T.C. DOĞUŞ UNIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

Ph.D in LOGISTICS AND SUPPLY CHAIN MANAGEMENT

CONTRACT MANAGEMENT IN HUMANITARIAN SUPPLY CHAINS

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ISTANBUL, JUNE 2019

SOSYAL BİLİMLER / FEN BİLİMLERİ ENSTİTÜSÜ

Tarih : 12/06/2019

Anabilim Dalı : Lojistik ve Tedarik Zinciri Yönetimi Doktora Programı

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İkinci Tez Danışmanının Adı Soyadı : -

Tezin Başlığı : Contract Management in Humanitarian Supply Chains

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ACKNOWLEDGMENTS AND PREFACE

Each person has targets and ideals in their lives. Mine was being successful with my PhD thesis. In the beginning, there were so many uncertainties but with time and experience it became clearer each day. In other words, I gained the appropriate knowledge and found the power to proceed with my study day by day. Too many things have changed in my life since I began working on my thesis but the only thing that did not change was the enthusiasm that I kept alive in myself. I would like to thank my advisor Assist. Prof. Dr. Peral Toktaş Palut for her infinite patience and support in this period, she always encouraged me to go further and motivated me. I also would like to thank Assist Prof. Dr. Bora Çekyay and Prof. Dr. İlker Topçu who have supported me in all my presentations and helped me to add value to my study. I also want to thank my family Sevgi Baylav, Cengiz Baylav and my husband Atakan Köprücü. They always supported me on my PhD study and motivated me when I became desperate sometimes. This was a long journey for me, and my hope is to go even further in my academic path and keep continuous learning as the purpose of my life.

ÖZET

Son dönemde yaşanan afetlerin sıklığında gözlemlenen artış neticesinde organizasyonlar ve enstitüler tarafından afet durumunda ürün sağlayabilmek adına çalışmalar yapılmaktadır. Buna rağmen doğal afet durumlarına yönelik tedarik zinciri uygulaması, gelişmişlik olarak ticari tedarik zincirinin yaklaşık yirmi yıl gerisindedir.

Tedarik zincirinin geliştirilmesi ve optimize edilmesi kapsamında geliştirilen modeller literatürde bulunmaktadır. Fakat kontrat yönetiminde çalışma sayısı ve kapsamı açısından literatürde açık alanlar bulunmaktadır. Çalışmanın özgün modeli olan geri ödeme kontrat modeli literatürde ilk kez uygulanmıştır. Model oluşturulurken aniden gerçekleşen doğal afet durumu göz önünde bulundurulmuş ve parametreler buna göre belirlenmiştir.

Kapsam olarak ticari tedarikçi ve kar amacı gütmeyen kuruluş arasındaki ticari ilişki incelenmiştir. Model tek tedarikçi ve tek kar amacı gütmeyen kuruluş arasındaki ticari ilşkiyi incelemktedir. İki farklı kontrat modeli (opsiyon kontratı ve geri ödeme kontratı) uygulaması yapılarak koordinasyon sağlanıp sağlanamadığı gözlemlenmiştir.

Stokastik model afet sonrası etkilenen nüfusa sağlanan miadsız ürünler üzerine oluşturulmuş ve baz olarak gazeteci çocuk modeli kullanılmıştır. Afet öncesi ve sonrası getirinin farklı olacağı ve kurban sayısında azalma gözlemlenebileceği göz önünde bulundurularak afet öncesi ve sonrası gelir iki farklı parametre olarak kullanılmıştır. Koordine olmayan ilk duruma göre karşılaştırılmaları yapılarak kazan-kazan sağlanıp sağlanamadığı ve kazan kazan durumunun hangi şartlar altında var olacağı değerlendirilmiştir.

Numerik değerlendirmeler yapılırken "emdat.com" sitesinden gerçek datalar alınarak parametrelerin ve değişkenlerin dağılımına bakılmış ve buna göre data üretilerek model üzerinde uygulaması yapılmıştır.

ANOVA testi kullanılarak, uygulanan kontratlar sonucunda tarafların aldıkları kar düzeyinde önemli derecede bir farklılık olup olmadığı araştırılmış ve hangi kontratta ortaklaşa karar alınabileceği gözlemlenmiştir. Kar amacı gütmeyen yardım kuruluşları açısından opsiyon ve geri ödeme kontratı arasında önemli derecede bir farklılık olmadığı ispatlanmış ve gözlemlenmiştir. Fakat tedarikçi açısından değerlendirmede opsiyon kontratının ortalama kar açısından geri ödeme kontratına göre daha yüksek değerler verdiği saptanmıştır. Bu durumda, her iki tarafın da opsiyon kontratında anlaşma ihtimali daha yüksek görünmektedir.

