IMPROVING COLLABORATIVE FORECASTING WITH FUZZY DELPHI IN FOOD SUPPLY CHAIN

(Case study in coffee shop retailer)

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AUTHENTICITY STATEMENT

In the name Allah, I hereby certify that this research is based on my own work except for the citations and summaries in which of those is explicitly knowledge. If in the future this statement is proved not right and violates the legal regulation of papers and intellectual property rights, I agree Universitas Islam Indonesia to revoke my bachelor certificate.

Yogyakarta, June 2018

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This thesis is dedicated for my mom, Siti Hadidjah, who always gives countless prays and support for me. My father, Untung Suwignyo, who always gives me strengths and given his trust to me to pursue what I always wanted. My twin, Abel Aditya who always beside me since we were brought together to this world, I hope many great things will happen to us in the future. My late Grandmother, Siti Nurhayati who gave me infinite love since I was a child. My alma mater Universitas Islam Indonesia, and all of my friends.

"So be patient. Indeed, the promise of ALLAH is truth"

– Q.S Ar-Rum: 60

"And Say: My lord, Increase me in knowledge"
– Q.S Thaha: 114

"So verily with the hardship there is relief, verily with the hardship there is relief"

– Q.S Al-Insyirah: 5-6

"Stop waiting for things to happen go out and make them happen"
– Anonymous

"It does not matter how slowly you go as long as you do not stop"
– Confucius

PREFACE

Assalamualaikum Warrahmatullahi Wabarakatuh.

Alhamdulillahirabbil 'alamin. Praise to Allah SWT the most glorious and the most merciful. Shalawat and Salam toward our adoration Prophet Muhammad SAW along with his family and followers. The guidance of Allah allows the author to finish this thesis. The accomplishment of this thesis is inseparable from the support of all parties. Therefore, the author profusely convey with great and gratitude to:

1. Allah SWT, for all uncountable blessings every day and also Rasulullah Muhammad SAW for His guidance in the right way.
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Finally, the Author realizes that there are still shortcomings as well as weaknesses in this report, so the building suggestions and critics are fully expected. The author hopes this paper would bring advantages for everyone who reads this.

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ABSTRACT

Collaborative forecasting is a method that derived from Collaborative Planning Forecasting and Replenishment (CPFR) that has goals on the information sharing between two parties in exchange of necessary information to generate single forecast between two partners. Collaborative forecasting has been widely used in multiple industries. Yet, there is scarcity of the research on the studies of collaborative forecasting in food supply chain industry as already highlighted by multiple researches. Furthermore, the main problem of the collaborative forecasting in food supply chain studies is the scarcity of the studies that examine how the supply chain stages conduct long term and accurate collaborative forecasting. Thus, fellow researcher Eksoz et al. create framework that helped to overcome the problem. Another problem arises when Eksoz et al. framework were not providing specific way to determine the appropriate forecasting technique that should be applied. Based on the issue, researcher has tried to improve the framework by using fuzzy Delphi method to address the forecasting technique and judgmental adjustment problem as proposed by the framework. This research uses fuzzy Delphi method to improve the collaborative forecasting framework to adjust forecasting result based on expert opinion and asses the accuracy improvement. It was found from the case study in coffee shop after implementing the collaborative framework combine with fuzzy Delphi that it needs five levels adjustment that translates Likert-Scale to the fuzzy method to adjust forecast result based on expert opinion. From the result, it is showed that accuracy improvement after the adjustment is 93% and 34% for Mean Squared Error and Tracking Signal, respectively.

Keywords: Collaborative forecasting, Food Supply Chain, Fuzzy Delphi

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INTRODUCTION

1.1 Background of Study

Currently, competition among companies is getting fiercer and hard for the business environment. This competition leads the firms with understanding that they cannot sustain by doing single-handedly business. Based on the issues company tries to survive by doing collaboration with others, that so-called as collaborative supply chain. Aligned with their need to sustain they try to collaborate with supply chain partners to retain what they have and to generate what they do not have (Kumar et al., 2017). Collaborative supply chain has many ways, tools, and initiatives to help company added competitive advantages among others. One of the initiations is Collaborative Planning, Forecasting and Replenishment (CPFR). CPFR is a collaborative initiative among supply chain members intended to improve the relationship among through a joint planning process that incorporates the sharing of information, risks, benefits, revenue, cost and synchronized forecast (Márcio et al., 2014). Based on the Marcio et al. (2014) CPFR enable to give supply chain partners some of the benefits, which will shorten the cycle time, reduce costs, increases sales revenue, improved forecast accuracy and service level.

CPFR is divided into Planning, Forecasting and Replenishment. Those sub categories have different output to the result of collaborative supply chain. In this study, researcher restricted the studies on collaborative forecasting. Every type of supply chain could implement the collaborative forecasting. The Importance of collaborative forecasting is to increase the accuracy towards the overall forecast.

Recently, one of the supply chains that has become interesting topic is food supply chain due to the unique characteristic of the supply chain itself that need special treatment. Furthermore, collaborative forecasting in food supply chain has lack of research on studies that examine how the supply chain stages conduct long term and accurate collaborative forecast, the mainly topic of collaborative forecast heavily address the industries of manufacture (Cheikhrouhou et al., 2011; Nakano, 2009; Wang, 2011), medical (Lin and Ho, 2014), tourism (Zhang and Song, 2012), and oil industries (Al-Saad et al., 2014).

One of many collaborative forecasting methods has been produced by the fellow researcher. Based on problem above Eksoz et al. (2014) created collaborative forecasting framework that specifically used for food supply chain. The framework has ten propositions, it was found that the framework has issues in forecasting technique propositions, it needs the combination of judgmental adjustment and quantitative forecasting result to implement collaborative forecasting, yet Eksoz et al. (2014) framework did not provide the specific way to the appropriate forecasting technique that should be applied.

Based on the issue, it needs the improvement of collaborative forecasting framework for implementation. By the improvement, researcher attempted to combine the framework of Eksoz et al. (2014) with the Duru et al. (2012) that combined the quantitative forecasting technique with judgmental adjustment with Fuzzy extended Delphi method for the adjustment of statistical time series. It was found from the Duru et al. (2012) studies that the method could help to increase the forecasting accuracy.

Fuzzy extended Delphi method is a fuzzy set theory combination with Delphi method. It was introduced by Kaufman and Gupta (1988). Fuzzy Delphi method used to solve the fuzziness in the group decision. On researcher case, the fuzzy Delphi method has been used to determine the judgmental adjustment in expert opinion to adjust the forecasting result. The fuzzy Delphi method improves uncertainty on decision space and also combines advantages of statistical methods, which is related to framework by Eksoz et al. (2014).

In this research case, the selection of coffee shop is based on one of the hottest categories in food and beverages in Indonesia as shown by the report of Euro business network (2014). The chosen coffee shop was Kontjo kopi. The technique of regression analysis is used to generate the demand data for forecasting. The fuzzy Delphi collaborative forecasting was implemented for coffee’s sales data in Kontjo Kopi coffee shop, and predictions were calculated for January until December 2017 by statistical methods and expert judgments. The collaborative forecasting involves the Kontjo Kopi and their supplier, Brother Roaster.

Furthermore, the fuzzy Delphi method will be analysed on its effectiveness if it is compared to the traditional statistical method. Fuzzy Delphi will highlight the difference accuracy when implementing collaborative forecasting framework combined with fuzzy Delphi method. To compare the accuracy researcher used Mean Squared Error (MSE) and Tracking signal (TS) method. The using of MSE and TS explained the effectiveness of the framework that researcher proposed. The MSE indicates the variance of forecast error and TS indicates the range of data. The effectiveness of the framework reflects the accuracy improvement that researcher try to highlight. The accuracy improvements have both impact to retailer and supplier, with the increasing accuracy the retailer able to make better plans by avoiding unnecessary order. In the other hand, the impact to supplier by using collaborative forecasting is, they are able to lower the inventory levels and improved service levels, which means that supplier able to match supply and demand in more cost effective way. Moreover, collaborative forecasting impact for both parties able to facilitate better pricing decisions and improve their revenue.

On the other hand, with this research will add deeper analysis to previous research. Since there are multiple ways to adjust forecast result varying from different industries and method that are applied in the forecast adjustment (Bruijn and Franses, 2016; Cheikhrouhou et al., 2011; Wi et al., 2012) this study will highlight the adjustment forecast based on expert opinion towards the forecast result specifically for food supply chain. These study aim to create understanding to readers the step and information needed to adjust the forecast result.

Finally, the proposed method contributes to the literature in a number of ways. First, this paper will investigate the accuracy of the fuzzy Delphi for collaborative forecasting. Second, this research extends the knowledge of the fuzzy Delphi method and its applications in food industries. Furthermore, the research will address the issue from Panahifar et al. (2015) that were lack of academic research existed on collaborative forecasting, this argument reinforced by Marcio et al. (2014) studied on collaborative forecasting, which found from 1998-2014. The studies on collaborative forecasting have already produced many journals, yet only few that have tested the hypothesis and framework to prior journal.

1.2 Problem Statement

This research attempts to solve several problems which are formulated by question as follows:

1. How to adjust forecasting result based on expert opinion?
2. What is the accuracy improvement after adjustment?

1.3 Objective Research

Based on the problem identification aftermentioned, there are objectives of this research should be solved, those are as follows:

1. To analyze adjusted forecasting result based on expert opinion.
2. To analyze the accuracy improvement after adjustment.

1.4 Benefit of Research

The benefits of this research are:

1. For Researcher:

   To extend insight and knowledge for research about collaborative forecasting, and experiences for researcher to solve the real case problem.

2. For Retailers and Suppliers

   To provide recommendation and new idea on how to add competitive advantage. Also, this method could be benefited as another tools to enhance relation between supplier and retailer.

3. For Scholars

   To extend knowledge of collaborative forecasting in food supply chain. Also, as stepping stone for other scholars to broadening more insight on food supply chain and collaborative forecasting to be able to research more regarding to the topics.

1.5 Problem Limitation

Problem limitations in this research are:

1. The research is focused on implementing and analyzing collaborative forecasting
2. Focused only in Small Medium Enterprise (SME's)
3. Retailer and supplier in this case were a coffee shop and coffee roaster company

1.6 Writing Systematics

Furthermore, this thesis writing will be continued as follows:

CHAPTER I INTRODUCTION

This chapter contains the background of the problem, the formulation of the problem, research objectives, research benefits, limitation of problem and systematic writing.

CHAPTER II LITERATURE REVIEW

This chapter contains the theory of the concept of Supply Chain Management, Food Supply Chain, Collaborative Supply chain, Collaborative Planning Forecasting and Replenishment, Forecasting, and Fuzzy Theory.

CHAPTER III RESEARCH METHODOLOGY

This chapter contains mindset and measures undertaken research objectives. The study was begun with preliminary investigation and identification of the problem and then proceed with the study of literature, collecting and processing of data, then the data are analyzed in order to obtain a conclusion from this study.

CHAPTER IV DATA COLLECTING AND PROCESSING

This chapter contains general data of enterprise, consisting of history demand data sales and forecasting result from retailer. The Processing process starts from generating regression analysis forecast and determining fuzzy rules to set up combined forecasting. Also, calculation and result from comparison model of regression analysis and combined forecasting with Fuzzy Delphi.

CHAPTER V DISCUSSION

This chapter describes the result of studies which include data generated during the research and data processing method which has determined.

CHAPTER VI CONCLUSION AND SUGGESTION

This chapter contains the conclusion that the answer for the formulation of the problem that has been established and promoted suggestion that may be required.

CHAPTER II

LITERATURE REVIEW

2.1 Previous Research

Collaborative Forecasting has been interesting topic that has more than dozens of papers published from 1998 – 2014 with large majority in conceptual, case study and simulation. Despite the numbers of paper has been published, it is found that only a few that test the hypothesis and conceptual framework of the prior journal (Márcio et al., 2014). It also found that only a few food supply chain industries in term of collaborative forecasting has been discussed (Eksoz et al., 2014).

Although the existing literature has analyzed many theoretical perspectives in relation to collaborative forecasting in the food supply chain, there is a scarcity of research examining how manufacturers and retailers conduct long-term and accurate collaborative forecasting for food supply chain. Eksoz et al. (2014) proposed framework to conduct collaborative forecasting through ten propositions. First, the propositions of internal integration among partners, the propositions identified the integration among internal needs to establish collaborative forecasting. Second, external integration proposition, external integration defined the department or group that responsible for integration. Third, information type, the information type such as change, assortment, and promotion plans that needed to share among partners. Fourth, information quality, after they exchanged the information type the information quality created to become parameter of good information among partners. Fifth, the forecasting technique, in this proposition, it is explained that the forecasting technique should be done according to the appropriate technique needed. Sixth, the judgmental adjustment, the propositions of judgmental adjustment highlighted after the traditional forecasting technique was done in propositions five. The judgmental adjustment needed to be done to increase the accuracy of forecasting. Seventh, the propositions of forecast horizon, the forecast horizon proposition defined how long the forecast should be conducted, for short term medium term or long term. Eight, propositions of forecaster, this proposition highlighted who should be in charge doing forecaster from both parties. Tenth, group-based forecasting, in this proposition, the framework showed what was the most appropriate technique based on time consideration. If both parties can conduct regular meeting then nominal group (NG) would be applied, yet if there is no enough time to conduct the meeting, then Delphi Technique (DT) would be employed.

