competitiveness, facility, inventory control, transportation, asset protection,

environmental regulation, legislation and commercial motivations (Vikram, 2004). The cross-sectional drivers are information, sourcing and pricing. (Muthusamy, 2014).

#### **2.4.1 Marketing Strategy**

Marketing is a blueprint to the role of reverse logistics for improving a company marketing position (Mehmet et al., 2018). In marketing system returning and recovering used product is an important element to upgrade a green profile of the company to pay an attention too. (Vikram, 2004). Marketing strategy is an important decision for integrated organizational pattern to specify a complex opportunity concerning marketing activities, products, and marketing resource for delivery of products that offer value to customer in exchanges with organization and helps the organization to achieve its specific objectives (Kelly, 2011). Implementing marketing strategy which better to increase advertising to improve product or service quality by focusing on financial return of marketing and for create investment in loyalty program (Henry et al., 2010).

#### **2.4.2 Transportation**

Transportation is one of reverse logistics tool that helps to move product through different stages in the logistic system (Micheal, 2011). Transportation is a planning of functional and sub-functional into system of products for maximizing the customer service and to minimize total costs (Ehsan, 2015). Transportation affects the logistics activities, production and sale which it cost could be regarded as a restricted for the objective market (Xiaw et al., 2011). Transportation cost of product with small volume, low weight and high value occupies a small part of sale and big, heavy weight and low products occupies big part of sale that affects profit more (Yungyu, 2005).

#### **2.4.3 Economic Sustainability**

Economic sustainability is the way of achieving economic growth by respecting environmental limits, finding ways to minimize damage to the natural world and making use of the earth's resources in a sustainable way (Magdalena, 2011). In the reverse logistics inbound flows, the used or returned product which shows a cheap resource from the value to be recovered should be economically attractive (Vikram, 2004).

#### **2.4.4 Facilities**

Facilities are the physical locations of a logistics system or supply chain that used to stored, assemble or fabricated. Production sites and storage sites are the common types of facility (Anil, 2009). The metrics of facilities influences the capacity, utilization, cycle time of production flow

time of efficiency, average production batch size, and production service level. (Muthusamy, 2014). Collection centers and distribution systems are strategic issues for most of companies. Locating facilities and allocating customers covers the main part of distribution system design (Fitsum, 2016). Locating fabrication, warehouse and assembly plants is important issue for Industrial firms. The Stores have to be located by retail outlets and ability to manufacture its products depends in the part location facilities. The quality of the services depends on the location of the facilities in relation to other facilities (Benaissa et al., 2011).

### **2.4.5 Environmental Regulation**

Environmental regulation using reverse logistics has become a key element of public environmental policy in several countries. (Vikram, 2004). Environmental responsibility is a part of corporate social responsibility that emerged in the recent year towards the natural world as human being activities a natural cycle to balance the environment and nature (Badenshorts, 2013). Taking a consideration to integrate the environment and the nature with the operations and activities is best regulation issue for organizations (Rama et al., 2016).

### **2.4.6 Information Technology**

According (Micheal, 2011), Information technology helps to connect the different stages of a logistics system in order to coordinate and maximize the overall of logistics system profitability. The metrics related to information such as forecast horizon, forecast error, seasonal factors, and variation from plan and ratio of demand and frequency of update influences the logistics process (Muthusamy, 2014). Using of information technology provides to reduce lead time, and other uncertainty activities between the manufacturers, suppliers, distributors, retailers and customers. This also helps to managers to develop a good flow of information in coordinated manner, in accessing information and data interchanging to improve the relationship between the customers and suppliers in order to manage the inventory at national and international levels. The common information technology tools that used in various organization are electronic data interchange (EDI), electronic fund transfer (EFT), internet and extranets (Rogers, 1998). EDI mostly used for procurement in purchasing order, order status and order flow-up system. This helps provide information using electronic catalog system to the customers by including all about of a specific product. The electronic fund transfer (EFT) is also another tool that develops a trading relationship with others in order to transfer funds from one account to another by using value added network

(VAN) (Micheal, 2011). Internets are combination coverage of local area network (LAN) and wide area network (WAN) which can help to communicate using internet system securely by firewall. Intranet is used inside a corporation that has different features of locations. Extranet provides to allow business to communicate and to share with external with a certain level of security and privacy (Henry et al., 2010).

### **2.4.7 Asset Protection**

Asset protection is a driver of logistic system for company to reverse or to return their product after use (Badenshorts, 2013). This helps to prevent a sensitive component from going out to secondary markets or competitors. This economical driven flow helps to expect more active role of receiving products and tendency towards a demand-pull condition (Vikram, 2004).

### **2.4.8 Sourcing Related Metrics**

Sourcing is business processes used to purchase products and services. The factors that affect the logistics system of sourcing related metrics are fraction on-time deliveries, supply quality and supply lead time, range of purchase price, average purchase quantity, day's payable outstanding and average purchase price (Muthusamy, 2014). Companies in most of manufacturing sectors interferes low cost material, domestic or imported. Appealing option of competitive advantage helps to improve their objective. The importing resource have its own advantage and disadvantage having lower cost of labor and lower cost of resources (Benita, 1998). The independence on suppliers and identifying risks will be increase by importing raw materials, components or products. The risks may result from culture, language, foreign exchange rate, regulations, and transportation delays, economic and political stabilities (Henry et al., 2010).

### **2.4.9 Legislation and Commercial Motivations**

Legislation and commercial motivations lead to push the logistics where the receiving party which enforces to respond to its customers' needs (Vikram, 2004). Receiving a government support for companies when importing a raw material, regulations, polices and advice for the sectors' is another logistics driver which can make a series of reforms to encourage exports by increasing manufacturing sectors' using logistics competency (Badenshorts, 2013). The increments of international trade for acquiring resource from the other supplier is the main challenge due to language barriers, transportation, tariffs, administrative practices, transportation costs and exchange rate (Henry et al., 2010).

#### **2.4.10 Pricing**

Pricing is used to decide how much to charge customers for its product and services. The pricing related metrics which affects the logistic system are day sales outstanding incremental fixed cost per order, profit margin measures, range of sale price and periodic sales, average order price and average sale price (Muthusamy, 2014).

#### **2.4.11 Competition**

Increases of competition forces for companies to return and refund excess product from their customers (Meyer et al., 2017). This returning system of used products helps to build up a green profile which increases company's attentions to. The system of Competitive intelligence helps for the organizations what they need to know about the current and future competition, including their own organization's strengths and weaknesses, financials, major clients, what detailed inspection reveals about existing products in the marketplace, what new technologies (particularly disruptive technologies) are on the horizon, how competitors responded to your previous initiatives, competitor strengths and weaknesses, and more (Rogers, 1998). Therefore, Competitive intelligence gives a big support on creation of competitive advantages and also improves the company's performance as a consequence of a better business planning, new product introduction, new market developments and initiatives identified by this activity (Wadie, 2012).

#### **2.4.12 Inventory Control**

Inventory control helps to manage any held product in the logistics system in the form of raw materials, finished goods and work in progress (Benaissa et al., 2011). The inventory related metrics affects the logistic system such as average safety inventory, average replenishment batch size, average inventory, and product with more than a specified number of days of inventory, fraction rate of timeout of stock, seasonal inventory and fill rate (Muthusamy, 2014).

### **2.5 Reverse Logistics Decisions**

Reverse logistics decision includes logistics issues of network design, inventory management, marketing, product quality and safety (Rogers, 1998). The reverse logistics firms and supply chains takes a decision on issues of return. They also need to define clearly the role of ICT and role of various stakeholders (Sabina, 2012). Three types of decisions are involved in the decision problem related to the design of the reverse logistics network: the first concerns the sites facility location (Mehmet et al., 2018). The second concerns the flow of matter and information between these

entities (Nizar et al., 2014). Finally, the third is investment in labor and equipment in each of these facilities (Benaissa et al., 2011). According (Rogers, 1998), (Mark and Patrick, 2013) identification of the various reverse logistics decisions; he classified them into strategic, tactical, and operational decisions (Sabina, 2012). In the logistics system process, an efficient management of product returns is termed as strategic issue. The main reverse logistics operating channels (manufacturing operation, third-party operation and joint operation) can be determined and evaluated using the techniques of analytical hierarchy process (AHP), TOPSIS and LP solver (Senthila et al., 2012). The difference between the three reverse logistics decisions.

Table 1: Reverse logistics decisions

| Strategic   | Tactical  | Operational                                  |
|---|---|--|
| Whether or not to integrate reverse logistics with the forward logistics                  | Decide transportation means and establish transportation routes   | Logistics and operations scheduling          |
| Allocate adequate financial resources   | Establish operational policies (production and inventory)   | Emphasize cost control                       |
| Categorize and define return Policies   | Define return policies for each Item  | Return acquisition activities                |
| Determine reasons, stakeholders, and issues related to RL                                 | Define technical support to offer (In-store, subcontractors, etc.)  | Consider time value of returns               |
| Evaluate internal expertise in RL and decide about outsourcing a few or all RL activities | Do the reverse logistics activities (transportation, warehousing, remanufacturing, etc., in-house or subcontract) | Train personnel on RL concepts and practices |

## 2.6 Challenges of Reverse logistics

According (Micheal, 2011), Issues that make it difficult to forecast and allocate resources to return systems in reverse logistics are factors like timing, quality and the quantity of product returns. The challenges of reverse logistics are caused due to different factors which are different from the forward flow (Sabina, 2012). According (Rogers, 1998) the main challenges of reverse logistics are:

- Lack of formal product returns procedures
- Lack of performance measurement for return process efficiency
- Large variations in timing, quality and quantity of product returns
- Delayed product returns reducing their market value
- Risk of cannibalizing new product markets
- Lack of local competence in inspection, evaluation and disposition of returns

There are only a few companies that have formalized information system and standard operating procedures for the management of returns. An ongoing issue is that the product returns that are

returned by end-users is that they are usually unpacked, unlabeled or missing other relevant product identifications (Sabina, 2012).

### 2.7 Reverse Logistics Modeling Approaches

According (Muthusamy, 2014), The field of reverse logistics is usually subdivided into three areas: inventory control, production, recovery and distribution planning. According (Jodejko, 2012), the most common reverse logistics modeling approaches are Deterministic, Stochastic and Hybrid modeling approaches. The Deterministic modeling approaches is used when all variables are perfectly known. In Stochastic modeling approaches at least one of the variables is unknown and is assumed to follow a known probability distribution. This model considers the demand in two ways when the demand for the new product is a consequence of the return and when the demand for new products does not depend on the number of returns, but the number of returns may depend on the previous demand (Meysam et al., 2014). Cohen and Lee (1988) develop a stochastic model of material requirement policy four cost based sub-models. These sub-models are material control, production control; finished goods stockpile (warehouse) and distribution (Benita, 1998).The Hybrid modeling approaches uses a simulation models that are capable of handling both deterministic and stochastic variables (Meysam et al., 2014).

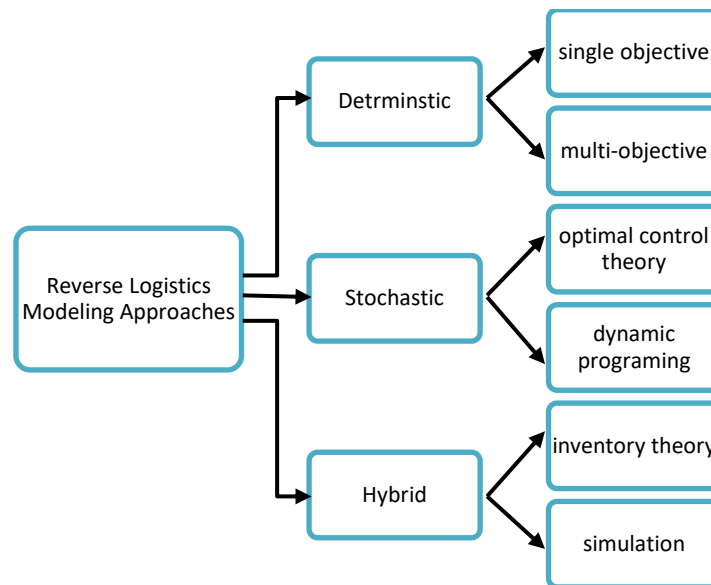


Figure 3: Reverse logistics modeling approaches (Meysam et al., 2014)

### 2.7.1 Generic Model

The generic model is used to configure regular flows in supply chain and to arrange components that realize reverse flow for product reuses including a set of elements of collectors, remanufacturers and recycler which are a generic supply chain model with a reverse logistics (Mostafa, 2016). The generic elements of this model are implemented as test-bed system for supply chain management including reverse logistics as shown in blew figure.

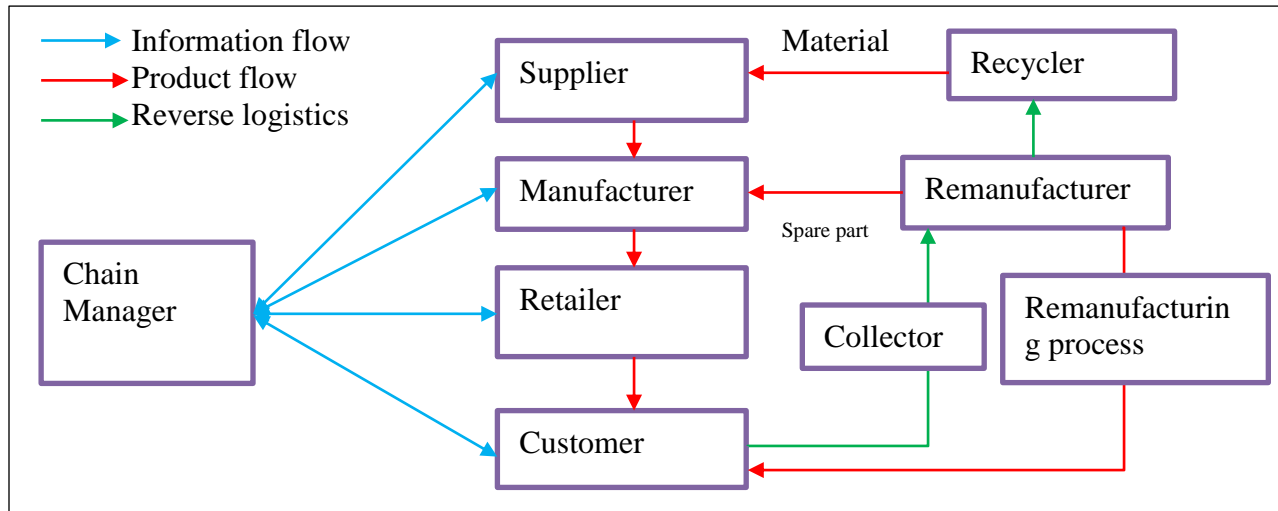


Figure 4: Generic supply chain model with reverse logistics (Mostafa, 2016)

### 2.7.2 Push Type Reverse Logistics Model

The customers return used products to collector, when customer disposes them. Push type reverse logistics model is the way of when collectors and manufacturer return the product to manufacturer in an order manner (Micheal, 2011). In this model remanufactured products are pushed to manufacturer, synchronizing with occurrence of reverse. When the demand volume from retailers increases volume of used product return to collectors also increases and they recycled by remanufacturers to stock as manufacturers buffer (Joseph et al., 2004).

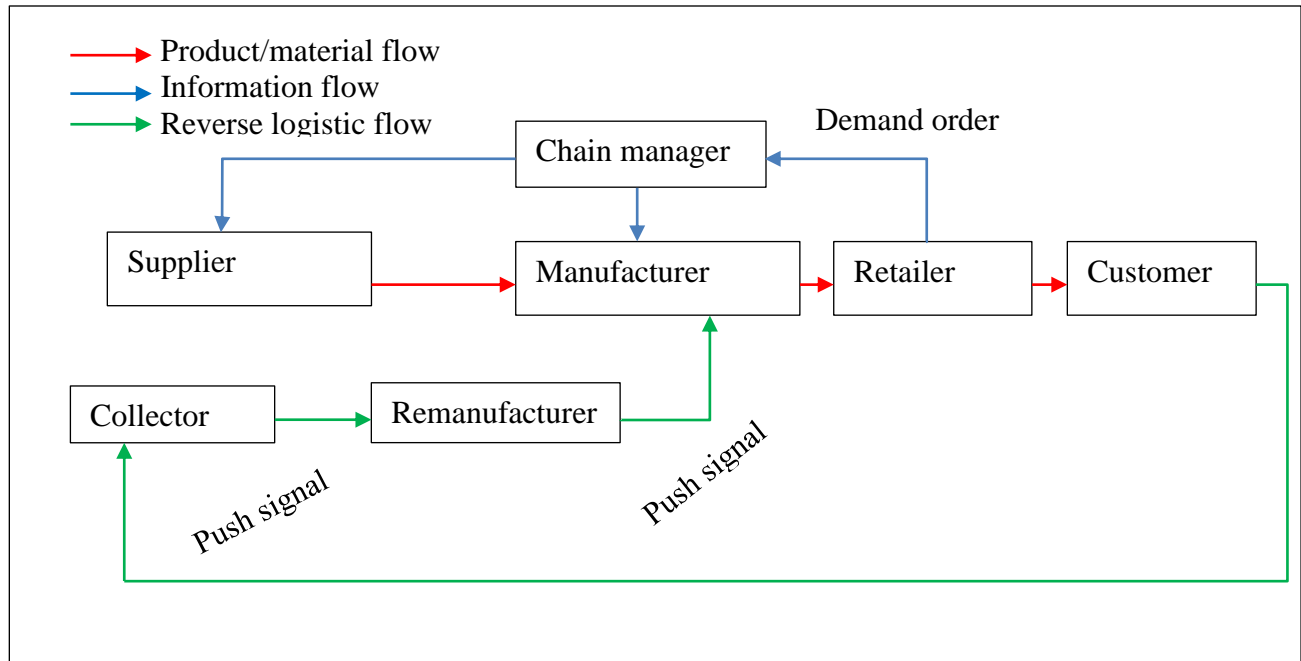


Figure 5: Push type reverse logistics model (Shigeki., 2013)

### 2.7.3 Pull-Type Reverse Logistics Model

According (Shigeki., 2013), When a need is arises from manufacturer; Remanufacturer pulls materials from Collector and regenerates the product reversely to the manufacturers. This model uses two pulling signals from manufacturer to remanufacturer and from remanufacturer to collectors to acquire usable materials (Micheal, 2011). In this model the manufacturer pulls the remanufacture and the remanufacture pulls the collectors. The reverse products are stocked at the collectors. In this pull type reverse logistics model when the demand volume decreases the volume of used product return to collector will decreases. When the used product volume is synchronized the volume of reuse and spare parts may up or down (Shigeki., 2013).

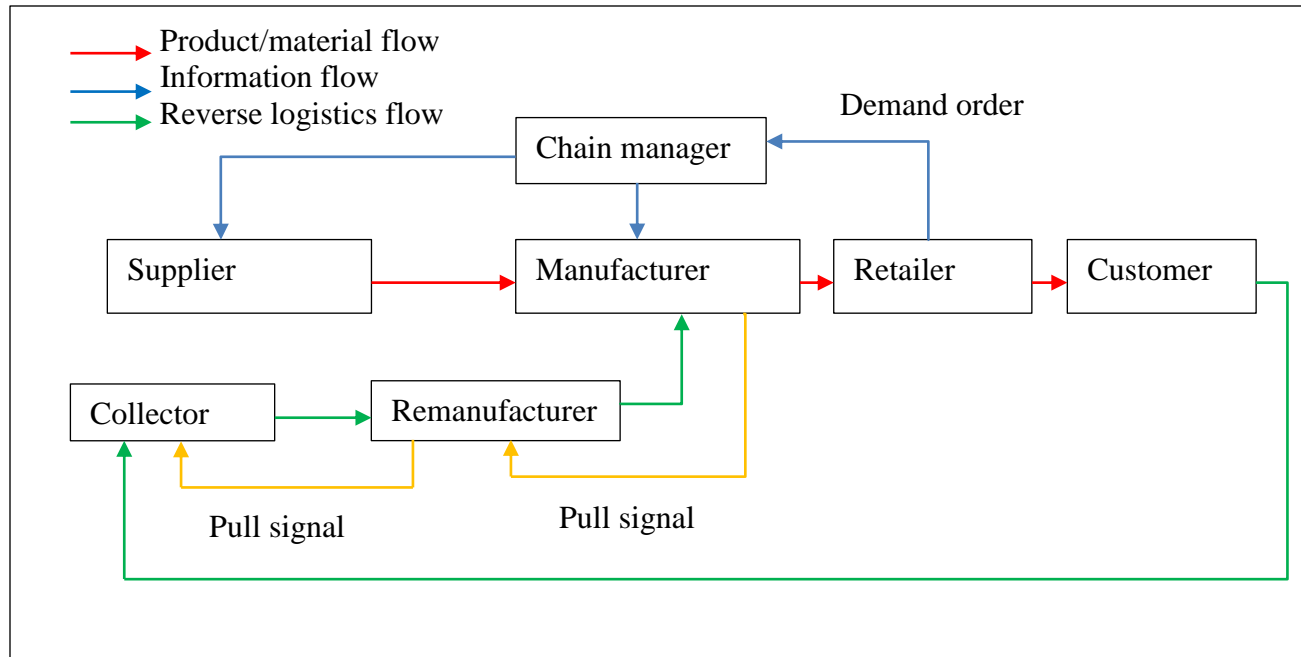


Figure 6: Pull type reverse logistics model (*Hatem, 2007*)

## 2.8 Common Algorithms and Optimizations Tools of Reverse Logistics

### 2.8.1 Stochastic Programming

Mathematical programming studies the theory and methods using random parameters with incomplete information (Ehsan, 2015). The mathematical problems may be either descriptive problem or optimization problem. The descriptive problems help to investigate the events by processing the given information using mathematical methods. The optimization problems also help to choose an optimal solution from the set of feasible solutions. The optimization problems may be classified as deterministic problem or stochastic problems (Mostafa, 2016).

### 2.8.2 Heuristic /Approximate/ Algorithm

Heuristic algorithm used to obtain good near optimal solution using low computation. The heuristic it may be constructive algorithm method or local search algorithm method (Mostafa, 2016). Constructive algorithms are used to generate solutions by iteration process by choosing the beginning event randomly until the solution is completed. The constructive algorithms are faster but low-quality solution is obtained comparing to local search algorithms. The local search algorithm also begins with complete solution and improves the current solution by local change continuously (Sanya, 2009).

### **2.8.3 Meta-heuristic Algorithm**

Meta-heuristic algorithm is a general purpose heuristic algorithm method designed to guide the core specific heuristic problems to search a high quality solutions (Mostafa, 2016). Meta-heuristic is a general algorithm framework which used for different optimization problem using few modifications to adapt the specific problems (Sanya, 2009).

### **2.8.4 Ant Colony Algorithm**

Ant colony algorithm is a population based-stochastic search algorithm which used to solve specific types of combination optimization problems (Mostafa, 2016). These problems are generally characterized by A set of constraints, A cost function, A finite set of sequence of components, A finite set of components from which solution are constructed, A solution is comprised of an ordered sequence of components and a finite set of possible transition among the components (Sanya, 2009).

### **2.8.5 Genetic Algorithm**

Genetic algorithm is stochastic searching method based on the natural selection and natural genetics behavior. This is used to solve problems when there is large space search with a little knowledge. This genetic heuristic optimization method which includes tabu search, simulated annealing and evolutionary strategies to obtain optimal or near-optimal solution for difficult problems (Mostafa, 2016). Genetic algorithm gives a better solution comparing to heuristic methods by selecting randomly based on natural selection process for solving both constrained and unconstrained optimization problems. Genetic algorithm and mixed integer programming algorithm can help to solve the reverse logistics problems related to location and allocation of facility for third part logistic system (Muthusamy, 2014).

### **2.8.6 Fuzzy TOPSIS Method**

Technique for order preference by similarity to ideal solution (TOPSIS) allows the decision maker to incorporate unquantifiable information, non-obtainable information and incomplete information (Hasan et al., 2010). Using TOPSIS, the best opportunity will be a value that is nearest to the positive ideal solution (maximizing benefit criteria and minimizing cost criteria) and farthest away from the negative ideal solution (Nazma et al., 2016). The TOPSIS method uses a weight a criterion which is known precisely and that reflects values used in the evaluation procedure (Senthila et al., 2012).

### 2.8.7 LINGO

LINGO is a tool that can be used to solve linear nonlinear optimization large problems in order to analyses the solution. This helps to use resources efficiently mostly inventory, time, money, machinery, staff and more (Fitsum, 2016). The LINGO solver displays the result including the model class, state, and objective, number of iterations, total variables and constraints (Alok et al., 2015). LINGO solver analysis the problems to group the modeling class of the stated problem. The LINGO *Model Class* field summarizes the properties of the stated model. The main modeling class of LINGO 17 solver is shown in the table 2 (LINGO, 2017).

Table 2: Modeling class of LINGO17

| Model Class                     | Abbreviation | Description   |
|---------------------------------|--------------|---|
| Linear Program                  | LP           | The model contains no integer restrictions on the variables and all expressions are linear.   |
| Nonlinear Program               | NLP          | At least one of the relationships in the model is nonlinear with respect to the variables.  |
| Mixed Integer Linear Program    | MILP         | The subset of the variables is restricted to integer values and All expressions are linear.   |
| Quadratic Program               | QP           | There are no integer restrictions and all expressions are linear or quadratic.  |
| Mixed Integer Quadratic Program | MIQP         | The subset of the variables has integer restrictions and all expressions are either linear or quadratic.  |
| Mixed Integer Nonlinear Program | MINLP        | The subset of the variables has integer restrictions and at least one of the expressions in the model is nonlinear. Generally, this class of model is very difficult to solve for all but the smallest cases. |
| Pure Integer Linear Program     | PILP         | All variables are restricted to integer values and all expressions are linear.  |
| Pure Integer Nonlinear Program  | PINLP        | All variables have integer restrictions and at least one of the expressions in the model is nonlinear. Generally, this class of model is very difficult to solve for all but the smallest cases.              |
| Pure Integer Quadratic Program  | PIQP         | All variables are restricted to integer values and all expressions are linear or quadratic.   |
| Conic Program                   | CONE         | All variables are continuous and the model is a conic (second-order cone) program.  |

|  |        |   |
|--|--------|---|
| Mixed Integer Conic Program                    | MICONE | A subset of the variables is restricted to integer values and the model is a conic (second-order cone) program. |
| Pure Integer Conic (Second-Order Cone) Program | PICONE | All the variables are restricted to integer values and the model is a conic (second-order cone) program, and.   |

**2.8.8 SPSS**

SPSS is a statistics tool that helps to interactive or batched statistical analysis. It has multi-layer perceptron and radial basis function neural network algorithms. (Amjad and Rashid, 2012) The factor analysis and neural network in the SPSS are used to predict and analysis the relationship between the variables (Bahaa et al., 2012). The SPSS neural network are used to provide an alternative predictive and to analysis the impact of each variable. (Mark and Patrick, 2013) The correlation in SPSS shows how strongly how two or more variables are related to each other or the degree of association between them (Eriksson and Sundh, 2010).

Generally, we can summarize the difference between the Algorithms, Optimization and multi-criteria decision-making Tools as shown in table 3. The SPSS and LINGO tools are used for this study due to their flexibility and multi-functionality as described in table 3.

Table 3: Advantage and disadvantage of reverse logistics tools.

| Algorithms, Optimization and multi-criteria decision-making Tools | Advantage   | Disadvantage   |
|---|---|--|
| AHP   | helps decision makers find one that best suits their goal and their understanding of the problem  | Even it compares the parameter with each other, the method accepts either qualitative or quantitative ratings. |
| Fuzzy TOPSIS  | Used to rank weighted criteria to choose a best result from the given alternatives  | It Deals with reasoning that is approximate rather than fixed and exact.                                       |
| IBM SPSS  | Multi-functional and flexible to analyses a set of variables  | It is difficult to interpret when it produces extremely complex models with multiple layers.                   |
| LINGO   | It used to solve linear nonlinear optimization large problems and possible to set declare variables as character format.                                  | Constraint limited, a maximum of 150constraints.   |
| LINDO   | Solves linear and non-linear optimization large problems and Can solve integer variables up to 50.  | Constraint limited, a maximum of 150 constraints and impossible to set the variables as character format.      |
| Genetic Algorithms  | It simulates processes in natural systems necessary for evolution; especially those follow the principles by Charles Darwin of ‘survival of the fittest’. | A random search used to solve optimization problems.   |
| Heuristic /Approximate/ Algorithm                                 | It used to obtain good near optimal solution using low computation.   | Difficult to achieve an optimal solution   |
| Ant Colony Algorithm  | It used to solve specific types of combination optimization problems.   | Difficult to solve more complex and generalized problems.  |

## Developing a Reverse Logistics Model for Raya Brewery

The approach, findings and limitation of different articles is summarized as in table 4:

Table 4: Comparison of literatures

| No. | Author                  | Title  | Approach   | Finding   | Limitation/Gap   |
|-----|-------------------------|--|--|---|--|
| 1   | (Dhananjaya, 2011)      | A study on Reverse Logistics,  | Rating factor  | Reverse logistics process in place leads to reduction in cost, optimal use of resources, better Customer satisfaction and improved customer loyalty, reduction in returns process time, and creating a green image.   | Does not consider the transportation cost how it optimizes the resource and how to reduce the costs to return the products.  |
| 2   | (Mostafa, 2016)         | An Optimization Model for Reverse Logistics Network under Stochastic Environment Using Genetic Algorithm | mixed integer linear programming model                               | To consider the minimizing of total shipping cost and fixed opening costs of the disassembly centers and the processing centers in reverse logistics is proposed and better having multi-product, multi-stage reverse logistics network.                              | It is probabilistic Priority-based genetic algorithm that do not consider how to solve the reverse logistics network design uncertainties of return time, pickup time and delivery time.                                     |
| 3   | (Juan, 2005)            | Logistics: Models & applications   | Branch-and-bound optimization methods using LINGO software.          | The variable that affects more the computational time was the number of planning periods.   | The heuristic algorithm did not show how the returning planning periods affect the reverse logistic.   |
| 4   | (Mohan et al., 2018)    | A Fuzzy Environment Strategies for Optimal Agricultural Land Allocation in Krishna Delta.                | Fuzzy Goal Programming (FGP)   | The results show that there is an improvement of land allocation for majority crops in preferential strategy compared to the competitive and Compensation strategies.   | Doesn't consider the impact of circular economy for computation in the formulation of a model to reduce the fertilizer consumption for the benefit of environment.   |
| 5   | (Hasan et al., 2010)    | a supply chain distribution network design model: fuzzy modeling approach                                | FGP approach (Max-min approach and lexicographic linear programming) | FGP approach provides decision maker in a supply chain a broad decision spectrum which is crucial in today's dynamic and competitive markets. FGP approach provides better results in terms of 'total service level' compared to the results of LP                    | Assumes Decision makers in plants, warehouses and retailers share information to design an effective distribution network. Decisions are made within a single period return.   |
| 6   | (Hagos, 2016)           | Assessment of Reverse Logistics on Used Water and Soft Drink Plastic Bottles in Addis Ababa city         | SPSS version 20  | creating awareness for the society as a whole, government support for all the collectors and recycling companies, supply of safety materials and equipment from the government, collaboration among all stakeholders are very important issues to return the products | The assessment Focuses only on one factor of reverse logistic, lack of considering other factors of the barriers and drivers.  |
| 7   | (Surendra et al., 2013) | Reverse Supply Chains Issues and Analysis  | Conceptual model   | Producer companies can be profitable when they manage properly the reverse logistic system by considering the customer returns, repair/service returns, EOL returns, reusable Container returns, and leased product returns.  | Majority of the proposed heuristics and models were developed considering one particular return type. There is a need for the development of models and/or heuristics that consider more than one return type simultaneously |
| 8   | (Ehsan, 2015)           | A Flexible Integrated Forward/ Reverse Logistics Model with Random Path-based Memetic Algorithm          | Random Path-based Memetic Algorithm                                  | designing the forward and reverse logistics separately leads to suboptimal designs with respect to strategic and tactical costs, the design of the forward and reverse logistics networks should be integrated  | objective functions, such as transportation cost, responsiveness, tardiness, and uncertainties are not considered  |
| 9   | (Joseph et al., 2004)   | Reverse Supply Chains for Commercial Returns   | Marginal value of time (MVT) Centralized & decentralized Model       | Responsive reverse supply chains are appropriate for products with high MVT, whereas efficient reverse supply chains are appropriate for products with low MVT.   | Time consuming (delay) due to Queue for Inspection and Testing   |
| 10  | (Micheal, 2011)         | Reverse Logistics Optimization A Research to the Uncertainties in the Third-Party Reverse Logistics      | SPSS   | Companies and businesses can save lots of unnecessary costs and time by giving a needed different solution to the different types of uncertainties.   | Lack of optimization the transportation cost and the different uncertainties.  |
| 11  | (Devika et al., 2012)   | A carbon footprint based reverse logistics network design model  | mixed integer linear model   | Using the proposed model, supply chain managers can make decisions by incorporating environmental emissions into their costs.   | This Can't handle the larger-sized problems.   |

## Developing a Reverse Logistics Model for Raya Brewery

|    |                        |   |                                     |  |   |
|----|------------------------|---|-------------------------------------|--|---|
| 12 | (Sharma. et. al, 2011) | Analysis of Barriers for Reverse Logistics: An Indian Perspective                                       | MICMAC                              | Lack of awareness about reverse Logistics, Financial Constraints and Legal issues are key barriers in the successful implementation of Reverse Logistics in Supply Chain.  | Deals only three factors, Lack of considering other drivers and barriers of reverse logistic.   |
| 13 | (Badenshorts, 2013)    | Prioritising the implementation of practices to overcome operational barriers in reverse logistics      | gap-and-opportunity analysis method | all the practices are important to at least a moderate extent but some are more difficult to implement.  | The practice is costly to implement and should be carefully considered in terms of value delivered to the Organization.   |
| 14 | (Sachin et al., 2016)  | Critical success factors for reverse logistics in Indian industries: a structural model                 | AHP                                 | The findings of this work show that the Global competitiveness main factor (GCF) is highly prioritized, and thus, needs to be focused greatly in order to increase the effectiveness and efficiency of RL adoption in business.  | The hierarchical intertwined interactions and feedback paths among recognized RL implementation are not revealed  |
| 15 | (Meyer et al., 2017)   | Drivers and barriers of reverse logistics practices: A study of large grocery retailers in South Africa | Face to face method                 | Optimizing profitability and cost reduction goals are the identified internal drivers, whereas the main external driver was to reduce the organizations' environmental impact  | Many of the RL practices are not conducted within the grocery retail industry   |
| 16 | (Serge et al., 2011)   | A reverse logistics decisions conceptual framework  | Conceptual framework                | Three real-world case studies are presented to test and to show the flexibility and applicability of the framework. The proposed conceptual framework will help practitioners in the field to structure their reverse logistics activities and also help academics in developing better decision models. | The conceptual framework is generic process mapping, decisions, economic aspects, and performance measures with a distinction made with respect to the strategic, tactical, and operational levels. |

From the above table literature summary, the most common literature gaps are:

The developed models don't consider how to reduce the transportation cost and the advantage of developing a collection center to return products from the end user customers to the origin of producers in the reverse logistic process. The missing proper network design leads to high expense of transportation cost due to lack of optimization technique. The other limitation of the researchers is they didn't pay an attention the impact of drivers and barriers of reverse logistic. Even if the products will not return in the required period of time (lack of responsiveness) which has negative effect in the production process. In the reverse logistics process there are different uncertainties which affect the system. In most of the literatures the uncertainties of demand, quantity, return time, pickup time and delivery time are not taken in to considerations in order to avoid the uncertainties which make a responsive to satisfy the customer needs. Most of the literatures deal in to products with end of life but not more concern on the products to be reused directly such as returning empty beer bottles and steel kegs. Therefore, this study focuses on developing a reverse logistics theoretical model by analyzing the barriers and drivers of the reverse logistics and how to develop a transportation model with proper collection center in order to avoid the uncertainty of reverse logistics of Raya Brewery.