ANAHTAR KELİMELER

Afet Sonrası Tedarik Zinciri Modeli, Koordinasyon, Opsiyon Kontrat Modeli, Geri Ödeme Kontrat Modeli

ABSTRACT

There is an increasing trend in the frequency of disasters in recent years. Organizations and institutions struggle to provide products and donations after disasters strike. However, when comparing humanitarian supply chain to commercial supply chain, it can be observed that humanitarian supply chain is approximately twenty years behind.

Some models are developed for optimizing humanitarian supply chains, but there is a gap in the literature for coordination with contracts. Contract models may be applied in different aspects.

For this study, “humoneytarian” relation between NGO and commercial supplier is under scope. Two different contract models (option contract and reimbursement (cost sharing) contract) are applied to see whether it is possible to coordinate humanitarian supply chain.

Originality of the study is based on reimbursement contract as there is no example of application before in literature. Stochastic model in the study is mainly based on classical newsvendor model and on non-perishable goods that are provided to victims just after the disaster occurs.

For revenue value of NGO, it has been assumed that the revenue will be different between just after disaster strikes and after some time. This is a natural fact of decrease in victim number and dissatisfaction by time. Therefore, revenue may be thought as a decreasing value by time. Model is applied for sudden onset natural disasters which causes an unstable demand.

Results are evaluated by numerical examples and interpretations are made with statistical methods. For numerical data “emdat.com” is used as a source which includes real data of disasters for many countries. Past 15 years of Turkey data is used for this study. As statistical method

To understand if there is a significance profit difference between contracts for sides or not, statistical methods were applied. One-way ANOVA is used, and as a result it is understood that for NGO there is no statistically significant difference between two contract types, however supplier will most probably choose option contract as the average profit is higher and there is a significant difference between average profit values of option and reimbursement contract. This leads the result that under given scenarios option contract will be the one which provides an eagerness for both sides.

KEYWORDS

Humanitarian Supply Chain, Relief Chain, Coordination, Option contract, Reimbursement Contract

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b_{NGO} : Backorder cost of products for NGO (per unit)

b_s: Backorder cost of supplier (per unit)

c: Capacity of the supplier (quantity that can be supplied in time after disaster strikes)

c_r: Retailer's marginal cost (per unit)

c_s: Production cost of supplier (per unit)

e: Exercise cost (per unit)

$f(q)$: Density function of demand

$F(q)$: Distribution function of demand

g_r: Goodwill penalty cost of retailer (per unit)

g_s : Goodwill penalty cost of supplier (per unit)

h : NGO's holding cost in case of overstock (per unit)

H_s : Holding cost of supplier (per unit)

$I(q)$: Expected leftover inventory (quantity)

$L(q)$: Lost sales function

O : Option cost (per unit)

p: Retail price (per unit)

$S(q)$: Expected sales

T: Transfer payment

t: Transportation cost (per unit)(paid to a third part carrier by NGO)

t_e: Transportation cost for express delivery (per unit) (paid by NGO to third party)

q: Order quantity of the retailer from supplier

v: Net salvage for retailer (per unit)

w: Wholesale price (per unit)

w_1: Social value of saving one life (per person)

w_2 : Social value of saving one life in case of backorder (per person)

X : Demand

μ: Mean demand value

$\emptyset$: Unit cost of products paid to the supplier (per unit)

δ_{NGO} : The probability of a disaster will occur which is forecasted by the NGO

$(1 - \delta_{NGO})$: The probability of no disasters will occur in the contract period

π_{NGO}^{D} : Profit of NGO in decentralized case

π_{NGO}^{O} : Profit of NGO in option contract case

π_{NGO}^{R} : Profit of NGO in reimbursement contract case

π_{S}^{D} : Profit of Supplier in decentralized case

π_{S}^{O} : Profit of Supplier in option contract case

π_{S}^{R} : Profit of Supplier in option contract case

π_{SC}^{D} : Profit of Supply Chain in decentralized case

π_{SC}^{O} : Profit of Supply Chain in option contract case

π_{SC}^{R} : Profit of Supply Chain in option contract case

1. INTRODUCTION

Increasing frequency of disasters brings out requirement for a better understanding and control of logistics and supply chain management. Based on saving human lives, humanitarian supply chain management seems to be crucial, however still twenty years behind commercial supply chain management.