Panahifar et al. (2015) studied the most efficient way and how to construct the collaborative planning, forecasting and replenishment (CPFR). From the study conducted by Panahifar et al. (2015), it was found the four core concepts to create efficient CPFR, which are CPFR enablers, CPFR barrier, trading partner selection and incentive alignment. In this study Panahifar et al. (2015) synthesized the CPFR to find the state of the art by explaining one by one the meaning of CPFR in more complex definitions. Panahifar et al. (2015) found that there were lack of research in Collaborative planning, collaborative forecasting and collaborative replenishment, it was found that there were needed more researches for this study such as comparison to other techniques, the barrier that needed to handle with CPFR and many other areas that needed to be explore. Thus, the Panahifar et al. (2015) suggested that the research on CPFR needed to be more broadening to the related industry.

Marcio et al. (2014) synthesized the collaborative planning, forecasting and replenishment journal in various years from 1998 to 2014. The studies mainly focused on giving the insight and guidance for other fellow researchers to breakdown problem in CPFR studies. It was found in the journal of the researches from 1998 to 2014 that only a few conducted test on the hypothesis and conceptual framework of the prior journal.

Research conduct by Cheikhrouhou et al. (2011) studied collaborative demand forecasting using fuzzy. Fuzzy method helps forecaster to generalize the judgment among forecaster fit into one single answer or in other words fuzzy helps to translate biased perception from forecaster into single perception. Furthermore, Cheikhrouhou et al. (2011) found new collaborative approach integrating human judgment to mathematical model in a structured way. The fuzzy model that adopted to formalize and characterize the factor and their weight because of occurrence of the factors as event is uncertain. It is found that the proposed method helps group of forecasters in structuring their judgment and providing global forecast using adjustment technique. Method also allows forecaster to identify different factors in order to integrate specific event and assess their impact (Cheikhrouhou et al., 2011)

Duru et al. (2012) studied focuses on fuzzy logic combination with Delphi method to interpret the judgmental adjustment based on three experts towards the forecasting quantitative on dry bulk freight case. Duru et al. (2012) used the concept of Fuzzy Delphi method to improving the forecasting accuracy through group decision consensus. Based on the case, the using of fuzzy extended Delphi method is crucial, due the previous forecast result with ARIMA method often has high error percentage and the judgmental adjustment from the expert not included in final result. This happens because the shipping freights has shown highly volatile and sporadic fluctuations, due to changes based on political and behavioral aspects whose prediction is purely a matter of judgment. Duru et al. (2012) built the fuzzy to adjust monthly forecasting based on experts opinion whether the forecasting result is adequate, more or lower than expected. Then, after all the opinion from experts collected, the previous forecasting result changed with new forecasting result with opinion from experts as adjustment. The concept brought by Duru et al. (2012) highlighted that using judgmental adjustment with fuzzy technique allows companies to have better accuracy. It is shown in the result that Fuzzy Delphi reduces 30 – 40 percent forecast error.

Kumar et al. (2017) studied on joint planning and problem solving roles in developing culture in supply chain collaboration, the studies focused on how to uncover it. It was found in the research by Kumar et al. (2017) that the collaboration needed the strong relationship to get the cooperation, coordination and integration. In the conclusion, Kumar et al. (2017) stated that collaborative activities are not independent and do not have a clear boundary. Thus, the activity of collaboration cannot be isolated to other activity, it needs other parties to carry the continuous relation among others.

Research was conducted by Wenjie Wang (2011) explained that Combined forecasting model is being chosen due to model have three advantages to increase accuracy of forecasting. First, combined forecasting can jointly utilize different forecasting models from different partners to smooth coordination in the supply chain and reduce forecasting discrepancies. Second, combined forecasting can use resources from both retailer and manufacturer in the supply chain to obtain more accurate forecasting results and achieve coordination between partners in the supply chain. Third, combined forecasting can be used for not only functional product forecast but also seasonal product forecasting, which is suitable for various products forecasting in the supply chain. Wang research focused on retailer and supplier integration to forecast demand using combined forecasting model, the data obtained from combined forecasting from both parties. The combined forecasting applied to reduce forecast discrepancies caused by forecasting model difference between both parties. Results showed by Wang, presented that the combined forecasting is effective to reduce discrepancies of forecasting.

Research by Zhang and Shong (2012) discussed the collaborative forecasting method application implemented to tourism industry. The studies focused on created web based design to forecast the information of tourist with joint forecasting with other institution. This research produced a proposed platform that will help the tourism supply chain members to mitigate the negative effect from the demand uncertainty. It might also save the cost from extra capacity, investment and inventories.

Nakano (2009) studied about collaborative forecasting in Japanese manufacture industry. Nakano (2009) tried to examine the impact of internal and external collaborative forecasting and planning on logistics and production performance. It was found that there are positive relationships between internal and external collaborative forecasting and planning. Upstream and downstream collaborative forecasting and planning are also positively related. Internal collaborative forecasting and planning has a positive effect on relative logistics and production performance. External collaborative forecasting and planning does not have a significant effect on relative logistics and production performance.

Al-Saad et al. (2014) studied about the implementation of collaborative forecasting application with AVAILS+, AVAILS+ is short term forecasting tool designed to lead the production assurance effort of the North Kuwait Asset. Based on the implementation of collaborative forecasting AL-Saad (2014) enabled to gain several aspects such as, improved predictability, performance gap identification and tracking, pattern flood optimization, strategic alignment of KPI's, and cross organization transparency.

Lin and Ho (2014) studied about implementation of CPFR in medical supply chain in Taiwan hospital. The study aimed to find the model for CPFR implementation for integrating operation, purchasing and logistics. Lin and Ho (2014) adopted the method of AHP to find critical success factor. It was found that most of the hospital still doing the manual operation. Thus, by bringing the CPFR into the table it can increase procurement efficiency, reduce procurement costs, shorten procurement time, raise quality and to make the best uses of all available resources.

Hudnurkar et al. (2014) studied about the effect of collaboration supply chain in several industries. The studies provide new insight on the effect of collaboration supply chain with the factor that influences the benefit for the supply chain. Some of the factors are: commitment, trust, adaptations, relationship, stakeholder, topology, technology, collaboration, strategy, process integrated, communication, long term relationship, co-operation, legal protection, government support, interpersonal relationship, information sharing, collaborative planning, incentive alignment, resource sharing, joint knowledge information availability, information quality, behavioral uncertainty, cultural, management controls, management commitment and supplier performance. It could be concluded from this study that collaborative supply chain has significant effect to supply chain, collaborative supply chain bring benefit such as cost saving, inventory reduction, increase visibility, reduction in bullwhip effect.

Cao and Zhang (2011) studied about the impact of supply chain collaboration to the firm performance. Cao and Zhang (2011) created the hypothesis that highlights the relation of supply chain collaboration to collaborative advantages and to the performance and to the otherwise. From that studies Cao and Zhang (2011) identified set of seven interconnecting dimensions that make up effective supply chain collaboration, which are: information sharing, goal congruence, decision synchronization, incentive alignment, resource sharing, collaborative, communication, and joint knowledge creation. Cao and Zhang (2011) conclude that effective supply chain collaboration leads to collaborative advantage and better firm performances. Cao and Zhang (2011) also encourage other fellow researcher to generate analysis from specific industries as in this journal only analyze the manufacturing industries.

Ramanathan and Gunaskeran (2012) studied about the impact of success in long term partnership of supply chain collaboration. The aim of the studies is to enlighten supply chain partner to the benefits of implementing supply chain collaboration to long term scenario. Ramanathan and Gunaskeran (2012) focused their studies in textile industry using questionnaire method to gather the data then used confirmatory analysis and structural equation modeling to provide the results of the studies. It was found and proven from this research, that by ensuring appropriate execution of supply chain plans, supply chains can enjoy the benefits of sales growth, market share and satisfaction in supply chain. Successful supply chain collaborations with satisfied partners will lead them to continue their future partnerships. The studies by Ramanathan and Gunaskeran (2012) gave two empirical contributions which are: collaborative practices trigger the high level of success in the collaborative supply chain. Second, the relationship among the construct collaborative practices, ensure the success of collaboration and long-term future collaborations.

Kurtulus (2017) studied about collaborative forecasting on retail supply chain. Kurtulus (2017) examined the collaborative forecasting based on the character of retailer supply chain members. The first one is value of collaborative forecasting when supply chain members are cooperative, followed by the decentralized forecasting, vendor managed inventory and adherence to plans. Second, value of collaborative forecasting when supply chain members are strategic, followed by the incentive due to better pricing, and investment are endogenous. From the studies Kurtulus (2017) concluded that collaborative forecasting more valuable when the information is low and collaborative forecasting is more valuable when partners can respond to better information.

Table 2.1 Research Position

Researcher	Research Focus			Case Study					Methods		
	CSC	**CF**	**CPFR**	**Manufacture**	**Medical**	**Tourism**	**Food**	**Others**	**Fuzzy Delphi**	**systematic literature review**	**others**
Eksoz et al. (2014)	√	√					√			√	
Panahifar et al. (2015)	√		√							√	
Marcio et al. (2015)	√		√							√	
Cheikhrouhou et al. (2011)		√		√					√		
Duru et al. (2012)		√						Service company	√		
Kumar et al. (2017)	√			√	√	√	√	Service company			Questionnaire
Wang (2011)		√	√	√							Combined forecasting
Zhang and Song (2012)		√				√					application design

	Research Focus			Case Study					Methods		
Researcher	**CSC**	**CF**	**CPFR**	**Manufacture**	**Medical**	**Tourism**	**Food**	**Others**	**Fuzzy Delphi**	**systematic literature review**	**others**
Nakano (2009)		√		√							Survey with analytical model
Al-Saad et al. (2014)		√						Oil company			AVAILS+
Lin and ho (2014)			√		√						AHP
Hudnurkar (2014)	√			√			√	Service company		√	
cao and zhang (2011)	√			√							confirmatory factor analysis and structural equation modeling
Ramanathan and Gunaskeran (2011)	√							Textile company			confirmatory factor analysis and structural equation modeling
Kurtulus (2017)		√						Retailer		√	

2.2 Background Study

2.2.1 Supply Chain Management

Supply Chain Management (SCM) has become the mantra of many companies seeking a way to meet the competitive challenge of today's business environment (College et al., 2000). According to Chopra and Meindl (2007) stated that Supply Chain is mechanism that consists of all parties involved, directly and indirectly, in order to fulfilling a costumer request. Chopra and Meindl also stated that, a Supply Chain is dynamic and involves the constant flow of information, product and funds between different stages. A typical supply chain may involve a variety of stages. These supply chain stages include: costumers, retailers, wholesalers or distributors, manufacturers, raw material supplier. Each stage in a supply chain is connected through the flow of products, information, and funds. Stage of supply chain is depicted in figure 2.1 below:

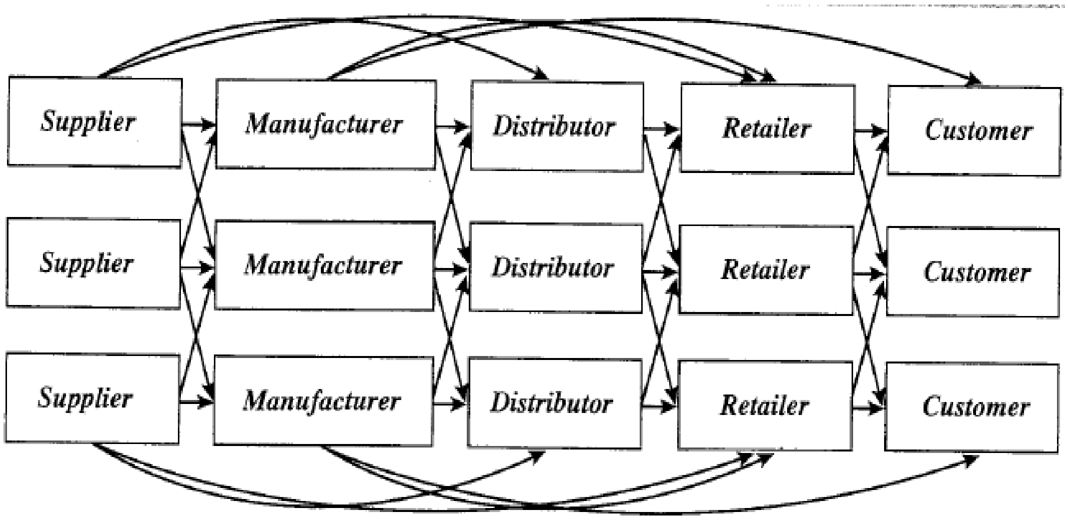

Figure 2.1 Supply Chain Stages

Source: Chopra and Meindl (2007)

Equally, objective of every supply chain should be maximized to the overall value generated. The value of a supply chain is the difference between what the final product is worth to the costumer and the costs the supply chains incurs in filling costumer's request. As studied by Suhong Li and colleagues, it is indicated that Supply Chain practices can lead to enhance competitive advantage that have direct and positive impact on organizational Performance and Improved Organizational Performance (Li et al., 2006).