## CHAPTER THREE

### 3. RESEARCH DESIGN AND METHODOLOGY

This section includes two main parts (research methodology and research design) with the planned procedure and the tools used to process the thesis. In order to achieve the stated objectives of the thesis the research methodology tool was carryout to develop a reverse logistics model for Raya Brewery Share Company.

#### 3.1 Research Design

The objective of this research is to develop a reverse logistics model for Raya Brewery Share Company to return the empty beer bottles and steel kegs. For that case a theoretical holistic model and an optimization collection center model is proposed. This study is carried out by considering the different literature gaps of the researchers and the existing problems of the company by using the data collecting techniques. A quantitative is addressed to solve the collection center and factor analysis process is carried out to identify the impact of drivers and barriers of reverse logistic. For this study, the following procedures or phase of the research design are addressed to come up with the final output. The procedures used in this research design are:

- ❖ First, the existing statue reverse logistics of Raya Brewery is studied. The different barriers and drivers of reverse logistics are identified and ranked using excel.
- ❖ Secondly, the relationship among the barriers and drivers is analyzed using factor analysis and multilayer neural network SPSS software.
- ❖ Thirdly, based on the analyses a reverse logistics theoretical holistic model, transportation and returning time models are developed.
- ❖ Fourthly, for the quantitative model of collection centers and transportation cost their optimality is checked using LINGO17.
- ❖ Finally, based on the results of the output conclusion, recommendation, and future research direction are addressed.

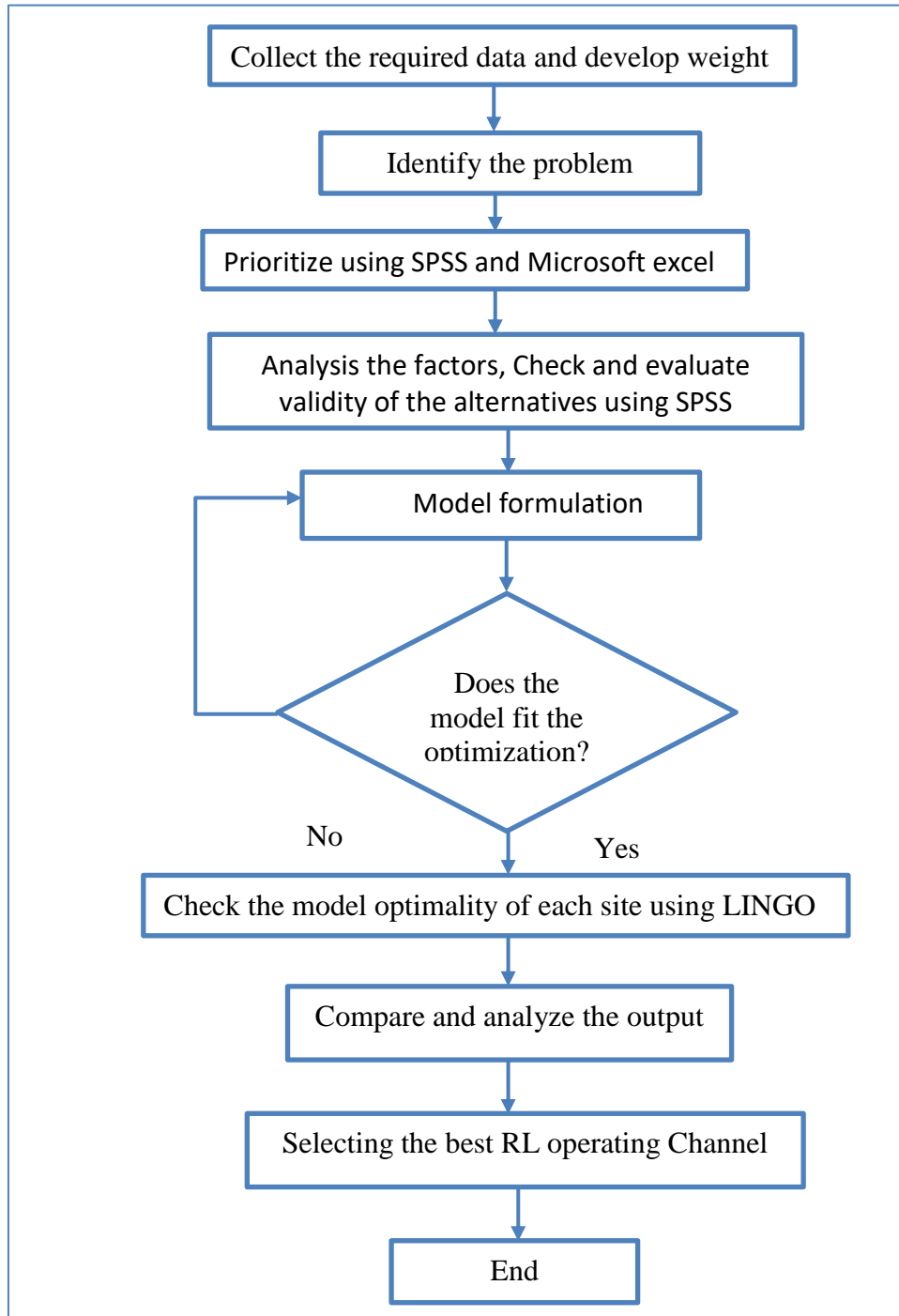


Figure 7: A procedure to develop reverse logistics model

### 3.2 Research Methodology

Methodology is a procedure which helps to choose the techniques used to gather the required information or data, designing process and the way of data presentation and data analysis using a helpful approach. The primary data are collected through questionnaire and face-to-face interview. Specifically, questionnaires are designed and distributed to selected staff members of the Raya Brewery. Interview was also held to top management officials of the company and to selected staffs. The secondary sources of data were used from different relevant published books, Journals, Articles, senior thesis work, manuals and available documents. The variable data's that was collected from the logistic department are the cost they expense for Transportation facility, demand capacity of each site or location. SPSS factor analyses tool is addressed to know the impact and relationship of the variables in reverse logistic. To develop the collection centers of Raya Brewery the constraints were solved using the LINGO 17 solver. The collected data were also analyzed to avoid the uncertainty parameters using Microsoft excel, SPSS and LINGO 17 solver software's. Generally, this research design and methodology of study was followed the following steps to achieve the study as shown in figure 8 below.

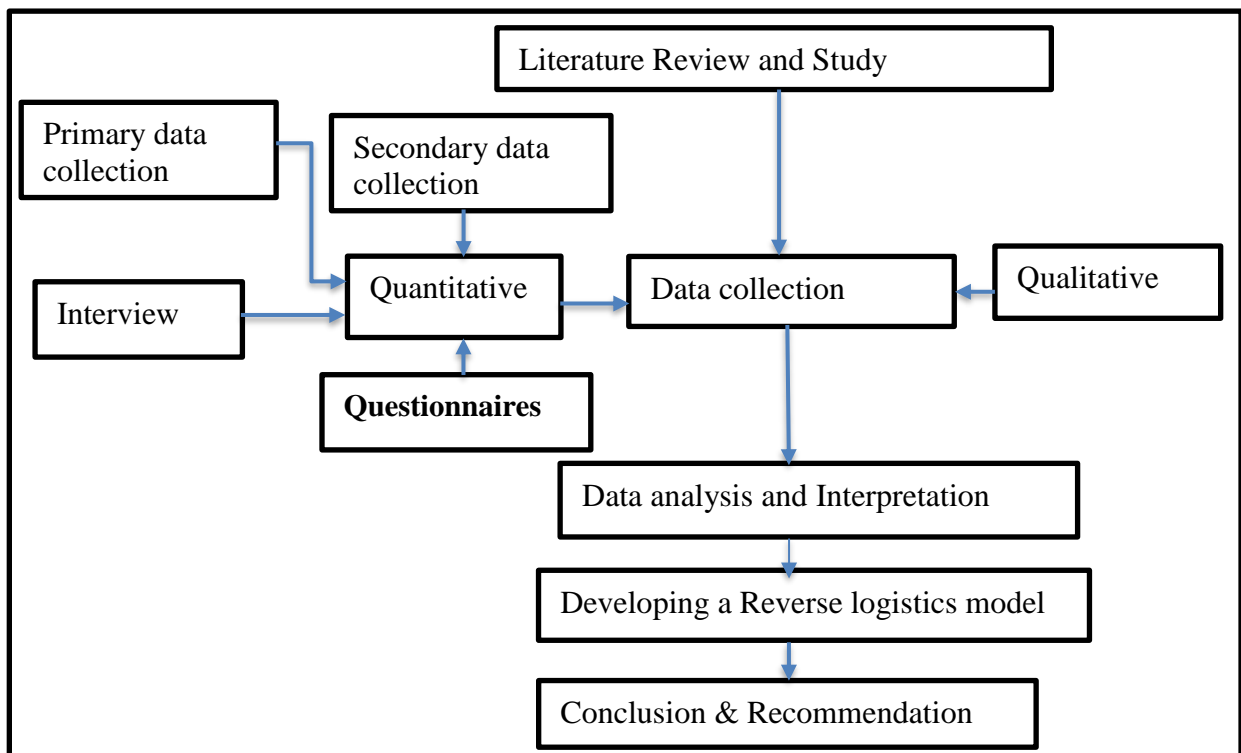


Figure 8: General framework

### **3.2.1 Reviewing a Literature**

The literature review was conducted relative to the concepts of logistic system and reverse logistics processes. This method is blueprint stage for the research which helps to summarize the previous finding in order to develop best way of reverse logistics returning system by identifying the gaps of different authors. The reviewing approach is done by referring different relevant published books, Journals, Articles, senior thesis work, manuals and available documents. The literature reviewing of this thesis focuses on the concepts of reverse logistics, drivers and barriers of reverse logistics, common algorithms of reverse logistic, components of logistics system, optimization techniques, decision methods, challenges and basic activities of reverse logistics.

### **3.2.2 Primary Data**

For better understanding of the problem area a direct data collection from the Raya Brewery is performed using observation, questionnaires, informal communication with employers and managers of the company. This technique helps to provide a relevant data information for the analyses purpose to achieve and to propose a better solution. Using this method, the amount of transportation cost expense per year, the number of beer bottles and steel kegs distributed and returned per day, beer bottles and steel kegs demands of agents and depots, production capacity of the company, the number of beer bottles and steel kegs bought per year were collected from the recorded data of Raya Brewery.

### **3.2.3 Secondary Data**

In this research the Secondary data specifies the way how to from whom the data is gathered. In this study the secondary data collection method was addressed including different published articles, books, journals, websites and a recorded data from the Raya Brewery Share Company and Asko Insight about Ethiopian brewery companies to strength the thesis. From Asko Insight the production capacity of the company and the number of beer bottles and steel kegs bought per year were collected. The different name of towns of Tigray and their distance from Mekelle were collected from southern Tigray Maychew city administration and from Google map.

### **3.2.3 Direct Observation**

This method helps the researcher how to collect the required data and information from the logistic process of raya Brewery share Company. In this study the direct observation technique is used to

analyses the annual reports, company profile brochure, recorded qualitative and quantitative data's using visual judgment.

### **3.2.4 Interviews**

The interviews used to strengthen the ideas collected through questionnaires and observations. The interview was made with the logistic management bodies, production, processing and planning, marketing and finance of Raya Brewery and respondents who are directly involved with the subject matter. This interview is done to cross check or triangulate the collected information using the questionnaire from the Raya Brewery whether the evidence is fact or not.

### **3.2.5 Questionnaire**

In order to gate helpful information questionnaire was develop to determine the existing logistic system. The target of using questionnaire is to understand the existing reverse logistics status of Raya Brewery. This questionnaire contains 30 questions with nominal scale, choice, and open ended and close ended formatting system. This questionnaire is distributed to 50 numbers of employers and only 40 papers are filled. For more detail see Appendix-B which attached in the appendix part.

### **3.2.6 Validity and Reliability of the Data**

Reliability of the research study is tested by using the SPSS software tool analysis through Cronbach's alpha value. During the analyses process a value of 0.976 is obtained in drivers of reverse logistics and 0.769 in barriers of reverse logistic. This result shows that, Cronbach's Alpha Based on Standardized Items is in acceptable range to proceed with the study according the Cronbach's standard because it is greater than 0.70 (Panayiotis, 2013). Generally, all the collected data are checked their validity using the tool of SPSS software. The LINGO optimization tool is also used to check whether the model optimality is valid or not, as result an optimal solution is found.

## CHAPTER FOUR

### 4. DATA ANALYSIS AND INTERPRETATION

This research study deals on developing a reverse logistics model for Raya Brewery. For gathering data, a questionnaire was formed in order to gate more information about reverse logistics of Raya Brewery Share Company. The questionnaires were distributed for 50 participants of the company basically for logistics department, marketing and finance, production, processing and planning sections of the company. The questionnaires were filled by 40 respondents; however, 10 participants have not returned the questionnaires.

The questionnaires have four main sections. The first section deals on more about the general information of the company including the socio-demographics (sex of respondent, age, profession, current position and level of qualification of education). The second section of the questionnaires also focuses on logistics related issues of the company. The third section part of the study deals on marketing and finance related issues. The fourth section of the questionnaires includes issues related to production, processing and planning strategies of Raya Brewery. The last section of the questionnaires focuses on questions that need a detail explanation concerning to Raya Brewery. The interview was also performed using the questions that were included in the last section of the questionnaires part to cross check and other logistics related issues.

#### 4.1 Demographic Profile of the Respondents

According the company respondents the human labors that derive the company most of them are males comparing to females in each department as shown in the following table. The age group 20-35 is the most productive labor comparing to relative the other age groups but comparing to the age group 36-50 as shown in table 5, it is very less. Most of the Raya Brewery Company are degree holders and have an experience more than three years.

Table 5: Demographic profile of the respondent

| Variable |        | Respondents %        |                     |                                   |
|----------|--------|----------------------|---------------------|-----------------------------------|
|          |        | Logistics department | Marketing & finance | Production, processing & planning |
| Gender   | Female | 29.41                | 25                  | 20                                |
|          | Male   | 70.59                | 75                  | 80                                |
| Age      | 20-35  | 47.06                | 37.5                | 33.33                             |
|          | 36-50  | 41.18                | 62.5                | 66.67                             |

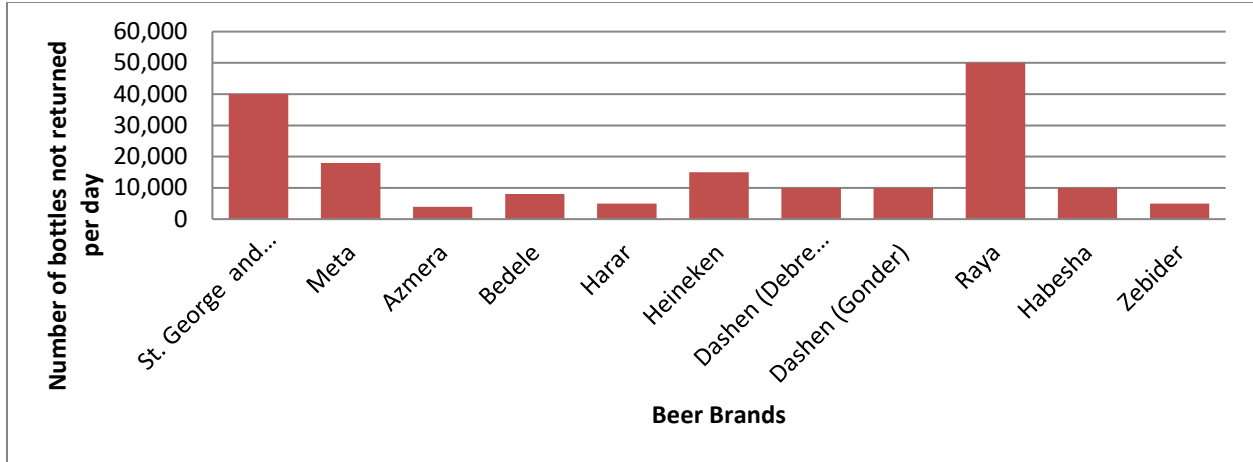
## Developing a Reverse Logistics Model for Raya Brewery

|                            |                            |       |    |       |
|----------------------------|----------------------------|-------|----|-------|
|                            | >50                        | 11.76 | 0  | 0     |
| Educational level          | Elementary school          | 0     | 0  | 0     |
|                            | High school                | 0     | 0  | 0     |
|                            | Certificate                | 0     | 0  | 0     |
|                            | Diploma                    | 17.65 | 25 | 13.33 |
|                            | Bachelor degree            | 76.47 | 75 | 86.67 |
|                            | Master's Degree            | 5.88  | 0  | 0     |
|                            | PhD                        | 0     | 0  | 0     |
| Work experience in company | ≤3 month                   | 0     | 0  | 0     |
|                            | Between 4 to 6 months      | 0     | 0  | 0     |
|                            | Between 7 months to 1 year | 0     | 0  | 13.33 |
|                            | Between 2 to 3 years       | 35.29 | 25 | 13.33 |
|                            | Greater than 3 years       | 64.71 | 75 | 73.34 |

From the above table it can be concluded that most of the employers have Work experience of greater than 3 years for logistics department (64.71%), for marketing and finance (25 %) and for production, processing and planning (73.34%). Similarly Work experiences of the workers who have between 2 to 3 years are for logistics department (35.29%), for marketing and finance (25 %) and for production, processing and planning (13.3%).

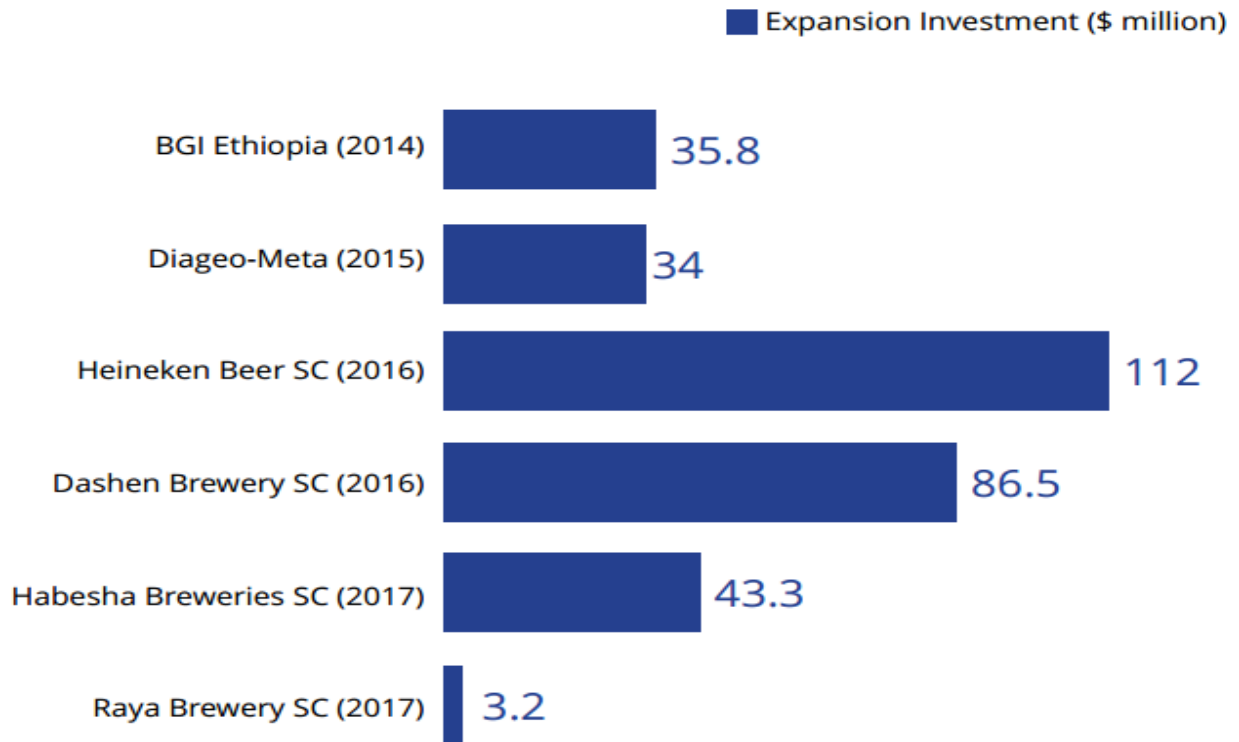
### 4.2 Existing Logistics System of Raya Brewery

The Raya Brewery Share Company distributes on average of 600,000 bottle beer and 200 kegs per day to three main depots. The beer products are delivered directly to main depots of Mekelle, Shire and Addis Ababa using its own 20 trucks; however, the agents can take product from the company using their own trucks. This company has 12 main agents that take the product directly from the company by their own transportation service to deliver to their customer. The agents can take the product simply from the company but customers can not take any product. The empty bottle beer and kegs returned only by the agents and the main depots. To reverse the empty bottle beer and kegs, this company collects four brand beers of Dashin Beer, St. George Beer, Habesha Beer and Raya Beer from the depots and agents. According to 75 % of respondents 550,000 empty beer bottles and 150 kegs are returned out of 600,000 empty beer bottle and 200 kegs respectively per day. The Raya Brewery has not formal reverse logistics returning system and collection centers. As result 50,000 numbers of bottles are not returned per day as shown in Fig. 9 and appendix A-5. For this reason, it has low expansion of investment comparing to the other Ethiopian beer brands as shown in Fig 10.



Source: (Bart-hass, 2017)

Figure 9: Number of bottles returned per day



Source: (Atlas Ethiopia, 2017)

Figure 10: Ethiopian brewery expansion investment.

The different barriers and drivers affect the reverse logistics system of Raya Brewery. The existing logistics network system of Raya Brewery has four main processes as shown in the figure 11.

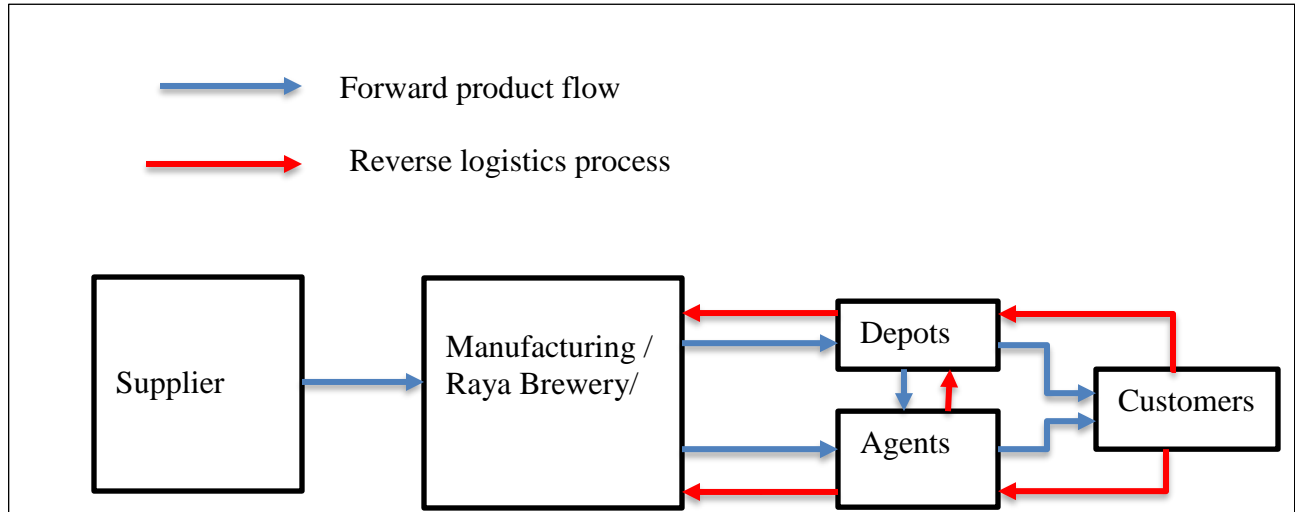


Figure 11: Existing Logistics System of Raya Brewery

Both the depots and agents have their own demand capacity of bottle beer and kegs as shown in below table 6.

Table 6: Demand of bottle beer and kegs of agents and depots

| A. Name of depot  | Beer bottle demand (kassa) per month | Kegs capacity per month |
|-------------------|--------------------------------------|-------------------------|
| 1. Mekelle        | 205920                               | 216                     |
| 2. Shire          | 13728                                | 80                      |
| 3. Addis Ababa    | 91520                                | 0                       |
| B. Name of agents |                                      |                         |
| 1. Maichew        | 9800                                 | 250                     |
| 2. Korem          | 7000                                 | 50                      |
| 3. Mohoni         | 11900                                | 120                     |
| 4. Alamata        | 9500                                 | 130                     |
| 5. Adi Gudem      | 12000                                | 80                      |
| 6. Adi Grat       | 9120                                 | 120                     |
| 7. Sokota         | 20000                                | 100                     |
| 8. Waja Tumuga    | 7000                                 | 50                      |
| 9. Awash          | 4500                                 | 0                       |
| 10. Logiya        | 2288                                 | 0                       |
| 11. Alaje         | 3500                                 | 0                       |
| 12. Assosa        | 5500                                 | 0                       |

### 4.3 Analyzing the Existing Logistics Problems

A proper and an efficient reverse logistics returning system helps to increase competitiveness in the market and also return on investment. Analyzing the barriers and drivers hindering the successful implementation of reverse logistics is an important issue. Most of time the barriers and

drivers of reverse logistics not only affect the system but also affects each other's (Badenshorts, 2013). The barriers and drivers have effects on the reverse logistic process and to each other's. In the Raya Brewery Share Company there is low of flow of return of products during product recalling process in the reverse process. The internal and external drivers have an impact in reverse logistic process as shown in the figure 12.

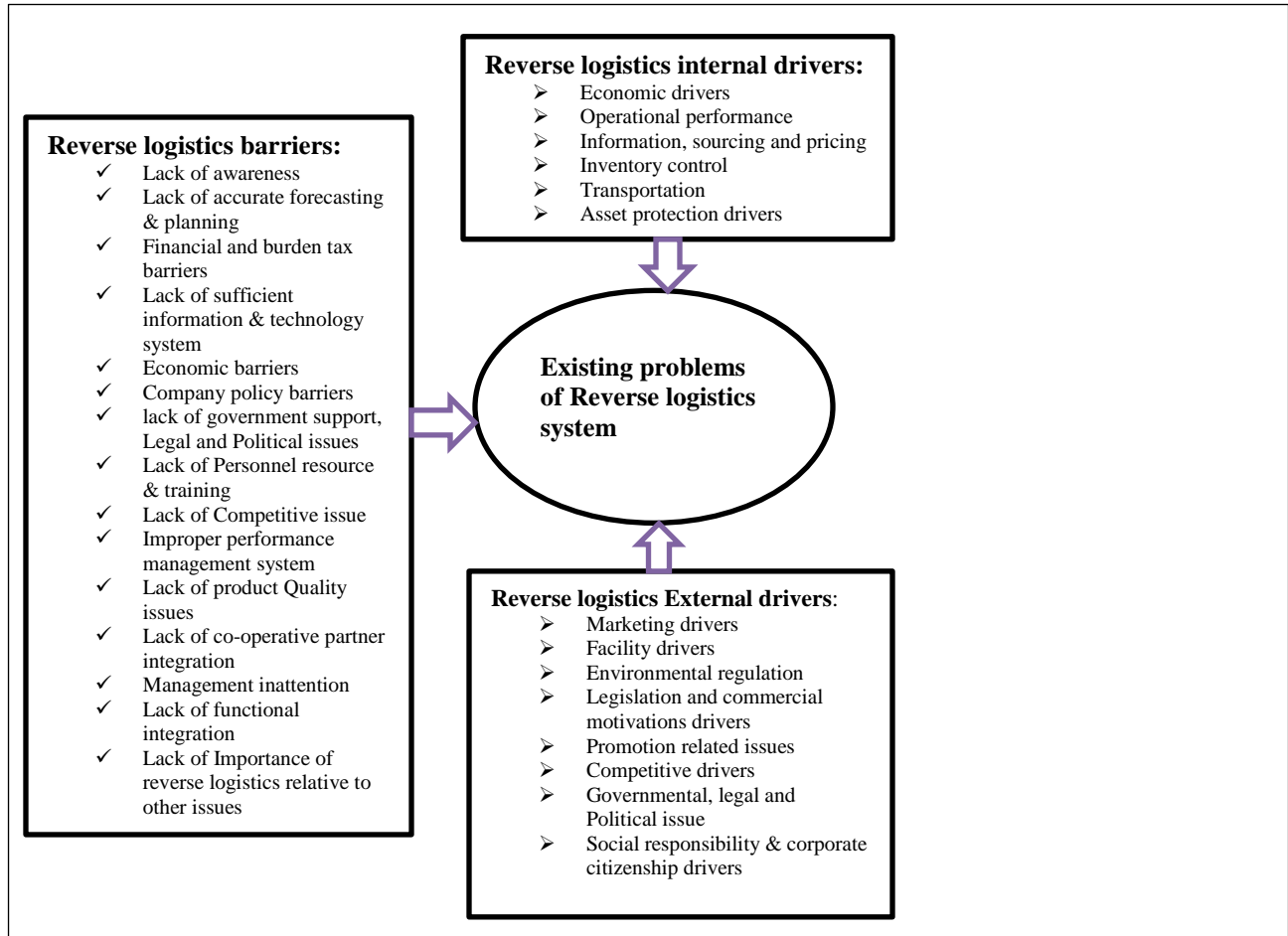


Figure 12: Drivers and Barriers of reverse logistics

According to the different researchers as shown in the below table, the drivers and barriers have their own impact in the reverse logistics process to return the products from the end users. These all the drivers and barriers of the reverse logistics are collected from the literature of the researchers (authors). Generally, the most common drivers and barriers of reverse logistics investigated are summarized in table 7 from the articles of the different researchers.

Table 7: Characteristics of partial review studies of drivers and barriers of reverse logistics.

| Drivers and Barriers of Reverse Logistics Activities |  | Authors  |
|--|--|--|
| 1  | Lack of awareness  | (Rogers, 1998), (Anil, 2009), (Hagos, 2016), (Magdalena, 2011)             |
| 2  | Lack of accurate forecasting and planning                        | (Joseph et al., 2004), (Basheer M. et al., 2016),                          |
| 3  | Financial and burden tax barriers and Marketing drivers          | (Mehmet et al., 2018), (Vikram, 2004), (Micheal, 2011), (Muthusamy, 2014)  |
| 4  | Lack of sufficient information & technology system               | (Rogers, 1998), (Muthusamy, 2014), (Henry et al., 2010)                    |
| 5  | Economic barriers and drivers                                    | (Magdalena, 2011), (Xiaw et al., 2011)                                     |
| 6  | Company policy barriers and Governmental,                        | (Badenshorts, 2013), (Vlachos, 2004)                                       |
| 7  | legal and Political issue drivers                                | (Badenshorts, 2013), (Vlachos, 2004), (Kelly, 2011)                        |
| 8  | Social responsibility & corporate citizenship drivers            | (Rama et al., 2016), (Surendra et al., 2013), (Dhananjaya, 2011)           |
| 9  | Lack of Personnel resource & training                            | (Sharma. et. al, 2011), (Vlachos, 2004)                                    |
| 10   | Lack of Competitive issue and Competitive drivers                | (Meyer et al., 2017), (Wadie, 2012)  |
| 11   | Improper Operational performance management system               | (Benita, 1998), (Dhananjaya, 2011), (Benaissa et al., 2011)                |
| 12   | Lack of collection facilities and Facility drivers               | (Micheal, 2011), (Anil, 2009), (Shigeki., 2013), (Nizar et al., 2014),     |
| 13   | Lack of product quality issues                                   | (Bahaa et al., 2012), (Zhiyong et al., 2007)                               |
| 14   | Lack of co-operative partner integration                         | (Badenshorts, 2013), (Meysam et al., 2014),                                |
| 15   | Lack of Management inattention                                   | , (Sharma. et. al, 2011), (Badenshorts, 2013)                              |
| 16   | Lack of functional integration                                   | (Alok et al., 2015), (Ehsan, 2015), , (Hatem, 2007), (Nazma et al., 2016)  |
| 17   | Lack of Importance of reverse logistics relative to other issues | (Jodejko, 2012), (Magdalena, 2011), (Sharma. et. al, 2011), (Sergio, 2014) |
| 18   | Inventory control drivers  | (Benaissa et al., 2011) (Vikram, 2004), (Rogers, 1998)                     |
| 19   | Transportation drivers   | (Micheal, 2011), (Rogers, 1998), (Yungyu, 2005)                            |
| 20   | Asset protection drivers   | (Badenshorts, 2013), (Muthusamy, 2014)                                     |
| 21   | Environmental regulation drivers                                 | (Badenshorts, 2013), (Rama et al., 2016), (Sabina, 2012)                   |
| 22   | sourcing and pricing drivers                                     | (Muthusamy, 2014), (Mehmet et al., 2018), (Wadie, 2012)                    |
| 23   | Legislation and commercial motivations drivers                   | (Badenshorts, 2013), (Kelly, 2011), (Micheal, 2011)                        |
| 24   | Promotion related issues   | (Meyer et al., 2017), (Sharma. et. al, 2011), (Vlachos, 2004)              |

#### 4.4 Analyzing Barriers of Reverse Logistics Activities

The reverse logistics of Raya Brewery Share Company is affected by different internal and external barriers. In this study the main examined internal barriers of reverse logistics that affect the company are lack of functional integration, lack of top management’s intention on reverse logistics, financial barriers, inadequate personal resources, poor information linking systems and operational barriers. Additionally, the main external barriers that influence the company are lack of collection centers, government support, Legal and Political issues, lack of Competitive issue and poor forecasting system.

#### 4.4.1 Analyzing the Internal Barriers

The internal barriers of reverse logistics have an impact within the company that affects the performance of reverse logistic practices internally. As 70.60 % of the respondent agrees that's, the Top managements posture on reverse logistics are not be committed in good manner to reverse logistics due to lack of awareness of the resulting benefits. A good Top management controlling system will help to ensure best decision views on reverse logistics to use the resource appropriately within effective performance. According (Meyer et al., 2017), most company practiced reverse logistics due to regulation of government or pressure and not for economic gain. For this case most of the managers will not thinking with their interest because of unprofitability issues.

The financial barriers also have an impact in the company that influences the long-term performance of facility location. According the respondents (70.59%), the financial management is one of the important determinant structures of reverse logistic system that can help to return the products of the empty bottles and steel kegs to their desired destination. It is important to improve the company internal accounting process to achieve its goal successfully because of the accounting problem drives the action of managers.

Lack of training and education is another internal barrier which affects the status of the reverse logistics process. As almost all the respondent agrees, the company has not a training and education chances to improve their knowledge and skills. According (Sharma. et. al, 2011), basically, giving training and education are the primary requirements to return successfully for any company. Addressing training and education can create awareness on the society. The company can create awareness by giving free training, helping the society in building infrastructures, promoting and initiating the collectors. According to 82.36% of the respondent, lack of functional integration affects the reverse logistics process due to poor communication and cooperation. In the integration process it is advisable to work collaboratively together to contribute and to ensure a continuous success of reverse logistics practice to achieve mutually acceptable outcomes (Rogers, 1998).