As the performance of an organization is linked to its supply chain system, it is important for the organization to focus on macro process. A good supply chain coordinates all the macro process across all stages. Integrating the macro process is a crucial thing for the organization. Macro process is consist of three parts process, supply chain management classified into three macro process (Chopra and Meindl, 2007) as shown in Figure 2.2:

1. Customer Relationship Management: Focus on the interface between firm and customers.

2. Internal Supply Chain Management: Focus on internal chain of the firm.

3. Supplier Relationship Management: focus on the interface between the firm and suppliers.

SUPPLIER	FIRM	CUSTOMER
SRM	ISCM	CRM
1. Source 2. Negotiate 3. Buy 4. Design Collaboration 5. Supply Collaboration	1. Strategic Planning 2. Demand Planning 3. Supply Planning 4. Fulfillment 5. Field Service	1. Market 2. Sell 3. Call Center 4. Order Management

Figure 2.2 Supply Chain Macro Process

Source: Chopra and Meindl (2007)

Li and colleagues examined the competitive advantage of supply chain by conceptualizes dimension of supply chain practices. Research by Li (2006) found that the competition in business is no longer among organizations, yet it was from supply chain itself. By that issue Li, develop five dimensions of supply chain practices:

1. Strategic Supplier Partnership

   Defines as the long-term relationship between the organization and supplier. It is designed to leverage the strategic operational capabilities of individual participating organizations to help them achieve significant ongoing benefits.

2. Costumer Relationship

   The entire array of practices that are employed for the purpose of managing customer complaints, building long-term relationship with customer, and improving customer satisfaction.

3. Level of Information Sharing

   The extent to which critical and proprietary information is communicated to one's supply partner. The information's range from strategic to tactical, also from general market to costumer information.

4. Quality of Information Sharing

   Refers to the accuracy, timeliness, adequacy and credibility of information exchanged. The significance of its impact on supply chain depends on what information shared, when and how it shared and with whom.

5. Postponements

   The practice of moving forward one or more operations or activities (making, sourcing and delivering) to a much later point in the supply chain.

2.2.1.1 Food supply chain

Food supply chain is complex supply chain as compared to other supply chain mainly due to different attributes associated with the nature of product which has direct impact on consumer health making food safety as one of the important requirement (Aung and Chang, 2014). According to Bourlakis and Weighman (2004) as cited in Eksoz et al. (2014) food supply chain (FSC) distinguishes itself from other supply chains due its purpose to "guarantee the provision of safe and healthy products that are fully traceable from farm to fork".

Fisher identified supply chain based on nature of the demand (Marshall L., 1997). Fisher divides product into two categories: Primarily functional Products with characteristic of stable, predictable and long life cycle. The other one was primarily innovative products with characteristic of unpredictable and short life cycle. Based on Fisher framework the food supply chain can be categorized in second categories.

Aleda et al. (2008) developed generic model of food supply chain, the model illustrates the supply chain of food industry from the upstream into downstream. Model by Aleda et al. (2008) had similar to general supply chain, the difference only the length of the stages and name of entity that involved in food supply chain. Figure 2.3 below explained the Aleda's model:

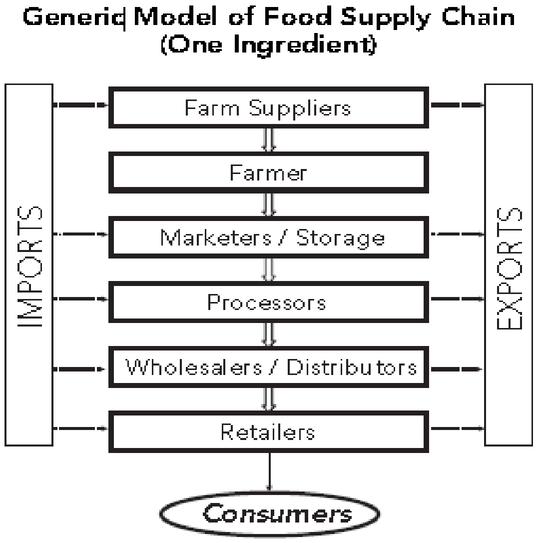

Figure 2.3 Food Supply Chain

Source: Aleda et al., (2008)

Although the food supply chain is considered as one of the promising industries, food supply chain still has main several issue that often occur in reality that can cause costly damage to the organization who involved in food supply chain. There are several main issues, which is traceability, transparency and quality. Yet, Eksoz et al. (2014) highlighted from his research that the key concern of Food supply chain is the short shelf life of perishable and seasonal products where substantial effort is required to keep product freshness and shelf availability (Eksoz et al., 2014).

2.2.2 Collaborative supply chain

Cao and Zhang (2011) described the supply chain collaboration is a partnership process where two or more autonomous firms work closely to plan and execute supply chain operations toward common goals and mutual benefits. The collaboration supply chain arises to ensure that the supply chain is efficient and responsive to dynamic market needs. According to Cao, the collaborative supply chain has seven core concepts that relate to collaborative advantages and firm performance. The seven core concept as follows:

1. Information Sharing

   Refers to the extents to which firm shares a variety of relevant, accurate, complete, and confidential information in a timely manner with its supply chain partners. As information sharing described as the heart, essential ingredient, and key requirement of supply chain collaboration.

2. Goal Congruence

   Extents to which supply chain partners perceive their own objectives are satisfied by accomplishing the supply chain objectives. It is the degree of goal agreement among supply chain partners.

3. Decision Synchronization

   Refers to the process by which supply chain partners orchestrate decision in supply chain planning and operations that optimize the supply chain benefits. Planning decisions are required to determine the most efficient and effective way to use the firm resources to achieve a specific set of objectives.

4. Incentive Alignment

   Refer to the process of sharing costs, risks and benefits among supply chain partners. It includes determining risk, cost, and benefits as well as formulating incentives schemes.

5. Resource Sharing

   Refers to the process of leveraging capabilities and asset and investigating in capabilities and asset with supply chain partners. Resource includes physical resource, such as manufacturing equipment, facility and technology.

6. Collaborative Communication

   Refers to the contact and message transmission process among supply chain partners in term of frequency, direction, mode, and influence strategies. The type of communication such as open, frequent, balanced two way and multilevel communication.

7. Joint Knowledge Creation

   Refers to the extent to which supply chain partners develop a better understanding of and response to the market and competitive environment by working together. There are two type of knowledge, which is knowledge exploration and knowledge exploitation.

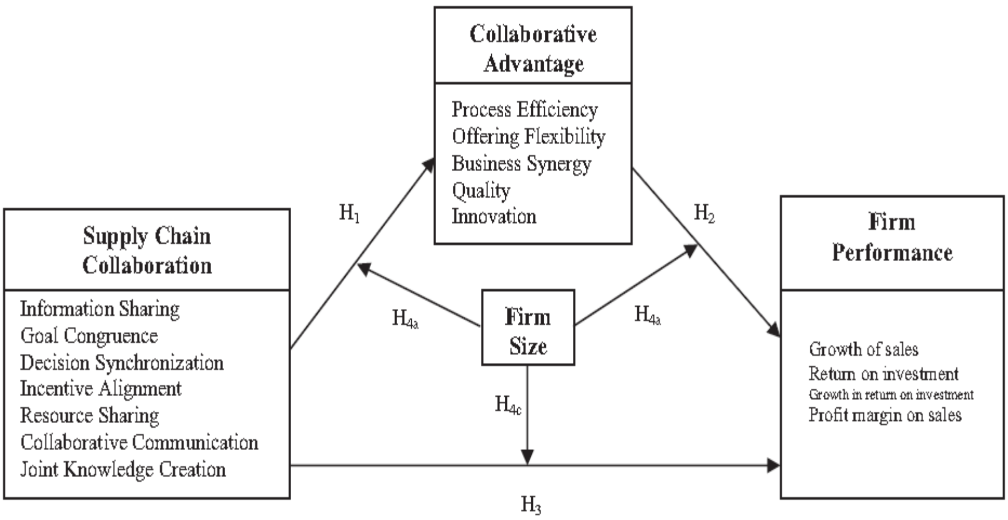

Figure 2.4 Collaboration Supply Chain

Source: Cao and Zhang (2011)

Cao and Zhang (2011) concluded that effective supply chain collaboration leads to collaborative advantages and better firm performance. The relationship implies that, in order for a supply chain as a whole to perform well, firm should try to create win-win solution that all participants collaborate to achieve business synergy and compete with other chains. They also added that collaborative relationship can help firm share risks, access complementary resources, reduce transaction costs and enhance productivity, and enhance performance and competitive advantage over time.

Ramanathan and Gunasekaran (2014) stated that supply chain collaboration has the 3 key aspects which is planning, execution and decision making, all of the three elements will trigger the success of collaboration. Ramanathan highlighted the impact of collaboration supply chain towards organization. They provided such framework of three key aspects that will help the organization to construct the collaborative supply chains:

1. Collaborative Planning

   Collaborative planning forms a basis for the execution of supply chain plans by involving all the supply chain members. Collaborative planning aims to improve the visibility between upstream and downstream partners, other than that collaborative planning will guarantee execution of plans and providing supply chain members agree with the plans.

2. Collaborative Execution

   The collaborative execution refers to mechanism of entity that involved in collaboration such as execution of delivery, set the time of delivery, and invest structure, team work coordination, resources sharing of technology and cost reduction.

3. Collaborative Decision Making

   Decision making refers to decision synchronization that play pivotal role in elements of supply chain collaborations. Decision making involves different supply chain members to support the supply chain. Decision type could be price, decision sharing, forecasting and plan change.

Ramanathan concluded that to ensure the appropriate execution of supply chain plans, supply chain's members can enjoy the benefits of sales growth, market share and satisfaction. Successful supply chain collaboration with satisfied partners will lead them to continue their future partnership. Also, success of collaboration by means of planning, execution and decision making are indirectly encourage participant supply chain members to engage in long term collaborative agreement.

Hudnurkar et al. (2014) highlighted the factors that affected collaboration in supply chain. From the article, it was found that the role of information sharing is highly significant in effective supply chain collaborations. The information sharing could offer several benefits such as, cost saving, inventory reduction, increase visibility, reduction bullwhip effect.

2.2.3 Collaborative Planning Forecasting and Replenishment

Collaborative Planning, Forecasting and Replenishment (CPFR) are a technological innovation tool that was first registered as a trademark by the voluntary Inter-Industry Commerce Standards (VICS). Panahifar et al. (2015) described that CPFR is collaboration where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronized forecast, on the basis of which the production and replenishment processes are determined.

Originally the concept of CPFR arised in 1995 when Wal-Mart and Warner-Lambert conducted a comprehensive cooperative plan in order to reduce inventory cost while at the same time enhancing product availability across the supply chain (Panahifar et al., 2015). On that year the project between Wal-Mart and Warner-Lambert called comprehensive cooperative plan that become the origin of CPFR. Later on the VICS improved the initial plan and converted into CPFR.

The CPFR has three keys of aspects, planning, forecasting and replenishment. The three of aspects are sequence to make the success of collaboration (Panahifar et al., 2015), the explanation each collaboration as follows:

1. Collaborative Planning

   Collaborative planning is a fundamental part of supply chain management. The collaborative planning is the first step of CPFR of two fundamental stages: front-end agreement and joint business plans. The collaborative planning is a crucial to create successful collaborative supply chain.

2. Collaborative Forecasting

   Collaborative forecasting focused on the information sharing between two parties in exchange of necessary information to generate single forecast between two partners. The objective of collaborative forecasting is to synchronize service demand forecast between all customer and suppliers.

3. Collaborative Replenishment

   Collaborative replenishment refers to make and fulfill order into customer in timely manner. Collaborative replenishment spreads replenishment activities across the supply chain and facilitates collaborative inventory management in operations. The benefit of collaborative replenishment is improved customer service levels, increased order accuracy and decreased inventory.

Focused on collaborative forecasting, collaborative forecasting originally broadens adaptation from the information sharing aspect in collaborative supply chain. The information starts as planning and forecasting as an execution in term of collaboration scheme. The forecasting collaboration needs exchange information from both organization, collaborative forecasting become crucial as the collaborative forecasting become reference on replenishment stages in CPFR (Panahifar et al., 2015)

According to Wang (2011) the collaborative forecasting process of CPFR gives a guarantee for precise demand by implementing the jointed forecasting process inside the corporation and among the supplying chain of partners. It also found that CPFR plays greatly major different in industrial and becoming more crucial in upcoming year as competition among company is getting tight (Panahifar et al., 2015).

2.2.4 Forecasting

Forecasting is a scientific method of determining demand in future, a starting point for all strategic planning. The importance of forecasting is lie on predicting the uncertainty of the future, such as logistical areas of production scheduling, inventory control, and aggregate planning need demand forecast (Chopra and Meindl, 2007).