The other challenge that hinders the reverse logistics process to return the empty bottles and steel kegs is the operational barrier in terms of physical activities from the customers. The operational barrier also includes the lack of effective management of the returning process. This problem results in complexity and difficulty of accurate forecasting system. According the respondents of 76.48%, mostly the logistical information is not linked properly to returning the empty bottles and steel kegs. Insufficient of information system is one of challenging barrier that affects to achieve

the goal of reverse logistics process. Therefore, to control the empty bottles and steel kegs products the returning system needs a strategic planning using advanced information technology. Additionally, 82.36% of lack of forecasting affects the returning process. Returning the bottles and steel kegs are the most common aspects of reverse logistics however, its results uncertainty for the company due to unknown returning periods and unknown number of quantities to return.

The level of existence of the barriers is evaluated using a likers scale, (Very low = 0, Low = 1, Medium = 3, High = 5 and Very high = 7).

Table 8: Barriers of Reverse Logistics Activities

| Barriers of Reverse Logistics Activities  | Level of Existence (%) |       |        |       |           |
|---|------------------------|-------|--------|-------|-----------|
|   | Very low               | Low   | Medium | High  | Very high |
| Lack of awareness (B <sub>1</sub> )   | 11.76                  | 5.88  | 58.83  | 17.65 | 5.88      |
| Lack of accurate forecasting & planning (B <sub>2</sub> )                           | 5.88                   | 11.76 | 23.53  | 11.76 | 47.07     |
| Financial and burden tax barriers(B <sub>3</sub> )                                  | 11.76                  | 17.65 | 17.65  | 52.94 | 0         |
| Lack of sufficient information & technology system (B <sub>4</sub> )                | 11.76                  | 11.76 | 52.95  | 5.88  | 17.65     |
| Economic barriers(B <sub>5</sub> )  | 58.83                  | 5.88  | 23.53  | 5.88  | 5.88      |
| Company policy barriers (B <sub>6</sub> )   | 17.65                  | 0     | 5.88   | 70.59 | 5.88      |
| lack of government support, Legal and Political issues (B <sub>7</sub> )            | 5.88                   | 0     | 70.6   | 11.76 | 11.76     |
| Lack of Personnel resource & training (B <sub>8</sub> )                             | 0                      | 11.76 | 64.71  | 17.65 | 5.88      |
| Lack of Competitive issue (B <sub>9</sub> )   | 0                      | 52.95 | 11.76  | 35.29 | 0         |
| Improper performance management system (B <sub>10</sub> )                           | 5.88                   | 23.53 | 47.06  | 23.53 | 0         |
| Lack of collection facilities (B <sub>11</sub> )                                    | 0                      | 5.88  | 5.88   | 11.76 | 76.48     |
| Lack of product Quality issues (B <sub>12</sub> )                                   | 64.71                  | 0     | 23.53  | 5.88  | 5.88      |
| Lack of co-operative supply chain partner integration (B <sub>13</sub> )            | 0                      | 58.82 | 17.65  | 23.53 | 0         |
| Lack of Management inattention (B <sub>14</sub> )                                   | 11.76                  | 11.76 | 0      | 70.60 | 5.88      |
| Lack of functional integration (B <sub>15</sub> )                                   | 11.76                  | 5.88  | 41.18  | 41.18 | 0         |
| Lack of Importance of reverse logistics relative to other issues (B <sub>16</sub> ) | 0                      | 5.88  | 52.94  | 41.18 | 0         |

Table 9: Reliability Statistics Barriers of Reverse Logistics Activities

| Reliability Statistics |  |                 |
|------------------------|--|-----------------|
| Cronbach's Alpha       | Cronbach's Alpha Based on Standardized Items | Number of Items |
| 0.695                  | 0.769  | 16              |

According the Cronbach's alpha standard (Panayiotis, 2013); the result 0.769 shows that, Cronbach's Alpha Based on Standardized Items is in acceptable range to proceed with the study since it is greater than 0.70.

#### 4.4.2 Analyzing the External Barriers

The external barriers of reverse logistics are factors that affect the logistics process outside the company. In the study the most common external barriers that examined in the company are lack of collection centers, lack of government support, Legal and Political issues, Lack of Competitive

issue and poor forecasting system. According the respondents (94.12%), lack of collection facilities to collect the empty beer bottles and steel kegs affects the logistics process of Raya Brewery. This can be minimized by developing a return center to handle product returns quickly and efficiently. As high volume of empty beer of bottles and kegs is collected in return center of the facility the way to ship to the next destination will be easy. This return system can be achieved mostly when retailers return the products to one or more return centers. The return centers help to reduce time delays in disposition and to speed up the processing time of the remaining products. According the interviews collected, centralized return center is the preferable for management strategy of reverse logistics system due to a positive impact on the bottom line but still it have its own drawback.

According to 93.12% of the respondents the government policy affects the Raya Brewery Share Company. To achieve the goal of the company government policy and financial support have great role in reverse logistics system. This can be achieved by giving free land for purpose of collection center. The other external barrier that affects the reverse logistics is transportation. The company expenses high transport cost (90,071,206 birr per year) due to lack of proper collection center, as result they search the empty beer bottles and steel kegs door to door which is time consuming and costly.

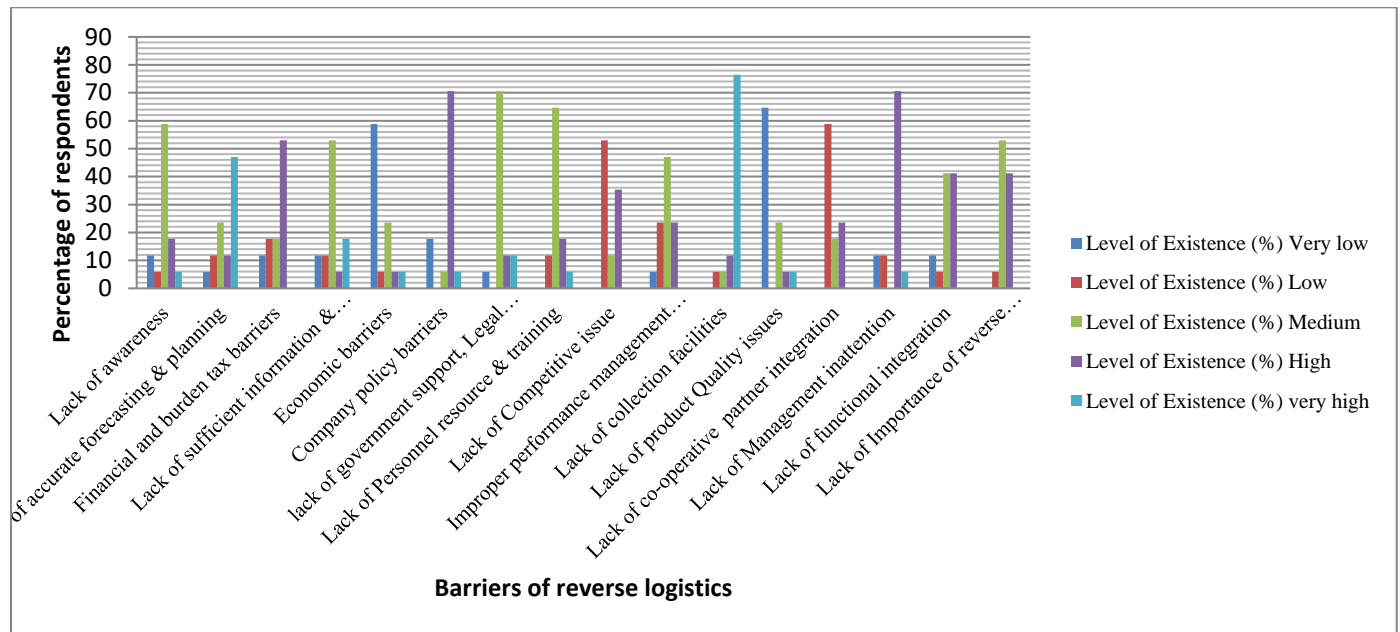


Figure13: Barriers of reverse logistics

Total score weight of each of the barriers that rated by the respondents can be calculated by adding each score with its coefficient of degree of existence. The total score is calculated as:

$$TSB_n = (0*VL) + (1*L) + (3*M) + (5*H) + (7*VH)$$

Then the total score for B<sub>1</sub> can be calculated as:

$$TSB_1 = (0*2) + (1*1) + (3*10) + (5*3) + (7*1) = 53$$

$$\text{For } TSB_2 = (0*1) + (1*2) + (3*4) + (5*2) + (7*8) = 80$$

Using the same procedure, the total score of each barrier is calculated using Microsoft excel as shown in the below table. The percentage of level of existence of the barriers (PB<sub>n</sub>) also can be calculated using:

$$PB_n = \left(\frac{TSB_n}{907} \times 100\right) \%$$

$$\text{Then for } B_1, PB_1 = \left(\frac{TSB_1}{907} \times 100\right) \% = \left(\frac{53}{907} \times 100\right) \% = 5.84\%$$

$$\text{For } B_2, PB_2 = \left(\frac{TSB_2}{907} \times 100\right) \% = \left(\frac{80}{907} \times 100\right) \% = 8.82\%$$

Then using the same procedure percentage of level existence of the barriers is calculated as shown in the below table using Microsoft excel. Therefore, the rank of the barriers can be determined either based on the total score or percentage of the existence using descending order.

Table 10: Percentage and total score of Barriers of Reverse Logistics

| Barriers of Reverse Logistics Activities (B <sub>n</sub> ) | Scores of Number of respondents |         |            |          |                |     | Total score | Percentage of weight score | Rank |
|--|---------------------------------|---------|------------|----------|----------------|-----|-------------|----------------------------|------|
|  | Very low (VL)                   | Low (L) | Medium (M) | High (H) | Very high (VH) |     |             |                            |      |
| B <sub>1</sub>   | 2                               | 1       | 10         | 3        | 1              | 53  | 5.84        | 11                         |      |
| B <sub>2</sub>   | 1                               | 2       | 4          | 2        | 8              | 80  | 8.82        | 2                          |      |
| B <sub>3</sub>   | 2                               | 3       | 3          | 9        | 0              | 57  | 6.28        | 7                          |      |
| B <sub>4</sub>   | 2                               | 2       | 9          | 1        | 3              | 55  | 6.06        | 10                         |      |
| B <sub>5</sub>   | 10                              | 1       | 4          | 1        | 1              | 25  | 2.76        | 15                         |      |
| B <sub>6</sub>   | 3                               | 0       | 1          | 12       | 1              | 70  | 7.72        | 3                          |      |
| B <sub>7</sub>   | 1                               | 0       | 12         | 2        | 2              | 60  | 6.62        | 6                          |      |
| B <sub>8</sub>   | 0                               | 2       | 11         | 3        | 1              | 57  | 6.28        | 7                          |      |
| B <sub>9</sub>   | 0                               | 9       | 2          | 6        | 0              | 45  | 4.96        | 13                         |      |
| B <sub>10</sub>  | 1                               | 4       | 8          | 4        | 0              | 48  | 5.29        | 12                         |      |
| B <sub>11</sub>  | 0                               | 1       | 1          | 2        | 13             | 105 | 11.58       | 1                          |      |
| B <sub>12</sub>  | 11                              | 0       | 4          | 1        | 1              | 24  | 2.65        | 16                         |      |
| B <sub>13</sub>  | 0                               | 10      | 3          | 4        | 0              | 39  | 4.30        | 14                         |      |
| B <sub>14</sub>  | 2                               | 2       | 0          | 12       | 1              | 69  | 7.61        | 4                          |      |
| B <sub>15</sub>  | 2                               | 1       | 7          | 7        | 0              | 57  | 6.28        | 7                          |      |
| B <sub>16</sub>  | 0                               | 1       | 9          | 7        | 0              | 63  | 6.95        | 5                          |      |

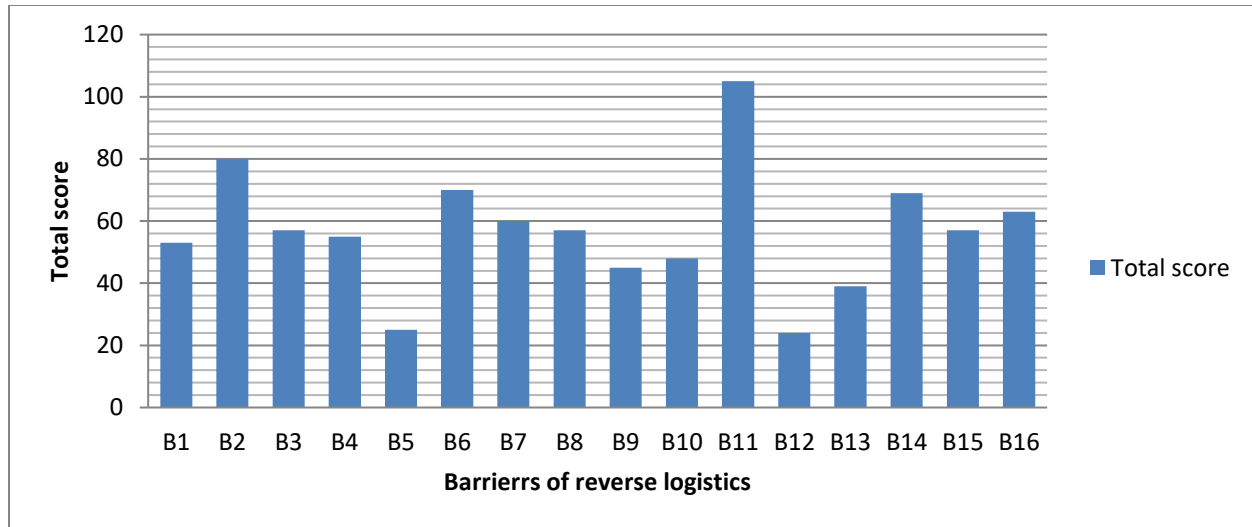


Figure 14: Graphical representation of barriers of reverse logistics

The relationship between the barriers of the reverse logistics variables is determined using the SPSS software tool. From the SPSS result the correlation analysis shows the relationship of the variables as shown in table 11, the variable B1 has a positive PC value with respect to variables of B1, B2, B3, B4, B5, B7, B8, B10, B12, B15 and B16. On the other hand, B1 variable has a negative PC value to the variables of B9, B11, B13 and B14. The positive correlation coefficient value of variable B1 to the other variable tells us, B1 has a strong relationship to each of the other variables. Whereas the negative correlation coefficient value of variable B1 to the other variables indicates that, B1 has less relationship between the variables. All the barrier variables have a perfect positive linear relationship with itself on the main diagonal with a correlation coefficient of value of 1. On the other hand, the significant value (2-tailed) of variable B1 less than 0.05 shows that the correlation is significant and the two variables are linearly related, however variables that have a correlation significant value of greater than 0.05 shows that the variables are non-linearly related. Generally, the impact or the relationship of the barriers of reverse logistics to the other variables is shown in table 11.

Where, PC = Pearson Correlation

S = significant Correlation (2-tailed)

Table 11: Correlation of the barriers of reverse logistics

| Barriers |    | B1     | B2    | B3    | B4     | B5    | B6    | B7     | B8    | B9    | B10    | B11   | B12    | B13     | B14   | B15   | B16    |
|----------|----|--------|-------|-------|--------|-------|-------|--------|-------|-------|--------|-------|--------|---------|-------|-------|--------|
| B1       | PC | 1      | .994  | .122  | .910   | .976  | -.064 | .978   | .962  | -.180 | .849   | -.340 | .120   | -.093   | -.200 | .751  | .838   |
|          | S  |        | .005  | .845  | .032   | .005  | .918  | .004   | .009  | .772  | .069   | .576  | .847   | .881    | .747  | .143  | .077   |
| B2       | PC | .994   | 1     | -.527 | .285   | .120  | -.341 | .205   | .113  | -.446 | -.252  | .929  | -.413  | -.389   | -.363 | -.314 | -.121  |
|          | S  | .005   |       | .361  | .643   | .847  | .574  | .740   | .857  | .452  | .683   | .022  | .489   | .518    | .548  | .607  | .846   |
| B3       | PC | .122   | -.527 | 1     | -.273  | -.066 | .893  | -.027  | .044  | .546  | .385   | -.464 | -.244  | .312    | .918  | .735  | .612   |
|          | S  | .845   | .361  |       | .656   | .915  | .041  | .965   | .944  | .341  | .522   | .431  | .692   | .609    | .028  | .157  | .273   |
| B4       | PC | .910*  | .285  | -.273 | 1*     | .975  | -.439 | .961*  | .941  | -.310 | .702*  | -.083 | .073   | -.129*  | -.556 | .422  | .586*  |
|          | S  | .032   | .643  | .656  |        | .005  | .459  | .009   | .017  | .612  | .187   | .894  | .908   | .836    | .331  | .479  | .299   |
| B5       | PC | .976** | .120  | -.066 | .975** | 1     | -.272 | .985** | .982  | -.197 | .821** | -.248 | .074   | -.054** | -.390 | .599  | .732** |
|          | S  | .005   | .847  | .915  | .005   |       | .658  | .002   | .003  | .751  | .088   | .688  | .905   | .931    | .517  | .286  | .160   |
| B6       | PC | -.064  | -.341 | .893* | -.439  | -.272 | 1*    | -.175  | -.210 | .207* | .019   | -.186 | -.088* | -.084   | .969  | .591* | .417   |
|          | S  | .918   | .574  | .041  | .459   | .658  |       | .779   | .734  | .739  | .975   | .765  | .888   | .893    | .007  | .294  | .484   |
| B7       | PC | .978** | .205  | -.027 | .961** | .985  | -.175 | 1**    | .965  | -.281 | .773** | -.150 | .059   | -.172** | -.313 | .643  | .769** |
|          | S  | .004   | .740  | .965  | .009   | .002  | .779  |        | .008  | .647  | .126   | .810  | .925   | .782    | .608  | .242  | .129   |
| B8       | PC | .962** | .113  | .044  | .941** | .982  | -.210 | .965** | 1     | -.034 | .892** | -.254 | -.092  | .091**  | -.293 | .647  | .798** |
|          | S  | .009   | .857  | .944  | .017   | .003  | .734  | .008   |       | .956  | .042   | .680  | .882   | .885    | .632  | .238  | .106   |
| B9       | PC | -.180  | -.446 | .546  | -.310  | -.197 | .207  | -.281  | -.034 | 1     | .366   | -.404 | -.611  | .954    | .415  | .135  | .164   |
|          | S  | .772   | .452  | .341  | .612   | .751  | .739  | .647   | .956  |       | .545   | .500  | .273   | .012    | .487  | .829  | .792   |
| B10      | PC | .849   | -.252 | .385  | .702   | .821  | .019  | .773   | .892  | .366  | 1      | -.558 | -.191  | .433    | .003  | .765  | .862   |
|          | S  | .069   | .683  | .522  | .187   | .088  | .975  | .126   | .042  | .545  |        | .329  | .758   | .467    | .996  | .132  | .060   |
| B11      | PC | -.340  | .929  | -.464 | -.083  | -.248 | -.186 | -.150  | -.254 | -.404 | -.558  | 1     | -.398  | -.415   | -.178 | -.492 | -.365  |
|          | S  | .576   | .022  | .431  | .894   | .688  | .765  | .810   | .680  | .500  | .329   |       | .507   | .488    | .775  | .400  | .546   |
| B12      | PC | .120   | -.413 | -.244 | .073   | .074  | -.088 | .059   | -.092 | -.611 | -.191  | -.398 | 1      | -.566   | -.259 | -.013 | -.192  |
|          | S  | .847   | .489  | .692  | .908   | .905  | .888  | .925   | .882  | .273  | .758   | .507  |        | .320    | .674  | .983  | .757   |
| B13      | PC | -.093  | -.389 | .312  | -.129  | -.054 | -.084 | -.172  | .091  | .954  | .433   | -.415 | -.566  | 1       | .128  | .022  | .103   |
|          | S  | .881   | .518  | .609  | .836   | .931  | .893  | .782   | .885  | .012  | .467   | .488  | .320   |         | .838  | .972  | .869   |
| B14      | PC | -.200  | -.363 | .918  | -.556  | -.390 | .969  | -.313  | -.293 | .415  | .003   | -.178 | -.259  | .128    | 1     | .491  | .338   |
|          | S  | .747   | .548  | .028  | .331   | .517  | .007  | .608   | .632  | .487  | .996   | .775  | .674   | .838    |       | .401  | .578   |
| B15      | PC | .751   | -.314 | .735  | .422   | .599  | .591  | .643   | .647  | .135  | .765   | -.492 | -.013  | .022    | .491  | 1     | .960   |
|          | S  | .143   | .607  | .157  | .479   | .286  | .294  | .242   | .238  | .829  | .132   | .400  | .983   | .972    | .401  |       | .010   |
| B16      | PC | .838   | -.121 | .612  | .586   | .732  | .417  | .769   | .798  | .164  | .862   | -.365 | -.192  | .103    | .338  | .960  | 1      |
|          | S  | .077   | .846  | .273  | .299   | .160  | .484  | .129   | .106  | .792  | .060   | .546  | .757   | .869    | .578  | .010  |        |

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\* . Correlation is significant at the 0.01 level (2-tailed).

A schematic representation of SPSS neural network is used to reduce and to predict the complexity of the variables of reverse logistic. The result of SPSS neural network multilayer perceptron shows that an analysis of the variables of the input layer/predictor (B1, B3, B6, B7, B9, B11, B12, B15 and B16), the hidden layer H (unobservable node) and output layer/responses (B2, B4, B5, B8, B13 and B14) by comparing using synaptic weight to minimize errors of the target value. As shown in figure 13, the positive synaptic weight (synaptic weight > 0) shows a high strength of relationship interneuron connection but the negative synaptic weight (synaptic weight < 0) indicates a non-linear relationship interneuron connection between the variables.

From table 11 we can conclude that lack of collection facility (B11) have statistically significant strong correlation relationship (PC=0.929, S= 0.022) with lack of accurate forecasting and planning. This indicates that lack collection center affects the accuracy of forecasting and planning of the empty bottles and steel kegs. Lack of awareness (B1) also have statistically significant strong

correlation relationship ( $PC=0.994$ ,  $S= 0.005$ ) with lack accuracy of forecasting and planning of (B2). Similarly, the statistically significant strong relationship among the other barriers is shade in whit color as shown in table 11.

From the factor analysis result of table 11 and figure 13, the barrier of lack of awareness (B1) also affects the information flow from the end user to the company, the political issue, performance management, the management intention, functional integration and importance reverse logistic to other relative issue. This lack of awareness affects the company functional integration because of poor communication and cooperation. Therefore, working cooperatively within the society can ensure acceptable outcomes and reverse logistics practice of returning the empty and steel kegs can achieved successfully.

The inaccurate forecasting and planning are resulted due to lack of creating awareness, poor information flow, political issues and lack of collection centers. Politically considering the beer as one region resource and criticizing it, results in forecasting of complexity. In order to return the empty bottles and kegs developing a proper collection center is can minimize the inaccuracy of forecasting. The customers can search a nearest center to submit the bottles and kegs and by registering their orders. To pick up the empty bottles and kegs the returner center should inform the company before they deliver to the center. This can make the company to handle easily in returning process to avoids delays and unexpected transportation expenses.

The other barrier that affect the reverse logistics process of Raya Brewery is lack of information how much empty beer bottles and steel kegs to be return. It is better to connect the company and the customers using phone, email, fax and free SMS service in order to have a smooth returning process.

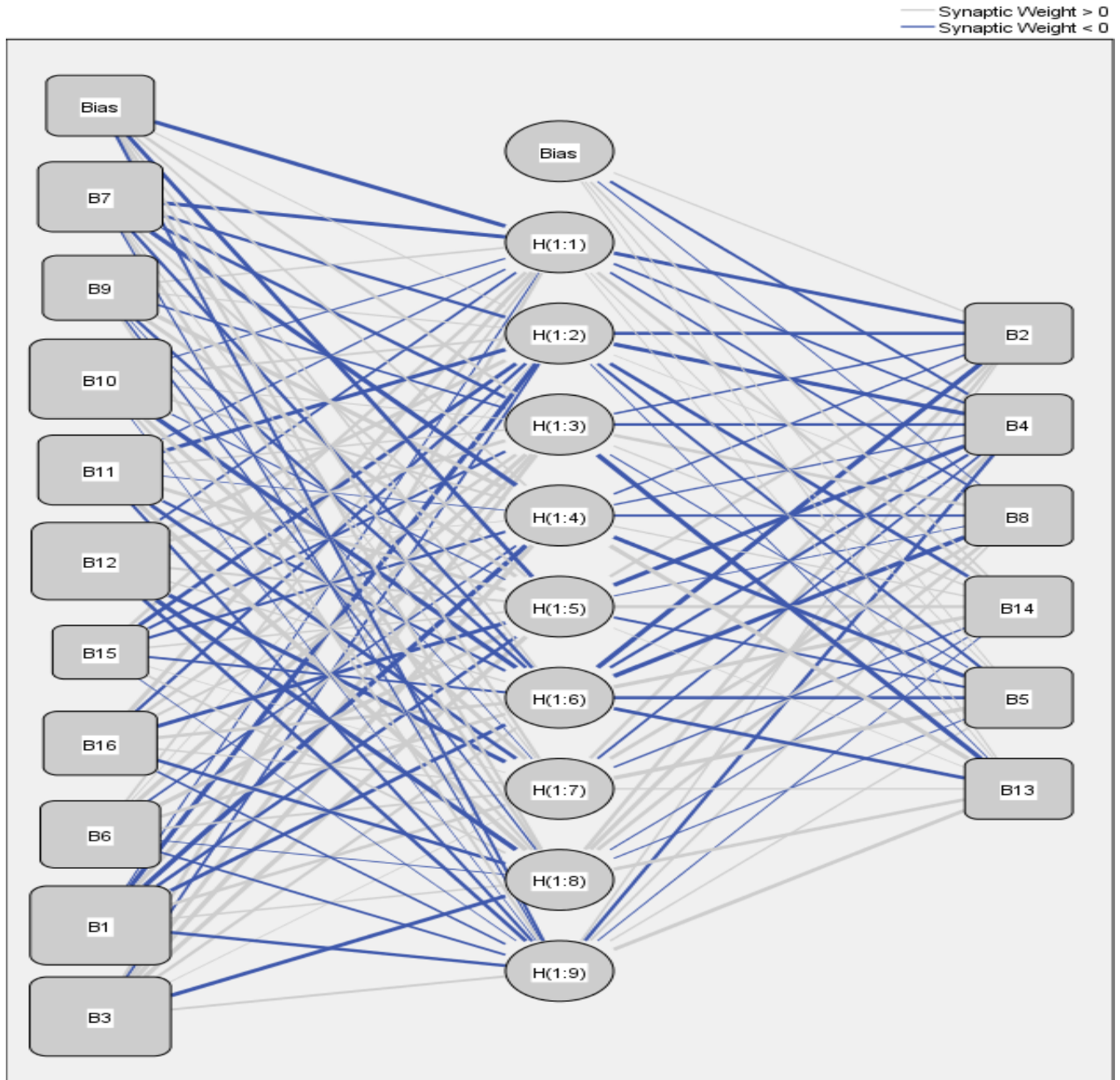


Figure 15: Barriers of reverse logistics Multi-layer perceptron network structure.

The neural network result shown in table 12, indicates a parameter estimation of both input and the output layer with respect to their biases. This parameter estimation tells us the relationship between the barrier variables of reverse logistic factors and the response from the input layer and hidden layer.

Table 12: Barriers Parameter Estimates

| Predictor      |        | Parameter Estimates |        |        |        |        |        |        |        |        |              |       |       |       |       |
|----------------|--------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------------|-------|-------|-------|-------|
|                |        | Predicted           |        |        |        |        |        |        |        |        |              |       |       |       |       |
|                |        | Hidden Layer 1      |        |        |        |        |        |        |        |        | Output layer |       |       |       |       |
|                |        | H(1:1)              | H(1:2) | H(1:3) | H(1:4) | H(1:5) | H(1:6) | H(1:7) | H(1:8) | H(1:9) | B2           | B4    | B8    | B14   | B5    |
| Input Layer    | (Bias) | -.495               | .031   | .287   | .167   | -.403  | .151   | .264   | .287   | -.248  |              |       |       |       |       |
|                | B7     | -.446               | -.339  | -.352  | -.545  | .226   | -.320  | .065   | .328   | -.103  |              |       |       |       |       |
|                | B9     | .155                | .078   | -.203  | .516   | .395   | -.313  | -.016  | -.133  | .220   |              |       |       |       |       |
|                | B10    | -.097               | .229   | .051   | .235   | -.094  | -.556  | .428   | .261   | -.004  |              |       |       |       |       |
|                | B11    | -.121               | -.467  | .145   | -.016  | .440   | -.276  | -.388  | .626   | -.280  |              |       |       |       |       |
|                | B12    | -.220               | .417   | .376   | .019   | .251   | .112   | -.464  | -.613  | -.361  |              |       |       |       |       |
|                | B15    | .331                | -.409  | -.266  | -.318  | .152   | -.241  | .004   | .177   | -.011  |              |       |       |       |       |
|                | B16    | .417                | -.318  | .338   | .250   | -.442  | .377   | .120   | -.366  | -.174  |              |       |       |       |       |
|                | B6     | .186                | .019   | .448   | -.159  | .470   | .368   | .227   | -.023  | -.213  |              |       |       |       |       |
|                | B1     | -.103               | -.505  | .406   | -.652  | -.342  | -.406  | .350   | .147   | -.349  |              |       |       |       |       |
| B3             | .337   | -.205               | .413   | .528   | .479   | .312   | .015   | -.434  | .233   |        |              |       |       |       |       |
| Hidden Layer 1 | (Bias) |                     |        |        |        |        |        |        |        |        | .067         | -.254 | -.027 | .159  | .042  |
|                | H(1:1) |                     |        |        |        |        |        |        |        |        | -.420        | -.215 | -.184 | .335  | .032  |
|                | H(1:2) |                     |        |        |        |        |        |        |        |        | -.396        | -.521 | .009  | -.370 | -.268 |
|                | H(1:3) |                     |        |        |        |        |        |        |        |        | -.161        | -.292 | .355  | .105  | -.060 |
|                | H(1:4) |                     |        |        |        |        |        |        |        |        | -.144        | -.108 | -.247 | .101  | -.469 |
|                | H(1:5) |                     |        |        |        |        |        |        |        |        | .320         | -.573 | -.031 | .340  | -.245 |
|                | H(1:6) |                     |        |        |        |        |        |        |        |        | -.609        | -.319 | -.636 | .453  | -.365 |
|                | H(1:7) |                     |        |        |        |        |        |        |        |        | .344         | -.205 | .389  | -.134 | .556  |
|                | H(1:8) |                     |        |        |        |        |        |        |        |        | .354         | .443  | .369  | -.065 | -.042 |
| H(1:9)         |        |                     |        |        |        |        |        |        |        | .148   | -.334        | .173  | -.038 | .103  |       |

A sensitive analysis of importance of each of predictor is addressed using the SPSS neural network multi-layer perceptron. The predicted model network value is varied for different values of the independent variables by measuring using the normalized importance as shown in figure 16. The Independent variable importance sensitive analysis has shown in figure 16, shows that the importance of each predictor determines the neural network of each variable. The result neural network multi-perceptron tells us Lack of collection facilities (100.0%), Company policy barriers (89.5%), Financial and burden tax barriers (77.7%), Improper performance management system (69.2%), Lack of Importance of reverse logistics relative to other issues (56.8%) and Lack of Competitive issue (55.2%) are the main predictors of reverse logistics relative to other issues.

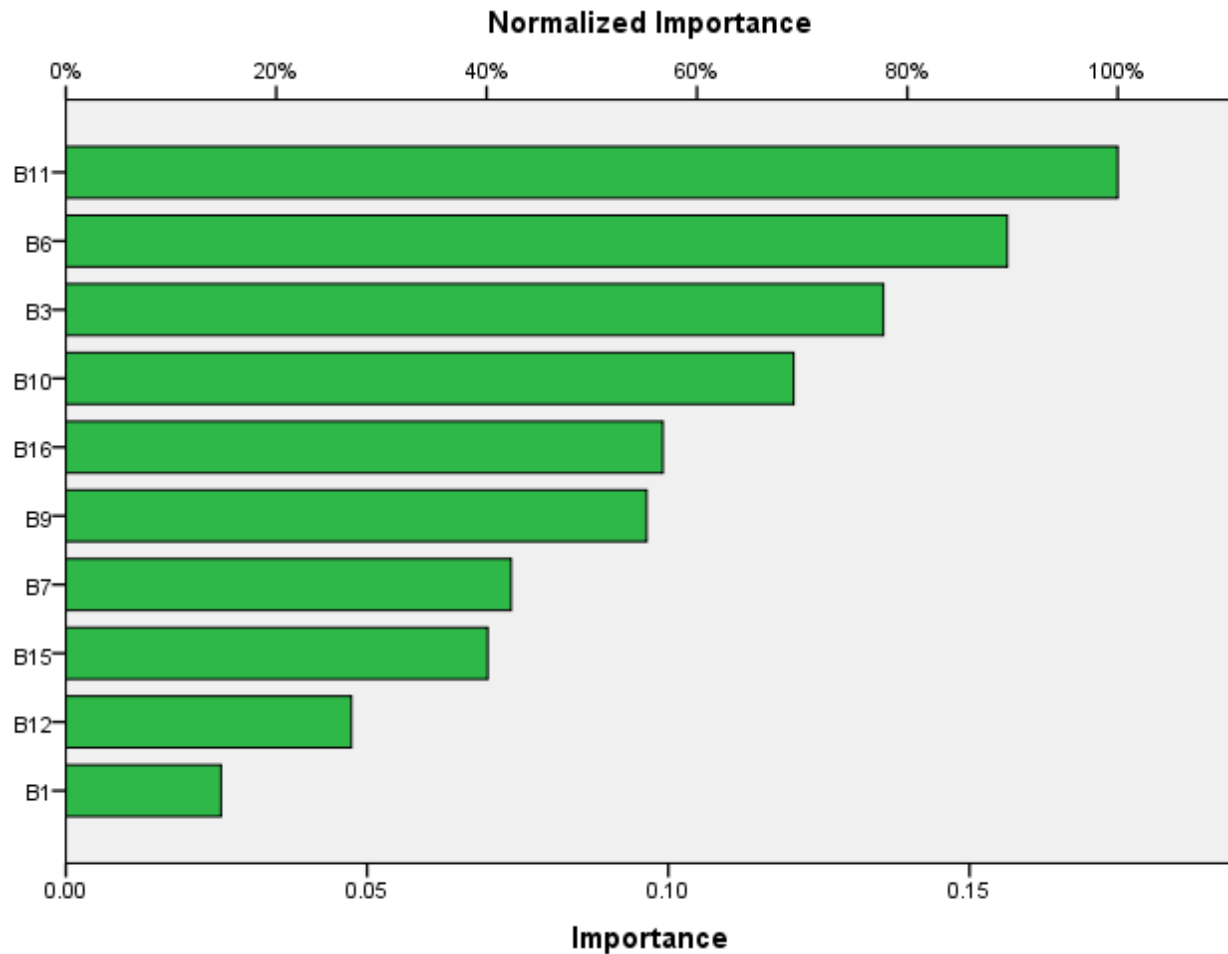


Figure 16: Barriers of reverse logistics importance chart

## 4.5 Analyzing Drivers of Reverse Logistics Activities

### 4.5.1 Analyzing Internal Drivers

The reverse logistics drivers can be categorized as internal or external drivers. The drivers of reverse logistics (internal driver) are factors that motivate the company to have a reverse logistics system by upgrading the profit using cost saving methods. The internal driver of reverse logistics includes the transportation, economic and operational performance drivers (Bahaa et al., 2012). According the 93.12% of the respondents the economic drivers enforces the company to overcome the challenges in the reverse process. The economic drivers can help to save for unwanted expenses and revenues opportunities by incorporating a practice of reverse logistics. Returning the empty bottles and steel kegs helps to the company to enhance and reduces cost related to the reverse logistic by addressing the economic derivers to create a cost saving in the reverse logistics process.

An effective management of reverse logistics system can help to reduce the transportation cost and minimizes cost. Based on the 94.12% of the respondent’s transportation affects the logistics activities of the company due to lack of collection centers. Because of that the company expenses a high transportation cost more than 90 million birr per year. Therefore, developing a proper collection center can help to solve the transportation problem in order to maximizing the customer service and to minimize the total transportation cost.

**4.5.2 Analyzing External Drivers**

Most of time the external driver deals on, drivers that resulted from out of the company to enable the company to enhance the customer value perception (Micheal, 2011). The most common external drivers are legal, environmental, competitiveness, social responsibility and corporate, government support and policy. According to 94.12% of the respondents the government support and legal driver enforces the producer’s for handling environmental safety. The environmental driver is also one of the key strategic issues that can be used to examine the potential of the company. According the respondents, the environmental driver drives the company to use the environmental regulation process to use the resources sustainably. On the other hand, the social responsibility and corporate citizenship and legal drivers directly enforce the company to have a sustainable image to increase the customer loyalty. According the respondent the government policy doesn’t support the company to have a temporary free place as center of returning or distributing center. Therefore, the government support and policy have a great role when it motivates and supports the company to return the empty bottles and kegs with high degree.

According the 94.12% of respondents are agreed the competitive driver pushes the reverse logistics of Raya Brewery Share Company to satisfy the customer using low price. Reducing inventory level using product return system which reduces the inventory level using product returning system reduces the inventory carrying cost will allows the company to be competitive.

Table 13: Percentage score of drivers of reverse logistics

| Drivers of Reverse Logistics Activities                                  | Respondents (%) |      |        |       |           |
|--|-----------------|------|--------|-------|-----------|
|  | Very low        | Low  | Medium | High  | Very high |
| Economic drivers ( <b>D<sub>1</sub></b> )                                | 0               | 5.88 | 23.53  | 41.18 | 29.41     |
| Competitive drivers ( <b>D<sub>2</sub></b> )                             | 0               | 5.88 | 29.41  | 11.76 | 52.95     |
| Operational performance drivers ( <b>D<sub>3</sub></b> )                 | 0               | 0    | 35.29  | 23.53 | 41.18     |
| Governmental, legal and Political issue drivers ( <b>D<sub>4</sub></b> ) | 0               | 5.88 | 23.53  | 52.94 | 17.65     |

|  |      |      |       |       |       |
|--|------|------|-------|-------|-------|
| Social responsibility & corporate citizenship drivers ( <b>D<sub>5</sub></b> ) | 0    | 0    | 23.53 | 58.82 | 17.65 |
| Marketing drivers ( <b>D<sub>6</sub></b> )                                     | 5.88 | 0    | 17.65 | 58.82 | 23.53 |
| Collection Facility drivers ( <b>D<sub>7</sub></b> )                           | 0    | 0    | 17.65 | 35.29 | 47.07 |
| Inventory control drivers ( <b>D<sub>8</sub></b> )                             | 5.88 | 0    | 11.76 | 52.94 | 29.42 |
| Transportation drivers ( <b>D<sub>9</sub></b> )                                | 0    | 5.88 | 11.76 | 35.29 | 47.06 |
| Asset protection drivers ( <b>D<sub>10</sub></b> )                             | 0    | 0    | 11.65 | 64.82 | 17.65 |
| Environmental regulation drivers ( <b>D<sub>11</sub></b> )                     | 0    | 0    | 17.65 | 47.06 | 35.29 |
| Information, sourcing and pricing drivers ( <b>D<sub>12</sub></b> )            | 0    | 5.88 | 23.53 | 58.82 | 11.77 |
| Legislation and commercial motivations drivers ( <b>D<sub>13</sub></b> )       | 0    | 5.88 | 23.53 | 52.94 | 17.65 |
| Promotion related issues (D14)   | 0    | 5.88 | 11.76 | 35.29 | 47.06 |

Table 14: Reliability Statistics of reverse logistic drivers

| Reliability Statistics |  |              |
|------------------------|--|--------------|
| Cronbach's Alpha       | Cronbach's Alpha Based on Standardized Items | No. of Items |
| 0.975                  | 0.976  | 14           |

According to the Alpha standard (Panayiotis, 2013), this result 0.976 shows that, Cronbach's Alpha Based on Standardized Items is in acceptable range to proceed with the study since it is greater than 0.70.

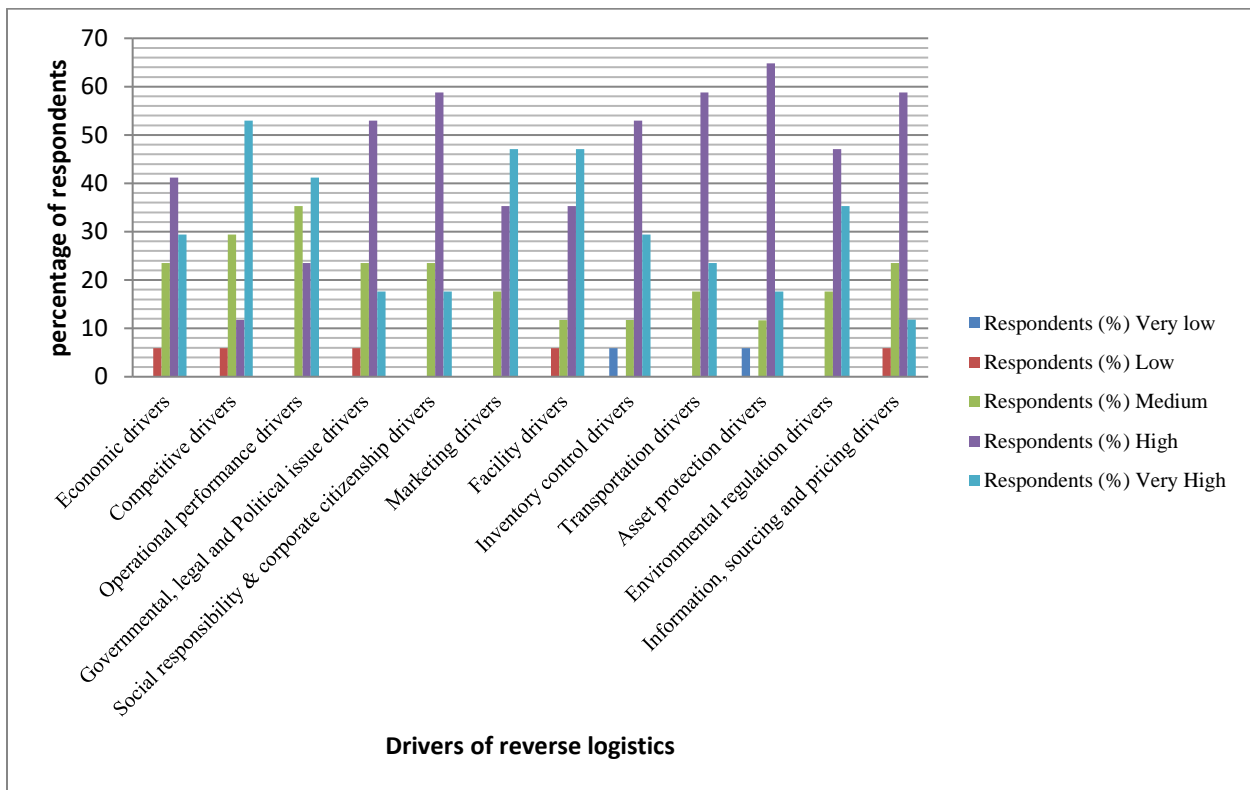


Figure 17: Percentage of drivers of reverse logistics

The total score of each of the reverse logistic drivers ( $TSD_n$ ) is calculated as:

$$TSD_n = (0*VL) + (1*L) + (3*M) + (5*H) + (7*VH)$$

Then the total score for  $D_1$  can be calculated as:

$$TSD_1 = (0*0) + (1*1) + (3*4) + (5*7) + (7*5) = 83$$

$$\text{For } TSD_2 = (0*0) + (1*1) + (3*5) + (5*2) + (7*9) = 89$$

Using the same procedure, the total score of each driver is calculated using Microsoft excel as shown in the below table. The percentage of degree of important ( $PD_n$ ) also can be calculated using:

$$PD_n = \left( \frac{TSD_n}{1203} \times 100 \right) \%$$

$$\text{Then for } D_1, PD_1 = \left( \frac{TSD_1}{1203} \times 100 \right) \% = \left( \frac{83}{1203} \times 100 \right) \% = 6.90\%$$

$$\text{For } D_2, PD_2 = \left( \frac{TSD_2}{1203} \times 100 \right) \% = \left( \frac{89}{1203} \times 100 \right) \% = 7.40\%$$

Then using the same procedure percentage of degree of importance of the reverse logistics drivers is calculated as shown in the below table using Microsoft excel. Therefore, the rank of the drivers of reverse logistics can be determined either based on the total score or percentage of the existence using descending order. The level of degree of important of the drivers scaled using liker scale, (Very low = 0, Low = 1, Medium = 3, High = 5 and Very high = 7).

Table 15: Recorded average score of reverse logistics drivers

| Drivers of Reverse Logistics Activities ( $D_n$ ) | Number of Respondents |     |        |      |           |             |                            |      |
|---|-----------------------|-----|--------|------|-----------|-------------|----------------------------|------|
|   | Very low              | Low | Medium | High | Very high | Total score | Percentage of weight score | Rank |
| <b>D<sub>1</sub></b>                              | 0                     | 1   | 4      | 7    | 5         | 83          | 6.90                       | 9    |
| <b>D<sub>2</sub></b>                              | 0                     | 1   | 5      | 2    | 9         | 89          | 7.40                       | 5    |
| <b>D<sub>3</sub></b>                              | 0                     | 0   | 6      | 4    | 7         | 87          | 7.23                       | 6    |
| <b>D<sub>4</sub></b>                              | 0                     | 1   | 4      | 9    | 3         | 79          | 6.57                       | 12   |
| <b>D<sub>5</sub></b>                              | 0                     | 0   | 4      | 10   | 3         | 83          | 6.90                       | 9    |
| <b>D<sub>6</sub></b>                              | 0                     | 0   | 3      | 0    | 4         | 87          | 7.23                       | 6    |
| <b>D<sub>7</sub></b>                              | 0                     |     | 3      | 6    | 8         | 95          | 7.90                       | 1    |
| <b>D<sub>8</sub></b>                              | 1                     | 0   | 2      | 9    | 5         | 86          | 7.15                       | 8    |
| <b>D<sub>9</sub></b>                              | 0                     | 1   | 2      | 6    | 8         | 93          | 7.73                       | 2    |
| <b>D<sub>10</sub></b>                             | 1                     | 0   | 2      | 11   | 3         | 82          | 6.82                       | 11   |
| <b>D<sub>11</sub></b>                             | 0                     | 0   | 3      | 8    | 6         | 91          | 7.56                       | 4    |
| <b>D<sub>12</sub></b>                             | 0                     | 1   | 4      | 10   | 2         | 77          | 6.40                       | 14   |
| <b>D<sub>13</sub></b>                             | 0                     | 1   | 4      | 9    | 3         | 79          | 6.57                       | 12   |
| <b>D<sub>14</sub></b>                             | 1                     | 0   | 2      | 6    | 8         | 92          | 7.65                       | 3    |

From table 15 and figure 16, we can conclude that the drivers of collection facility, transportation, competitive, promotion related issues and environmental regulation are the main factors that affect the reverse logistics of Raya Brewery.

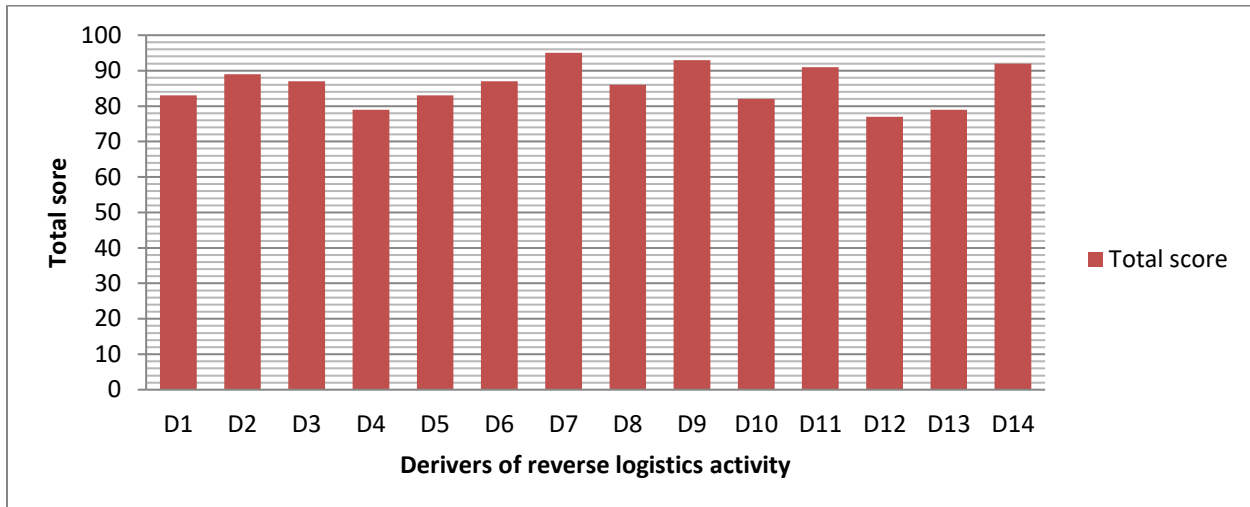


Figure 18: Comparison average of reverse logistics drivers

From the SPSS result the correlation analysis the relationship of the driver variable D1 has a positive PC value with respect to all driver variables. The positive correlation coefficient value of variable D1 to the other variable tells us, D1 have a strong relationship to each of the of the variable. All The driver variables as shown in table 16 have a perfect positive linear relationship with itself on the main diagonal with correlation coefficient of value of 1. From the result, significant value (2- tailed) of variable D1 less than 0.05 value indicates that the correlation is highly strong and the two variables are linearly related, but correlation significant value of greater than 0.05 indicates the drivers have not great impact between them. Generally, the relationship of all the drivers of reverse logistic with each other variables is shown in table 16.

Table 16: Correlation factor of reverse logistics drivers

| Drivers |    | D1    | D2    | D3    | D4    | D5    | D6    | D7    | D8    | D9    | D10   | D11   | D12   | D13   | D14   |
|---------|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| D1      | PC | 1     | .528  | .771  | .921  | .915  | .878  | .839  | .909  | .936  | .833  | .975  | .856  | .921  | .838  |
|         | S  |       | .360  | .127  | .027  | .030  | .050  | .076  | .033  | .019  | .080  | .005  | .064  | .027  | .076  |
| D2      | PC | .528  | 1     | .901* | .160  | .154  | .789* | .742  | .286  | .221* | .018  | .521  | .021* | .160  | .743  |
|         | S  | .360  |       | .037  | .797  | .805  | .112  | .151  | .641  | .721  | .977  | .368  | .974  | .797  | .150  |
| D3      | PC | .771  | .901* | 1     | .503  | .505* | .855  | .757  | .526* | .523  | .331  | .727* | .387  | .503  | .758* |
|         | S  | .127  | .037  |       | .387  | .386  | .065  | .138  | .363  | .365  | .586  | .164  | .520  | .387  | .138  |
| D4      | PC | .921* | .160  | .503  | 1*    | .995  | .642  | .606* | .903  | .977  | .944* | .881  | .990  | 1*    | .605  |
|         | S  | .027  | .797  | .387  |       | .000  | .243  | .279  | .036  | .004  | .016  | .049  | .001  | .000  | .279  |
| D5      | PC | .915* | .154  | .505  | .995* | 1     | .651  | .607* | .923  | .985  | .960* | .890  | .985  | .995* | .607  |
|         | S  | .030  | .805  | .386  | .000  |       | .234  | .278  | .025  | .002  | .009  | .043  | .002  | .000  | .278  |
| D6      | PC | .878  | .789  | .855  | .642  | .651  | 1     | .980  | .809  | .736  | .607  | .922  | .531  | .642  | .980  |
|         | S  | .050  | .112  | .065  | .243  | .234  |       | .003  | .098  | .156  | .278  | .026  | .357  | .243  | .003  |
| D7      | PC | .839  | .742  | .757  | .606  | .607  | .980  | 1     | .802  | .714  | .600  | .899  | .498  | .606  | 1.000 |
|         | S  | .076  | .151  | .138  | .279  | .278  | .003  |       | .102  | .176  | .285  | .038  | .393  | .279  | .000  |
| D8      | PC | .909* | .286  | .526  | .903* | .923  | .809  | .802* | 1     | .973  | .955* | .962  | .866  | .903* | .802  |
|         | S  | .033  | .641  | .363  | .036  | .025  | .098  | .102  |       | .005  | .011  | .009  | .058  | .036  | .103  |
| D9      | PC | .936* | .221  | .523  | .977* | .985  | .736  | .714* | .973  | 1     | .974* | .941  | .954  | .977* | .713  |
|         | S  | .019  | .721  | .365  | .004  | .002  | .156  | .176  | .005  |       | .005  | .017  | .012  | .004  | .176  |
| D10     | PC | .833  | .018  | .331  | .944  | .960  | .607  | 1     | .862  | .862  | 1     | .947  | .944  | .599  | .944  |
|         | S  | .080  | .977  | .586  | .016  | .009  | .278  | 0     | .060  | 0.060 |       | .014  | .016  | .286  | .016  |
| D11     | PC | .975  | .521  | .727  | .881  | .890  | .922  | .899  | .962  | .941  | .862  | 1     | .812  | .881  | .899  |
|         | S  | .005  | .368  | .164  | .049  | .043  | .026  | .038  | .009  | .017  | .060  |       | .095  | .049  | .038  |
| D12     | PC | .856  | .021  | .387* | .990  | .985  | .531* | .498  | .866  | .954* | .947  | .812  | 1*    | .990  | .498  |
|         | S  | .064  | .974  | .520  | .001  | .002  | .357  | .393  | .058  | .012  | .014  | .095  |       | .001  | .394  |
| D13     | PC | .921  | .160* | .503  | 1     | .995* | .642  | .606  | .903* | .977  | .944  | .881* | .990  | 1     | .605* |
|         | S  | .027  | .797  | .387  | .000  | .000  | .243  | .279  | .036  | .004  | .016  | .049  | .001  |       | .279  |
| D14     | PC | .838* | .743  | .758  | .605* | .607  | .980  | 1*    | .802  | .713  | .599* | .899  | .498  | .605* | 1     |
|         | S  | .076  | .150  | .138  | .279  | .278  | .003  | .000  | .103  | .176  | .286  | .038  | .394  | .279  |       |

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

From the result of SPSS neural network multilayer perceptron, the driver variables of the input layer/predictor (D4, D5, D6, D7, D11, D13, and D14), the hidden layer H (unobservable node) and output layer/responses (D1, D2, D3, D8, D9, D10 and D12) the synaptic weight minimizes the errors of the target value. As shown in figure 17 the positive synaptic weight (synaptic weight > 0) shows a high strength of relationship interneuron connection but the negative synaptic weight (synaptic weight < 0) indicates a non-linear relationship interneuron connection between the variables. The drivers shown in figure 17 as an input layers are governmental, legal and political issue drivers (D4), social responsibility and corporate citizenship drivers (D5), marketing drivers (D6), facility drivers (D7), environmental regulation drivers (D11), legislation and commercial motivations drivers (D13), and promotion related issues (D14) affects the output layers of economic drivers (D1), competitive drivers (D2), Operational performance drivers (D3), inventory control drivers (D8), transportation drivers (D9), asset protection drivers (D10),

information, sourcing and pricing drivers (D12). We can conclude that the most influential factors in predicting the reverse logistic of Raya Brewery are collection facility drivers (100%), environmental regulation drivers (81.8%), legislation and commercial motivations drivers (29.9%), legal and political issue drivers (33.0%), social responsibility & corporate citizenship drivers (47.0%) marketing drivers (29.7%), governmental, legislation and commercial motivations drivers (52.0%), and promotion related issues (39.4%) as shown in figure 18.

From table 16 we can conclude that the collection facility driver has strong correlation strength ( $PC=0.980$ ,  $S= 0.003$ ) with marketing drivers. The economic drivers (D1) also have statistically significant strong correlation relationship ( $PC=0.975$ ,  $S= 0.005$ ) with Environmental regulation drivers (D11). The competitive drivers (D2) and Operational performance drivers (D3) also have strong strength with correlation relationship of  $PC =0.901$ ,  $S =0.037$ . Similarly, the statistically significant strong relationship among the other derivers is shade in whit color as shown in table 16.

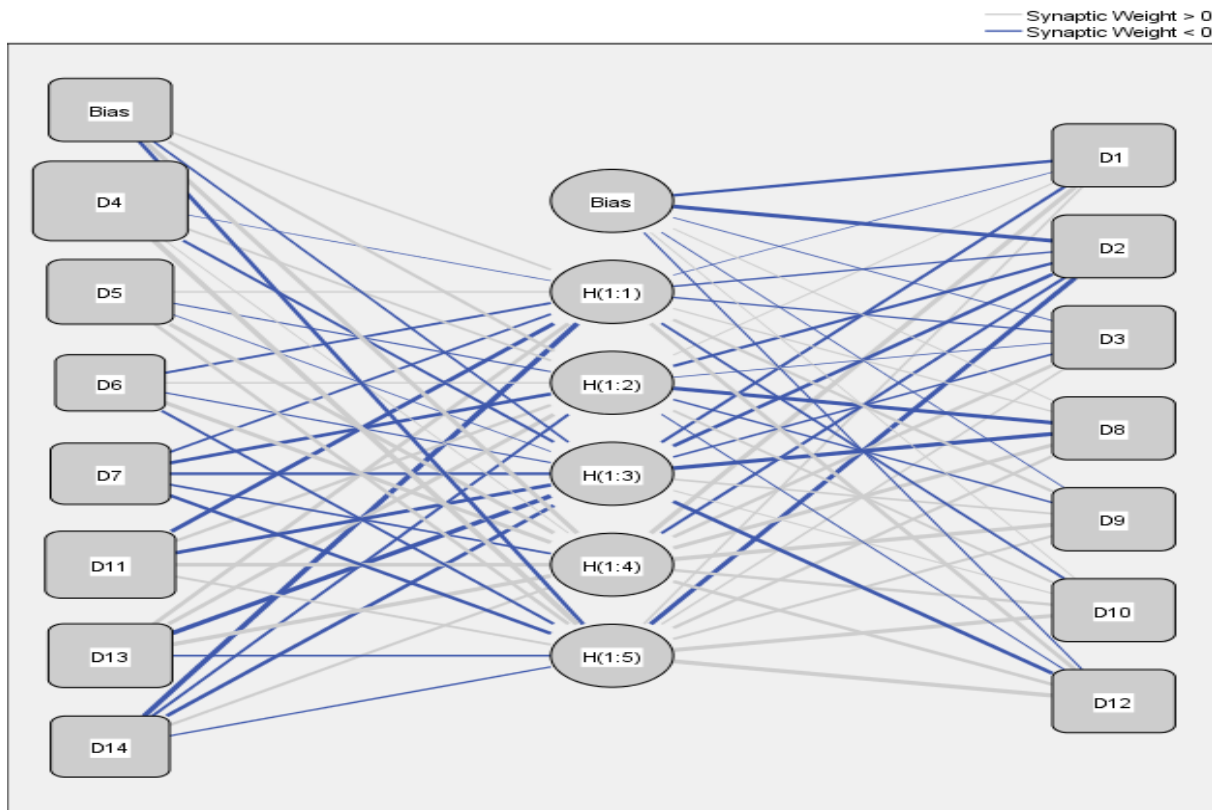


Figure 19: Drivers of reverse logistics Multi-layer perceptron network structure.

The neural network result shown in table 16 indicates a parameter estimation of both input and the output layer with respect to their biases. This parameter estimation indicates that the relationship

between the variables of reverse logistics factors and the response from the input layer and hidden layer.

Table 17: Drivers Parameter Estimates

| Parameter Estimates |        |                |        |        |        |        |              |       |       |       |       |       |       |
|---------------------|--------|----------------|--------|--------|--------|--------|--------------|-------|-------|-------|-------|-------|-------|
| Predictor           |        | Predicted      |        |        |        |        |              |       |       |       |       |       |       |
|                     |        | Hidden Layer 1 |        |        |        |        | Output Layer |       |       |       |       |       |       |
|                     |        | H(1:1)         | H(1:2) | H(1:3) | H(1:4) | H(1:5) | D1           | D2    | D3    | D8    | D9    | D10   | D12   |
| Input Layer         | (Bias) | .157           | .286   | -.146  | .437   | -.319  |              |       |       |       |       |       |       |
|                     | D4     | -.006          | .162   | -.248  | .030   | .731   |              |       |       |       |       |       |       |
|                     | D5     | .062           | -.051  | -.011  | .421   | .319   |              |       |       |       |       |       |       |
|                     | D6     | -.196          | .070   | -.057  | .464   | -.213  |              |       |       |       |       |       |       |
|                     | D7     | -.170          | -.395  | -.299  | -.161  | -.322  |              |       |       |       |       |       |       |
|                     | D11    | -.441          | .309   | -.431  | .500   | .188   |              |       |       |       |       |       |       |
|                     | D13    | .374           | .411   | -.797  | .604   | -.103  |              |       |       |       |       |       |       |
|                     | D14    | -.719          | -.244  | -.358  | .251   | -.070  |              |       |       |       |       |       |       |
| Hidden Layer 1      | (Bias) |                |        |        |        |        | -.317        | -.556 | -.014 | .039  | -.017 | .028  | -.058 |
|                     | H(1:1) |                |        |        |        |        | .000         | -.071 | -.066 | .058  | .279  | -.163 | .358  |
|                     | H(1:2) |                |        |        |        |        | .043         | -.290 | -.010 | -.499 | -.077 | .186  | -.044 |
|                     | H(1:3) |                |        |        |        |        | -.260        | -.357 | -.112 | -.630 | .160  | .045  | -.387 |
|                     | H(1:4) |                |        |        |        |        | .490         | -.265 | .328  | .455  | .637  | .313  | .334  |
|                     | H(1:5) |                |        |        |        |        | .084         | -.487 | .073  | .287  | .248  | .558  | .649  |

From the result of multi-layer perceptron neuron network of normalized importance chart as shown in (Figure 18) the independent variables of collection facility drivers (100%), environmental regulation drivers (81.8%), legislation and commercial motivations drivers (29.9%), legal and political issue drivers (33.0%), social responsibility and corporate citizenship drivers (47.0%) marketing drivers (29.7%), governmental, legislation and commercial motivations drivers (52.0%), and promotion related issues (39.4%) are the most important predictors of the output layers of the reverse logistics.

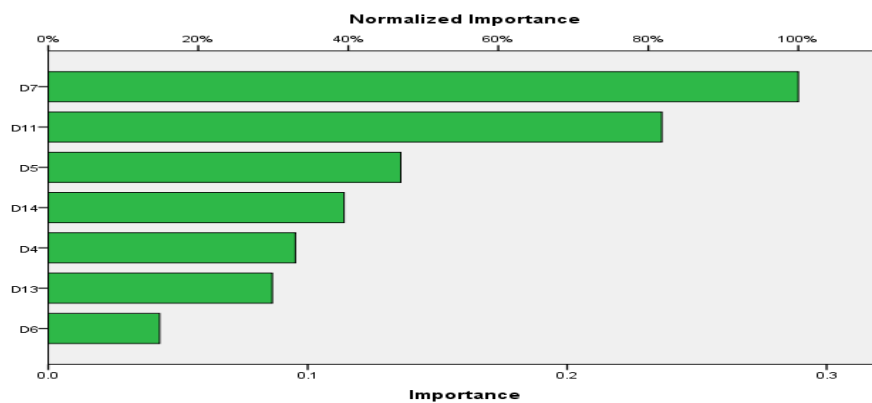


Figure 20: Drivers of reverse logistics Independent variable importance chart

#### 4.6 Analyzing the Cycle Time of Returning Process

Reducing the return processing time is one of the important systems to handle easily the reverse logistic process. When companies do not monitor the length of the processing cycle time of their product, they will challenge to know their statues as well. One of the most obstacles to deal with reverse logistic is lack of information about the process. As shown in the figure below the Raya Brewery have lack of formalized returning system in order to monitor the reverse logistics. According the respondents, about 33.33% of the distributed bottles are not returned on time which stays between 3 weeks to 1 month in the hand of customer.

Table 18: Length of time taken to Return empty bottles and steel kegs to company

| Length of time taken to Return empty bottles and steel kegs to company | Respondents % |
|--|---------------|
| Less than 1 day  | 6.67 %        |
| Between 1 to 2 days  | 6.67 %        |
| Between 3 to 6 days'   | 20 %          |
| Between1 to 2 weeks  | 26.66 %       |
| Between 3 weeks to 1 month   | 33.33 %       |
| More than 1 month to 2 months  | 6.67 %        |
| More than 2 months   | 0 %           |

Then using SPSS20 tool, we can check validity of the data as shown in the below table.

Table 19: Validation of Percent of return time

| Length of time taken to Return empty bottles and steel kegs to company |                               |           |         |               |                    |
|--|-------------------------------|-----------|---------|---------------|--------------------|
|  |                               | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid  | Between 1 to 2 days           | 1         | 14.3    | 14.3          | 14.3               |
|  | Between 3 to 6 days'          | 1         | 14.3    | 14.3          | 28.6               |
|  | Between 3 weeks to 1 month    | 1         | 14.3    | 14.3          | 42.9               |
|  | Between1 to 2 weeks           | 1         | 14.3    | 14.3          | 57.1               |
|  | Less than 1 day               | 1         | 14.3    | 14.3          | 71.4               |
|  | More than 1 month to 2 months | 1         | 14.3    | 14.3          | 85.7               |
|  | More than 2 months            | 1         | 14.3    | 14.3          | 100.0              |
|  | Total                         | 7         | 100.0   | 100.0         |                    |

As shown on the above table 18 disposition cycle time is one of the difficult processes in the reverse logistic process. This is caused due to the lack return center network. But in the logistic process disposition time will be decreased, when there is a clear tactical centralized return center.

This reduction of disposition time helps to improve the information system and creates a clear understanding of how to the material to return. Reducing the cycle time to return products have a direct and positive impact in the logistics process.

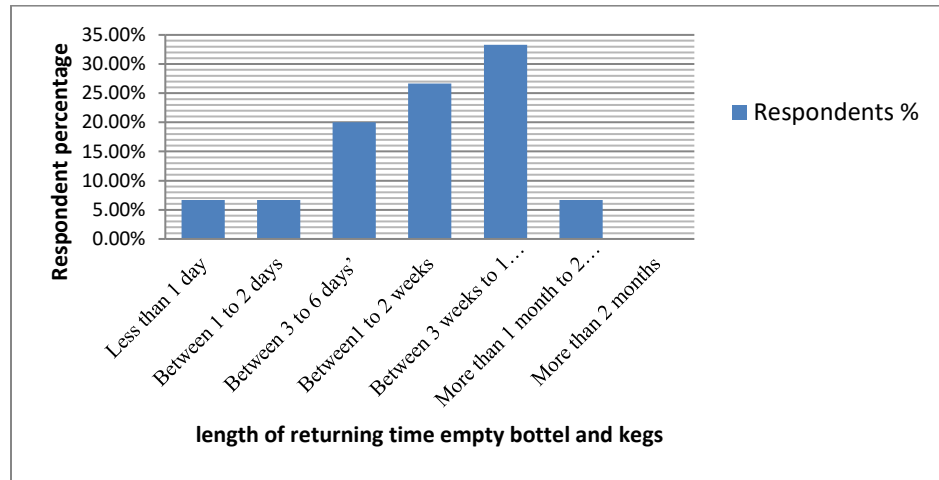


Figure 21: length of returning time of empty bottles and kegs

#### 4.7 Analyzing the Return Streams and Reverse Logistics System

Returning the empty bottles and steel kegs from the end users is not an easy task in the reverse logistic process. The most difficult controlling return streams that exist in the company are Product acquisitions (52.94%), Remarketing (47.06), Reverse distribution (52.94%) and Product recalls (64.71%) as shown in the table below.

In this study the product acquisition task of returning the empty bottles and steel kegs are the main issues that will creates a profitable chain. Returning the empty products can be done carefully by managing the time of product return, quantity and quality of the bottles. According the respondents (96.7%) agreed that, the most convenient ways of collecting empty bottles and kegs for the company will be from custom to retailer, retailer to wholesaler, wholesaler to agent, and agent to producer in order to preserve the return resource and to minimize the transportation cost. Therefore, developing a close coordination and relationship between the retailers, distributors, wholesaler, agents, producers and collectors can help the company to gate products within required period of time. Basically, in the inspection and disposition process testing the products to be returned is time consuming and labor-intensive task. This problem will be solved by developing a collection center facility. According the respondent the level of how to control the return stream activities are shown in table 20.

Table 20: level of controlling return stream activities

| Return streams   | Easy to control | Intermediate | Difficult to control | Unknown |
|--|-----------------|--------------|----------------------|---------|
| Product acquisitions (obtaining product from the last user or point of return)   | 0%              | 47.06%       | 52.94%               | 0%      |
| Remarketing (selling refurbished products, developments of secondary market)     | 11.76%          | 35.29%       | 47.06%               | 5.88%   |
| Reverse distribution (logistic involved to transport returned products)          | 35.29%          | 11.76%       | 52.94%               | 0%      |
| Test, sort and disposition (deciding on the final destination of return product) | 5.88%           | 47.06%       | 47.06%               | 0%      |
| Distribution related returns (wrong or damaged delivers)                         | 52.94%          | 35.29%       | 11.76%               | 0%      |
| End of use return (leasing)  | 23.53%          | 23.53%       | 0%                   | 52.94%  |
| Commercial return from customers (convenience return)                            | 11.76%          | 23.53%       | 11.76%               | 52.94%  |
| Warranty returns   | 23.53%          | 11.76%       | 11.76%               | 52.94%  |
| Commercial returns from channel partner (overstock, channel clearance)           | 11.76%          | 5.88%        | 47.06%               | 35.29%  |
| Maintenance, repair and overhaul return  | 11.76%          | 23.53%       | 0%                   | 64.71%  |
| Product recalls  | 11.76%          | 23.53%       | 64.71%               | 0%      |
| Raw material surplus   | 52.94%          | 35.29%       | 11.76%               | 0%      |
| Quality control returns  | 64.71%          | 23.53%       | 11.76%               | 0%      |
| Production leftovers/ by-products  | 35.29%          | 23.53%       | 5.88%                | 35.29%  |
| End of life product return   | 23.53%          | 11.76%       | 11.76%               | 52.94%  |

Mostly as shown in table 21 the activities performed are centralized (in-house) activities. According the respondent as shown in table 21 the common activities that done in house are Centralized collection center, Test, sort and disposition (deciding on the final destination of return product), Reverse distribution (logistics involved to transport returned products), Product acquisitions (obtaining product from the last user or point of return) and Product recalls. The remaining activities are performed by third party. The main activities that performed by the third party are shown blow in table 21. When companies are unable to control the cost of the reverse logistic operation, third party logistic provider is taken as an option. The third-party logistics providers have an ability to cut off the reverse logistics process to save money and time. Most developed countries run their company activities of reverse logistic process operation to third-party logistics due to well understanding of the issues to address and to overcome the reverse logistics operational barriers (Micheal, 2011).