` Forecasting is a key driver of virtually design and plan the decision that will be made in both an enterprise and a supply chain. Enterprises always forecast the demand and uses it to make decisions. A relatively recent phenomenon, however, is to create collaborative forecast for an entire supply chain and use this as the basis for decisions. Collaborative forecasting greatly increases the accuracy of forecast and allows the supply chain to maximize its performance. Without collaboration, supply chain stages farther from demand will likely have poor forecast that will lead to supply chain inefficiencies and a lack of responsiveness.

According to Chopra and Meindl (2007) forecasting methods are classified according to the following four types:

1. Qualitative

   Qualitative forecasting method is primarily subjective and rely on human judgment. They are most appropriate when little historical data are available or when experts have market intelligence that may affect the forecast. Such methods may also be necessary to forecast demand several years into the future in a new industry.

2. Time Series

   Time series forecasting method uses historical demand to make a forecast. It is based on the assumption that past demand history is a good indicator of future demand. This method is the most appropriate when the basic demand pattern does not vary significantly from one year to the next. It is considered as the simplest method to be implemented and can serve as a good starting point for a demand forecast.

3. Causal

   Causal forecasting method assumes that the demand forecast is highly correlated with certain factors in the environment (the state of the economy, interest rate, etc.). Causal forecasting method finds this correlation between demand and environmental factors and use it to estimate what environmental factors will be to forecast future demand. For example, product pricing is strongly correlated with demand. Companies can thus use causal methods to determine the impact of price promotions on demand.

4. Simulation

   Simulation forecasting method imitates the consumer choices that give rise to demand to arrive at a forecast. Using simulation, a firm can combine time series and causal methods to answer such question as: What will be the impact of a price promotion? What will be the impact of a competitor opening store nearby. Airline simulates customer buying behavior to forecast demand for higher-fare seats when there are no seats available at the lower fares.

Furthermore, every instance of demand has a random component. A good forecasting method should capture the systematic component of demand but not the random component. The random component manifests itself in the form of a forecast error. Forecast errors contain valuable information and must be analyzed carefully for two reasons. The first one is whether the current forecast method is predicting method consistently a positives error, which needed to be corrected. The second one is the contingency plan must account for forecast error. Based on the explanation before there are ways to measure error in the forecast, which are:

1. Mean Squared Error (MSE)

   The MSE can be related to the variance of the forecast error. In effect, we can estimate that the random component of demand has a mean of 0 and a variance of MSE

2. Mean Absolute Deviation (MAD)

   MAD can be used to estimate the standard deviation of the random component assuming the random component is normally distributed. In this case the standard deviation of the random component is θ = 1.25 MAD, then estimates that the mean of the random component is 0 and the standard deviation of the random component demand is θ.

3. Mean Absolute Percentage Error (MAPE)

   MAPE is the average absolute error as a percentage of demand. To determine whether a forecast method consistently over or under estimates demand, then can use the sum of forecast errors to evaluate the bias. The bias will fluctuate around 0 if the error is truly random and not biased on way or the other. Ideally, if plot all the errors, the slope of the best straight line passing should be 0.

4. Tracking Signal (TS)

   Tracking signal is the ration of the bias and the MAD. The tracking signal use period set by range, the ranged based on the calculation of the calculated forecast. If one of the forecast exceed or lower than range it can be assume that forecasting is biased and suggest choosing new forecasting method.

2.2.5 Fuzzy Logic

A. Definition of Fuzzy

Fuzzy logic is a mathematical expression that is used to represent uncertainty, inaccuracy, lack of information, and ambiguity between true or false at the same time but some great truth and error of a value depends on the weight of its membership. Fuzzy logic is used for state a group or set entities that can be distinguished with other groups based on the degree of crisp membership. The crisp set is a way to dichotomize the individuals in some given universe or discourse into two groups; members and nonmembers (Klir and Yuan, 1995). Fuzzy logic is used to convert heuristic control rules stated by human operator into an automatic control strategy (Mamdani and Assilian, 1975). Fuzzy logic has a three core concepts namely, fuzzy sets, linguistic variables, and possibility distribution (Wu et al., 2011).

B. Fuzzy Sets

Fuzzy set is an extension of classic theory, it is arranged from a set which determined by the membership functions, with the main function of membership function itself give the value of the value elements inside fuzzy set with the range of value which commonly used is the interval [0,1] Klir et al., (1995). A value in the interval [0,] has a degree of membership (=µ*x*) from one member of the fuzzy set (*x*) is said that fuzzy sets are mapped to values in the interval [0,1] by the functions µ. There are only two grades of membership function in a classic set. Membership function in fuzzy classic set is defines as follow:

$$\mu_A(x) = \begin{cases} 1 & if \quad x \in A \\ 0 & if \quad x \notin A \end{cases} \tag{2.1}$$

That is $\mu_A(x) = 1$ which means that x be a member of A, and $\mu_A(x) = 0$ for x is not as a member of A, this classic fuzzy set is different with fuzzy logic that using interval 0 and 1. A value in the interval are called membership value is denoted by $\mu_A(x)$, the degree of membership is a value that indicates how much the level of membership of element (x) in a set (A).

C. Membership Functions

Membership function is a curve showing mapping of data input points into the membership value having intervals between 0 and 1. A fuzzy set over the universe of discourse X, A, $\subseteq X$ [0,1], is described by the degree of membership $\mu_A(X) \in [0,1]$ for each $x \in X$. Linear functions of triangular number and trapezoid are popular membership function. The representation of triangular curve number is basically a combination of two linear representation (linear rises curve and linear down curve). Triangular membership function can be defined as:

$$\mu(x; a, b, c) = \begin{cases} \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b < x \leq c \\ 0, & \text{otherwise} \end{cases} \tag{2.2}$$

With a graphic of membership functions is shown in Figure 2.5:

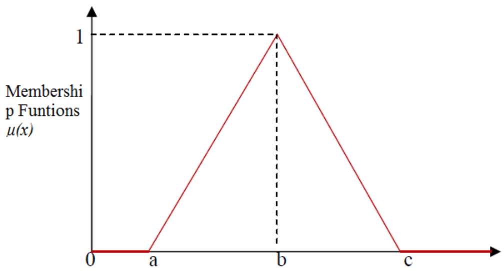

Figure 2.5 Membership Function of Triangular Fuzzy Number

D. Operations in Fuzzy Set

Like the set of crisp sets, there are several operations are used to define specifically to combine and modify fuzzy sets. The membership value as a result of a two-set operation are known as *fire strength* or *α-cut*. There are three basic operators created by Zadeh, as follows: AND, OR, and NOT.

1. AND Operator

   AND operation is related to intersection of the sets number. Intersection of 2 sets is the minimum of each pair of elements on both sets.

$$\mu_{A \cap B} = \text{MIN}\ (\mu_A\,(x),\ \mu_B\,(y))$$

2. OR Operator

   OR (union) operation is associated with the combined operation of the set. The union of 2 sets is the maximum of each pair of elements on both sets.

$$\mu_{A \cap B} = \text{MAX}\ (\mu_A\,(x),\ \mu_B\,(y)) \qquad (2.3)$$

3. NOT Operator

   NOT operation is related to the compliment operation on the set. NOT operation is obtained by subtracting the membership value elements with the value of 1.

$$\mu_A = 1\text{-}\ (\mu_A\,(x)) \qquad (2.4)$$

2.2.6 Fuzzy Delphi

Fuzzy Delphi method was proposed by Kaufman and Gupta (1988) and also was proposed by Ishikawa et al. (1993). The fuzzy Delphi was combination of fuzzy logic and Delphi technique. The Delphi technique used verbal expression to measure the views from the respondent, and then the fuzzy used to determine the fuzziness among the respondent answers.

The fuzzy Delphi methodology starts with expert give independent opinions then the subjective information are converted into objective data using fuzzy number. Then a fuzzy statistical analysis is done and is communicated to experts. Then experts reviews are analyze and process is repeated until outcome converges to a reasonable solution (Roy and Garai, 2012). The Fuzzy Delphi method can better express the opinions from the experts ensuring the completeness and consistency of the group opinions as it takes into account the fuzziness that cannot be avoided during the survey process.

According to Habibi et al. (2015), to create Fuzzy Delphi it needs the following step to be addressed:

1. Collect and fuzzify expert opinions

   First develop fuzzy spectrum for the fuzzification of respondent linguistic expressions. For this purpose, fuzzy spectrum development methods or common fuzzy spectrum can be used. This step includes creating the triangular fuzzy number from the experts.

2. Fuzzy aggregate opinions

   After the selection or development of appropriate fuzzy spectrum, expert opinions are collected and fuzzified. In the second step, expert opinions should be aggregated.

3. Deffuzification

   After fuzzy aggregation of expert opinions, the values should be deffuzified. In different methods that are done with fuzzy approach, the researcher ultimately converts final fuzzy values into a crist and understandable number.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Methodology

This research is conducted by using a combination of qualitative and quantitative approach method. Qualitative research is a variety of research that identifies a situation that achieved through an holistic perspective and concerned with the opinions, experiences and feelings of individuals as a subject in producing a subjective data (Hancock, 1998). Quantitative research is a method that involves data collection typically numeric, use mathematical model as the methodology of data analysis (Williams, 2007).

3.2 Location and Object of Research

This research is conducted in small and medium enterprise of coffee shop retailer and roaster bean supplier in Yogyakarta. The case study of collaborative forecasting was taken place in Kontjo Kopi coffee shop located in Perumnas street, Condongcatur, Depok, Sleman, Yogyakarta as retailer and the supplier chosen was Brother Roaster located in Sleman, Yogyakarta.

Currently, Kontjo Kopi is a company that runs business process of coffee shop retailer since 2016. The concept of coffee shop was adopted from the theme of family as it reflected on its name *"kontjo"* or in Indonesian means *"teman dekat"*. It is expected that customers feel close to Kontjo Kopi. Kontjo Kopi serves foods and beverages in their menu. The beverages menu itself serves six types of drinks from single origin, café latter, cappuccino, green tea latte, vanilla latte and chocolate. For the food, Kontjo kopi serves French fries and sausage menu. The other object of research is Brother Roaster. Brother Roaster is company that runs bean roasting business and supplies it to the coffee shops since 2012. Brother Roaster focused on roasting the green beans from all type of the beans that comes from all over Indonesian. Kontjo Kopi and Brother Roaster already partners since 2016, making Brother Roaster one of the suppliers for café latte product that used Bajawa beans as main ingredients.

3.3 Place and Time of Research

The research for analyzing collaborative forecasting was located in Kontjo Kopi coffee shop and Brother Roaster. The time of the research is from January 2017 until December 2017.

3.4 Problem Identification

The problem identification is the early step of this study. The problem identification is obtained from literature review that has been conducted. According from the framework by Eksoz et al. (2014) there were ten propositions in order to create collaborative forecasting. Based on the framework there were, internal integration, external integration, information type, information quality, forecasting technique, judgmental adjustment, forecast horizon, forecast frequency, forecaster and group based forecasting, as shown in table 3.1 below:

Table 3.1 Collaborative Framework aspects and details

Aspects	Details
Internal Integration	Analyzing what integration that have been done from both parties in order to create own forecast
External Integration	Analyzing what kind of external integration that needed to be address and what behavior needed to conduct collaboration
Information Type	Set a type of information needed in order to create collaborative forecasting

Aspects	Details
Information Quality	A parameter that create by both parties in order to feel satisfied with collaboration
Forecasting Technique	Set a technique of forecasting is needed to obtain collaborative forecasting
Judgmental Adjustment	The opinion from both parties that needed after quantitative forecasting generated
Forecast Horizon	Set strategic of forecasting horizon conduct by both parties
Forecast Frequency	Set frequency of forecasting together while joint collaborative forecasting
Forecaster	Set a person who responsible to conduct forecasting in collaborative forecasting
Group Forecasting Technique	Set a Group forecasting method with consideration of a time that will prefer suitable technique to conduct collaborative forecasting

From the explanation of ten propositions from Eksoz et al. (2014) framework it was found that the propositions have an issue in order to implement the collaborative forecasting. The issue was located in forecasting technique and judgmental adjustment propositions. Eksoz et al. (2014) did not give specific way how to calculate the forecasting technique and judgmental adjustment. Based on the issue, researcher combines the Eksoz et al. (2014) framework with Duru et al. (2012) technique, with Fuzzy Delphi to implement collaborative forecasting.

This research suggests to coffee shop retailer to conduct the collaborative forecasting with their supplier to increase accuracy and add competitive advantage over others. Hence, this research aims to identify the feasibility of collaborative forecasting implementation towards the coffee shop with Eksoz et al. (2014) framework and Duru et al. (2012) method. The result of this research will be the improvement of accuracy forecasting by highlighting comparison between existing forecast technique and collaborative forecasting implementation.

3.5 Problem Formulation

This research focuses in analyzing collaborative forecasting in coffee shop retailer. Later after identifying the problem, problem formulation can be resumed. Problem formulation is being used to direct the solution from the problem and as a foundation to make a conclusion.

3.6 Data collection

This research uses two types of data, which are:

1. Primary Data

   Primary data is a data that obtained from direct sources. Primary data of this research is obtained from both owner of the Kontjo Kopi and Brother Roaster. The data that will be uses are sales data of coffee latte that used Bajawa beans from January 2017 until December 2017.