Table 21: Activity of reverse logistics (In-house and Third-party)

| Activity   | In-house (an activity done by the company Itself) | Third-party (an activity done externally by others) | Both in-house & third-party |
|--|---|---|-----------------------------|
| Centralized collection center  | 88.24%  | 0%  | 11.76%                      |
| Refurbishing (recovering process, e.g. Manufacturing, repair)                    | 23.53%  | 64.71%  | 11.76%                      |
| Remanufacturing  | 23.53%  | 64.71%  | 11.76%                      |
| Test, sort and disposition (deciding on the final destination of return product) | 100%  | 0%  | 0%                          |
| Reverse distribution (logistic involved to transport returned products)          | 88.24%  | 0%  | 11.76%                      |
| Product acquisitions (obtaining product from the last user or point of return)   | 100%  | 0%  | 0%                          |
| Product recalls  | 100%  | 0%  | 0%                          |
| Outlet sales   | 11.76%  | 88.24%  | 0%                          |
| Remarketing (selling refurbished products, developments of secondary market)     | 11.76%  | 76.48%  | 11.76%                      |
| Salvage  | 23.53%  | 64.71%  | 11.76%                      |

#### 4.8 Modified Framework of Reverse Logistics

Reverse logistics process contains the components of inspection, disposal, sorting, collection and disassembly. In the reverse process considering a proper testing, disposal and collection centers are important when a company planned to return the products to its source. If the company didn't recycle the product sending to the primary manufacturers is best way to conserve the resource. This framework is developed from the generic model, pull and push models and from the existing

reverse logistics network of Raya Brewery as shown in figure 22 below. The framework can be used by the company in order to overcome cost related problems in reverse logistics system as a tool to identify the best practices in order to implement. This thesis can help to guide for further study to address other related reverse logistic problem areas.

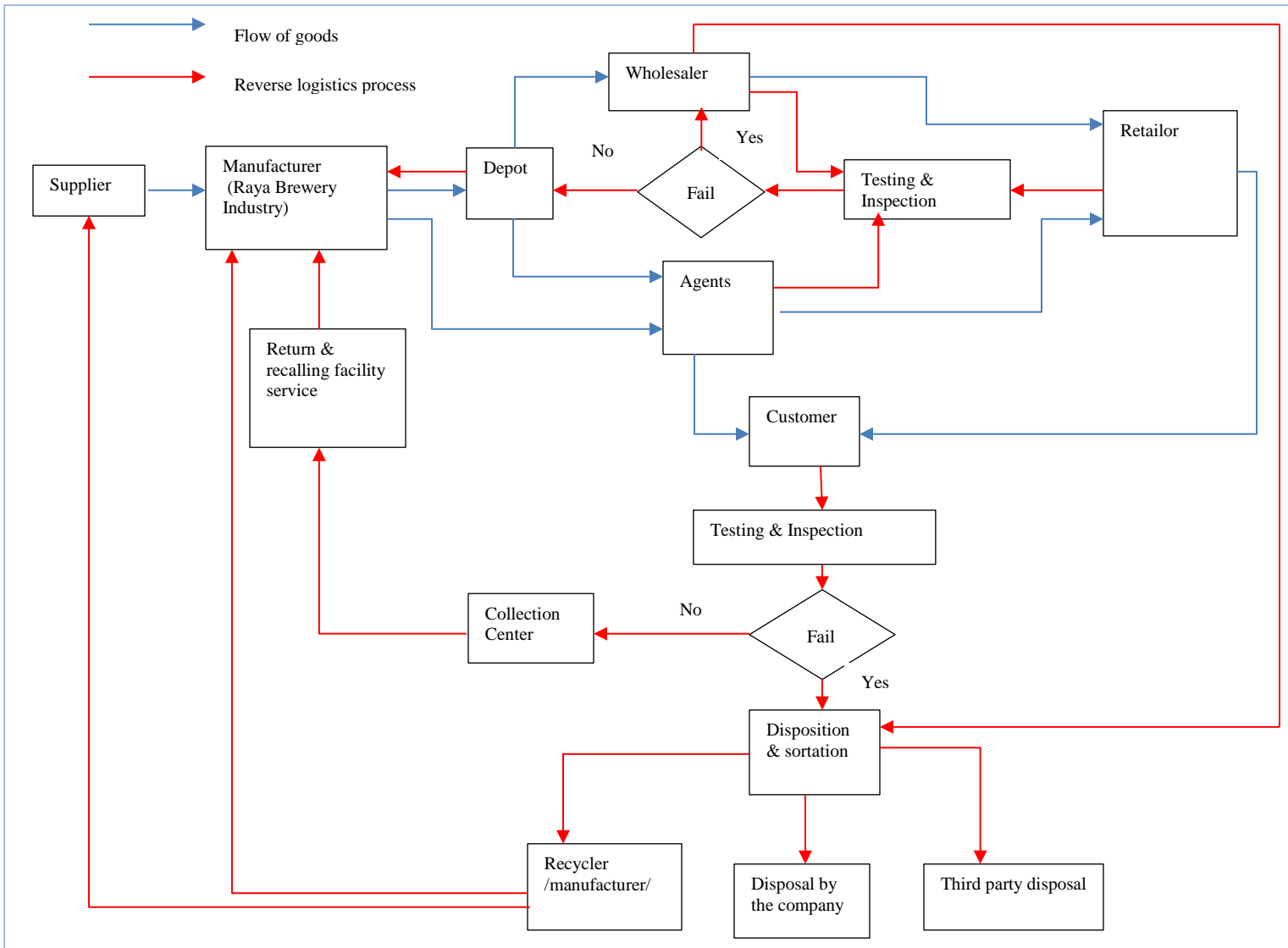


Figure 22: Modified framework of reverse logistics (*Shigeki., 2013*)

#### 4.9 Proposed Reverse Logistics Holistic Model

From the above data analysis and interpretation, the identified existing internal and external barriers and drivers of the company can be addressed by developing a reverse logistics holistic model to avoid the different uncertainties. The multi-layer perceptron neural network result shows

that the relationship of both drivers and barriers of reverse logistics. This model is created by combining models of the drivers and barriers that illustrated before and gives a final a structural model as shown in Figure 23. This model contains nine neurons and one hidden layer. This neural network indicates that an optimal prediction analysis of variables of the reverse logistics with testing average over all relative error of 0.052 and testing sum of square error of 0.31.

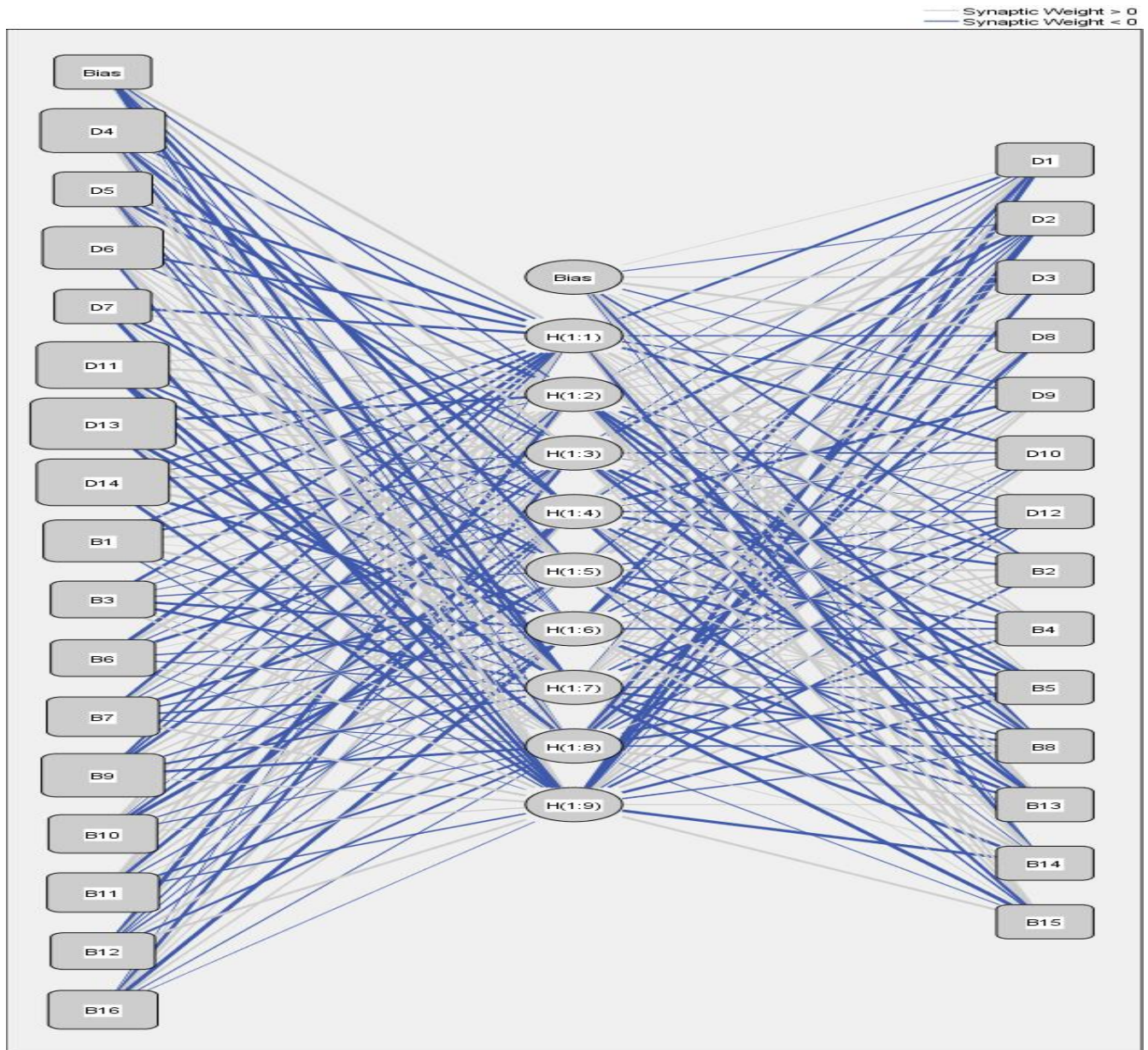


Figure 23: Barriers and drivers of reverse logistics MLP network structure model.

From figure 23 strength of the resulted relationship between the barriers and drivers is shown in appendix A-6. This table shows the resulted strong relationship between the factors of reverse logistic.

From the result of multi-layer perceptron neuron network of normalized importance chart as shown in Figure 24, the independent variables of D13, D14, D11, D4, B9, D6, B1, B7, B11, B16 and B10 are the most important predictors of the output layers of the reverse logistic. From this figure the importance of factors of the input layer which affects the output layer according the result of the neural network which have one hidden layer with an optimal nine number of units in hidden layer. Now we can conclude that the factors which affect the reverse logistics system of Raya Brewery are factors placed in the input layer that leads a high impact as ranked by the neural network analysis. The increment of the normalized importance shows that how much the network model predicted value changes for the independent variables reverse logistics. We can conclude from this figure most of the variables that have a normalized importance greater than 70%, has a significant dominant impact on the reverse logistics system of Raya Brewery. The resulted dominant factors are Lack of collection facilities (100%) Social responsibility and corporate citizenship drivers (80.7%), collection Facility drivers (76.3%), Promotion related issues (75.9%), Lack of awareness (70.3%), Financial and burden tax barriers (74%) and Lack of product Quality issues (71.8%) as shown in table 22 and figure 24. Therefore, these variables are the most influential factors in predicting the reverse logistics.

Table 22: Independent Variable Importance

| Barriers and drivers                                   | Importance | Normalized Importance |
|--|------------|-----------------------|
| Governmental, legal and Political issue drivers        | .056       | 63.4%                 |
| Social responsibility & corporate citizenship drivers  | .071       | 80.7%                 |
| Marketing drivers                                      | .052       | 58.8%                 |
| Collection Facility drivers                            | .067       | 76.3%                 |
| Environmental regulation drivers                       | .034       | 38.6%                 |
| Legislation and commercial motivations drivers         | .061       | 69.0%                 |
| Promotion related issues                               | .067       | 75.9%                 |
| Lack of awareness                                      | .062       | 70.3%                 |
| Financial and burden tax barriers                      | .065       | 74.0%                 |
| Company policy barriers                                | .057       | 64.1%                 |
| lack of government support, Legal and Political issues | .038       | 42.5%                 |
| Lack of Competitive issue                              | .053       | 60.4%                 |

|  |      |        |
|--|------|--------|
| Improper performance management system                           | .049 | 55.4%  |
| Lack of collection facilities                                    | .088 | 100.0% |
| Lack of product Quality issues                                   | .063 | 71.8%  |
| Lack of functional integration                                   | .061 | 69.3%  |
| Lack of Importance of reverse logistics relative to other issues | .055 | 62.4%  |

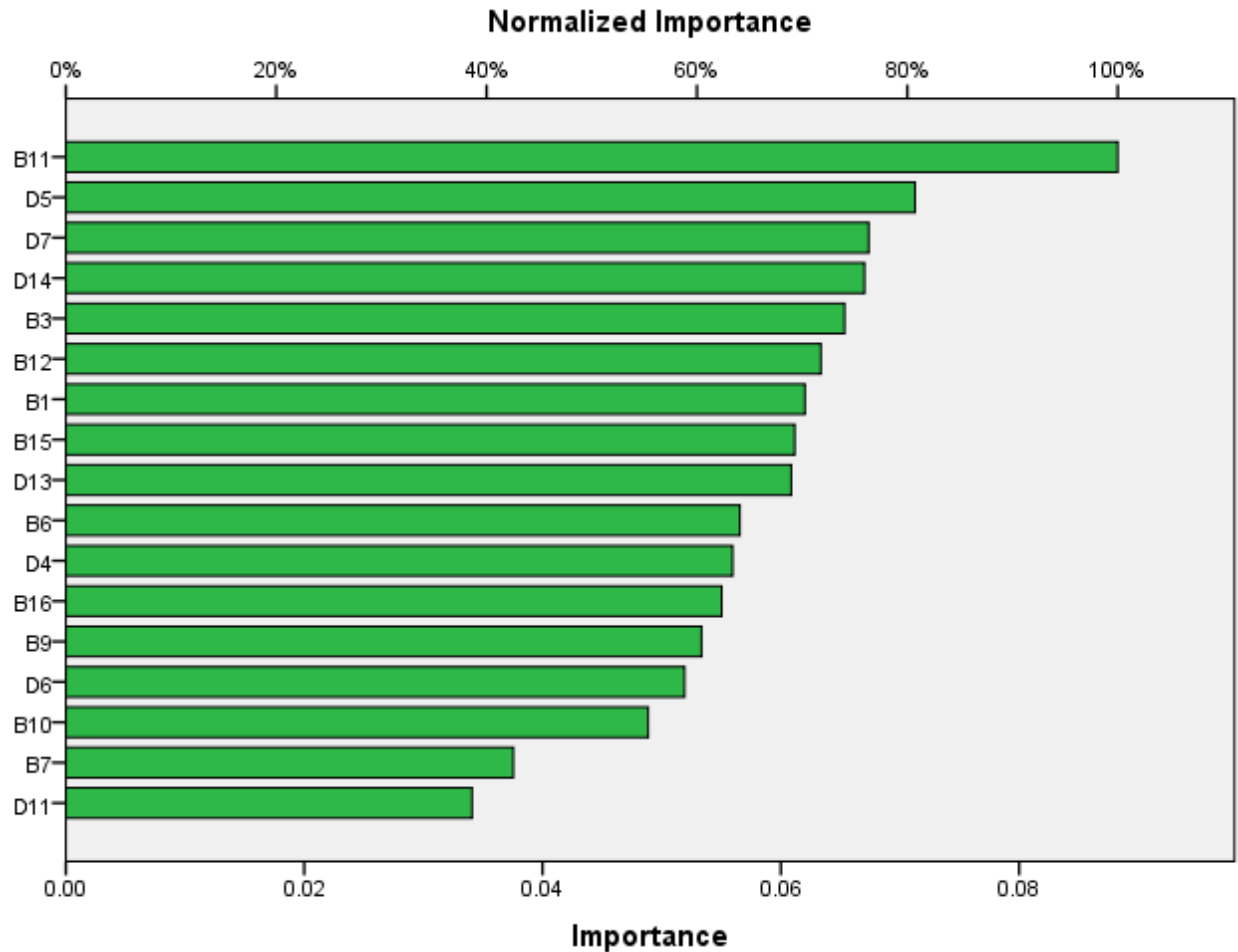


Figure 24: Multi-layer perceptron Independent variable importance chart

The parameter estimation of each barrier and drivers of reverse logistics is shown in appendix A-3. This parameter estimation shows the relationship between the variables of reverse logistics factors and the response from the input layer and hidden layer. From the result of multi-layer perceptron neural network, the predicted by observed chart shown in figure 25, tells us the predicted observed-value for each dependent variable and a response category cluster variable the percentage value increases due to the transportation drivers. Additionally, the transportation driver which is influenced due to lack of collection facilities has shown in figure 23, shows that as the

residual value increase the predicted value increases at the same time. The Residual by predicted chart shows the predicted-value for each transportation drivers.

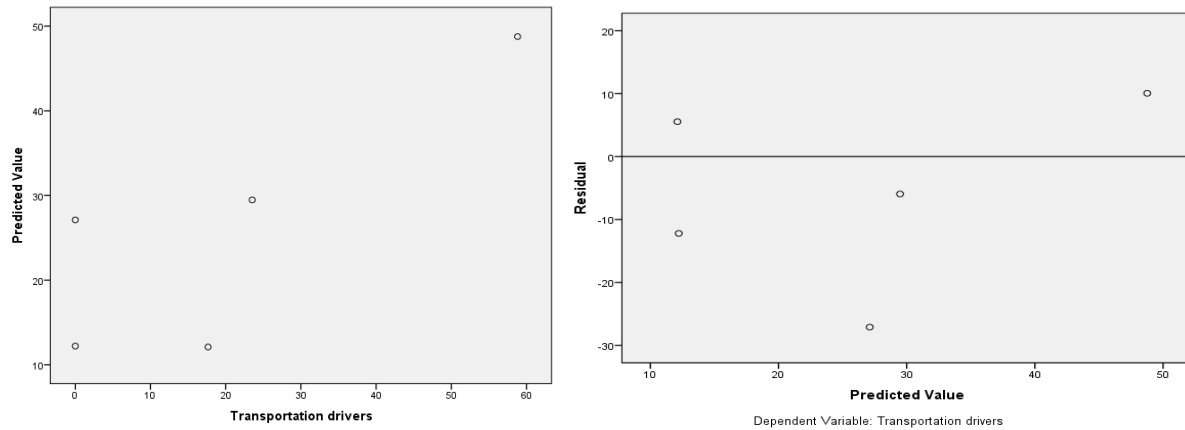


Figure 25: predicted-by- observed-value chart of transportation drivers

Now from the above results and discussions in order to manage the reverse logistics factors, it is possible to propose a holistic reverse logistics model by comparing the results from multi-layer perceptron neural network as shown in figure 26.

The reverse logistics holistic model is developed based on the analysis part of SPSS neural network results and adopting from reverse logistics barriers based interpretive structural model. The barriers based interpretive structural model includes components of product quality control, management inattention, creating awareness, government support, financial constraints, performance measurement, and cooperative behavior of the chain members, forecasting and planning. However, the developed reverse logistic holistic model additionally includes proper collection facility, transportation service (by the company itself, agents or third-party), competitiveness, promotion and advertisement (using social media, television, radio, Facebook, you tube), testing and inspection, inventory control, asset protection, functional integration, motivation, information and technology system (using phone, E-mail, fax, free SMS, Facebook, webs and you tube) and giving advance training. In figure 26 the blue arrows represent the relationship between the elements of reverse logistics holistic model.

- ❖ Competitiveness helps for the company to know the strength and weakness of in the marketplace and how to response it. This can also improve the company returning performance by achieving a better planning and accurate forecasting, introducing new technology and information system. It also helps the company what they need to know about the future and current competition.
- ❖ Forecasting and planning play a great role to predict the how to return the empty beer bottles and steel kegs to the future by considering the present and past performance. Assigning the different levels of managers and experts in the reverse logistics process improves the forecasting and planning. In the planning process the responsibilities of the top managers have an ability to increase the chance of the empty bottles and steel kegs to return.
- ❖ Promotion and advertisement have a great significant role for survival in the marketplace. The advertisement which is a major component of promotion helps to deliver all massages through mass media. This can create awareness by selecting a right message strategy using a social media like you tub, Facebook, television and radio.
- ❖ Advance training creates a good image to manage the products in the reverse logistics process by focusing issues related to the concept of reverse logistics. This can change the attitude of the societies and the company employees.
- ❖ Corporate citizenship helps for butter customer service by increasing level of customer awareness to return the empty bottles and steel kegs to provide a potential benefit. It also helps to hold a value to be responsible with reverse logistics activities.
- ❖ Government support in reverse logistics process system has its own advantage when they help the company by giving a free land for the purpose of collection center without a tax to increase the volume of bottles and steel kegs to return.
- ❖ Quality control in the reverse logistic helps to avoid breakages bottles from returning by using test and inspection at the source and also it helps to manage the unwanted other brand bottles.
- ❖ Inventory control is good in the reverse logistics process especially at the collection center. The collected bottles and steel kegs should be return using transportation service at the required time.

- ❖ Functional integration can be achieved using a good communication and cooperation system. The company can work collaboratively with customers and the societies to attribute a successful practice of reverse logistic. Understanding the function of reverse logistics practice helps to achieve the end goals and objectives of the company.
- ❖ Management commitment have significance role in shaping the reverse logistics practice to make the company to have a good flow of products. The commitment of managers is very important not only reverse flow but also the forward way.
- ❖ Creating awareness used to implement the benefit of reverse logistics to increase the volume of products to return. This can be achieved using a social media and tract paper which helps to motivate the societies.

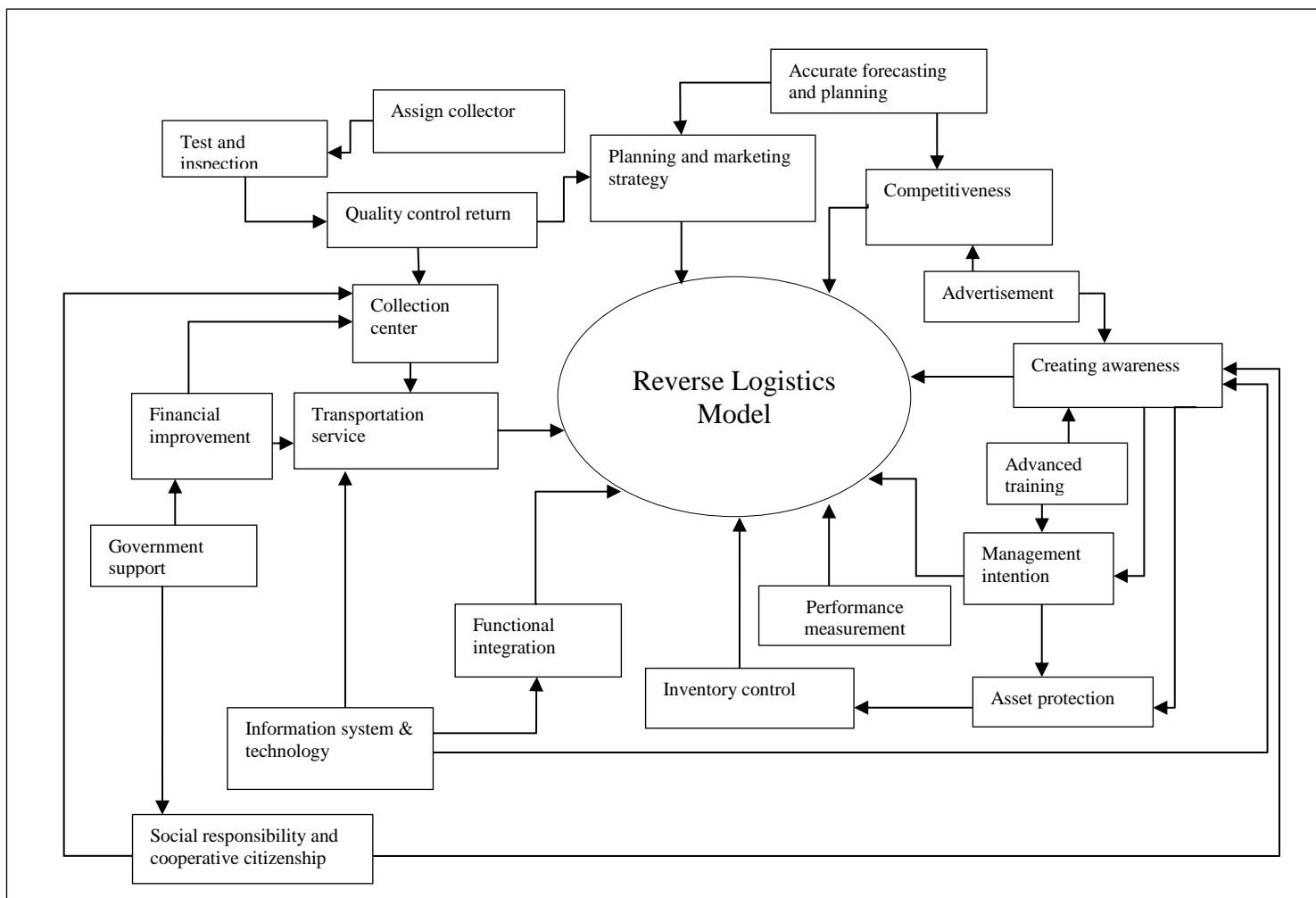


Figure 26: Proposed Reverse logistics holistic model

Generally, we can summarize the existing statues of Raya Brewery Share Company according the above data analysis and interpretation compering to the proposed holistic model as:

- ❖ It has not a proper collection center to return the empty beer bottles and steel kegs because of this it expenses a total transportation cost of 90,071,206 birr per year.
- ❖ The Raya Brewery has lack of formalized returning system in order to monitor the reverse logistics.
- ❖ The most factors that affect the reverse logistics of the company are location facilities (collection center), transportation, product acquisition, product recall and inaccurate forecasting. Due to these problems the empty beer bottles and steel kegs are not return to the company in required period of time.
- ❖ The inaccurate forecasting and planning are resulted due to lack of creating awareness, poor information flow, political issues and lack of collection centers.
- ❖ This company also lack of training related to reverse logistic that affects the company functional integration, communication and cooperation.

Therefore, it is important to propose and develop a collection center that helps to reduce the unwanted transportation expenses. According the LINGO result, assigning a proper collection center can minimize the reverse logistics related cost. Therefore, there will be an effective product returning flow and controlling system to avoid the different uncertainties.

### **4.10 Selection of Collection Center and Model Formulation for Reverse Logistics**

#### **4.10.1 Selection of Collection Centers**

Collection center can be defined in logistic term as process by which recyclable materials are collected from the required stream and delivered to processing facility. In reverse logistics management, collecting the required product is the important process which uses inspection and testing to transport the required products to the producer. There are two most common ways of collecting system (Centralized return centers and decentralized return centers) (Rogers, 1998). In designing of reverse logistics collection centers, when cost efficiency is the objective then centralized system is recommended, but if responsiveness is the goal decentralized system is recommended to minimize time delays in the return process (Joseph et al., 2004).

In this study the Centralized return center is used to handle product returns quickly and efficiently. High volume of product can collect when the products collected in central facility to ship to the

next destination. This return system is done when retailers return the products to one or more centralized return centers. Decentralizing the returns process helps to reduce time delays in disposition and to speed up the processing time of the remaining products. According the interviews collected, centralized return center is the preferable for management strategy of reverse logistics system due to a positive impact on the bottom line but still it have its own drawback.

The location of collection centers can be determined using facility location model. Measuring the facility location conditions is very difficult due to nature of the complex characteristic of tangible (wages cost, transportation rate and production cost) and non-tangible (quality, frequency, reliability and security). However, we can use Centre of gravity to locate a collection model based on consideration of volume of goods moved, market condition and the transportation cost in order to deliver to the nearest collection center. According (Anil, 2009), this method minimizes the weighted distance between the locations that used to return the product to the required station point. The first task using the center of gravity model is collecting the coordinate system of the locations by putting a grid over an ordinary map. Therefore, using this method the main collection centers for Raya Brewery Share Company is computed as shown below in table 22. The optimality of the collection centers is checked up using a LINGO 17 tool as shown in appendix A-2. According to the Tigray regional state city administration report of 2010 E.C, the main largest and small towns of Tigray are listed in table 22. Therefore, by using the method of center of gravity, the yellow color shaded towns are selected as candidate of a collection center due to high beer and draught consumption as shown in table 22 below.

Table 23: Selection of collection centers

| S.No | Town     | Longitudinal, latitude ( °N, °E) | Amount beer and draught consumed per month | Lx          | Ly          |
|------|----------|----------------------------------|--|-------------|-------------|
| 1    | Mekelle  | 13.49360, 39.43750               | 206640                                     | 2788317.504 | 8149365     |
| 2    | Adi Grat | 14.27800, 39.40600               | 15840                                      | 226163.52   | 624191.04   |
| 3    | Shire    | 14.10570, 38.48490               | 137310                                     | 1936853.667 | 5284361.619 |
| 4    | Aksum    | 14.13400, 38.74700               | 25000                                      | 353350      | 968675      |
| 5    | Adwa     | 14.16360, 38.89370               | 15300                                      | 216703.08   | 595073.61   |
| 6    | Alamata  | 13.44970, 39.35370               | 16550                                      | 222592.535  | 651303.735  |
| 7    | Wukiro   | 13.78440, 39.60530               | 12000                                      | 165412.8    | 475263.6    |
| 8    | Humera   | 14.28040, 36.61750               | 31200                                      | 445548.48   | 1142466     |
| 9    | Maychew  | 12.78670, 39.54330               | 9950                                       | 127227.665  | 393455.835  |
| 10   | Korem    | 12.50730, 39.52010               | 7000                                       | 87551.1     | 276640.7    |
| 11   | Shiraro  | 14.39710, 37.77430               | 21900                                      | 315296.49   | 827257.17   |
| 12   | Abiy Adi | 13.62380, 39.00200               | 1890                                       | 257489.82   | 737137.8    |

|  |              |                    |        |                 |                 |
|--|--------------|--------------------|--------|-----------------|-----------------|
| 13   | Mohoni       | 13.80283, 39.34590 | 11940  | 164805.7902     | 469790.046      |
| 14   | Adishihu     | 13.25000, 39.33000 | 4200   | 55650           | 165186          |
| 15   | Gijet        | 13.32800, 39.17260 | 380    | 50646.4         | 148855.88       |
| 16   | Alaje        | 13.00000, 39.19600 | 7000   | 91000           | 274372          |
| 17   | Adi Gudem    | 13.24490, 39.52010 | 12000  | 158938.8        | 474241.2        |
| 18   | Freweyni     | 14.05420, 39.57180 | 2500   | 35135.5         | 98929.5         |
| 19   | Edaga Hamus  | 14.17900, 39.56140 | 5500   | 77984.5         | 217587.7        |
| 20   | Hawuzen      | 13.97960, 39.42950 | 7000   | 97857.2         | 276006.5        |
| 21   | Enticho      | 14.27900, 39.15180 | 3900   | 55688.1         | 152692.02       |
| 22   | Dansha       | 13.51670, 37.18330 | 4000   | 54066.8         | 148733.2        |
| 23   | Hagereselam  | 13.65030, 39.17260 | 6000   | 81901.8         | 235035.6        |
| 24   | Endaba Guna  | 13.56580, 38.11300 | 8000   | 108526.4        | 304904          |
| 25   | Rama         | 14.41400, 38.78390 | 3300   | 47566.2         | 127986.87       |
| 26   | Selekileka   | 14.11790, 38.47610 | 4200   | 59295.18        | 161599.62       |
| 27   | Agulae       | 13.69450, 39.59240 | 2000   | 27389           | 79184.8         |
| 28   | Edaga Aribi  | 14.26700, 39.45000 | 2500   | 35667.5         | 98625           |
| 29   | Nebelet      | 14.54800, 39.16500 | 2100   | 30550.8         | 82246.5         |
| 30   | Werkamba     | 13.66670, 38.91666 | 5300   | 72433.51        | 206258.298      |
| 31   | Yechilay     | 13.28300, 39.00000 | 2000   | 2656.6          | 78000           |
| 32   | Wukiro Maray | 13.47401, 39.35540 | 3500   | 47159.035       | 137743.9        |
| 33   | Adi Hagerey  | 14.52000, 38.06000 | 2800   | 40656           | 106568          |
| 34   | Bizet        | 12.23000, 39.15000 | 2500   | 30575           | 97875           |
| 35   | Chercher     | 12.53330, 39.76670 | 3000   | 37599.9         | 119300.1        |
| Total  |              |                    | 626630 | 8630166.076     | 24386912.84     |
| $C_x = \frac{\sum Lx}{\sum \text{Amount of beer and draught consumed}},$ |              |                    |        | $C_x = 13.7723$ | $C_y = 38.9176$ |
| $C_y = \frac{\sum Ly}{\sum \text{Amount of beer and draught consumed}},$ |              |                    |        |                 |                 |

The center of gravity is (13.71833, 38.89397). Therefore, using the center of gravity as starting point, it is possible now to search the nearest collection center for the optimal location from the above lists. Using the center of gravity, the main collection centers which are nearest to the coordinate (13.71833, 38.89397) are Mekelle, Adi Grat, Shire, Aksum, Adwa, Abiy Adi, Mohoni, Alamata, Maychew, Hawuzen, Enticho, Hagereselam, Rama, Selekileka, Shiraro, Humera, Werkamba and Wukiro Maray.

#### 4.10.2 Transportation Model Formulation for Reverse Logistics

A reverse logistics model is proposed to address the gaps in the return process of empty beer bottles and steel kegs by developing a collection center. Basically, this model focuses on minimization of transport cost of collection centers.

Model Assumption:

In developing a model of reverse logistics, the following consideration and assumptions are proposed:

- ✓ The volume of products to return with respect to distance should have proportional transportation costs.
- ✓ The demands of location sites are known.
- ✓ The transportation and labor cost are known.
- ✓ The initial collection points will be the generating.
- ✓ The final destination of returned empty bottles and steel keg is Raya Brewery.

$$\text{Minimize Total Transport Cost} = \sum_{i=1}^{18} CC_i ARP_{il} + \sum_{i=1}^{18} TC_l ARP_i \quad (1)$$

Subjected to:

$$\sum_{i=1}^{18} ARP_i \geq dc_i \quad (2)$$

$$\sum_{i=1}^{18} ARP_i \leq CaC_i, \forall i \in I \quad (3)$$

$$ARP, CC, TC \geq 0 \quad (4)$$

Notice:

$ARP_{il}$  - number of returned products transferred from customer centers  $l$  to collection centers  $i$ .