2. Secondary Data

   Secondary data is obtained from several literature reviews and books. Secondary data are used for supporting the research in term of argument and statement towards the research.

3.7 Data Collecting Method

The methods of data collecting in this research are interview and observation. Data collecting method is used to get information to implement collaborative forecasting. The methods are:

1. Interview

   Interview is conducted by two parties, researcher as an interviewer will ask several questions while the interviewee provides the answers based on the questions. Interview is conducted to the both owner of the Kontjo Kopi and Brother Roaster.

2. Observation

   Observation is used to observe the business process of Kontjo kopi and Brother Roaster. Observation is performed to gather information for analyzing collaborative forecasting

3.8 Data Processing

In this research, there will be three data processing techniques to get the result in analyzing collaborative forecasting frameworks; there are the regression analysis calculation, collaborative forecasting calculation with Fuzzy Delphi and comparison model with mean squared error and tracking signal.

3.8.1 Regression Analysis

The regression analysis forecasting is classified from the quantitative forecasting techniques with time series criteria. Time series categorized as static or adaptive. In static methods, the estimates of parameters and demand patterns are not updated as new demand is observed, static method include regression (Chopra and Meindl, 2007).

Regression analysis calculation was the existing technique that used by the coffee shop retailer to calculate the demand. Based on the explanation above, Equation 3.1 to Equation 3.3 show the calculation of the regression analysis forecast:

$$Y'(t) = a + b(t) \tag{3.1}$$

$$b = \frac{n\sum_{i=1}^{n} tY(t) - \sum_{i=1}^{n} Y(t) \sum_{i=1}^{n} t}{n\sum_{i=1}^{n} t^2 - (\sum_{i=1}^{n} t)2} \tag{3.2}$$

$$a = \frac{\sum_{i=1}^{n} Y(t) - b\sum_{i=1}^{n} t}{n} \tag{3.3}$$

Where :

a: Raw results from least square criterion

b: Raw results from least square criterion

t: Period from index

n: Number of observation

$Y'(t)$: The Data of t

3.8.2 Fuzzy Delphi

Fuzzy Delphi in this research is collaborative forecasting technique that will be applied to the researcher case. Fuzzy Delphi will be used for combining the statistical forecast and judgmental adjustment to the final results. The Delphi technique will be the input opinion from the experts and the fuzzy logic are method to interpret the opinion to the forecasting results.

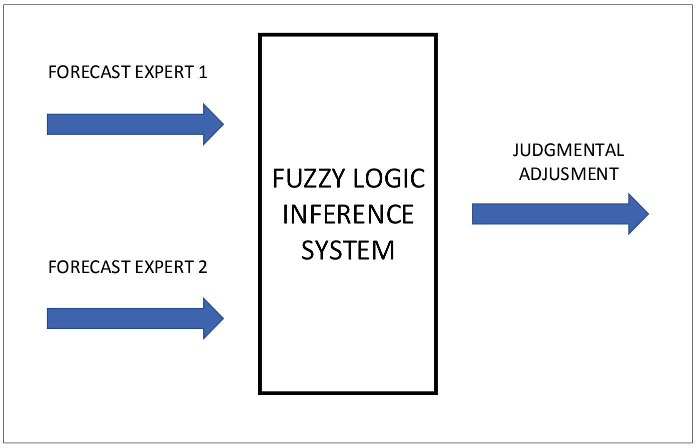

Figure 3.1 Fuzzy Logic Diagram of Fuzzy Delphi

Below are the steps of creating fuzzy Delphi on this research:

1. Fuzzy set Determination
   Fuzzy set determine the likert scale to the fuzzy inference system.

2. Membership Function Determination
   Determining the weighting scale of the likert scale to the fuzzy logic

3. Rule Determination
   Determining the rule that used to process the input

4. Deffuzification analysis
   Analyze the result of fuzzy that will be used in next step of point of view.

5. Expert point of view determination
   Expert's point of view input based on the experts' judgmental adjustment on selected period.

3.8.3 Comparison Model

Comparison model will compare the result of regression analysis and fuzzy judgmental adjustment, to compare the model it will be used two measurements of forecast error which is Mean Squared Error (MSE) and Tracking Signal (TS). Below are the equation to calculate MSE and TS:

- Mean Squared Error Equation:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 \qquad (3.4)$$

Where:

n = is the value of the forecast

$\hat{Y}$ = is a vector of n predictions

Y = is the vector of observed values of the variable being predicted

- Tracking Signal Equation

$$\text{Tracking Signal (TS)} : \frac{CFE}{MAD} \tag{3.5}$$

Where:

CFE = is cumulative forecasting error obtained from cumulative error forecasting on previous period plus forecasting error in same period.

MAD = is mean absolute deviation obtained from cumulative absolute deviation divided by the period of the forecasting one by one.

The results of the comparison model will highlight which one is the better model to be implemented and as indicator of the effectiveness of the framework. Then the model that has better MSE and TS will be selected.

3.9 Research Flowchart

The research diagram is used to solve problems. Research diagram explain the steps of conducting research from the beginning until final result. The research diagram can be seen in figure 3.3 below:

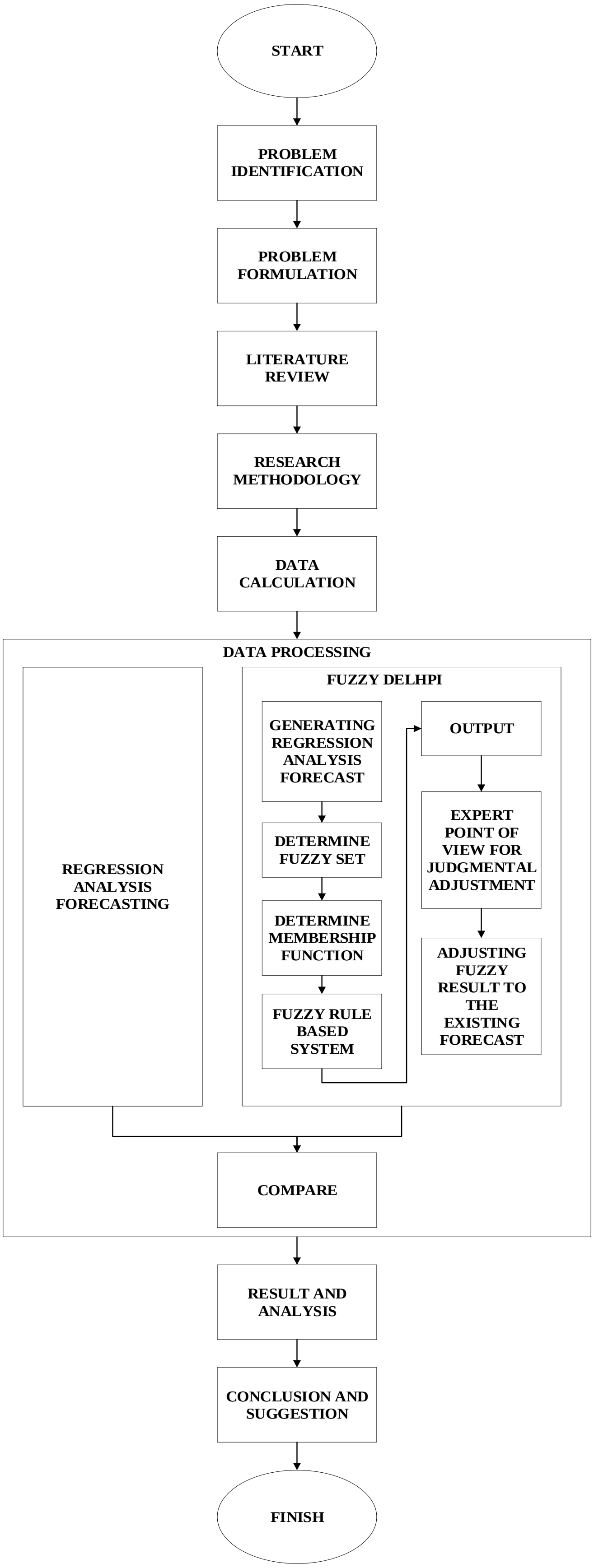

Figure 3.2 Research Flowchart

3.10 Discussion

After all the data processing finished, then discussion will be conducted starting from the result of calculation using regression analysis forecasting, Fuzzy Delphi until the model comparison. Discussion section explains the result and the framework's highlight.

3.11 Conclusion and recommendation

This chapter would be briefly explaining the answers of all the problem formulations that have already formulated in the beginning of the research. Besides, there are several suggestions that can be used by the institution and further research.

CHAPTER IV

DATA COLLECTING AND PROCESSING

4.1 Data Collecting

Based on the research methodology, in order to construct collaborative forecasting framework with Fuzzy Delphi, researcher needs to collect certain data to support the implementation of collaborative forecasting. The data needed to create collaborative forecasting are the demand data. In this research, researcher focused only to one product and one supplier, the product chosen is coffee latte which used the Bajawa beans as the main ingredients and Brother Roaster as supplier.

4.1.1 Historical Data

4.1.1.1 Demand Data

After collecting the sales data from Kontjo kopi, researcher gathers the demand data of coffee latte which use Bajawa beans. The Bajawa beans that sent by the supplier are based on the order from the Kontjo kopi. Demand data are used to generate the forecasting result. First, the demand data are used for the existing forecasting technique from the coffee shop which is regression analysis forecasting. Second, they are used for generating collaborative forecasting with Fuzzy Delphi. Demand data used for this research ranged from January 2017 to December 2017 which can be seen in Table 4.1 below:

Table 4.1 Demand Data

Month	Demand
January	390
January	395
February	380
February	390
March	600
March	630
April	700
April	650
May	600
May	620
June	500
June	480
July	630
July	690
August	360
August	420
September	730
September	770
October	600
October	640
November	430
November	510
December	560
December	620

From the data above, the calculation of the demand is 10 grams of Bajawa beans for every 1 cup of coffee latte. Thus, 390 demands mean 39 cups of coffee in January for example. The conversion from the cup of coffee to the grams is based on system order to supplier. The Kontjo Kopi orders beans in grams to the supplier, supplier accepts the order and send the beans in grams to the coffee shop retailer. The orders from the Kontjo kopi is executed every 2 weeks, then the shipment from the supplier follows the order from the Konjto Kopi.

4.2 Data Processing

4.2.1 Regression Analysis Forecasting

Based on the observation on the retailer, it used regression analysis as their forecast technique. Regression analysis equation is the first step to generate regression analysis forecasting result. Below is the calculation of regression analysis equation result, as seen in table 4.2 below:

Table 4.2 Regression Analysis Equation Result

Regression Equation	
B	5,11
A	490,01
Y(t)	a + b(t)

Table 4.3 Forecast Result Regression Analysis

Month	Demand	Forecast	Month	Demand	Forecast
January	390	495	July	630	557
January	395	500	July	690	562
February	380	505	August	360	567
February	390	510	August	420	572
March	600	516	September	730	577
March	630	521	September	770	582
April	700	526	October	600	587
April	650	531	October	640	592
May	600	536	November	430	597
May	620	541	November	510	603
June	500	546	December	560	608
June	480	551	December	620	613

The calculation done by retailer used the set of forecasting to 24 periods, and in figure 4.1 below is the trend line of the regression analysis compared to the actual demands:

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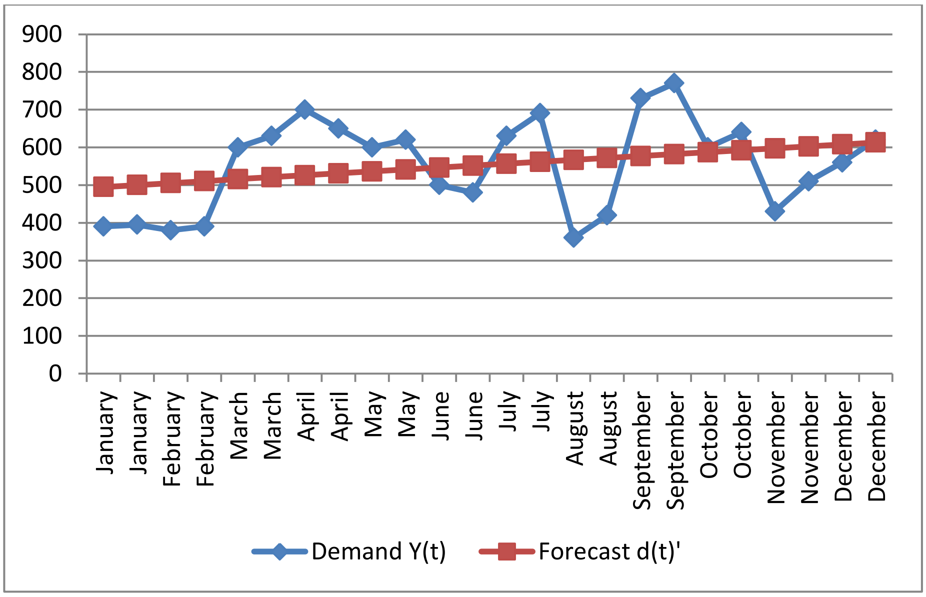

Figure 4.1 Regression Analysis Forecasting

4.2.2 Collaborative Forecasting Framework Implementation

In Eksoz et al. (2014) framework they suggested to use combined forecasting technique as a tool to implement the framework, it leads researcher try to combine the quantitative technique and judgmental adjustment. In this research, researcher used the fuzzy logic to interpret the judgmental adjustment from retailer and the supplier as the expert of the forecasting. Fuzzy logic then used as the method to obtain result on two experts in term of difference view of forecasting, then the optimal result of forecasting can be generated. By using fuzzy judgmental adjustment it leads to better accuracy.