$CaC_i$  - capacity of collection center  $i$

$CC_i$  - collection cost of returned products at collection centers  $i$

$dc_i$  - the distance cost between customer center  $l$  and collection  $i$

$I$  - set of selected sites for collection center, 1,2, 3,.....18

$L$  - Fixed set of points for customer centers, 1, 2, 3.....35

$TC_l$  - transportation cost of returned product from customer  $l$

The above objective function indicates the way how to optimize the transportation cost of the selected sites related to the collection centers in order to return the empty bottles and steel kegs to Raya Brewery Share Company. The objective function of this model is normally a minimization of transportation cost. The variables show that the quantities of beer bottles and steel kegs to be return to the collection centers to deliver to final destination. Now it is possible to decide from the output which variable (site) is best to assign nearest to the other variable (collection center). The goal of this model is to find the values of the model's that gives a best solution for the objective function which subjected to the restrictions. This model contains 288 variables and 35 constraints. The constraint indicates that, the limits on the variables which are expressed in terms of formulas and which are a function of the model's variables.

#### 4.10.3 Result and Analysis of the Model

After formulation of the minimization model, the model is solved using LINGO 17 tool. Then LINGO will display the compiling model and determines whether the model confirms to all syntax requirements. An error message is displayed, when the entered data doesn't fit the requirement of the model. Finally, the LINGO 17 displays the output of the model when it fits the requirement. The output is displayed as either feasible state or infeasible state. The feasible state indicates that the LINGO 17 has found a solution that satisfies all the constraints of the model. On the other hand, the infeasible state indicates that the LINGO 17 has found a tentative solution, but none of them satisfies all the constraints in the model (LINGO, 2017).

From the LINGO 17 output, the global optimum state indicates that the model doesn't contain non-linear constraints and all the optimized linear models will be terminated as best solution. On the other hand, the local optimum state indicates that, the model contains one or more non-linear constraints which any of them are not best solution for the model. Therefore, the developed model shows that the state is a global optimum which contains a feasible optimum solution with a LP model class as shown in table 23.

Table 24: Result of transportation model

| Result statuses         |                |
|-------------------------|----------------|
| Objective value         | 5934133        |
| Total variable          | 288            |
| Total constraints       | 35             |
| Total non-zero          | 864            |
| Total solver iterations | 18             |
| Solution State          | Global optimal |

The company expense an annual transportation cost of 90,071,206 birr per year with a monthly average of 7,505,933.83 birr per month. From the output of the model the total minimized total transport cost is 5,934,133 birr per month (71,209,596 birr per year). The developed model saves a transportation expense of 1,571,800.83 birr per month comparing to the monthly transportation of the company. Then developing a proper collection facility can save the company from transportation expense of 1,571,800.83 birr per month (18,861,610 birr per year). Then the result of the model shows that improvements of 20.941% from the previous reverse logistics system of the company.

From the LINGO result report reduced cost it is possible to interpret that, the variables in the optimal solution automatically has reduced a cost of zero. As shown the result in appendix A-2, the reduced cost of Amount (Mekelle, Wukiro) shows that the reduced cost is zero which indicates that the variable is in optimal solution. This means that Mekelle is an optimal location of collection center for Wukiro. Therefore, the empty beer bottles and steel kegs of Wukiro should return to Mekelle. The optimal collection center for Wukiro and Adi-Gudem is Mekelle, but the rest sites can't be assigned to Mekelle. Similarly, Amount (Mekelle, Humera) shows that to return the amount of the empty beer bottles and steel kegs a penalty that have to pay is 3535 birrs. This tells us Mekelle is not an optimal to be a collection center for Humera. The optimum location and the nearest location of collection centers for Endaba-Guna, Dansha and Adi- Hagerey is shire which each of them a zero reduced cost, but rest sites can't be assigned to shire due to high penalty cost or non-optimality. Therefore, the same interpretation is following to all site which shown in appendix A-2.

From appendix A-2 the slack ( $\leq$ ) or surplus ( $\geq$ ) columns in LINGO report indicates that how close the solution is satisfying the constraints. From the result all from the 2<sup>nd</sup> to 9<sup>th</sup> satisfied the constraints because exactly the values become zero. All the results shown in the slack or surplus are zero and positive values that indicates all values satisfies the constraints. If the constraint is violated the slack or surplus will be negative value. The dual prices (shadow) price also shows that how to increase or reduce to improve the objective value or how to pay for additional units of resources. Therefore, for the minimization model the negative value indicates that how much amount of cost is reduced from the objective value. The 1<sup>st</sup> row tells us to reduce by one unit from the objective value and 2<sup>nd</sup> row by 686 units too.

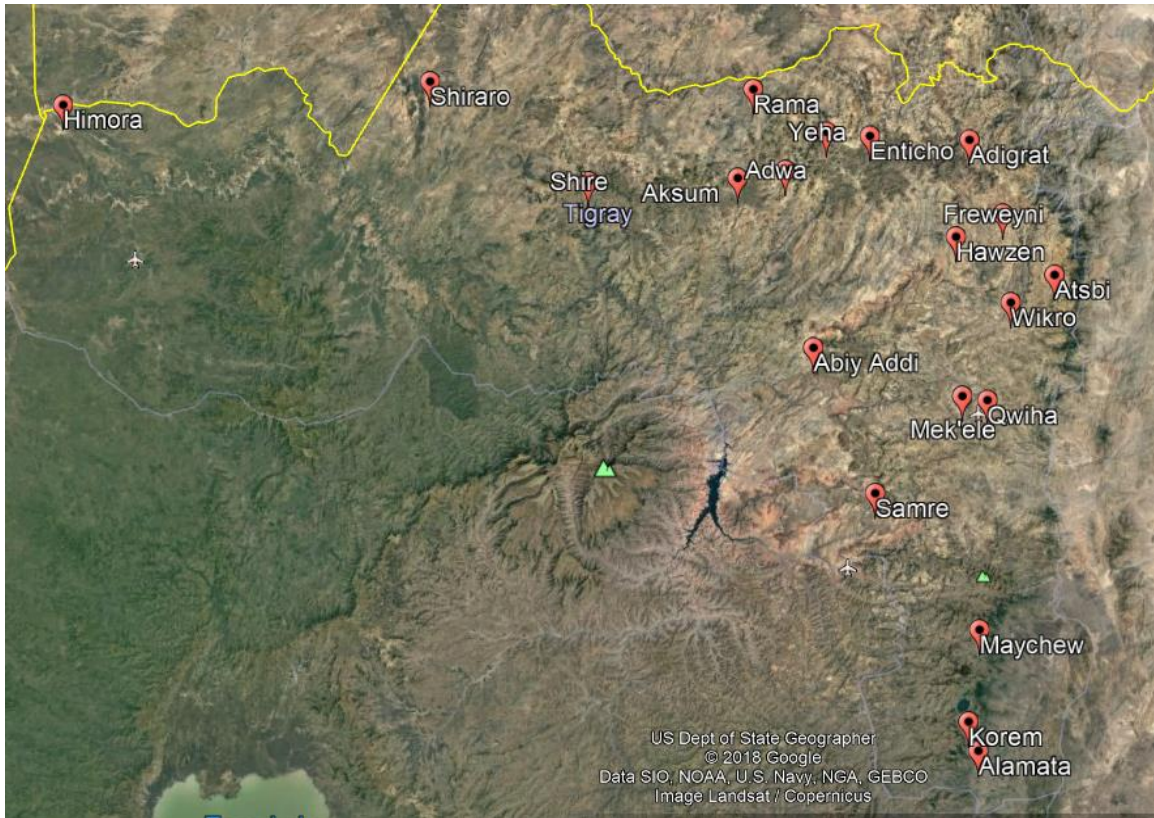


Figure 27: Location map of collection centers

#### 4.11 The Uncertainties in Reverse Logistics

Considering one of the significant factors that influences the reverse logistics system to return the empty beer bottles and steel kegs is uncertainty. According to the different literatures, different uncertainties are common during the reverse logistic process. During the returning process of the empty beer bottles and steel kegs, the common identified uncertainties are Demand uncertainty, Pickup time, Volume of empty beer bottles and kegs return, return frequency, Location /Address and responsiveness.

Developing a centralized return system helps to minimize the uncertainties compared to the decentralized return system as many researchers studied (Mostafa, 2016), (Rogers, 1998). But the centralized return system needs a centralized information system in order to avoid the uncertainties. In the reverse logistic strategy, the demand uncertainty becomes very high but stable and low on the supply side.

Most of the time, companies focus on the cycle time, lead time, and delivery time; however, the pickup time is the key factor in the reverse logistic process. Then, to reduce the pickup time, arranging a fixed pickup time can solve the problem, but still it can't give a best solution to satisfy for all

customers need. To avoid uncertainties of return time for Mekelle collection center, the delivery time and pickup time (AM) and return time (PM) can be scheduled by considering a maximum loading and unloading time of 2 hours. Therefore, the return time can be minimized as in appendix A-4.

Table 25: Result of the return time model

| Result statues          |                |
|-------------------------|----------------|
| Objective value         | 28             |
| Total variable          | 14             |
| Total constraints       | 15             |
| Total non-zero          | 35             |
| Total solver iterations | 18             |
| Solution State          | Global optimal |

The objective value 28 hours shows that, we need a maximum of 28 hours of return time for seven day delivering period. Knowing the volume of return is one of the uncertainties in reverse logistics which affects the reverse logistic process. This is because of the returning transportation cost is depending on the amount of the empty beer bottles and steel kegs to be return due to a dynamic behavior. The other challenging uncertainty is the return frequency how often the empty beer bottles and steel kegs are return from the customers basically from the collection centers. This can be minimized by assigning the business customers (retailers) than individual to offer a regular pickup service.

The location / address pickup can be reduced by developing a proper collection center rather than picking door-to-door service and the customers with the receivers (collectors). Additionally, predicting return reasons of the broken bottles due to accident for disposal issue and expired products are difficult in the reverse logistics process. Therefore, to avoid the uncertainty of returning process of empty beer bottles and steel kegs of Raya Brewery a proper information flow of reverse logistics among the customer, collectors and transportation service provider each component is important.

#### **4.12 Major Findings of the Research**

As discussed in the literature and data analysis parts (correlation and neural network analysis) the barriers and the drivers influence the reverse logistics process of Raya Brewery internally and externally. These factors hinder the company in return the empty beer bottles and steel kegs. Therefore, the returning task becomes a complex process because of the difficulty acquisition beer

bottles and steel kegs at the return stream line if the factors that influence the reverse logistics not addressed well. The other finding is gating the products in the required period of time is the challenging and dynamic behavior due to unpermitted sharing of bottles and steel kegs by the other beer producer (competitors) when market fluctuation and customer shift is occurred. For this reason, the producers are forced to buy a new bottle. However; when a proper collection center is assigned it can minimize this problem and also the transportation expenses. The sharing empty beer bottles and steel kegs by other brands have its own advantage basically for those who have high financial capacity but, for those who have low financial capacity it has a negative effect because they can't collect the bottles from everywhere door-to-door due to lack of collection facilities and financial capacity. Assigning a proper collection center not only it minimizes the transportation cost but also it can help to manage and control easily the flow of the empty beer bottles and steel kegs. The other finding is predicting the availability of empty beer bottles and a steel keg to be return is difficult and complex due to delays, breakage and unpermitted sharing of bottles. The uncertainties of quantity, demand, returning time and pickup time is in the reverse logistic process are dynamic situations to manage easily.

### **4.13 Testing and Validating the Model**

Validating the developed reverse logistics holistic and the transportation model is important in order to implement it practically. Testing the model will help to in providing a better decision making for capturing the planned target of the reverse logistic system. The transportation model is tested using LINGO 17 tool and an optimal solution is found comparing the existing system of Raya Brewery. The holistic model part is tested using the SPSS tool and it gives a training of 60% and testing of 40% with 100% percentage of validation. The result of this test indicates that an optimal predication analysis of the variables of the reverse logistics with average overall relative error of 0.052 and sum square of error of 0.31.

## CHAPTER FIVE

### 5. CONCLUSION AND RECOMMENDATION

#### 5.1 Conclusion

Reverse logistics is an important concept and interesting issue that can help to return with an effective flow of products from the customers to the producer to reuse the product. This study is conducted by studying the existing status of reverse logistics system of Raya Brewery in order to identify the key problems that hinders the company. After studying the current status and identifying the problems, a literature review was addressed. This paper basically focuses on developing a reverse logistics model for Raya Brewery to return the empty beer bottles and steel kegs. The study presented a conceptual reverse logistics model to address the barriers and drivers of reverse logistics and a transportation model is formulated to determine the optimum collection centers. The barriers and drivers were analyzed using SPSS neural network factor analysis method and the models of transportation and time uncertainty are solved using LINGO17 optimization tool.

As result of this study, it is known that the reverse logistics of Raya Brewery is affected by different barriers and drivers internally and externally as stated using the correlation factor and a neural network analysis. We can conclude from the result that the factors have impact directly and indirectly on the reverse process. The most influential factors that affect the reverse logistics of the company are location facilities (collection center), transportation, product acquisition, product recall and inaccurate forecasting. The issue of collecting and returning the empty beer bottles and steel kegs from the end users is not an easily activity in the reverse logistic process. In order to return them a proper collection center is addressed to minimize the transportation cost expenses. Therefore, developing a proper collection center with a close coordination and relationship between each collection centers, retailers, wholesalers, agents and the producers will help the company to gate the empty beer bottles and steel kegs on time when proper fixed arrangement of pickup time is assigned for each collection centers.

The contribution of this study is developing a conceptual reverse logistics holistic model to return the empty beer bottles and steel kegs and also formulating transportation model to minimize a transportation cost by developing collection centers. This model can help to analyses other barriers and drivers of reverse logistics. This study can also contribute in developing a good understanding of reverse logistics to manage barriers, drivers and collection centers of Raya Brewery. In general, it can be concluded that developing conceptual holistic model and transportation model for

collection centers is important to manage the empty beer bottles and steel kegs. Therefore, using and applying this model approach and developing a reverse logistics holistic model will help to manage properly the beer bottles and steel kegs by addressing the barriers and drivers of reverse logistics.

## **5.2 Recommendation**

Reverse logistics is important issue to producers to return the products to use directly or to recycle. As result, the producers are challenged to utilize their resources effectively in the reverse logistic process. Based on the study findings, the following recommendations are proposed to reverse logistics providers:

- ❖ The developed reverse logistics holistic model is easy and simple road map. Therefore, logistics decision makers are recommended to use it to identify a realistic representation of the problems of drivers and barriers to implement a reverse logistics system.
- ❖ The developed transportation model is flexible and simple to use. Therefore, it is helpful to check and decide the optimization made for the collection centers.
- ❖ The developed transportation model also can help to minimize the total transportation cost expense by assigning proper collection sites to improve the profitability goals and also it can help to avoid the uncertainties during delivery time, pickup time and return time.

## **5.3 Future Research Direction**

Reverse logistics is new field which plays a great role for continuous development and for a smooth flow of returning products. There are many techniques and method that can be used to optimize a reverse logistics. However; the study is looks like a general guide line which have an advantage to researchers. For researchers in order to develop a real optimization method, considering all the different reverse logistics barriers, drivers and uncertainties cases will be an important issue. Therefore, it is recommended for researchers to study and optimize the uncertainties of reverse logistics during the returning process. As result, designing an effective and efficient integrated reverse and forward logistics system to return product for recycling or direct reuse will be a good research title in the future. The other attractive and interesting future research direction will be maximizing a responsiveness multi-period and multi-product integrated logistics network as an objective function.

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## Appendix A

### A-1: Formulation of LP Model

#### MODEL 1: LP

! This is model helps to select a collection centers which have an optimal solution for Raya Brewery Share Company for the different Site of Tigray region with in relation with respect to collection centers;

#### SETS:

COLLECTION / Mekelle Adi\_Grat Shire Aksum Adwa Alamata Maychew Abiy\_Adi Mohoni Hawuzen Enticho Hagere\_salam Rama Selekileka Werkamba Wkiro\_Maray/: CAPACITY;  
 SITES /Wukiro Humera Korem Shiraro Adishihu Gijet Alaje Adi\_Gudem Freweyni Edaga\_hamus Dansha Endaba\_Guna Agulae Nebelet Yechilay Adi\_Hagerey Bizet Chercher/ : DISTANCE;  
 LINKS( COLLECTION, SITES): COST, AMOUNT;

#### ENDSETS

! The main objective of the model is to minimize the total amount of cost to return the empty bottle and steel kegs from the end users or customers to Raya Brewery Share Company;

MIN = @SUM( LINKS( M, N):

COST( M, N) \* AMOUNT( M, N));

! The distance relation with respect to the amount of bottles and steel kegs required for both collection centers and sites are;

@FOR( SITES( N):

@SUM( COLLECTION( M): AMOUNT( M, N)) >=

DISTANCE( N));

! The relation of capacity of all sites and the amount of bottles and steel kegs required for all collection centers is determined as ;

@FOR( COLLECTION( M):

@SUM( SITES( N): AMOUNT( M, N)) <=

CAPACITY( M));

! The required data capacity, distance and cost of each site and collection centers is given as follows;

#### DATA:

CAPACITY = 206640 15840 137310 25000 15300 16550 9950 18900 11940 7000 3900 6000 3300 4200 5300 3500;

DISTANCE = 160 663 42 491 38 147 67 88 195 210 216 297 150 355 195 464 281 50;

COST = 686 7341 2418 4894 6359 8729 1058 586 1173 1402 8729 3906 543 1917 1560 4507 2404 3763

1016 7556 2876 5094 1720 1588 1531 1045 500 744 8929 3033 171 1245 2290 4708 1732 4236

3735 3806 5996 1360 5123 3563 4894 4421 3480 2990 5195 329 3978 2318 3220 973 2218 7584

2819 4780 5080 2318 4207 2576 3978 3506 2333 2089 6153 1288 2976 1402 2304 1130 1402 6680

2547 5008 4808 2561 3935 2375 3706 3234 2060 1817 6397 1517 2705 1130 2032 2175 1030 6397

3162 10088 286 7642 1417 2962 1331 3132 3219 3892 9101 6582 3019 4393 3048 7240 4880 1330

2290 9487 6010 7026 543 9960 2103 1261 2790 3005 9960 5981 2147 3520 2790 6640 4021 958

1989 6353 3463 3892 2604 1044 2375 1889 1488 1745 7727 2848 2147 1474 701 3506 2332 5066

2290 9459 830 7011 773 2089 1001 1259 2776 3019 9630 5967 2147 3520 2776 6626 4021 716

816 8228 3606 4922 2547 2390 2318 1846 315 558 8757 3878 973 429 1875 4536 1560 4393

1960 5595 4837 3134 3706 2919 3477 3005 1474 1231 6969 2089 2132 1674 2576 2748 456 5538

1245 6583 3663 4121 2075 1245 1846 1359 1731 1975 7956 3077 1088 1717 901 3735 2576 4557

3077 5509 5338 3048 4465 2919 4236 3764 2590 2347 6883 2003 3234 1660 2561 2662 1560 6940

3320 4250 5567 1803 4684 3134 4464 1130 2833 2576 5638 7584 3477 1889 2790 1417 1803 7155

1746 6110 3706 3663 2848 1288 2619 2132 1245 1474 7498 2619 1560 1145 945 3263 2118 5309

3077 4479 5323 2018 4450 2890 4221 3749 2590 2332 5853 987 3234 1646 2547 1631 1560 6912;

#### ENDDATA

END

### A-2: Result of LP Model

Global optimal solution found.

Objective value: 5934133.  
 Infeasibilities: 0.000000  
 Total solver iterations: 18  
 Elapsed runtime seconds: 0.14

Model Class: LP

Total variables: 288  
 Nonlinear variables: 0  
 Integer variables: 0  
 Total constraints: 35

## Developing a Reverse Logistics Model for Raya Brewery

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Nonlinear constraints: 0  
 Total nonzeros: 864  
 Nonlinear nonzeros: 0

| Variable                     | Value    | Reduced Cost |
|------------------------------|----------|--------------|
| CAPACITY( MEKELLE)           | 206640.0 | 0.000000     |
| CAPACITY( ADI_GRAT)          | 15840.00 | 0.000000     |
| CAPACITY( SHIRE)             | 137310.0 | 0.000000     |
| CAPACITY( AKSUM)             | 25000.00 | 0.000000     |
| CAPACITY( ADWA)              | 15300.00 | 0.000000     |
| CAPACITY( ALAMATA)           | 16550.00 | 0.000000     |
| CAPACITY( MAYCHEW)           | 9950.000 | 0.000000     |
| CAPACITY( ABIY_ADI)          | 18900.00 | 0.000000     |
| CAPACITY( MOHONI)            | 11940.00 | 0.000000     |
| CAPACITY( HAWUZEN)           | 7000.000 | 0.000000     |
| CAPACITY( ENTICHO)           | 3900.000 | 0.000000     |
| CAPACITY( HAGERE_SELAM)      | 6000.000 | 0.000000     |
| CAPACITY( RAMA)              | 3300.000 | 0.000000     |
| CAPACITY( SELEKILEKA)        | 4200.000 | 0.000000     |
| CAPACITY( WERKAMBA)          | 5300.000 | 0.000000     |
| CAPACITY( WKIRO_MARAY)       | 3500.000 | 0.000000     |
| DISTANCE( WUKIRO)            | 160.0000 | 0.000000     |
| DISTANCE( HUMERA)            | 663.0000 | 0.000000     |
| DISTANCE( KOREM)             | 42.00000 | 0.000000     |
| DISTANCE( SHIRARO)           | 491.0000 | 0.000000     |
| DISTANCE( ADISHIHU)          | 38.00000 | 0.000000     |
| DISTANCE( GIJET)             | 147.0000 | 0.000000     |
| DISTANCE( ALAJE)             | 67.00000 | 0.000000     |
| DISTANCE( ADI_GUEM)          | 88.00000 | 0.000000     |
| DISTANCE( FREWEYNI)          | 195.0000 | 0.000000     |
| DISTANCE( EDAGA_HAMUS)       | 210.0000 | 0.000000     |
| DISTANCE( DANSHA)            | 216.0000 | 0.000000     |
| DISTANCE( ENDABA_GUNA)       | 297.0000 | 0.000000     |
| DISTANCE( AGULAE)            | 150.0000 | 0.000000     |
| DISTANCE( NEBELET)           | 355.0000 | 0.000000     |
| DISTANCE( YECHILAY)          | 195.0000 | 0.000000     |
| DISTANCE( ADI_HAGEREY)       | 464.0000 | 0.000000     |
| DISTANCE( BIZET)             | 281.0000 | 0.000000     |
| DISTANCE( CHERCHER)          | 50.00000 | 0.000000     |
| COST( MEKELLE, WUKIRO)       | 686.0000 | 0.000000     |
| COST( MEKELLE, HUMERA)       | 7341.000 | 0.000000     |
| COST( MEKELLE, KOREM)        | 2418.000 | 0.000000     |
| COST( MEKELLE, SHIRARO)      | 4894.000 | 0.000000     |
| COST( MEKELLE, ADISHIHU)     | 6359.000 | 0.000000     |
| COST( MEKELLE, GIJET)        | 8729.000 | 0.000000     |
| COST( MEKELLE, ALAJE)        | 1058.000 | 0.000000     |
| COST( MEKELLE, ADI_GUEM)     | 586.0000 | 0.000000     |
| COST( MEKELLE, FREWEYNI)     | 1173.000 | 0.000000     |
| COST( MEKELLE, EDAGA_HAMUS)  | 1402.000 | 0.000000     |
| COST( MEKELLE, DANSHA)       | 8729.000 | 0.000000     |
| COST( MEKELLE, ENDABA_GUNA)  | 3906.000 | 0.000000     |
| COST( MEKELLE, AGULAE)       | 543.0000 | 0.000000     |
| COST( MEKELLE, NEBELET)      | 1917.000 | 0.000000     |
| COST( MEKELLE, YECHILAY)     | 1560.000 | 0.000000     |
| COST( MEKELLE, ADI_HAGEREY)  | 4507.000 | 0.000000     |
| COST( MEKELLE, BIZET)        | 2404.000 | 0.000000     |
| COST( MEKELLE, CHERCHER)     | 3763.000 | 0.000000     |
| COST( ADI_GRAT, WUKIRO)      | 1016.000 | 0.000000     |
| COST( ADI_GRAT, HUMERA)      | 7556.000 | 0.000000     |
| COST( ADI_GRAT, KOREM)       | 2876.000 | 0.000000     |
| COST( ADI_GRAT, SHIRARO)     | 5094.000 | 0.000000     |
| COST( ADI_GRAT, ADISHIHU)    | 1720.000 | 0.000000     |
| COST( ADI_GRAT, GIJET)       | 1588.000 | 0.000000     |
| COST( ADI_GRAT, ALAJE)       | 1531.000 | 0.000000     |
| COST( ADI_GRAT, ADI_GUEM)    | 1045.000 | 0.000000     |
| COST( ADI_GRAT, FREWEYNI)    | 500.0000 | 0.000000     |
| COST( ADI_GRAT, EDAGA_HAMUS) | 744.0000 | 0.000000     |
| COST( ADI_GRAT, DANSHA)      | 8929.000 | 0.000000     |
| COST( ADI_GRAT, ENDABA_GUNA) | 3033.000 | 0.000000     |
| COST( ADI_GRAT, AGULAE)      | 171.0000 | 0.000000     |

## Developing a Reverse Logistics Model for Raya Brewery

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|                              |          |          |
|------------------------------|----------|----------|
| COST( ADI_GRAT, NEBELET)     | 1245.000 | 0.000000 |
| COST( ADI_GRAT, YECHILAY)    | 2290.000 | 0.000000 |
| COST( ADI_GRAT, ADI_HAGEREY) | 4708.000 | 0.000000 |
| COST( ADI_GRAT, BIZET)       | 1732.000 | 0.000000 |
| COST( ADI_GRAT, CHERCHER)    | 4236.000 | 0.000000 |
| COST( SHIRE, WUKIRO)         | 3735.000 | 0.000000 |
| COST( SHIRE, HUMERA)         | 3806.000 | 0.000000 |
| COST( SHIRE, KOREM)          | 5996.000 | 0.000000 |
| COST( SHIRE, SHIRARO)        | 1360.000 | 0.000000 |
| COST( SHIRE, ADISHIHU)       | 5123.000 | 0.000000 |
| COST( SHIRE, GIJET)          | 3563.000 | 0.000000 |
| COST( SHIRE, ALAJE)          | 4894.000 | 0.000000 |
| COST( SHIRE, ADI_GUEDEM)     | 4421.000 | 0.000000 |
| COST( SHIRE, FREWEYNI)       | 3480.000 | 0.000000 |
| COST( SHIRE, EDAGA_HAMUS)    | 2990.000 | 0.000000 |
| COST( SHIRE, DANSHA)         | 5195.000 | 0.000000 |
| COST( SHIRE, ENDABA_GUNA)    | 329.0000 | 0.000000 |
| COST( SHIRE, AGULAE)         | 3978.000 | 0.000000 |
| COST( SHIRE, NEBELET)        | 2318.000 | 0.000000 |
| COST( SHIRE, YECHILAY)       | 3220.000 | 0.000000 |
| COST( SHIRE, ADI_HAGEREY)    | 973.0000 | 0.000000 |
| COST( SHIRE, BIZET)          | 2218.000 | 0.000000 |
| COST( SHIRE, CHERCHER)       | 7584.000 | 0.000000 |
| COST( AKSUM, WUKIRO)         | 2819.000 | 0.000000 |
| COST( AKSUM, HUMERA)         | 4780.000 | 0.000000 |
| COST( AKSUM, KOREM)          | 5080.000 | 0.000000 |
| COST( AKSUM, SHIRARO)        | 2318.000 | 0.000000 |
| COST( AKSUM, ADISHIHU)       | 4207.000 | 0.000000 |
| COST( AKSUM, GIJET)          | 2576.000 | 0.000000 |
| COST( AKSUM, ALAJE)          | 3978.000 | 0.000000 |
| COST( AKSUM, ADI_GUEDEM)     | 3506.000 | 0.000000 |
| COST( AKSUM, FREWEYNI)       | 2333.000 | 0.000000 |
| COST( AKSUM, EDAGA_HAMUS)    | 2089.000 | 0.000000 |
| COST( AKSUM, DANSHA)         | 6153.000 | 0.000000 |
| COST( AKSUM, ENDABA_GUNA)    | 1288.000 | 0.000000 |
| COST( AKSUM, AGULAE)         | 2976.000 | 0.000000 |
| COST( AKSUM, NEBELET)        | 1402.000 | 0.000000 |
| COST( AKSUM, YECHILAY)       | 2304.000 | 0.000000 |
| COST( AKSUM, ADI_HAGEREY)    | 1130.000 | 0.000000 |
| COST( AKSUM, BIZET)          | 1402.000 | 0.000000 |
| COST( AKSUM, CHERCHER)       | 6680.000 | 0.000000 |
| COST( ADWA, WUKIRO)          | 2547.000 | 0.000000 |
| COST( ADWA, HUMERA)          | 5008.000 | 0.000000 |
| COST( ADWA, KOREM)           | 4808.000 | 0.000000 |
| COST( ADWA, SHIRARO)         | 2561.000 | 0.000000 |
| COST( ADWA, ADISHIHU)        | 3935.000 | 0.000000 |
| COST( ADWA, GIJET)           | 2375.000 | 0.000000 |
| COST( ADWA, ALAJE)           | 3706.000 | 0.000000 |
| COST( ADWA, ADI_GUEDEM)      | 3234.000 | 0.000000 |
| COST( ADWA, FREWEYNI)        | 2060.000 | 0.000000 |
| COST( ADWA, EDAGA_HAMUS)     | 1817.000 | 0.000000 |
| COST( ADWA, DANSHA)          | 6397.000 | 0.000000 |
| COST( ADWA, ENDABA_GUNA)     | 1517.000 | 0.000000 |
| COST( ADWA, AGULAE)          | 2705.000 | 0.000000 |
| COST( ADWA, NEBELET)         | 1130.000 | 0.000000 |
| COST( ADWA, YECHILAY)        | 2032.000 | 0.000000 |
| COST( ADWA, ADI_HAGEREY)     | 2175.000 | 0.000000 |
| COST( ADWA, BIZET)           | 1030.000 | 0.000000 |
| COST( ADWA, CHERCHER)        | 6397.000 | 0.000000 |
| COST( ALAMATA, WUKIRO)       | 3162.000 | 0.000000 |
| COST( ALAMATA, HUMERA)       | 10088.00 | 0.000000 |
| COST( ALAMATA, KOREM)        | 286.0000 | 0.000000 |
| COST( ALAMATA, SHIRARO)      | 7642.000 | 0.000000 |
| COST( ALAMATA, ADISHIHU)     | 1417.000 | 0.000000 |
| COST( ALAMATA, GIJET)        | 2962.000 | 0.000000 |
| COST( ALAMATA, ALAJE)        | 1331.000 | 0.000000 |
| COST( ALAMATA, ADI_GUEDEM)   | 3132.000 | 0.000000 |
| COST( ALAMATA, FREWEYNI)     | 3219.000 | 0.000000 |
| COST( ALAMATA, EDAGA_HAMUS)  | 3892.000 | 0.000000 |
| COST( ALAMATA, DANSHA)       | 9101.000 | 0.000000 |
| COST( ALAMATA, ENDABA_GUNA)  | 6582.000 | 0.000000 |

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|                              |          |          |
|------------------------------|----------|----------|
| COST( ALAMATA, AGULAE)       | 3019.000 | 0.000000 |
| COST( ALAMATA, NEBELET)      | 4393.000 | 0.000000 |
| COST( ALAMATA, YECHILAY)     | 3048.000 | 0.000000 |
| COST( ALAMATA, ADI_HAGEREY)  | 7240.000 | 0.000000 |
| COST( ALAMATA, BIZET)        | 4880.000 | 0.000000 |
| COST( ALAMATA, CHERCHER)     | 1330.000 | 0.000000 |
| COST( MAYCHEW, WUKIRO)       | 2290.000 | 0.000000 |
| COST( MAYCHEW, HUMERA)       | 9487.000 | 0.000000 |
| COST( MAYCHEW, KOREM)        | 6010.000 | 0.000000 |
| COST( MAYCHEW, SHIRARO)      | 7026.000 | 0.000000 |
| COST( MAYCHEW, ADISHIHU)     | 543.0000 | 0.000000 |
| COST( MAYCHEW, GIJET)        | 9960.000 | 0.000000 |
| COST( MAYCHEW, ALAJE)        | 2103.000 | 0.000000 |
| COST( MAYCHEW, ADI_GUDEM)    | 1261.000 | 0.000000 |
| COST( MAYCHEW, FREWEYNI)     | 2790.000 | 0.000000 |
| COST( MAYCHEW, EDAGA_HAMUS)  | 3005.000 | 0.000000 |
| COST( MAYCHEW, DANSHA)       | 9960.000 | 0.000000 |
| COST( MAYCHEW, ENDABA_GUNA)  | 5981.000 | 0.000000 |
| COST( MAYCHEW, AGULAE)       | 2147.000 | 0.000000 |
| COST( MAYCHEW, NEBELET)      | 3520.000 | 0.000000 |
| COST( MAYCHEW, YECHILAY)     | 2790.000 | 0.000000 |
| COST( MAYCHEW, ADI_HAGEREY)  | 6640.000 | 0.000000 |
| COST( MAYCHEW, BIZET)        | 4021.000 | 0.000000 |
| COST( MAYCHEW, CHERCHER)     | 958.0000 | 0.000000 |
| COST( ABIY_ADI, WUKIRO)      | 1989.000 | 0.000000 |
| COST( ABIY_ADI, HUMERA)      | 6353.000 | 0.000000 |
| COST( ABIY_ADI, KOREM)       | 3463.000 | 0.000000 |
| COST( ABIY_ADI, SHIRARO)     | 3892.000 | 0.000000 |
| COST( ABIY_ADI, ADISHIHU)    | 2604.000 | 0.000000 |
| COST( ABIY_ADI, GIJET)       | 1044.000 | 0.000000 |
| COST( ABIY_ADI, ALAJE)       | 2375.000 | 0.000000 |
| COST( ABIY_ADI, ADI_GUDEM)   | 1889.000 | 0.000000 |
| COST( ABIY_ADI, FREWEYNI)    | 1488.000 | 0.000000 |
| COST( ABIY_ADI, EDAGA_HAMUS) | 1745.000 | 0.000000 |
| COST( ABIY_ADI, DANSHA)      | 7727.000 | 0.000000 |
| COST( ABIY_ADI, ENDABA_GUNA) | 2848.000 | 0.000000 |
| COST( ABIY_ADI, AGULAE)      | 2147.000 | 0.000000 |
| COST( ABIY_ADI, NEBELET)     | 1474.000 | 0.000000 |
| COST( ABIY_ADI, YECHILAY)    | 701.0000 | 0.000000 |
| COST( ABIY_ADI, ADI_HAGEREY) | 3506.000 | 0.000000 |
| COST( ABIY_ADI, BIZET)       | 2332.000 | 0.000000 |
| COST( ABIY_ADI, CHERCHER)    | 5066.000 | 0.000000 |
| COST( MOHONI, WUKIRO)        | 2290.000 | 0.000000 |
| COST( MOHONI, HUMERA)        | 9459.000 | 0.000000 |
| COST( MOHONI, KOREM)         | 830.0000 | 0.000000 |
| COST( MOHONI, SHIRARO)       | 7011.000 | 0.000000 |
| COST( MOHONI, ADISHIHU)      | 773.0000 | 0.000000 |
| COST( MOHONI, GIJET)         | 2089.000 | 0.000000 |
| COST( MOHONI, ALAJE)         | 1001.000 | 0.000000 |
| COST( MOHONI, ADI_GUDEM)     | 1259.000 | 0.000000 |
| COST( MOHONI, FREWEYNI)      | 2776.000 | 0.000000 |
| COST( MOHONI, EDAGA_HAMUS)   | 3019.000 | 0.000000 |
| COST( MOHONI, DANSHA)        | 9630.000 | 0.000000 |
| COST( MOHONI, ENDABA_GUNA)   | 5967.000 | 0.000000 |
| COST( MOHONI, AGULAE)        | 2147.000 | 0.000000 |
| COST( MOHONI, NEBELET)       | 3520.000 | 0.000000 |
| COST( MOHONI, YECHILAY)      | 2776.000 | 0.000000 |
| COST( MOHONI, ADI_HAGEREY)   | 6626.000 | 0.000000 |
| COST( MOHONI, BIZET)         | 4021.000 | 0.000000 |
| COST( MOHONI, CHERCHER)      | 716.0000 | 0.000000 |
| COST( HAWUZEN, WUKIRO)       | 816.0000 | 0.000000 |
| COST( HAWUZEN, HUMERA)       | 8228.000 | 0.000000 |
| COST( HAWUZEN, KOREM)        | 3606.000 | 0.000000 |
| COST( HAWUZEN, SHIRARO)      | 4922.000 | 0.000000 |
| COST( HAWUZEN, ADISHIHU)     | 2547.000 | 0.000000 |
| COST( HAWUZEN, GIJET)        | 2390.000 | 0.000000 |
| COST( HAWUZEN, ALAJE)        | 2318.000 | 0.000000 |
| COST( HAWUZEN, ADI_GUDEM)    | 1846.000 | 0.000000 |
| COST( HAWUZEN, FREWEYNI)     | 315.0000 | 0.000000 |
| COST( HAWUZEN, EDAGA_HAMUS)  | 558.0000 | 0.000000 |
| COST( HAWUZEN, DANSHA)       | 8757.000 | 0.000000 |