Combined forecasting technique applies the period data one to twelve from the previous forecasting regression analysis. Two experts are compulsory to do the judgmental adjustment every month from period one until period twelve. The selection of twelve periods is based on the agreement between retailer and supplier that will conduct the collaborative meeting every 6 months or twice in a year. As the previous agreement, researcher conducted the Fuzzy Delphi until June.

4.2.2.1 Fuzzy Inference System Determination

Fuzzy inference systems are used to determine how many input and output each dimensions of collaborative forecasting framework. In building a fuzzy inference system, this research uses Mamdani inference model. Fuzzy inference system input in collaborative forecasting framework will be defined as below:

1. Forecasting Expert 1
   Forecasting expert 1 will adjust the forecasting based on the desire of the expert and put it as the expert view as the next stage of the fuzzy system

2. Forecasting Expert 2
   Forecasting expert 2 will adjust the forecasting based on the desire of the expert and put it as the expert view as the next stage of the fuzzy system

Fuzzy inference system ouput in collaborative forecasting framework will be defined as below:

1. Judgmental forecast adjustment

   The output of the expert will present as the adjustment to the existing forecasting

4.2.2.2 Fuzzy Set Determination

Fuzzy sets determination is used to determine the score of expert's linguistic variables for each dimension and attributes of collaborative forecasting framework. The figure of fuzzy sets determination can be seen in Figure 4.3 below:

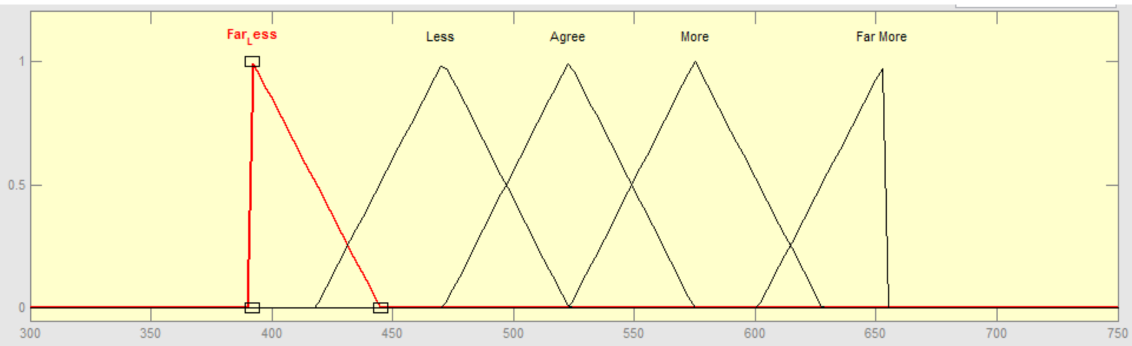

Figure 4.2 Fuzzy Set Determination of Collaborative Forecasting Framework

The weights of fuzzy set are based on Likert Scale. The range of Likert scale are, Far less than statistical forecast (-15% - -25% | around -20%) is 1; Less than statistical forecast (-5% - -15% | around -10%) is 2; Agree with statistical forecast (-5% - 5% | around 0%) is 3; More than statistical forecast (5% - 15% | around 10%) is 4; Far more than statistical forecast (15% - 25% | around 20%) is 5. Likert scale is translated into 5 parameters. Likert scale is translated into, Far Less than statistical forecast with the weights of score are 1 and 2; Less than statistical forecast with the weight score are 1, 2, 3; Agree with statistical forecast with the weights score are 2, 3, 4; More than statistical forecast with the weights score are 3, 4, 5; Far more than statistical forecast with the weight score are 4 and 5.

4.2.2.3 Membership Function

After defining fuzzy set, membership functions are used to define each membership function of dimensions in collaborative forecasting framework.

1. Forecasting Expert 1

   In forecasting expert 1 membership functions have the range of input from 300 to 750, the chosen range based on the varying forecasting resulted from 400 to 600. For the input diagram, the input is started by calculating the mean of the forecasting which is 523, then 523 become the based value to set the Likert scale range. The first Likert scale is Far less than statistical forecast (-15% - -25% | around -20%) which translated into (445 - 392 | around 418). The second Likert scale is less than statistical forecast (-5% - -15% | around -10%) which translated into (497 - 445 | around 471). The third Likert scale is Agree with statistical forecast (-5% - 5% | around 0%) which translated into (497 - 549 | around 523). The fourth Likert scale is More than statistical forecast (5% - 15% | around 10%) which translated into (549 601 | around 575). The fifth Likert scale is Far more than statistical forecast (15% - 25% | around 20%) which translated into (601 - 654 | around 628%). The value of forecasting result above becomes the input value to the range of fuzzy membership function with 5 linguistic variables and 5 parameters. Expert 1 has 5 linguistic variables, which are Far less than statistical forecast (FL), Less than statistical forecast (L), Agree with statistical forecast (A), More than statistical forecast (M), Far more than statistical forecast (FM). FL with the weights of score are 392, 392, 445; L with the weights score are 418, 471, 523; A with the weight score are 471, 523, 575; M with the weight score are 523, 575, 628; FM with the weight score 601, 654, 654. Membership functions of collaborative framework shown in figure 4.3 below:

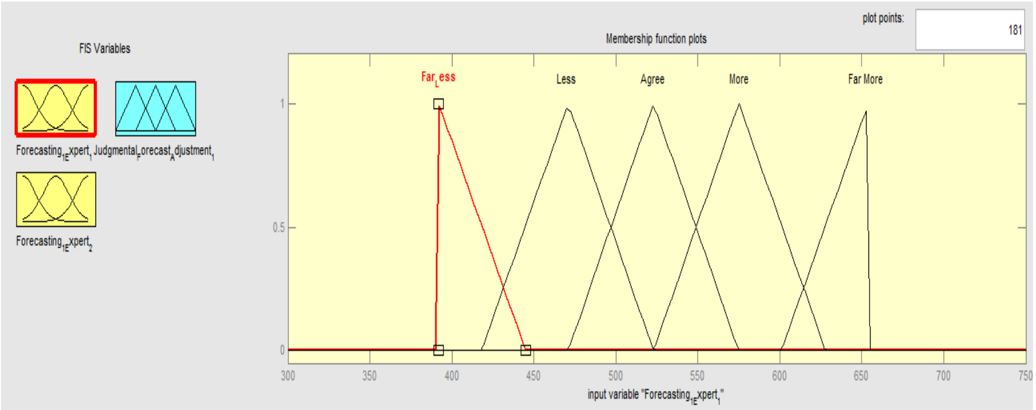

Figure 4.3 Membership Function of Forecasting Expert 1

2. Forecasting Expert 2

In forecasting expert 2 membership functions have the range of input from 300 to 750, the chosen range based on the varying forecasting resulted from 400 to 600. For the input diagram, the input is started by calculating the mean of the forecasting which is 523, then 523 become the based value to set the Likert scale range. The first Likert scale is Far less than statistical forecast (-15% - -25% | around -20%) which translated into (445 - 392 | around 418). The second Likert scale is less than statistical forecast (-5% - -15% | around -10%) which translated into (497 - 445 | around 471). The third Likert scale is Agree with statistical forecast (-5% - 5% | around 0%) which translated into (497 - 549 | around 523). The fourth Likert scale is More than statistical forecast (5% - 15% | around 10%) which translated into (549 601 | around 575). The fifth Likert scale is Far more than statistical forecast (15% - 25% | around 20%) which translated into (601 - 654 | around 628%). The value of forecasting result above becomes the input value to the range of fuzzy membership function with 5 linguistic variables and 5 parameters. Expert 1 has 5 linguistic variables, which are Far less than statistical forecast (FL), Less than statistical forecast (L), Agree with statistical forecast (A), More than statistical forecast (M), Far more than statistical forecast (FM). FL with the weights of score are 392, 392, 445; L with the weights score are 418, 471, 523; A with the weight score are 471, 523, 575; M with the weight score are 523, 575, 628; FM with the weight score 601, 654, 654. Membership functions of collaborative framework shown in figure 4.4 below:

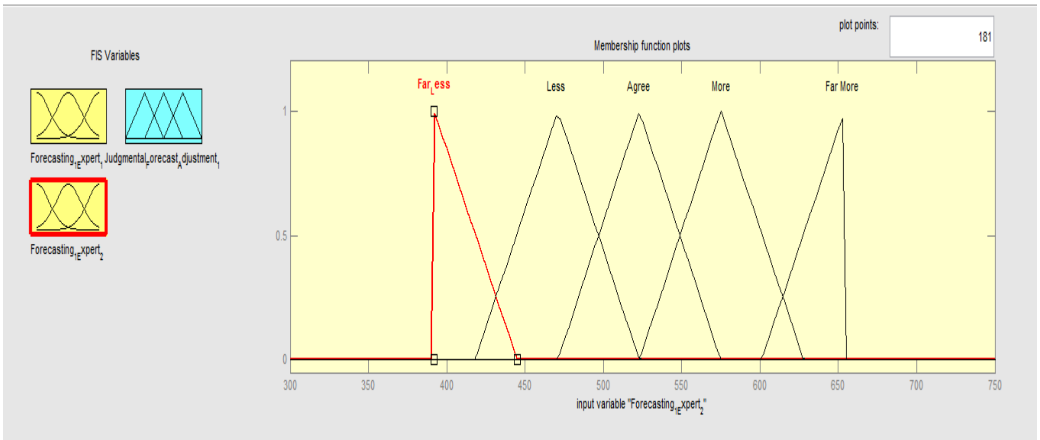

Figure 4.4 Membership Function of Forecasting Expert 2

3. Judgmental Forecast Adjustment

In Judgmental forecast adjustment membership functions have the range of input from 300 to 750, the chosen range based on the varying forecasting result from 400 to 600. For the input diagram the input start by calculating the mean of the forecasting which is 523, then 523 become the based valued to set the Likert scale range. The first Likert scale is Far less than statistical forecast (-15% - -25% | around -20%) which translated into (445 - 392 | around 418). The second Likert scale is less than statistical forecast (-5% - -15% | around -10%) which translated into (497 - 445 | around 471). The third Likert scale is Agree with statistical forecast (-5% - 5% | around 0%) which translated into (497 - 549 | around 523). The fourth Likert scale is More than statistical forecast (5% - 15% | around 10%) which translated into (549 601 | around 575). The fifth Likert scale is Far more than statistical forecast (15% - 25% | around 20%) which translated into (601 - 654 | around 628%). The value of forecasting result above becomes the input value to the range of fuzzy membership function with 5 linguistic variables and 5 parameters. Expert 1 has 5 linguistic variables, which are Far less than statistical forecast (FL), Less than statistical forecast (L), Agree with statistical forecast (A), More than statistical forecast (M), Far more than statistical forecast (FM). FL with the weights of score are 392, 392, 445; L with the weights score are 418, 471, 523; A with the weight score are 471, 523, 575; M with the weight score are 523, 575, 628; FM with the weight score 601, 654,

654. Membership functions of collaborative framework shown in figure 4.5 below:

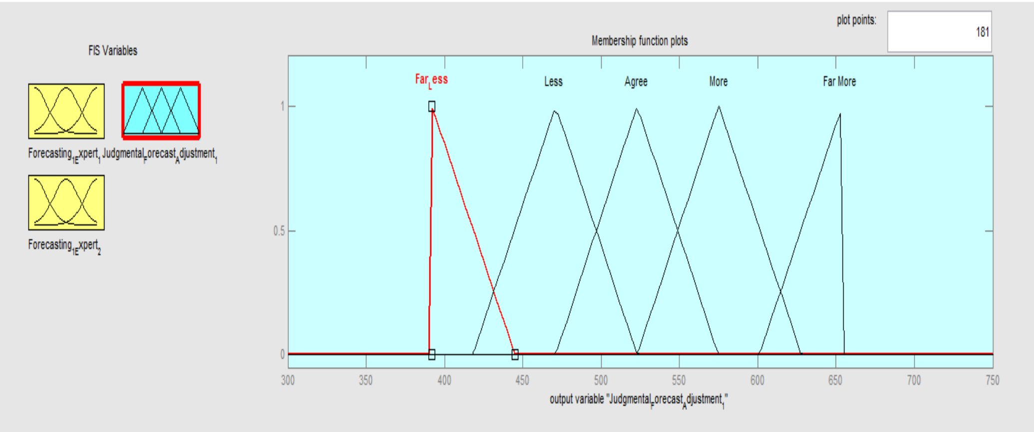

Figure 4.5 Membership Function of Judgmental Adjustment Forecasting

4.2.2.4 Fuzzy Rule System

Development of fuzzy rule system uses Mamdani Inference System. The general form of fuzzy rules is shown as below:

1. Forecasting Expert 1 = f_1
2. Forecasting Expert 2 = f_2
3. Judgmental Adjustment = JA

R_1 = IF f_1 is FL AND f_2 is FL THEN JA is FL

R_2 = IF f_1 is FL AND f_2 is L THEN JA is L

R_3 = IF f_1 is FL AND f_2 is A THEN JA is L

R_4 = IF f_1 is FL AND f_2 is M THEN JA is A

R_5 = IF f_1 is FL AND f_2 is FM THEN JA is A

R_6 = IF f_1 is L AND f_2 is FL THEN JA is L

R_7 = IF f_1 is L AND f_2 is L THEN JA is L

R_8 = IF f_1 is L AND f_2 is A THEN JA is L

R_9 = IF f_1 is L AND f_2 is M THEN JA is A

R_{10} = IF f_1 is L AND f_2 is FM THEN JA is A

R_{11} = IF f_1 is A AND f_2 is FL THEN JA is L

R_{12} = IF f_1 is A AND f_2 is L THEN JA is L

R_{13} = IF f_1 is A AND f_2 is A THEN JA is A

R_{14} = IF f_1 is A AND f_2 is M THEN JA is M

R_{15} = IF f_1 is A AND f_2 is FM THEN JA is M

R_{16} = IF f_1 is M AND f_2 is FL THEN JA is A

R_{17} = IF f_1 is M AND f_2 is L THEN JA is A

R_{18} = IF f_1 is M AND f_2 is A THEN JA is M

R_{19} = IF f_1 is M AND f_2 is M THEN JA is M

R_{20} = IF f_1 is M AND f_2 is FM THEN JA is M

R_{21} = IF f_1 is FM AND f_2 is FL THEN JA is A

R_{22} = IF f_1 is FM AND f_2 is L THEN JA is A

R_{23} = IF f_1 is FM AND f_2 is A THEN JA is M

R_{24} = IF f_1 is FM AND f_2 is M THEN JA is M

R_{25} = IF f_1 is FM AND f_2 is FM THEN JA is FM

4.2.2.5 Deffuzification

Defuzzification is used to obtain the result of final crisp output from fuzzy set. The output of fuzzy set from dimensions and attributes are shown as follows:

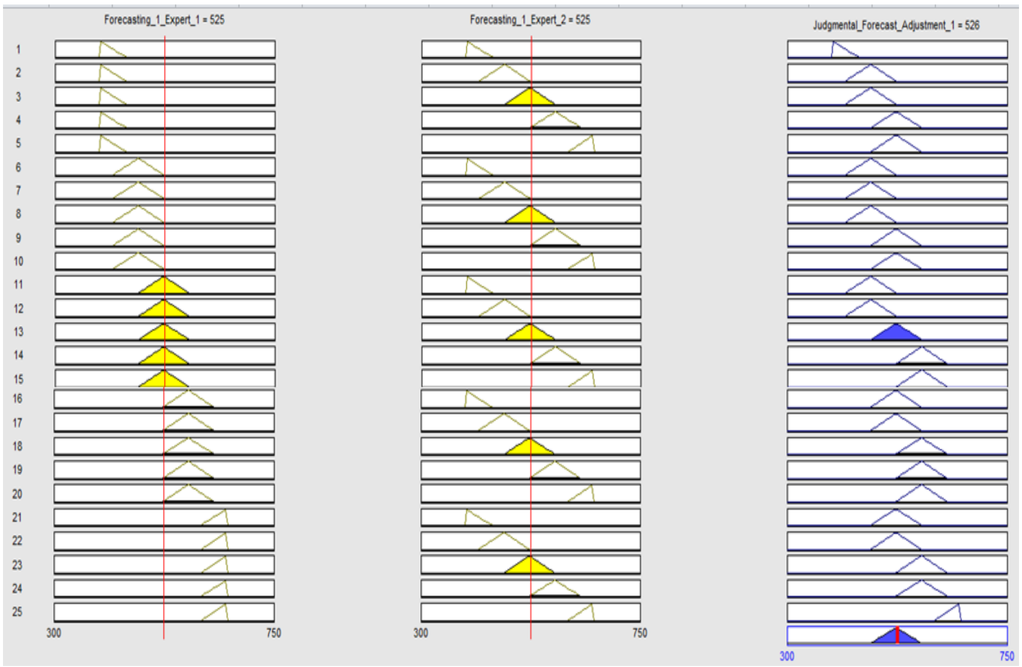

Figure 4.6 Fuzzy Rule Output Collaborative Forecasting Framework

The calculation process of judgmental adjustment output is 526. Forecasting expert 1 is 525, and forecasting expert 2 is 525. From the figure, it can be resumed that the deffuzification results the number of the demand forecast.

4.2.2.6 Expert Point Of view

In this section, experts' point of view will determine the number of adjustments based on their opinions toward the existing forecasting on 12 periods, starting from the January until June. The judgmental adjustment calculated for each of every month by experts based on their opinion. Below are the adjustments of the forecast by using the expert point of view;

1. January

   Based on the existing forecasting, on January period 1 the existing forecast is 495. Then both of retailer and supplier suggested that the forecast of January period 1 should be 400 from forecasting expert 1 and 400 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

   R_1 = [400 400] → [410]

   From the fuzzy result, it is shown that for January period 1 the adjustment is 410, the result then inputted to the forecasting results.

2. January

   Based on the existing forecasting, on January period 2 the existing forecast is 500. Then both of retailer and supplier suggested the forecast of January period 2 should be 410 from forecasting expert 1 and 420 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

   R_1 = [410 420] → [423]

From the fuzzy result, it is shown that for January period 2 the adjustment is 423, the result then inputted to the forecasting results.

3. February

Based on the existing forecasting, on February period 3 the existing forecast is 505. Then both of retailer and supplier suggested the forecast of February period 3 should be 420 from forecasting expert 1 and 420 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

$R_1 \quad = [420\ 420] \rightarrow [423]$

From the fuzzy result it is shown that for February period 3 the adjustment is 423, the result then inputted to the forecasting results.

4. February

Based on the existing forecasting, on February period 4 the existing forecast is 510. Then both of retailer and supplier suggested the forecast of February period 4 should be 420 from forecasting expert 1 and 450 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

$R_1 \quad = [420\ 450] \rightarrow [471]$

From the fuzzy result it is shown that for February period 4 the adjustment is 471, the result then inputted to the forecasting results.

5. March

Based on the existing forecasting, on March period 5 the existing forecast is 516. Then both of retailer and supplier suggested the forecast of March period 5 should be 550 from forecasting expert 1 and 650 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [550 650] → [575]

From the fuzzy result it is shown that for March period 5 the adjustment is 575, the result then inputted to the forecasting results.

6. March

Based on the existing forecasting, on March period 6 the existing forecast is 521. Then both of retailer and supplier suggested the forecast of March period 6 should be 600 from forecasting expert 1 and 650 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [600 650] → [575]

From the fuzzy result it is shown that for March period 6 the adjustment is 575, the result then inputted to the forecasting results.

7. April

Based on the existing forecasting, on April period 7 the existing forecast is 526. Then both of retailer and supplier suggested the forecast of April period 7 should be 650 from forecasting expert 1 and 650 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [650 650] → [636]

From the fuzzy result it is shown that for April period 7 the adjustment is 636, the result then inputted to the forecasting results.

8. April

Based on the existing forecasting, on April period 8 the existing forecast is 531. Then both of retailer and supplier suggested the forecast of April period 8 should be 645 from forecasting expert 1 and 650 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [654 650] → [635]

From the fuzzy result it is shown that for April period 8 the adjustment is 635, the result then inputted to the forecasting results.

9. May

Based on the existing forecasting, on May period 9 the existing forecast is 536. Then both of retailer and supplier suggested the forecast of May period 9 should be 580 from forecasting expert 1 and 600 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [580 600] → [575]

From the fuzzy result it is shown that for May period 9 the adjustment is 575, the result then inputted to the forecasting results.

10. May

Based on the existing forecasting, on May period 10 the existing forecast is 541. Then both of retailer and supplier suggested the forecast of May period 10 should be 620 from forecasting expert 1 and 650 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [620 650] → [603]

From the fuzzy result it is shown that for May period 10 the adjustment is 603, the result then inputted to the forecasting results.

11. June

Based on the existing forecasting, on June period 11 the existing forecast is 546. Then both of retailer and supplier suggested the forecast of June period 11 should be 520 from forecasting expert 1 and 520 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [520 520] → [519]

From the fuzzy result it is shown that for June period 11 the adjustment is 519, the result then inputted to the forecasting results.

12. June

Based on the existing forecasting, on June period 12 the existing forecast is 551. Then both of retailer and supplier suggested the forecast of June period 12 should be 500 from forecasting expert 1 and 500 from forecasting expert 2, the result of the expert view with the fuzzy rule are:

R_1 = [500 500] → [499]

From the fuzzy result it is shown that for June period 12 the adjustment is 499, the result then inputted to the forecasting results.

4.2.2.7 Fuzzy Delphi Results

After generating fuzzy logic, the researcher obtains the forecast adjustment from expert 1 and expert 2. The adjustment results then inputted into the forecast result, below is the table of the adjustments:

Table 4.4 Fuzzy Delphi Result

Period	Month	Demand	Forecast	Fuzzy Delphi
1	January	390	495	410
2	January	395	500	423
3	February	380	505	423
4	February	390	510	471
5	March	600	516	575
6	March	630	521	575
7	April	700	526	636
8	April	650	531	635
9	May	600	536	575
10	May	620	541	603
11	June	500	546	519
12	June	480	551	499

From the table, it can be seen that the adjustment is different from the forecasting, this result is emerged due to the opinion of expert itself. Figure 4.7 below will highlight the different result from regression analysis forecasting and combining forecasting with Fuzzy Delphi:

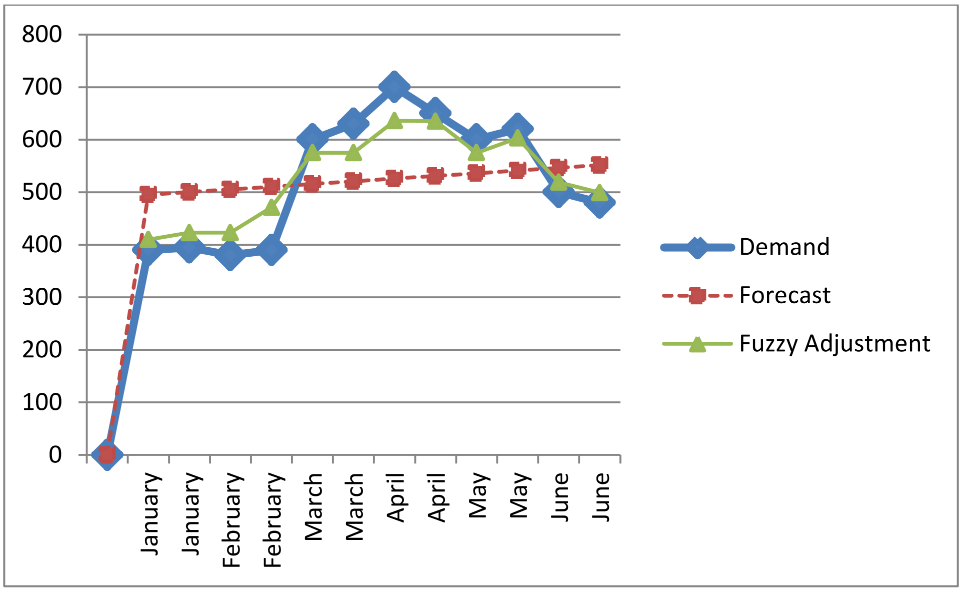

Figure 4.7 Fuzzy Delphi Result

From the table above the blue line represents the actual demand data, while the red and green line represents regression analysis and combined forecasting with Fuzzy Delphi sequentially. The difference from the regression analysis forecasting and combined forecasting with Fuzzy Delphi can be seen through the gap of the results. From regression analysis forecasting, the result follows the trend line that increased from period 1 until period 2. Yet, the difference of combined forecasting with Fuzzy Delphi is the result of following the historical demand. These results purely based on the experts' opinions to predict the forecast to historical demand for a better sense. This combined forecasting with Fuzzy Delphi makes the forecast leads to better accuracy.

4.2.3 Comparison Model with Mean Squared Error and Tracking Signal

In order to answer second problem formulation which is to measure effectiveness of collaborative forecasting with Fuzzy Delphi, researcher compares regression analysis forecasting result with combined forecasting with Fuzzy Delphi.