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|                                  |          |          |
|----------------------------------|----------|----------|
| COST( HAWUZEN, ENDABA_GUNA)      | 3878.000 | 0.000000 |
| COST( HAWUZEN, AGULAE)           | 973.0000 | 0.000000 |
| COST( HAWUZEN, NEBELET)          | 429.0000 | 0.000000 |
| COST( HAWUZEN, YECHILAY)         | 1875.000 | 0.000000 |
| COST( HAWUZEN, ADI_HAGEREY)      | 4536.000 | 0.000000 |
| COST( HAWUZEN, BIZET)            | 1560.000 | 0.000000 |
| COST( HAWUZEN, CHERCHER)         | 4393.000 | 0.000000 |
| COST( ENTICHO, WUKIRO)           | 1960.000 | 0.000000 |
| COST( ENTICHO, HUMERA)           | 5595.000 | 0.000000 |
| COST( ENTICHO, KOREM)            | 4837.000 | 0.000000 |
| COST( ENTICHO, SHIRARO)          | 3134.000 | 0.000000 |
| COST( ENTICHO, ADISHIHU)         | 3706.000 | 0.000000 |
| COST( ENTICHO, GIJET)            | 2919.000 | 0.000000 |
| COST( ENTICHO, ALAJE)            | 3477.000 | 0.000000 |
| COST( ENTICHO, ADI_GUDEM)        | 3005.000 | 0.000000 |
| COST( ENTICHO, FREWEYNI)         | 1474.000 | 0.000000 |
| COST( ENTICHO, EDAGA_HAMUS)      | 1231.000 | 0.000000 |
| COST( ENTICHO, DANSHA)           | 6969.000 | 0.000000 |
| COST( ENTICHO, ENDABA_GUNA)      | 2089.000 | 0.000000 |
| COST( ENTICHO, AGULAE)           | 2132.000 | 0.000000 |
| COST( ENTICHO, NEBELET)          | 1674.000 | 0.000000 |
| COST( ENTICHO, YECHILAY)         | 2576.000 | 0.000000 |
| COST( ENTICHO, ADI_HAGEREY)      | 2748.000 | 0.000000 |
| COST( ENTICHO, BIZET)            | 456.0000 | 0.000000 |
| COST( ENTICHO, CHERCHER)         | 5538.000 | 0.000000 |
| COST( HAGERE_SELAM, WUKIRO)      | 1245.000 | 0.000000 |
| COST( HAGERE_SELAM, HUMERA)      | 6583.000 | 0.000000 |
| COST( HAGERE_SELAM, KOREM)       | 3663.000 | 0.000000 |
| COST( HAGERE_SELAM, SHIRARO)     | 4121.000 | 0.000000 |
| COST( HAGERE_SELAM, ADISHIHU)    | 2075.000 | 0.000000 |
| COST( HAGERE_SELAM, GIJET)       | 1245.000 | 0.000000 |
| COST( HAGERE_SELAM, ALAJE)       | 1846.000 | 0.000000 |
| COST( HAGERE_SELAM, ADI_GUDEM)   | 1359.000 | 0.000000 |
| COST( HAGERE_SELAM, FREWEYNI)    | 1731.000 | 0.000000 |
| COST( HAGERE_SELAM, EDAGA_HAMUS) | 1975.000 | 0.000000 |
| COST( HAGERE_SELAM, DANSHA)      | 7956.000 | 0.000000 |
| COST( HAGERE_SELAM, ENDABA_GUNA) | 3077.000 | 0.000000 |
| COST( HAGERE_SELAM, AGULAE)      | 1088.000 | 0.000000 |
| COST( HAGERE_SELAM, NEBELET)     | 1717.000 | 0.000000 |
| COST( HAGERE_SELAM, YECHILAY)    | 901.0000 | 0.000000 |
| COST( HAGERE_SELAM, ADI_HAGEREY) | 3735.000 | 0.000000 |
| COST( HAGERE_SELAM, BIZET)       | 2576.000 | 0.000000 |
| COST( HAGERE_SELAM, CHERCHER)    | 4557.000 | 0.000000 |
| COST( RAMA, WUKIRO)              | 3077.000 | 0.000000 |
| COST( RAMA, HUMERA)              | 5509.000 | 0.000000 |
| COST( RAMA, KOREM)               | 5338.000 | 0.000000 |
| COST( RAMA, SHIRARO)             | 3048.000 | 0.000000 |
| COST( RAMA, ADISHIHU)            | 4465.000 | 0.000000 |
| COST( RAMA, GIJET)               | 2919.000 | 0.000000 |
| COST( RAMA, ALAJE)               | 4236.000 | 0.000000 |
| COST( RAMA, ADI_GUDEM)           | 3764.000 | 0.000000 |
| COST( RAMA, FREWEYNI)            | 2590.000 | 0.000000 |
| COST( RAMA, EDAGA_HAMUS)         | 2347.000 | 0.000000 |
| COST( RAMA, DANSHA)              | 6883.000 | 0.000000 |
| COST( RAMA, ENDABA_GUNA)         | 2003.000 | 0.000000 |
| COST( RAMA, AGULAE)              | 3234.000 | 0.000000 |
| COST( RAMA, NEBELET)             | 1660.000 | 0.000000 |
| COST( RAMA, YECHILAY)            | 2561.000 | 0.000000 |
| COST( RAMA, ADI_HAGEREY)         | 2662.000 | 0.000000 |
| COST( RAMA, BIZET)               | 1560.000 | 0.000000 |
| COST( RAMA, CHERCHER)            | 6940.000 | 0.000000 |
| COST( SELEKILEKA, WUKIRO)        | 3320.000 | 0.000000 |
| COST( SELEKILEKA, HUMERA)        | 4250.000 | 0.000000 |
| COST( SELEKILEKA, KOREM)         | 5567.000 | 0.000000 |
| COST( SELEKILEKA, SHIRARO)       | 1803.000 | 0.000000 |
| COST( SELEKILEKA, ADISHIHU)      | 4684.000 | 0.000000 |
| COST( SELEKILEKA, GIJET)         | 3134.000 | 0.000000 |
| COST( SELEKILEKA, ALAJE)         | 4464.000 | 0.000000 |
| COST( SELEKILEKA, ADI_GUDEM)     | 1130.000 | 0.000000 |
| COST( SELEKILEKA, FREWEYNI)      | 2833.000 | 0.000000 |
| COST( SELEKILEKA, EDAGA_HAMUS)   | 2576.000 | 0.000000 |

## Developing a Reverse Logistics Model for Raya Brewery

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| COST( SELEKILEKA, DANSHA)       | 5638.000 | 0.000000 |
| COST( SELEKILEKA, ENDABA_GUNA)  | 7584.000 | 0.000000 |
| COST( SELEKILEKA, AGULAE)       | 3477.000 | 0.000000 |
| COST( SELEKILEKA, NEBELET)      | 1889.000 | 0.000000 |
| COST( SELEKILEKA, YECHILAY)     | 2790.000 | 0.000000 |
| COST( SELEKILEKA, ADI HAGEREY)  | 1417.000 | 0.000000 |
| COST( SELEKILEKA, BIZET)        | 1803.000 | 0.000000 |
| COST( SELEKILEKA, CHERCHER)     | 7155.000 | 0.000000 |
| COST( WERKAMBA, WUKIRO)         | 1746.000 | 0.000000 |
| COST( WERKAMBA, HUMERA)         | 6110.000 | 0.000000 |
| COST( WERKAMBA, KOREM)          | 3706.000 | 0.000000 |
| COST( WERKAMBA, SHIRARO)        | 3663.000 | 0.000000 |
| COST( WERKAMBA, ADISHIHU)       | 2848.000 | 0.000000 |
| COST( WERKAMBA, GIJET)          | 1288.000 | 0.000000 |
| COST( WERKAMBA, ALAJE)          | 2619.000 | 0.000000 |
| COST( WERKAMBA, ADI GUDEM)      | 2132.000 | 0.000000 |
| COST( WERKAMBA, FREWEYNI)       | 1245.000 | 0.000000 |
| COST( WERKAMBA, EDAGA_HAMUS)    | 1474.000 | 0.000000 |
| COST( WERKAMBA, DANSHA)         | 7498.000 | 0.000000 |
| COST( WERKAMBA, ENDABA_GUNA)    | 2619.000 | 0.000000 |
| COST( WERKAMBA, AGULAE)         | 1560.000 | 0.000000 |
| COST( WERKAMBA, NEBELET)        | 1145.000 | 0.000000 |
| COST( WERKAMBA, YECHILAY)       | 945.0000 | 0.000000 |
| COST( WERKAMBA, ADI HAGEREY)    | 3263.000 | 0.000000 |
| COST( WERKAMBA, BIZET)          | 2118.000 | 0.000000 |
| COST( WERKAMBA, CHERCHER)       | 5309.000 | 0.000000 |
| COST( WKIRO_MARAY, WUKIRO)      | 3077.000 | 0.000000 |
| COST( WKIRO_MARAY, HUMERA)      | 4479.000 | 0.000000 |
| COST( WKIRO_MARAY, KOREM)       | 5323.000 | 0.000000 |
| COST( WKIRO_MARAY, SHIRARO)     | 2018.000 | 0.000000 |
| COST( WKIRO_MARAY, ADISHIHU)    | 4450.000 | 0.000000 |
| COST( WKIRO_MARAY, GIJET)       | 2890.000 | 0.000000 |
| COST( WKIRO_MARAY, ALAJE)       | 4221.000 | 0.000000 |
| COST( WKIRO_MARAY, ADI GUDEM)   | 3749.000 | 0.000000 |
| COST( WKIRO_MARAY, FREWEYNI)    | 2590.000 | 0.000000 |
| COST( WKIRO_MARAY, EDAGA_HAMUS) | 2332.000 | 0.000000 |
| COST( WKIRO_MARAY, DANSHA)      | 5853.000 | 0.000000 |
| COST( WKIRO_MARAY, ENDABA_GUNA) | 987.0000 | 0.000000 |
| COST( WKIRO_MARAY, AGULAE)      | 3234.000 | 0.000000 |
| COST( WKIRO_MARAY, NEBELET)     | 1646.000 | 0.000000 |
| COST( WKIRO_MARAY, YECHILAY)    | 2547.000 | 0.000000 |
| COST( WKIRO_MARAY, ADI HAGEREY) | 1631.000 | 0.000000 |
| COST( WKIRO_MARAY, BIZET)       | 1560.000 | 0.000000 |
| COST( WKIRO_MARAY, CHERCHER)    | 6912.000 | 0.000000 |
| AMOUNT( MEKELLE, WUKIRO)        | 160.0000 | 0.000000 |
| AMOUNT( MEKELLE, HUMERA)        | 0.000000 | 3535.000 |
| AMOUNT( MEKELLE, KOREM)         | 0.000000 | 2132.000 |
| AMOUNT( MEKELLE, SHIRARO)       | 0.000000 | 3534.000 |
| AMOUNT( MEKELLE, ADISHIHU)      | 0.000000 | 5816.000 |
| AMOUNT( MEKELLE, GIJET)         | 0.000000 | 7685.000 |
| AMOUNT( MEKELLE, ALAJE)         | 0.000000 | 57.00000 |
| AMOUNT( MEKELLE, ADI GUDEM)     | 88.00000 | 0.000000 |
| AMOUNT( MEKELLE, FREWEYNI)      | 0.000000 | 858.0000 |
| AMOUNT( MEKELLE, EDAGA_HAMUS)   | 0.000000 | 844.0000 |
| AMOUNT( MEKELLE, DANSHA)        | 0.000000 | 3534.000 |
| AMOUNT( MEKELLE, ENDABA_GUNA)   | 0.000000 | 3577.000 |
| AMOUNT( MEKELLE, AGULAE)        | 0.000000 | 372.0000 |
| AMOUNT( MEKELLE, NEBELET)       | 0.000000 | 1488.000 |
| AMOUNT( MEKELLE, YECHILAY)      | 0.000000 | 859.0000 |
| AMOUNT( MEKELLE, ADI HAGEREY)   | 0.000000 | 3534.000 |
| AMOUNT( MEKELLE, BIZET)         | 0.000000 | 1948.000 |
| AMOUNT( MEKELLE, CHERCHER)      | 0.000000 | 3047.000 |
| AMOUNT( ADI_GRAT, WUKIRO)       | 0.000000 | 330.0000 |
| AMOUNT( ADI_GRAT, HUMERA)       | 0.000000 | 3750.000 |
| AMOUNT( ADI_GRAT, KOREM)        | 0.000000 | 2590.000 |
| AMOUNT( ADI_GRAT, SHIRARO)      | 0.000000 | 3734.000 |
| AMOUNT( ADI_GRAT, ADISHIHU)     | 0.000000 | 1177.000 |
| AMOUNT( ADI_GRAT, GIJET)        | 0.000000 | 544.0000 |
| AMOUNT( ADI_GRAT, ALAJE)        | 0.000000 | 530.0000 |
| AMOUNT( ADI_GRAT, ADI GUDEM)    | 0.000000 | 459.0000 |
| AMOUNT( ADI_GRAT, FREWEYNI)     | 0.000000 | 185.0000 |

## Developing a Reverse Logistics Model for Raya Brewery

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| AMOUNT( ADI_GRAT, EDAGA_HAMUS) | 0.000000 | 186.0000 |
| AMOUNT( ADI_GRAT, DANSHA)      | 0.000000 | 3734.000 |
| AMOUNT( ADI_GRAT, ENDABA_GUNA) | 0.000000 | 2704.000 |
| AMOUNT( ADI_GRAT, AGULAE)      | 150.0000 | 0.000000 |
| AMOUNT( ADI_GRAT, NEBELET)     | 0.000000 | 816.0000 |
| AMOUNT( ADI_GRAT, YECHILAY)    | 0.000000 | 1589.000 |
| AMOUNT( ADI_GRAT, ADI_HAGEREY) | 0.000000 | 3735.000 |
| AMOUNT( ADI_GRAT, BIZET)       | 0.000000 | 1276.000 |
| AMOUNT( ADI_GRAT, CHERCHER)    | 0.000000 | 3520.000 |
| AMOUNT( SHIRE, WUKIRO)         | 0.000000 | 3049.000 |
| AMOUNT( SHIRE, HUMERA)         | 663.0000 | 0.000000 |
| AMOUNT( SHIRE, KOREM)          | 0.000000 | 5710.000 |
| AMOUNT( SHIRE, SHIRARO)        | 491.0000 | 0.000000 |
| AMOUNT( SHIRE, ADISHIHU)       | 0.000000 | 4580.000 |
| AMOUNT( SHIRE, GIJET)          | 0.000000 | 2519.000 |
| AMOUNT( SHIRE, ALAJE)          | 0.000000 | 3893.000 |
| AMOUNT( SHIRE, ADI_GUEDEM)     | 0.000000 | 3835.000 |
| AMOUNT( SHIRE, FREWEYNI)       | 0.000000 | 3165.000 |
| AMOUNT( SHIRE, EDAGA_HAMUS)    | 0.000000 | 2432.000 |
| AMOUNT( SHIRE, DANSHA)         | 216.0000 | 0.000000 |
| AMOUNT( SHIRE, ENDABA_GUNA)    | 297.0000 | 0.000000 |
| AMOUNT( SHIRE, AGULAE)         | 0.000000 | 3807.000 |
| AMOUNT( SHIRE, NEBELET)        | 0.000000 | 1889.000 |
| AMOUNT( SHIRE, YECHILAY)       | 0.000000 | 2519.000 |
| AMOUNT( SHIRE, ADI_HAGEREY)    | 464.0000 | 0.000000 |
| AMOUNT( SHIRE, BIZET)          | 0.000000 | 1762.000 |
| AMOUNT( SHIRE, CHERCHER)       | 0.000000 | 6868.000 |
| AMOUNT( AKSUM, WUKIRO)         | 0.000000 | 2133.000 |
| AMOUNT( AKSUM, HUMERA)         | 0.000000 | 974.0000 |
| AMOUNT( AKSUM, KOREM)          | 0.000000 | 4794.000 |
| AMOUNT( AKSUM, SHIRARO)        | 0.000000 | 958.0000 |
| AMOUNT( AKSUM, ADISHIHU)       | 0.000000 | 3664.000 |
| AMOUNT( AKSUM, GIJET)          | 0.000000 | 1532.000 |
| AMOUNT( AKSUM, ALAJE)          | 0.000000 | 2977.000 |
| AMOUNT( AKSUM, ADI_GUEDEM)     | 0.000000 | 2920.000 |
| AMOUNT( AKSUM, FREWEYNI)       | 0.000000 | 2018.000 |
| AMOUNT( AKSUM, EDAGA_HAMUS)    | 0.000000 | 1531.000 |
| AMOUNT( AKSUM, DANSHA)         | 0.000000 | 958.0000 |
| AMOUNT( AKSUM, ENDABA_GUNA)    | 0.000000 | 959.0000 |
| AMOUNT( AKSUM, AGULAE)         | 0.000000 | 2805.000 |
| AMOUNT( AKSUM, NEBELET)        | 0.000000 | 973.0000 |
| AMOUNT( AKSUM, YECHILAY)       | 0.000000 | 1603.000 |
| AMOUNT( AKSUM, ADI_HAGEREY)    | 0.000000 | 157.0000 |
| AMOUNT( AKSUM, BIZET)          | 0.000000 | 946.0000 |
| AMOUNT( AKSUM, CHERCHER)       | 0.000000 | 5964.000 |
| AMOUNT( ADWA, WUKIRO)          | 0.000000 | 1861.000 |
| AMOUNT( ADWA, HUMERA)          | 0.000000 | 1202.000 |
| AMOUNT( ADWA, KOREM)           | 0.000000 | 4522.000 |
| AMOUNT( ADWA, SHIRARO)         | 0.000000 | 1201.000 |
| AMOUNT( ADWA, ADISHIHU)        | 0.000000 | 3392.000 |
| AMOUNT( ADWA, GIJET)           | 0.000000 | 1331.000 |
| AMOUNT( ADWA, ALAJE)           | 0.000000 | 2705.000 |
| AMOUNT( ADWA, ADI_GUEDEM)      | 0.000000 | 2648.000 |
| AMOUNT( ADWA, FREWEYNI)        | 0.000000 | 1745.000 |
| AMOUNT( ADWA, EDAGA_HAMUS)     | 0.000000 | 1259.000 |
| AMOUNT( ADWA, DANSHA)          | 0.000000 | 1202.000 |
| AMOUNT( ADWA, ENDABA_GUNA)     | 0.000000 | 1188.000 |
| AMOUNT( ADWA, AGULAE)          | 0.000000 | 2534.000 |
| AMOUNT( ADWA, NEBELET)         | 0.000000 | 701.0000 |
| AMOUNT( ADWA, YECHILAY)        | 0.000000 | 1331.000 |
| AMOUNT( ADWA, ADI_HAGEREY)     | 0.000000 | 1202.000 |
| AMOUNT( ADWA, BIZET)           | 0.000000 | 574.0000 |
| AMOUNT( ADWA, CHERCHER)        | 0.000000 | 5681.000 |
| AMOUNT( ALAMATA, WUKIRO)       | 0.000000 | 2476.000 |
| AMOUNT( ALAMATA, HUMERA)       | 0.000000 | 6282.000 |
| AMOUNT( ALAMATA, KOREM)        | 42.00000 | 0.000000 |
| AMOUNT( ALAMATA, SHIRARO)      | 0.000000 | 6282.000 |
| AMOUNT( ALAMATA, ADISHIHU)     | 0.000000 | 874.0000 |
| AMOUNT( ALAMATA, GIJET)        | 0.000000 | 1918.000 |
| AMOUNT( ALAMATA, ALAJE)        | 0.000000 | 330.0000 |
| AMOUNT( ALAMATA, ADI_GUEDEM)   | 0.000000 | 2546.000 |

## Developing a Reverse Logistics Model for Raya Brewery

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| AMOUNT ( ALAMATA, FREWEYNI)     | 0.000000 | 2904.000 |
| AMOUNT ( ALAMATA, EDAGA_HAMUS)  | 0.000000 | 3334.000 |
| AMOUNT ( ALAMATA, DANSHA)       | 0.000000 | 3906.000 |
| AMOUNT ( ALAMATA, ENDABA_GUNA)  | 0.000000 | 6253.000 |
| AMOUNT ( ALAMATA, AGULAE)       | 0.000000 | 2848.000 |
| AMOUNT ( ALAMATA, NEBELET)      | 0.000000 | 3964.000 |
| AMOUNT ( ALAMATA, YECHILAY)     | 0.000000 | 2347.000 |
| AMOUNT ( ALAMATA, ADI_HAGEREY)  | 0.000000 | 6267.000 |
| AMOUNT ( ALAMATA, BIZET)        | 0.000000 | 4424.000 |
| AMOUNT ( ALAMATA, CHERCHER)     | 0.000000 | 614.0000 |
| AMOUNT ( MAYCHEW, WUKIRO)       | 0.000000 | 1604.000 |
| AMOUNT ( MAYCHEW, HUMERA)       | 0.000000 | 5681.000 |
| AMOUNT ( MAYCHEW, KOREM)        | 0.000000 | 5724.000 |
| AMOUNT ( MAYCHEW, SHIRARO)      | 0.000000 | 5666.000 |
| AMOUNT ( MAYCHEW, ADISHIHU)     | 38.00000 | 0.000000 |
| AMOUNT ( MAYCHEW, GIJET)        | 0.000000 | 8916.000 |
| AMOUNT ( MAYCHEW, ALAJE)        | 0.000000 | 1102.000 |
| AMOUNT ( MAYCHEW, ADI_GUEM)     | 0.000000 | 675.0000 |
| AMOUNT ( MAYCHEW, FREWEYNI)     | 0.000000 | 2475.000 |
| AMOUNT ( MAYCHEW, EDAGA_HAMUS)  | 0.000000 | 2447.000 |
| AMOUNT ( MAYCHEW, DANSHA)       | 0.000000 | 4765.000 |
| AMOUNT ( MAYCHEW, ENDABA_GUNA)  | 0.000000 | 5652.000 |
| AMOUNT ( MAYCHEW, AGULAE)       | 0.000000 | 1976.000 |
| AMOUNT ( MAYCHEW, NEBELET)      | 0.000000 | 3091.000 |
| AMOUNT ( MAYCHEW, YECHILAY)     | 0.000000 | 2089.000 |
| AMOUNT ( MAYCHEW, ADI_HAGEREY)  | 0.000000 | 5667.000 |
| AMOUNT ( MAYCHEW, BIZET)        | 0.000000 | 3565.000 |
| AMOUNT ( MAYCHEW, CHERCHER)     | 0.000000 | 242.0000 |
| AMOUNT ( ABIY_ADI, WUKIRO)      | 0.000000 | 1303.000 |
| AMOUNT ( ABIY_ADI, HUMERA)      | 0.000000 | 2547.000 |
| AMOUNT ( ABIY_ADI, KOREM)       | 0.000000 | 3177.000 |
| AMOUNT ( ABIY_ADI, SHIRARO)     | 0.000000 | 2532.000 |
| AMOUNT ( ABIY_ADI, ADISHIHU)    | 0.000000 | 2061.000 |
| AMOUNT ( ABIY_ADI, GIJET)       | 147.0000 | 0.000000 |
| AMOUNT ( ABIY_ADI, ALAJE)       | 0.000000 | 1374.000 |
| AMOUNT ( ABIY_ADI, ADI_GUEM)    | 0.000000 | 1303.000 |
| AMOUNT ( ABIY_ADI, FREWEYNI)    | 0.000000 | 1173.000 |
| AMOUNT ( ABIY_ADI, EDAGA_HAMUS) | 0.000000 | 1187.000 |
| AMOUNT ( ABIY_ADI, DANSHA)      | 0.000000 | 2532.000 |
| AMOUNT ( ABIY_ADI, ENDABA_GUNA) | 0.000000 | 2519.000 |
| AMOUNT ( ABIY_ADI, AGULAE)      | 0.000000 | 1976.000 |
| AMOUNT ( ABIY_ADI, NEBELET)     | 0.000000 | 1045.000 |
| AMOUNT ( ABIY_ADI, YECHILAY)    | 195.0000 | 0.000000 |
| AMOUNT ( ABIY_ADI, ADI_HAGEREY) | 0.000000 | 2533.000 |
| AMOUNT ( ABIY_ADI, BIZET)       | 0.000000 | 1876.000 |
| AMOUNT ( ABIY_ADI, CHERCHER)    | 0.000000 | 4350.000 |
| AMOUNT ( MOHONI, WUKIRO)        | 0.000000 | 1604.000 |
| AMOUNT ( MOHONI, HUMERA)        | 0.000000 | 5653.000 |
| AMOUNT ( MOHONI, KOREM)         | 0.000000 | 544.0000 |
| AMOUNT ( MOHONI, SHIRARO)       | 0.000000 | 5651.000 |
| AMOUNT ( MOHONI, ADISHIHU)      | 0.000000 | 230.0000 |
| AMOUNT ( MOHONI, GIJET)         | 0.000000 | 1045.000 |
| AMOUNT ( MOHONI, ALAJE)         | 67.00000 | 0.000000 |
| AMOUNT ( MOHONI, ADI_GUEM)      | 0.000000 | 673.0000 |
| AMOUNT ( MOHONI, FREWEYNI)      | 0.000000 | 2461.000 |
| AMOUNT ( MOHONI, EDAGA_HAMUS)   | 0.000000 | 2461.000 |
| AMOUNT ( MOHONI, DANSHA)        | 0.000000 | 4435.000 |
| AMOUNT ( MOHONI, ENDABA_GUNA)   | 0.000000 | 5638.000 |
| AMOUNT ( MOHONI, AGULAE)        | 0.000000 | 1976.000 |
| AMOUNT ( MOHONI, NEBELET)       | 0.000000 | 3091.000 |
| AMOUNT ( MOHONI, YECHILAY)      | 0.000000 | 2075.000 |
| AMOUNT ( MOHONI, ADI_HAGEREY)   | 0.000000 | 5653.000 |
| AMOUNT ( MOHONI, BIZET)         | 0.000000 | 3565.000 |
| AMOUNT ( MOHONI, CHERCHER)      | 50.00000 | 0.000000 |
| AMOUNT ( HAWUZEN, WUKIRO)       | 0.000000 | 130.0000 |
| AMOUNT ( HAWUZEN, HUMERA)       | 0.000000 | 4422.000 |
| AMOUNT ( HAWUZEN, KOREM)        | 0.000000 | 3320.000 |
| AMOUNT ( HAWUZEN, SHIRARO)      | 0.000000 | 3562.000 |
| AMOUNT ( HAWUZEN, ADISHIHU)     | 0.000000 | 2004.000 |
| AMOUNT ( HAWUZEN, GIJET)        | 0.000000 | 1346.000 |
| AMOUNT ( HAWUZEN, ALAJE)        | 0.000000 | 1317.000 |

## Developing a Reverse Logistics Model for Raya Brewery

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|                                    |          |          |
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| AMOUNT( HAWUZEN, ADI_GUDEM)        | 0.000000 | 1260.000 |
| AMOUNT( HAWUZEN, FREWEYNI)         | 195.0000 | 0.000000 |
| AMOUNT( HAWUZEN, EDAGA_HAMUS)      | 210.0000 | 0.000000 |
| AMOUNT( HAWUZEN, DANSHA)           | 0.000000 | 3562.000 |
| AMOUNT( HAWUZEN, ENDABA_GUNA)      | 0.000000 | 3549.000 |
| AMOUNT( HAWUZEN, AGULAE)           | 0.000000 | 802.0000 |
| AMOUNT( HAWUZEN, NEBELET)          | 355.0000 | 0.000000 |
| AMOUNT( HAWUZEN, YECHILAY)         | 0.000000 | 1174.000 |
| AMOUNT( HAWUZEN, ADI_HAGEREY)      | 0.000000 | 3563.000 |
| AMOUNT( HAWUZEN, BIZET)            | 0.000000 | 1104.000 |
| AMOUNT( HAWUZEN, CHERCHER)         | 0.000000 | 3677.000 |
| AMOUNT( ENTICHO, WUKIRO)           | 0.000000 | 1274.000 |
| AMOUNT( ENTICHO, HUMERA)           | 0.000000 | 1789.000 |
| AMOUNT( ENTICHO, KOREM)            | 0.000000 | 4551.000 |
| AMOUNT( ENTICHO, SHIRARO)          | 0.000000 | 1774.000 |
| AMOUNT( ENTICHO, ADISHIHU)         | 0.000000 | 3163.000 |
| AMOUNT( ENTICHO, GIJET)            | 0.000000 | 1875.000 |
| AMOUNT( ENTICHO, ALAJE)            | 0.000000 | 2476.000 |
| AMOUNT( ENTICHO, ADI_GUDEM)        | 0.000000 | 2419.000 |
| AMOUNT( ENTICHO, FREWEYNI)         | 0.000000 | 1159.000 |
| AMOUNT( ENTICHO, EDAGA_HAMUS)      | 0.000000 | 673.0000 |
| AMOUNT( ENTICHO, DANSHA)           | 0.000000 | 1774.000 |
| AMOUNT( ENTICHO, ENDABA_GUNA)      | 0.000000 | 1760.000 |
| AMOUNT( ENTICHO, AGULAE)           | 0.000000 | 1961.000 |
| AMOUNT( ENTICHO, NEBELET)          | 0.000000 | 1245.000 |
| AMOUNT( ENTICHO, YECHILAY)         | 0.000000 | 1875.000 |
| AMOUNT( ENTICHO, ADI_HAGEREY)      | 0.000000 | 1775.000 |
| AMOUNT( ENTICHO, BIZET)            | 281.0000 | 0.000000 |
| AMOUNT( ENTICHO, CHERCHER)         | 0.000000 | 4822.000 |
| AMOUNT( HAGERE_SELAM, WUKIRO)      | 0.000000 | 559.0000 |
| AMOUNT( HAGERE_SELAM, HUMERA)      | 0.000000 | 2777.000 |
| AMOUNT( HAGERE_SELAM, KOREM)       | 0.000000 | 3377.000 |
| AMOUNT( HAGERE_SELAM, SHIRARO)     | 0.000000 | 2761.000 |
| AMOUNT( HAGERE_SELAM, ADISHIHU)    | 0.000000 | 1532.000 |
| AMOUNT( HAGERE_SELAM, GIJET)       | 0.000000 | 201.0000 |
| AMOUNT( HAGERE_SELAM, ALAJE)       | 0.000000 | 845.0000 |
| AMOUNT( HAGERE_SELAM, ADI_GUDEM)   | 0.000000 | 773.0000 |
| AMOUNT( HAGERE_SELAM, FREWEYNI)    | 0.000000 | 1416.000 |
| AMOUNT( HAGERE_SELAM, EDAGA_HAMUS) | 0.000000 | 1417.000 |
| AMOUNT( HAGERE_SELAM, DANSHA)      | 0.000000 | 2761.000 |
| AMOUNT( HAGERE_SELAM, ENDABA_GUNA) | 0.000000 | 2748.000 |
| AMOUNT( HAGERE_SELAM, AGULAE)      | 0.000000 | 917.0000 |
| AMOUNT( HAGERE_SELAM, NEBELET)     | 0.000000 | 1288.000 |
| AMOUNT( HAGERE_SELAM, YECHILAY)    | 0.000000 | 200.0000 |
| AMOUNT( HAGERE_SELAM, ADI_HAGEREY) | 0.000000 | 2762.000 |
| AMOUNT( HAGERE_SELAM, BIZET)       | 0.000000 | 2120.000 |
| AMOUNT( HAGERE_SELAM, CHERCHER)    | 0.000000 | 3841.000 |
| AMOUNT( RAMA, WUKIRO)              | 0.000000 | 2391.000 |
| AMOUNT( RAMA, HUMERA)              | 0.000000 | 1703.000 |
| AMOUNT( RAMA, KOREM)               | 0.000000 | 5052.000 |
| AMOUNT( RAMA, SHIRARO)             | 0.000000 | 1688.000 |
| AMOUNT( RAMA, ADISHIHU)            | 0.000000 | 3922.000 |
| AMOUNT( RAMA, GIJET)               | 0.000000 | 1875.000 |
| AMOUNT( RAMA, ALAJE)               | 0.000000 | 3235.000 |
| AMOUNT( RAMA, ADI_GUDEM)           | 0.000000 | 3178.000 |
| AMOUNT( RAMA, FREWEYNI)            | 0.000000 | 2275.000 |
| AMOUNT( RAMA, EDAGA_HAMUS)         | 0.000000 | 1789.000 |
| AMOUNT( RAMA, DANSHA)              | 0.000000 | 1688.000 |
| AMOUNT( RAMA, ENDABA_GUNA)         | 0.000000 | 1674.000 |
| AMOUNT( RAMA, AGULAE)              | 0.000000 | 3063.000 |
| AMOUNT( RAMA, NEBELET)             | 0.000000 | 1231.000 |
| AMOUNT( RAMA, YECHILAY)            | 0.000000 | 1860.000 |
| AMOUNT( RAMA, ADI_HAGEREY)         | 0.000000 | 1689.000 |
| AMOUNT( RAMA, BIZET)               | 0.000000 | 1104.000 |
| AMOUNT( RAMA, CHERCHER)            | 0.000000 | 6224.000 |
| AMOUNT( SELEKILEKA, WUKIRO)        | 0.000000 | 2634.000 |
| AMOUNT( SELEKILEKA, HUMERA)        | 0.000000 | 444.0000 |
| AMOUNT( SELEKILEKA, KOREM)         | 0.000000 | 5281.000 |
| AMOUNT( SELEKILEKA, SHIRARO)       | 0.000000 | 443.0000 |
| AMOUNT( SELEKILEKA, ADISHIHU)      | 0.000000 | 4141.000 |
| AMOUNT( SELEKILEKA, GIJET)         | 0.000000 | 2090.000 |

## Developing a Reverse Logistics Model for Raya Brewery

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|                                   |          |          |
|-----------------------------------|----------|----------|
| AMOUNT( SELEKILEKA, ALAJE)        | 0.000000 | 3463.000 |
| AMOUNT( SELEKILEKA, ADI GUDEM)    | 0.000000 | 544.0000 |
| AMOUNT( SELEKILEKA, FREWEYNI)     | 0.000000 | 2518.000 |
| AMOUNT( SELEKILEKA, EDAGA HAMUS)  | 0.000000 | 2018.000 |
| AMOUNT( SELEKILEKA, DANSHA)       | 0.000000 | 443.0000 |
| AMOUNT( SELEKILEKA, ENDABA GUNA)  | 0.000000 | 7255.000 |
| AMOUNT( SELEKILEKA, AGULAE)       | 0.000000 | 3306.000 |
| AMOUNT( SELEKILEKA, NEBELET)      | 0.000000 | 1460.000 |
| AMOUNT( SELEKILEKA, YECHILAY)     | 0.000000 | 2089.000 |
| AMOUNT( SELEKILEKA, ADI HAGEREY)  | 0.000000 | 444.0000 |
| AMOUNT( SELEKILEKA, BIZET)        | 0.000000 | 1347.000 |
| AMOUNT( SELEKILEKA, CHERCHER)     | 0.000000 | 6439.000 |
| AMOUNT( WERKAMBA, WUKIRO)         | 0.000000 | 1060.000 |
| AMOUNT( WERKAMBA, HUMERA)         | 0.000000 | 2304.000 |
| AMOUNT( WERKAMBA, KOREM)          | 0.000000 | 3420.000 |
| AMOUNT( WERKAMBA, SHIRARO)        | 0.000000 | 2303.000 |
| AMOUNT( WERKAMBA, ADISHIHU)       | 0.000000 | 2305.000 |
| AMOUNT( WERKAMBA, GIJET)          | 0.000000 | 244.0000 |
| AMOUNT( WERKAMBA, ALAJE)          | 0.000000 | 1618.000 |
| AMOUNT( WERKAMBA, ADI GUDEM)      | 0.000000 | 1546.000 |
| AMOUNT( WERKAMBA, FREWEYNI)       | 0.000000 | 930.0000 |
| AMOUNT( WERKAMBA, EDAGA HAMUS)    | 0.000000 | 916.0000 |
| AMOUNT( WERKAMBA, DANSHA)         | 0.000000 | 2303.000 |
| AMOUNT( WERKAMBA, ENDABA GUNA)    | 0.000000 | 2290.000 |
| AMOUNT( WERKAMBA, AGULAE)         | 0.000000 | 1389.000 |
| AMOUNT( WERKAMBA, NEBELET)        | 0.000000 | 716.0000 |
| AMOUNT( WERKAMBA, YECHILAY)       | 0.000000 | 244.0000 |
| AMOUNT( WERKAMBA, ADI HAGEREY)    | 0.000000 | 2290.000 |
| AMOUNT( WERKAMBA, BIZET)          | 0.000000 | 1662.000 |
| AMOUNT( WERKAMBA, CHERCHER)       | 0.000000 | 4593.000 |
| AMOUNT( WKIRO_MARAY, WUKIRO)      | 0.000000 | 2391.000 |
| AMOUNT( WKIRO_MARAY, HUMERA)      | 0.000000 | 673.0000 |
| AMOUNT( WKIRO_MARAY, KOREM)       | 0.000000 | 5037.000 |
| AMOUNT( WKIRO_MARAY, SHIRARO)     | 0.000000 | 658.0000 |
| AMOUNT( WKIRO_MARAY, ADISHIHU)    | 0.000000 | 3907.000 |
| AMOUNT( WKIRO_MARAY, GIJET)       | 0.000000 | 1846.000 |
| AMOUNT( WKIRO_MARAY, ALAJE)       | 0.000000 | 3220.000 |
| AMOUNT( WKIRO_MARAY, ADI GUDEM)   | 0.000000 | 3163.000 |
| AMOUNT( WKIRO_MARAY, FREWEYNI)    | 0.000000 | 2275.000 |
| AMOUNT( WKIRO_MARAY, EDAGA HAMUS) | 0.000000 | 1774.000 |
| AMOUNT( WKIRO_MARAY, DANSHA)      | 0.000000 | 658.0000 |
| AMOUNT( WKIRO_MARAY, ENDABA GUNA) | 0.000000 | 658.0000 |
| AMOUNT( WKIRO_MARAY, AGULAE)      | 0.000000 | 3063.000 |
| AMOUNT( WKIRO_MARAY, NEBELET)     | 0.000000 | 1217.000 |
| AMOUNT( WKIRO_MARAY, YECHILAY)    | 0.000000 | 1846.000 |
| AMOUNT( WKIRO_MARAY, ADI HAGEREY) | 0.000000 | 658.0000 |
| AMOUNT( WKIRO_MARAY, BIZET)       | 0.000000 | 1104.000 |
| AMOUNT( WKIRO_MARAY, CHERCHER)    | 0.000000 | 6196.000 |

| Row | Slack or Surplus | Dual Price |
|-----|------------------|------------|
| 1   | 5934133          | -1.000000  |
| 2   | 0.000000         | -686.0000  |
| 3   | 0.000000         | -3806.000  |
| 4   | 0.000000         | -286.0000  |
| 5   | 0.000000         | -1360.000  |
| 6   | 0.000000         | -543.0000  |
| 7   | 0.000000         | -1044.000  |
| 8   | 0.000000         | -1001.000  |
| 9   | 0.000000         | -586.0000  |
| 10  | 0.000000         | -315.0000  |
| 11  | 0.000000         | -558.0000  |
| 12  | 0.000000         | -5195.000  |
| 13  | 0.000000         | -329.0000  |
| 14  | 0.000000         | -171.0000  |
| 15  | 0.000000         | -429.0000  |
| 16  | 0.000000         | -701.0000  |
| 17  | 0.000000         | -973.0000  |
| 18  | 0.000000         | -456.0000  |
| 19  | 0.000000         | -716.0000  |
| 20  | 206392.0         | 0.000000   |
| 21  | 15690.00         | 0.000000   |

## Developing a Reverse Logistics Model for Raya Brewery

|    |           |          |
|----|-----------|----------|
| 22 | 135179.0  | 0.000000 |
| 23 | 25000.00  | 0.000000 |
| 24 | 15300.00  | 0.000000 |
| 25 | 16508.00  | 0.000000 |
| 26 | 9912.0000 | 0.000000 |
| 27 | 18558.00  | 0.000000 |
| 28 | 11823.00  | 0.000000 |
| 29 | 6240.0000 | 0.000000 |
| 30 | 3619.0000 | 0.000000 |
| 31 | 6000.0000 | 0.000000 |
| 32 | 3300.0000 | 0.000000 |
| 33 | 4200.0000 | 0.000000 |
| 34 | 5300.0000 | 0.000000 |
| 35 | 3500.0000 | 0.000000 |

### A-3: Barriers and drivers parameter estimations the neural network model

| Parameter Estimates |        |                |        |              |        |        |        |        |
|---------------------|--------|----------------|--------|--------------|--------|--------|--------|--------|
| Predictor           |        | Predicted      |        |              |        |        |        |        |
|                     |        | Hidden Layer 1 |        |              |        |        |        |        |
|                     |        | H(1:1)         | H(1:2) | H(1:3)       | H(1:4) | H(1:5) | H(1:6) | H(1:7) |
| Input Layer         | (Bias) | .366           | -.139  | .330         | -.140  | -.394  | -.070  | -.429  |
|                     | D4     | -.181          | .068   | -.050        | -.573  | .217   | -.043  | -.290  |
|                     | D5     | -.455          | -.295  | -.342        | .134   | .319   | -.017  | -.180  |
|                     | D6     | -.388          | .310   | -.130        | .025   | .173   | .021   | .566   |
|                     | D7     | -.445          | .229   | .069         | -.282  | -.250  | .023   | .025   |
|                     | D11    | .149           | .413   | .524         | -.132  | -.251  | -.302  | .326   |
|                     | D13    | .171           | -.429  | .253         | .075   | .299   | -.374  | -.474  |
|                     | D14    | -.317          | -.095  | -.124        | .529   | .449   | -.469  | .001   |
|                     | B1     | -.367          | .062   | -.254        | .434   | .008   | .413   | -.123  |
|                     | B3     | -.337          | .188   | -.109        | -.046  | -.122  | -.417  | -.431  |
|                     | B6     | -.460          | .403   | -.076        | -.411  | .048   | -.164  | -.131  |
|                     | B7     | -.339          | .347   | -.096        | .231   | -.465  | -.160  | -.252  |
|                     | B9     | -.208          | -.167  | -.363        | .242   | .143   | -.150  | -.293  |
|                     | B10    | .184           | .149   | -.020        | -.287  | -.493  | .382   | -.120  |
| B11                 | .179   | .219           | .192   | -.358        | .149   | -.117  | .057   |        |
| B12                 | .073   | -.460          | .176   | -.118        | -.058  | -.136  | .221   |        |
| B16                 | -.021  | .081           | -.327  | .249         | .092   | -.465  | .159   |        |
| Hidden Layer 1      | (Bias) |                |        |              |        |        |        |        |
|                     | H(1:1) |                |        |              |        |        |        |        |
|                     | H(1:2) |                |        |              |        |        |        |        |
|                     | H(1:3) |                |        |              |        |        |        |        |
|                     | H(1:4) |                |        |              |        |        |        |        |
|                     | H(1:5) |                |        |              |        |        |        |        |
|                     | H(1:6) |                |        |              |        |        |        |        |
|                     | H(1:7) |                |        |              |        |        |        |        |
|                     | H(1:8) |                |        |              |        |        |        |        |
| H(1:9)              |        |                |        |              |        |        |        |        |
| Parameter Estimates |        |                |        |              |        |        |        |        |
| Predictor           |        | Predicted      |        |              |        |        |        |        |
|                     |        | Hidden Layer 1 |        | Output Layer |        |        |        |        |
|                     |        | H(1:8)         | H(1:9) | D1           | D2     | D3     | D8     | D9     |
| Input Layer         | (Bias) | -.021          | .035   |              |        |        |        |        |
|                     | D4     | .262           | .341   |              |        |        |        |        |
|                     | D5     | -.152          | .282   |              |        |        |        |        |
|                     | D6     | .000           | -.234  |              |        |        |        |        |
|                     | D7     | .020           | -.419  |              |        |        |        |        |
|                     | D11    | -.489          | -.236  |              |        |        |        |        |
|                     | D13    | .284           | -.379  |              |        |        |        |        |
|                     | D14    | .133           | -.390  |              |        |        |        |        |
|                     | B1     | .224           | -.109  |              |        |        |        |        |
|                     | B3     | .121           | .274   |              |        |        |        |        |
| B6                  | .121   | -.010          |        |              |        |        |        |        |
| B7                  | -.080  | .339           |        |              |        |        |        |        |

## Developing a Reverse Logistics Model for Raya Brewery

|                            |        |              |       |              |       |       |       |       |
|----------------------------|--------|--------------|-------|--------------|-------|-------|-------|-------|
|                            | B9     | -0.421       | .215  |              |       |       |       |       |
|                            | B10    | -.109        | .120  |              |       |       |       |       |
|                            | B11    | -.275        | -.156 |              |       |       |       |       |
|                            | B12    | -.247        | .293  |              |       |       |       |       |
|                            | B16    | -.076        | -.017 |              |       |       |       |       |
| Hidden Layer 1             | (Bias) |              |       | .022         | -.082 | .145  | .408  | -.131 |
|                            | H(1:1) |              |       | -.300        | .173  | .081  | -.160 | -.166 |
|                            | H(1:2) |              |       | -.069        | .492  | .107  | .171  | .005  |
|                            | H(1:3) |              |       | -.092        | -.431 | .477  | .300  | .123  |
|                            | H(1:4) |              |       | .354         | -.143 | .164  | .089  | -.445 |
|                            | H(1:5) |              |       | .264         | -.122 | .112  | .525  | .359  |
|                            | H(1:6) |              |       | -.409        | -.116 | .006  | .055  | -.195 |
|                            | H(1:7) |              |       | -.039        | .244  | .065  | .243  | .050  |
|                            | H(1:8) |              |       | .264         | -.400 | .131  | -.379 | .120  |
| H(1:9)                     |        |              | -.484 | -.437        | -.374 | -.011 | .227  |       |
| <b>Parameter Estimates</b> |        |              |       |              |       |       |       |       |
| Predictor                  |        | Predicted    |       |              |       |       |       |       |
|                            |        | Output Layer |       |              |       |       |       |       |
|                            |        | D10          | D12   | B2           | B4    | B5    | B8    | B13   |
| Input Layer                | (Bias) |              |       |              |       |       |       |       |
|                            | D4     |              |       |              |       |       |       |       |
|                            | D5     |              |       |              |       |       |       |       |
|                            | D6     |              |       |              |       |       |       |       |
|                            | D7     |              |       |              |       |       |       |       |
|                            | D11    |              |       |              |       |       |       |       |
|                            | D13    |              |       |              |       |       |       |       |
|                            | D14    |              |       |              |       |       |       |       |
|                            | B1     |              |       |              |       |       |       |       |
|                            | B3     |              |       |              |       |       |       |       |
|                            | B6     |              |       |              |       |       |       |       |
|                            | B7     |              |       |              |       |       |       |       |
|                            | B9     |              |       |              |       |       |       |       |
|                            | B10    |              |       |              |       |       |       |       |
| B11                        |        |              |       |              |       |       |       |       |
| B12                        |        |              |       |              |       |       |       |       |
| B16                        |        |              |       |              |       |       |       |       |
| Hidden Layer 1             | (Bias) | .076         | .147  | -.241        | .188  | .119  | -.293 | .255  |
|                            | H(1:1) | -.408        | .019  | .427         | .097  | .045  | .307  | .206  |
|                            | H(1:2) | .364         | -.110 | -.315        | .279  | -.407 | -.415 | -.232 |
|                            | H(1:3) | -.220        | -.015 | .124         | -.380 | -.492 | -.104 | -.468 |
|                            | H(1:4) | -.064        | -.185 | -.405        | .408  | -.304 | -.259 | .253  |
|                            | H(1:5) | .050         | -.168 | .349         | -.273 | -.473 | .181  | -.356 |
|                            | H(1:6) | .208         | -.126 | .311         | -.224 | .078  | -.186 | -.449 |
|                            | H(1:7) | -.129        | -.410 | .112         | .244  | -.166 | -.378 | -.328 |
|                            | H(1:8) | -.106        | -.241 | .122         | -.358 | -.383 | -.182 | .375  |
| H(1:9)                     | .324   | -.107        | -.273 | .275         | -.402 | -.158 | .114  |       |
| <b>Parameter Estimates</b> |        |              |       |              |       |       |       |       |
| Predictor                  |        |              |       | Predicted    |       |       |       |       |
|                            |        |              |       | Output Layer |       |       |       |       |
|                            |        |              |       | B14          |       | B15   |       |       |
| Input Layer                | (Bias) |              |       |              |       |       |       |       |
|                            | D4     |              |       |              |       |       |       |       |
|                            | D5     |              |       |              |       |       |       |       |
|                            | D6     |              |       |              |       |       |       |       |
|                            | D7     |              |       |              |       |       |       |       |
|                            | D11    |              |       |              |       |       |       |       |
|                            | D13    |              |       |              |       |       |       |       |
|                            | D14    |              |       |              |       |       |       |       |
|                            | B1     |              |       |              |       |       |       |       |
|                            | B3     |              |       |              |       |       |       |       |
| B6                         |        |              |       |              |       |       |       |       |
| B7                         |        |              |       |              |       |       |       |       |

|                |        |       |       |
|----------------|--------|-------|-------|
|                | B9     |       |       |
|                | B10    |       |       |
|                | B11    |       |       |
|                | B12    |       |       |
|                | B16    |       |       |
| Hidden Layer 1 | (Bias) | -.027 | .004  |
|                | H(1:1) | -.365 | .192  |
|                | H(1:2) | .426  | .215  |
|                | H(1:3) | .070  | .194  |
|                | H(1:4) | -.050 | -.305 |
|                | H(1:5) | .401  | -.134 |
|                | H(1:6) | .364  | .022  |
|                | H(1:7) | -.453 | -.526 |
|                | H(1:8) | .050  | -.056 |
|                | H(1:9) | -.480 | .286  |

**A-4: Minimizing return time uncertainties model**

```

MODEL:
SETS:
TIME_TABLE: DELIVERY_TIME, PICKUP_TIME, RETURN_TIME;
ENDSETS
DATA:
TIME_TABLE = MONDAY TUESDAY WEDNSDAY THURSDAY FRIDAY SATERDAY SUNDAY;
DELIVERY_TIME = 8 8 8 8 8 8 8;
ENDDATA
MIN = @SUM( TIME_TABLE( I): RETURN_TIME( I));
@FOR( TIME_TABLE( J):
PICKUP_TIME( J) =
@SUM( TIME_TABLE( I) | I #LE# 2:
RETURN_TIME( @WRAP( J + I, 7)));
PICKUP_TIME( J) >= DELIVERY_TIME( J)
);
END
    
```

**The model gives the following result:**

```

Global optimal solution found.
Objective value:                28.00000
Infeasibilities:                0.00000
Total solver iterations:        7
Elapsed runtime seconds:        0.06

Model Class:                    LP

Total variables:                14
Nonlinear variables:           0
Integer variables:              0

Total constraints:              15
Nonlinear constraints:          0

Total nonzeros:                35
Nonlinear nonzeros:            0

Variable      Value      Reduced Cost
DELIVERY_TIME( MONDAY)    8.000000    0.000000
DELIVERY_TIME( TUESDAY)  8.000000    0.000000
DELIVERY_TIME( WEDNSDAY) 8.000000    0.000000
DELIVERY_TIME( THURSDAY) 8.000000    0.000000
DELIVERY_TIME( FRIDAY)   8.000000    0.000000
DELIVERY_TIME( SATERDAY) 8.000000    0.000000
DELIVERY_TIME( SUNDAY)   8.000000    0.000000
PICKUP_TIME( MONDAY)     8.000000    0.000000
PICKUP_TIME( TUESDAY)    8.000000    0.000000
PICKUP_TIME( WEDNSDAY)   8.000000    0.000000
    
```

## Developing a Reverse Logistics Model for Raya Brewery

|                        |          |          |
|------------------------|----------|----------|
| PICKUP_TIME( THURSDAY) | 8.000000 | 0.000000 |
| PICKUP_TIME( FRIDAY)   | 8.000000 | 0.000000 |
| PICKUP_TIME( SATERDAY) | 8.000000 | 0.000000 |
| PICKUP_TIME( SUNDAY)   | 8.000000 | 0.000000 |
| RETURN_TIME( MONDAY)   | 4.000000 | 0.000000 |
| RETURN_TIME( TUESDAY)  | 4.000000 | 0.000000 |
| RETURN_TIME( WEDNSDAY) | 4.000000 | 0.000000 |
| RETURN_TIME( THURSDAY) | 4.000000 | 0.000000 |
| RETURN_TIME( FRIDAY)   | 4.000000 | 0.000000 |
| RETURN_TIME( SATERDAY) | 4.000000 | 0.000000 |
| RETURN_TIME( SUNDAY)   | 4.000000 | 0.000000 |

| Row | Slack or Surplus | Dual Price |
|-----|------------------|------------|
| 1   | 28.00000         | -1.000000  |
| 2   | 0.000000         | 0.500000   |
| 3   | 0.000000         | -0.500000  |
| 4   | 0.000000         | 0.500000   |
| 5   | 0.000000         | -0.500000  |
| 6   | 0.000000         | 0.500000   |
| 7   | 0.000000         | -0.500000  |
| 8   | 0.000000         | 0.500000   |
| 9   | 0.000000         | -0.500000  |
| 10  | 0.000000         | 0.500000   |
| 11  | 0.000000         | -0.500000  |
| 12  | 0.000000         | 0.500000   |
| 13  | 0.000000         | -0.500000  |
| 14  | 0.000000         | 0.500000   |
| 15  | 0.000000         | -0.500000  |

### A-5: Production Capacity of Ethiopian Brewers (Bart-hass, 2017)

| N<br>o | Owner                        | Brand             | Locations                | Number of bottles distributed per day | Number of bottles returned per day | Number of bottles not returned per day |
|--------|------------------------------|-------------------|--------------------------|---------------------------------------|------------------------------------|--|
| 1      | BGI                          | St. George Castel | Addis Ababa<br>Kombolcha | 3,600,000                             | 3,560,000                          | 40,000                                 |
| 2      | Diageo                       | Meta              | Sebeta                   | 1,700,000                             | 1,682,000                          | 18,000                                 |
|        |                              | Azmera            |                          | 300,000                               | 296,000                            | 4,000                                  |
| 3      | Heineken                     | Bedele            | Ilubabor, SNNP in Bedele | 800,000                               | 792,000                            | 8,000                                  |
|        |                              | Harar             | Harar                    | 500,000                               | 495,000                            | 5,000                                  |
|        |                              | Heineken          | Walia (A.A)              | 1,500,000                             | 1,485,000                          | 15,000                                 |
| 4      | Dashen (Duet & Vasari Group) | Dashen            | Gonder                   | 800,000                               | 790,000                            | 10,000                                 |
|        |                              | Dashen            | Deber-Birhan             | 800,000                               | 790,000                            | 10,000                                 |
| 5      | Raya Brewery                 | Raya              | Maichew (Tigray)         | 600,000                               | 550,000                            | 50,000                                 |
| 6      | Habesha (35% Bavaria N.V)    | Habesha           | Deber-Birhan             | 300,000                               | 290,000                            | 10,000                                 |
| 7      |                              | Zebider           | AA Kirkos                | 350,000                               | 345,000                            | 5,000                                  |
| Total  |                              |                   |                          | 11,250,000                            | 11,075,000                         | 175,000                                |

**A-6: Strong correlation relationship of barriers and drivers of reverse logistic**

| Strong relationship result |   | Pearson Correlation | Significant Correlation (2-tailed) |
|----------------------------|---|---------------------|------------------------------------|
| 1                          | Economic driver with transportation   | 0.936               | 0.019                              |
| 2                          | Competitive driver with lack of accurate forecasting and planning                                 | 0.987               | 0.002                              |
| 3                          | Governmental, legal and political issue with information sourcing and pricing drivers             | 0.990               | 0.001                              |
| 4                          | Social responsibility and cooperative citizenship with lack of collection facility                | 0.940               | 0.017                              |
| 5                          | Market drivers with lack of collection facilities   | 0.934               | 0.020                              |
| 6                          | Inventory control driver with asset protection  | 0.955               | 0.011                              |
| 7                          | Transportation driver with information sourcing and pricing driver                                | 0.954               | 0.012                              |
| 8                          | Legislation and commercial motivation with lack of accurate forecasting and planning              | 0.929               | 0.022                              |
| 9                          | Promotion related issue with environmental regulation   | 0.899               | 0.038                              |
| 10                         | Lack of awareness with lack of sufficient information and technology system                       | 0.910               | 0.032                              |
| 11                         | Financial and burden taxi with lack of collection facility  | 0.938               | 0.018                              |
| 12                         | Lack of sufficient information and technology system with lack of personnel resource and planning | 0.941               | 0.017                              |
| 13                         | Company policy with asset protection  | 0.949               | 0.014                              |
| 14                         | Lack of government support with economic barriers   | 0.985               | 0.002                              |
| 15                         | Lack of cooperative supply chain partner integration with lack competitive                        | 0.954               | 0.012                              |
| 16                         | Lack of management intention with asset protection driver   | 0.924               | 0.025                              |

## Appendix-B: Questionnaire



### ADDIS ABABA UNIVERSITY INSTITUTE OF TECHNOLOGY SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

**Thesis Title:** “*Developing a Reverse Logistic Model for Raya Brewery*”

*Survey Questionnaire for Raya Brewery Industry*

**Acknowledgement to the respondent**

I would like to express my appreciation for your dedicated cooperation. Had it not been your genuine cooperation of filling this questionnaire, it would have not been possible to conduct this thesis. This questionnaire is conducted for the purpose of fundamental academic research. Therefore, I assure you that the information obtained from this questionnaire will be kept confidential and will not be transferred to other parties for any other purpose. You may feel free to verify these statements from me personally.

*Yours Sincerely,*

**Berhe Syum** (Industrial Engineering MSc student)

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School of Mechanical and Industrial Engineering

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## Part one: General information of Respondent

The following questions refers to your personal background and experience and you are cordially invited to provide the most appropriate response (by filling the blanks and putting a thick mark in the box provided) to each of the questions as per the response choices provided under each question.

**N.B: Reverse logistic** is the process of planning, implementing, and controlling the efficient and cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of conforming to customer requirements and recapturing value or proper disposal.

1. Sex of respondent: Female      Male
  
2. Your age in years: \_\_\_\_\_
3. What is your profession? \_\_\_\_\_
4. What is your position in this company? \_\_\_\_\_
5. What was the highest level of education you completed? **Mark only one.**  

|  |  |
|--|--|
| <input type="checkbox"/> Elementary school | <input type="checkbox"/> High school     |
| <input type="checkbox"/> Certificate       | <input type="checkbox"/> Diploma         |
| <input type="checkbox"/> Bachelor degree   | <input type="checkbox"/> Master's Degree |
| <input type="checkbox"/> PhD               |  |

other \_\_\_\_\_
6. How many years did you work in this Raya brewery company?  

|  |   |
|--|---|
| <input type="checkbox"/> ≤3 month              | <input type="checkbox"/> Between 7 months to 1 year |
| <input type="checkbox"/> Between 4 to 6 months | <input type="checkbox"/> Between 2 to 3 years       |
| <input type="checkbox"/> Greater than 3 years  |   |
7. Did you have attended any reverse logistic formal training in this Raya brewery company?  
 Yes       No

**Part Two: Logistic Related Issues**

8. What barriers of Reverse Logistics Activities do exist in your firm? Check all that if the following barriers exist in your system and Please rate the level of existence of the barriers using, (Very low = 0, Low = 1, Medium = 3, High = 5 and Very high = 7) by putting ‘X’ mark in the corresponding cell.

| Barriers of Reverse Logistics Activities                         | Level of Existence |   |   |   |   |
|--|--------------------|---|---|---|---|
|  | 0                  | 1 | 3 | 5 | 7 |
| Lack of awareness  |                    |   |   |   |   |
| Lack of accurate forecasting & planning                          |                    |   |   |   |   |
| Financial and burden tax barriers                                |                    |   |   |   |   |
| Lack of sufficient information & technology system               |                    |   |   |   |   |
| Economic barriers  |                    |   |   |   |   |
| Company policy barriers  |                    |   |   |   |   |
| lack of government support, Legal and Political issues           |                    |   |   |   |   |
| Lack of Personnel resource & training                            |                    |   |   |   |   |
| Lack of Competitive issue  |                    |   |   |   |   |
| Improper performance management system                           |                    |   |   |   |   |
| Lack of product Quality issues                                   |                    |   |   |   |   |
| Lack of co-operative supply chain partner integration            |                    |   |   |   |   |
| Management inattention   |                    |   |   |   |   |
| Lack of functional integration                                   |                    |   |   |   |   |
| Lack of Importance of reverse logistics relative to other issues |                    |   |   |   |   |

9. Which of Reverse Logistics Drivers do you think that can helps to motivate your company as well? Check all that if the following Drivers are helpful and Please rate the Degree of importance for the Reverse Logistics Drivers using, (Very low = 0, Low = 1, Medium = 3, High = 5 and Very high = 7) by putting ‘X’ mark in the corresponding cell.

| Derivers of Reverse Logistics Activities              | Degree of importance |   |   |   |   |
|---|----------------------|---|---|---|---|
|   | 0                    | 1 | 3 | 5 | 7 |
| Economic drivers’                                     |                      |   |   |   |   |
| Competitive drivers                                   |                      |   |   |   |   |
| Operational performance drivers’                      |                      |   |   |   |   |
| Governmental, legal and Political issue drivers       |                      |   |   |   |   |
| Social responsibility & corporate citizenship drivers |                      |   |   |   |   |
| Marketing drivers’                                    |                      |   |   |   |   |
| Facility drivers’                                     |                      |   |   |   |   |
| Inventory control drivers’                            |                      |   |   |   |   |
| Transportation drivers’                               |                      |   |   |   |   |
| Asset protection drivers’                             |                      |   |   |   |   |
| Environmental regulation drivers’                     |                      |   |   |   |   |
| Information, sourcing and pricing drivers             |                      |   |   |   |   |
| Legislation and commercial motivations drivers’       |                      |   |   |   |   |
| Promotion related issues drivers’                     |                      |   |   |   |   |

**Logistic Management and Controlling Related Issues**

10. Which of the following return streams are easy or difficult to control? Mark **x** in the required table below.

| Return streams   | Easy to control | Intermediate | Difficult to control | Unknown |
|--|-----------------|--------------|----------------------|---------|
| Product acquisitions (obtaining product from the last user or point of return)   |                 |              |                      |         |
| Remarketing (selling refurbished products, developments of secondary market)     |                 |              |                      |         |
| Reverse distribution (logistic involved to transport returned products)          |                 |              |                      |         |
| Test, sort and disposition (deciding on the final destination of return product) |                 |              |                      |         |
| Distribution related returns (wrong or damaged delivers)                         |                 |              |                      |         |
| End of use return (leasing)  |                 |              |                      |         |
| Commercial return from customers (convenience return)                            |                 |              |                      |         |
| Warranty returns   |                 |              |                      |         |
| Commercial returns from channel partner (overstock, channel clearance)           |                 |              |                      |         |
| Maintenance, repair and overhaul return  |                 |              |                      |         |
| Product recalls  |                 |              |                      |         |
| Raw material surplus   |                 |              |                      |         |
| Quality control returns  |                 |              |                      |         |
| Production leftovers/ by-products  |                 |              |                      |         |
| End of life product return   |                 |              |                      |         |

11. Which of the following Reverse Logistics activities does your company perform either in-house or by utilizing a third party or both? Make  $\checkmark$  in the required table given below.

| Activity   | In-house (an activity done by the company Itself) | Third party (an activity done externally by others) | Both in-house & third party |
|--|---|---|-----------------------------|
| Centralized collection center  |   |   |                             |
| Refurbishing (recovering process, e.g. Manufacturing, repair)                    |   |   |                             |
| Remanufacturing  |   |   |                             |
| Test, sort and disposition (deciding on the final destination of return product) |   |   |                             |
| Reverse distribution (logistic involved to transport returned products)          |   |   |                             |
| Product acquisitions (obtaining product from the last user or point of return)   |   |   |                             |
| Product recalls  |   |   |                             |
| Outlet sales   |   |   |                             |
| Remarketing (selling refurbished products, developments of secondary market)     |   |   |                             |
| Salvage  |   |   |                             |

**Part Three: Marketing and Finance Related Issues**

12. What percentage of your total logistics costs do your Reverse logistics costs represent?

| Types of cost                      | Cost in birr per year |
|------------------------------------|-----------------------|
| Material cost (raw material cost)  |                       |
| Manufacturing costs                |                       |
| Material cost (for returned units) |                       |
| Shortage Cost                      |                       |
| Purchasing costs                   |                       |
| Recycling costs                    |                       |
| Disassembly costs                  |                       |
| Remanufacturing costs              |                       |
| Repairing costs                    |                       |
| Disposal costs                     |                       |
| Inventory Holding costs            |                       |
| Transportation costs               |                       |

a) Total fixed cost = \_\_\_\_\_

b) Total variable cost = \_\_\_\_\_

13. How many bottles and steel kegs you bought per year? Fill the table below.

| Year (E.C) | No of bottles you bought | No of steel kegs you bought | Total No of bottles and steel kegs you bought |
|------------|--------------------------|-----------------------------|---|
| 2007       |                          |                             |   |
| 2008       |                          |                             |   |
| 2009       |                          |                             |   |
| 2010       |                          |                             |   |

14. Rate the importance to your customers considering the following factors in their decision to use you as their supplier. Please rate the level of importance, with (0= unimportant; 1= less important; 3= moderately important; 5= very important; 7= Very highly important) and put 'X' mark in the corresponding cell.

| Factor              | Degree of importance |   |   |   |   |
|---------------------|----------------------|---|---|---|---|
|                     | 0                    | 1 | 3 | 5 | 7 |
| Speed of delivery   |                      |   |   |   |   |
| Price               |                      |   |   |   |   |
| Cost reduction      |                      |   |   |   |   |
| Quality of service  |                      |   |   |   |   |
| Variety of products |                      |   |   |   |   |
| Return policy       |                      |   |   |   |   |

**Part Four: Production, Planning and Processing Related Issues**

15. How many beers of bottles and steel kegs you distribute to your customers per day?

a. Total No of bottles distributed per day\_\_\_\_\_

b. Total No of steel kegs distributed per day\_\_\_\_\_

16. How many used beers of bottles and steel kegs you return to your company per day?

a. Total No of used bottles return per day\_\_\_\_\_

b. Total No of used steel kegs return per day\_\_\_\_\_

17. How long is the return processing cycle time for most of the bottles and steel kegs you handle?

Less than 1 day

Between 1 to 2 days

Between 3 to 6 days'

Between 1 to 2 weeks

Between 3 weeks to 1 month

More than 1 month to 2 months

More than 2 months

18. How long is the life cycle of a typical beer bottle product?

≤3 months

Between 4 to 6 months

Between 7 to 12 months'

Between 13 to 18 months

Between 19 months to 2 years

Between 3 to 4 years

Between 5 to 6 years'

Greater than 6 years

19. From the following ways of collecting products, which one is most convenient for your company?

directly by the producer

From customer → Retailer → Producer

From customer → Retailer → Wholesaler → Producer

From customer → Retailer → Wholesaler → Agent → Producer

20. From question number 19, please specify the reason for your choice.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

21. Which of the following return streams are the most important **in terms of volume** in your company? Mark **X** in the table blow using, (Very low =0, Low =1, Medium = 3, High =5, and Very high =7)

| Return streams (activities)  | Degree of importance |   |   |   |   |
|--|----------------------|---|---|---|---|
|  | 0                    | 1 | 3 | 5 | 7 |
| End of life return   |                      |   |   |   |   |
| End of use return (leasing)  |                      |   |   |   |   |
| Commercial return from customers (convenience return)                  |                      |   |   |   |   |
| Warranty returns   |                      |   |   |   |   |
| Commercial returns from channel partner (overstock, channel clearance) |                      |   |   |   |   |
| Maintenance, repair and overhaul return                                |                      |   |   |   |   |
| Product recalls  |                      |   |   |   |   |
| Distribution related returns (wrong or damaged delivers)               |                      |   |   |   |   |
| Raw material surplus   |                      |   |   |   |   |
| Quality control returns  |                      |   |   |   |   |
| Production leftovers/ by-products                                      |                      |   |   |   |   |

22. Do the returned beer bottles and steel kegs erode overtime? Make **X** from the alternatives given below.

- Not eroded     
  Slow erosion     
  Fast erosion

23. What hardware or software technologies do you have installed, or plan to install, to assist your returns handling which mentioned below?

- Computerized return tracking     
  Automated material handling equipment  
 Radio frequency     
  Bar codes  
 Electronic Data Interchange  
 Computerized returns entry at most downstream point in supply chain

**Part Five: Please Try to Answer the Following Questions in Detail.**

1. What are the major problems in the current reverse logistics system of your company exists?

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2. How do you return the used bottles and steel kegs from your customer to your company?

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3. Do you have a collection center in order to return your product?

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4. Can you list out the benefits of a good reverse logistics process from your experience in your company?

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5. What factors are driving you to apply the reverse logistic system?

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6. Do you have a collection center to return on time the empty bottle and kegs from the end users?

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