4.2.3.1 Regression Analysis Calculation Mean Squared Error and Tracking Signal

The Regression analysis forecast is obtained from the retailer itself that conducted while doing the forecasting for their own purpose. Retailer adopted the regression analysis forecasting technique to forecast the sales of their product. Below are the calculations of MSE and TS of the forecasting with regression analysis for 12 periods of Bajawa beans used for making coffee latte:

Table 4.5 Calculation of MSE and TS Regression Analysis Forecasting

FE	**CFE**	**AD**	**CAD**	**MAD**	**TS**	**UCL**	**LCL**	**Squared Error**
-105	-105	105	105	105.13	-1.00	4	-4	11053.0
-105	-210	105	210	105.19	-2.00	4	-4	11077.3
-125	-336	125	336	111.92	-3.00	4	-4	15716.1
-120	-456	120	456	114.06	-4.00	4	-4	14515.2
84	-372	84	541	108.13	-3.44	4	-4	7124.3
109	-263	109	650	108.32	-2.42	4	-4	11944.4
174	-88	174	824	117.73	-0.75	4	-4	30337.1
119	31	119	943	117.89	0.26	4	-4	14175.3
64	95	64	1007	111.90	0.85	4	-4	4089.0
79	173	79	1086	108.59	1.60	4	-4	6214.1
-46	127	46	1132	102.93	1.24	4	-4	2142.3
-71	56	71	1204	100.30	0.56	4	-4	5098.1

Table 4.6 TS and MSE Results

Tracking Signal	**Mean Squared Error**
-1.01	11123.8

From the table above, the results of the tracking signal and Mean squared error for the regression analysis forecasting are obtained. From that point, it can be seen that the tracking signal score is -1.01 and for the mean squared error score is 11123.8. This result will be compared to combined forecasting with Fuzzy Delphi.

4.2.3.2 Combined forecasting with Fuzzy Delphi Mean Squared Error and Tracking Signal

The combined forecasting with Fuzzy Delphi obtained from both expert 1 and expert 2 as representation from retailer and supplier. The results of the adjustment are based on their judgment on the existing forecast whether it should be lower or higher. Below are the calculations of MSE and TS of the combined forecasting with Fuzzy Delphi for 12 periods of Bajawa beans used for making coffee latte:

Table 4.7 Calculation of MSE and TS Combined forecasting with Fuzzy Delphi

FE	CFE	AD	CAD	MAD	TS	UCL	LCL	Squared Error
-20	-20	20	20	20.00	-1.00	4	-4	400
-28	-48	28	48	24.00	-2.00	4	-4	784
-43	-91	43	91	30.33	-3.00	4	-4	1849
-81	-172	81	172	43.00	-4.00	4	-4	6561
25	-147	25	197	39.40	-3.73	4	-4	625
55	-92	55	252	42.00	-2.19	4	-4	3025
64	-28	64	316	45.14	-0.62	4	-4	4096
15	-13	15	331	41.38	-0.31	4	-4	225
25	12	25	356	39.56	0.30	4	-4	625
17	29	17	373	37.30	0.78	4	-4	289
-19	10	19	392	35.64	0.28	4	-4	361
-19	-9	19	411	34.25	-0.26	4	-4	361

Table 4.8 TS and MSE Results

Tracking Signal	Mean Squared Error
-1.31	1600.1

From the table above we can get the results of the tracking signal and Mean squared error for the combined forecasting with Fuzzy Delphi done by the expert 1 and expert 2. From that point, it can be seen that the tracking signal score is -1.31 and for the mean squared error score is 1600.1.This result will be compared to combined forecasting with Fuzzy Delphi.

4.2.3.3 Comparison Result with MSE and TS

After calculating both regressions analysis and combined forecasting with Fuzzy Delphi, it can be generated the MSE and TS score. It will be highlighted the difference of the regression analysis and combined forecasting with Fuzzy Delphi in table below:

Table 4.9 Comparison MSE and TS

	Regression Analysis	**Fuzzy Delphi**
Tracking Signal	-1.01	-1.31
Mean Squared Error	11123.8	1600.1

From the table above, it can be seen that the tracking signal from regression analysis is -1.01 and from Fuzzy Delphi is -1.31, this score represents that the Fuzzy Delphi has the better results due to the value of the score is lower than the other. From the mean squared error results, it can be seen that the regression analysis has the score of 11123.8 while the Fuzzy Delphi is 1600.1, it indicates that the Fuzzy Delphi is better due to lower error results if compared to regression analysis. Thus, it can be concluded that both of MSE and TS from Fuzzy Delphi is superior to Regression analysis, and collaborative forecasting framework with Fuzzy Delphi is effective.

For proving other effectiveness of collaborative forecasting with Fuzzy Delphi researcher will highlight the difference of tracking signal from regression analysis and combined forecasting with Fuzzy Delphi in Table 4.10 and figure 4.8 below:

Table 4.10 Comparing TS

UCL	LCL	TS RA	TS FA
4	-4	-1.00	-1.00
4	-4	-2.00	-2.00
4	-4	-3.00	-3.00
4	-4	-4.00	-4.00
4	-4	-3.44	-3.73
4	-4	-2.42	-2.19
4	-4	-0.75	-0.62
4	-4	0.26	-0.34
4	-4	0.85	0.28
4	-4	1.60	0.75
4	-4	1.24	0.25
4	-4	0.56	-0.29

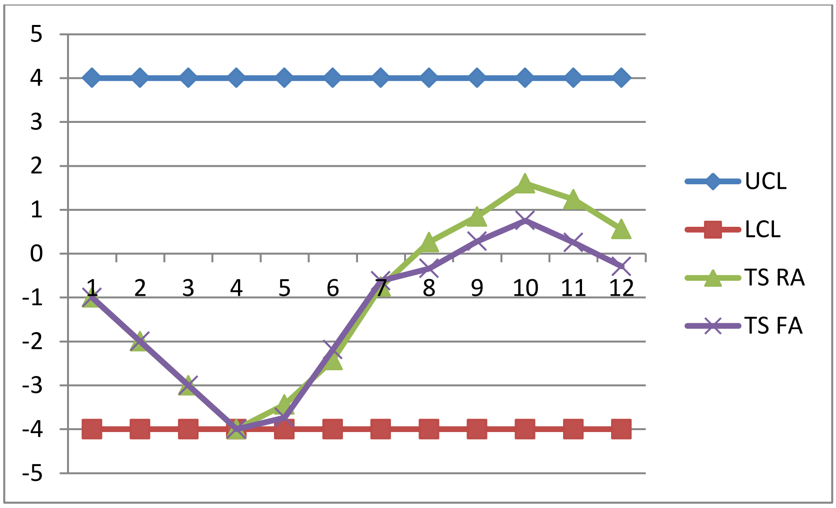

Figure 4.8 Tracking Signal Difference

From the table 4.10 and figure 4.8 above, it can be seen there is different value and graph between regression analysis and combined forecasting with Fuzzy Delphi. The graphs show that Fuzzy Delphi is better towards the regression analysis due to better score in average than regression analysis.

From the calculation above, that collaborative forecasting with fuzzy Delphi helps the users to increase the accuracy of forecasting. With the increasing accuracy, it potentially will gain benefits for both retailer and supplier. In the retailer side, better accuracy means a better plan in ordering beans to supplier. It means that retailer can avoid unnecessary order to supplier and maximize their cost for another product or category. In the supplier side, the supplier has ability to produce more beans in precise order, it creates supplier able to match the supply and demand in more effective way. Moreover, supplier could also increase their service level by making better replenishment due to information provided by retailer. The overall benefit from the operation aspects lead to retailer and supplier could reduce the cost from unnecessary planning or ordering which will lead to generate more revenues.

CHAPTER V

DICUSSION

5.1 Result Analysis

These discussions provide an analysis of framework of collaborative forecasting with Fuzzy Delphi. First of all, this research is based on the framework created by Eksoz et al. (2014) in order to construct the collaborative forecasting process in the object chosen. The concept brought by Eksoz et al. (2014) suggested 10 propositions, which are, external integration, internal integration, information type, information quality, forecast technique, judgmental adjustment, forecast horizon, forecast frequency, forecaster and group forecasting technique. However, the concept has a flaw in propositions of forecasting technique and judgmental adjustment which already addressed by combining the framework with fuzzy Delphi method to complete the implementation.

Furthermore, after interviewing the Kontjo kopi and Brother Roaster toward other propositions of Eksoz et al. (2014) framework, it was found several issues. First, when applying the concept in real condition, some of the propositions do not suit the real condition. For an example, in integration propositions, based on the real condition of the company that has been analyzed by the researcher, the internal integration do not really necessary because of the size of the company itself. Thus, the framework by Eksoz et al. (2014) needed to be specific on size of the companies for it can be applied. Second, the information quality propositions, in the real condition the information quality are really hard to measure. Whereas, the case suggests to create parameter of information, but to create the parameter is basically based on their willingness to share the truth. Third, forecast horizon propositions, in the real condition and size of the enterprise that researcher encounter, the forecast horizon does not play significant impact to the forecasting result. Yet, the framework should be adjusted to how big the enterprise is, to identify whether it needs forecast horizon propositions. Overall, the frameworks by Eksoz et al. (2014) give crucial information and guidance on how to implement the collaborative forecasting in food supply chain but still need adjustments on specific size of companies.

It is proven that Fuzzy Delphi technique proposed by Duru et al. (2012) can reduce the researcher objective by 30-40 percent on the forecast error. To create the Fuzzy Delphi, it takes the cooperation among other parties to determine the value of the fuzzy set, fuzzy rule and in the expert point of view. Without the cooperation and feedback information between other parties it is hard to determine the fuzzy because the result is based on the expert judgment.

Based on the success of the implementation collaborative forecasting with Fuzzy Delphi, it is interesting to investigate whether the framework is sufficient to be used in more than one supplier participate as the objective. It can be added one or more suppliers with same product category or different product category to the research objective as in this research only involving one product which is Bajawa beans with only one supplier. Whereas, many of the retailers should have more than one product category in their menu, also retailers generally have more than one supplier to supply the products' demands. Thus, creating more complex chains consist of more than one suppliers with more than one product is also considered as good additional to further research in the future.

Furthermore, regarding the food supply chain industry which researcher preferred to investigate due to the few experiments on the collaborative forecasting in food supply chain, researcher can conclude that other industry with similar category might also implement this concept. For an example in the food supply chain industry, the supplier supplies the food to the retailer and retailer created the final product based on multiple products from supplier. It is the same in the apparel or furniture industry, in which the supplier sends the material of woods or wool or zipper to the retailer in order to create the final products. Based on similar characteristic of the supply chain, it is interesting to investigate whether this concept or this result of the research can be implemented into another industry with similar characteristic with food supply chain industry.

The full benefit of this research can be shown when it is fully implemented in the coffee shop retailer. The benefit that the both of companies will get is the increased revenue of the coffee shop. By forecasting accurate number of beans orders from supplier, it can reduce the waste beans from redundant ordering. It helps the companies to maintain level of keeps in the storage; it can maintain the freshness of the beans by ordering correct number in the future. Finally, the collaborative forecasting could also help the relationship among supplier and retailer with continuous interaction and coordination.

In context of development collaborative forecasting studies, the research’s result provides a deeper understanding in other ways of enhancing effectiveness in the collaborative supply chain techniques. It also gives recommendation to the owner in order to enhance the quality of their supply chain.

CHAPTER VI

CONCLUSION AND SUGGESTION

6.1 Conclusion

Based on data processing and analysis that has been performed in previous chapter, the conclusion can be drawn as follows:

1. In order to adjust the forecasting result based on expert opinion, it needs discussion from both experts of Kontjo Kopi and Brother Roaster. From the discussion, it generates five levels of adjustments, which are far less than statistical forecast, less than statistical forecast, agree with statistical forecast, more than statistical forecast, and far more than statistical forecast. This five levels adjustment is translated into Likert-Scale to the Fuzzy Delphi method. Then, experts from both Kontjo Kopi and Brother Roaster give opinion towards the existing forecast in every selected period with five levels of adjustments that has been agreed. From the adjustment, it will be generated the final forecasting results of Collaborative forecasting with fuzzy Delphi

2. In order to analyze the accuracy improvement, researcher compared regression analysis models and combined forecasting with Fuzzy Delphi. The Mean Squared Error (MSE) and Tracking Signal (TS) are taken as the indicator to evaluate accuracy improvement. The MSE and TS of regression analysis model showed 11123.8 and -1.01 respectively. While combined forecasting with Fuzzy Delphi results are 1600.1 for MSE and -1.31 for TS. From the result, it is shown

that accuracy improvement after the adjustment is 93% and 34% for MSE and TS respectively. From the result, the increase accuracy improvement will help both supplier and retailer to achieve several benefits. In the retailer side, better accuracy means that retailer able to better plan in ordering beans to supplier. It means that retailer can avoid unnecessary order and maximize their cost for another product or category. In the supplier side, the supplier has ability to produce more beans in precise order, it allows supplier able to match the supply and demand in more effective way. Moreover, supplier could also increase their service level by making better replenishment due to information provided by retailer. The overall benefit from the operation aspects lead to retailer and supplier reduce the cost from unnecessary planning or ordering which will lead retailer and supplier has ability to generate more revenue.

6.2 Suggestion

The suggestion that can be given from the results of this research for the company and further research are:

1. Kontjo Kopi and Brother roaster need to frequently hold meeting in order to get better result of collaborative forecasting, allowing each one to give feedback on what are needed to be improved on the collaborative forecasting.

2. This framework of collaborative forecasting with Fuzzy Delphi could be implemented with similar characteristic of supply chain for an example, apparel and furniture industry.

3. Encouraging other fellow researcher to create more complex chain by adding more suppliers in supply chain or adding product category by more than one product.

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