Mainly, there are many studies and models developed for commercial supply chains which aim to optimize the system by maximizing profit or minimizing costs. This may be again a concern for humanitarian supply chain, however focus should always be saving human lives. Therefore, humanitarian supply chain is significantly different from commercial supply chains by means of targets.

To optimize humanitarian supply chains an alternative approach to classical parameters and different way of thinking is needed. Optimization can also take place in many ways. Each component of supply chain can be optimized or scheduled. Contract management is also one of those, which has a scope of commercial relation and agreement by sides according to their profit values.

There is a significant literature on contract management which has its focus on commercial supply chains. It has been found out many times how a regular supply chain model can be coordinated by contracts and basically which of these provides a win-win basis. However, this is not the case for humanitarian supply chains. There are just a few studies which works on relief and humanitarian supply chains. These studies apply basic contract types and search whether an agreement can be made, and the system is coordinated. The motivation of this study is the gap in the literature for coordination of humanitarian supply chain by contract management.

The coordination is aimed to be obtained between NGO and commercial supplier. A stochastic newsvendor-based model is used for defining profit functions of both sides and the supply chain. Decentralized model is evaluated and found out that base model is not coordinated for sides when they aim to have their own maximized profit values. While, NGO gets the biggest part of the profit, supplier seems to have a very small and even negative portion of the profit which does not provide a basis for agreement of sides.

Some reasons may be provided for this consequence. Firstly, revenue of NGO for saving one human life is calculated based on the value of human life according to countries. This is specified as a very large quantity when compared to other costs and commercial supplier's profit. Another reason is supplier's capacity. When the supplier is not able to meet the demand regarding its capacity, a backorder cost is being paid and the profit becomes even less. In order to balance this situation and coordinate sides to agree on one single quantity is aimed by applying contract models.

After validating decentralized model does not coordinate the system and can not provide a basis for agreement for both sides, two different contract models have been applied on the model.

First contract model applied was option contract model which has an implication in literature before. The main difference of this application is the base model as it considers different parameters. Option contract is applied in accordance with its nature. NGO pays an option price for the quantity that has been agreed on by both sides and commercial supplier holds the stock until disaster strikes. If disaster strikes depending on the demand occurred NGO exercises the contract quantity. Other probabilities are also considered by the model such as overstock and understock possibility. As option contract balance the profit for both sides by charging cost to NGO side and make NGO to decide on a more logical quantity compared to decentralized case it also serves as a more suitable tool for both sides and coordinate the model.

Secondly, reimbursement contract is applied to base model. This model has a wide range of implementations in health sector by many commercial companies based on government agreements. According to this contract model, NGO is responsible for paying a share of supplier's cost after getting its profit. This again enables a balance between the sides. By charging additional cost on NGO, supplier's burden decreases and becomes more eager on an agreement.

Rest of the study is organized as follows, second section of the study gives general information on contract types in literature, in third section there is a literature study which includes relief material management and supply chain coordination with contracts. Fourth section is the main part with methodology which is divided in several parts. Current supply chain and decentralized model is presented, option contract model and cost sharing model are described and implemented on the model. Numerical examples are given, and data consistencies are checked for both models. In last section of methodology one-way Anova comparison is made between model results. Fifth section is conclusion and as a last part bibliography is provided.

2. HUMANITARIAN SUPPLY CHAIN AND CONTRACTS

The significance of humanitarian supply chains becomes more obvious as one of the European Ambassadors stated in a post Asian Tsunami conference that “We don’t need a donors’ conference; we need a logistics conference.” (Thomas & Kopczak, 2005) This statement highlights the necessity of coordination for disaster relief as it is widely known that humanitarian logistics is so behind when compared to commercial supply chains and also there is a gap of applying existing models and ideas that are used for commercial supply chains (Awan & Rahman, 2010). However, it is an interesting fact that logistics costs have a share of 80% of the total costs in disaster relief (Van Wassenhove, 2006).

Cozzolino (2012) states that disasters can be divided into four categories such as; calamities, destructive actions, plagues and crises which are also represented in Fig 1.1. Calamities (earthquakes, tornados, etc.) are sudden-onset disasters which strike by natural causes; destructive actions (terrorist attacks, industrial accidents, etc.) are again sudden-onset disasters which are caused by man-made actions. Plagues (famines, droughts, etc.) are slow-onset disasters with natural causes and finally crises (political, etc.) are slow-onset occurrences caused by man-made actions. All disaster types need to be managed in different ways. In this study the type of disaster that is going to be used is calamities.

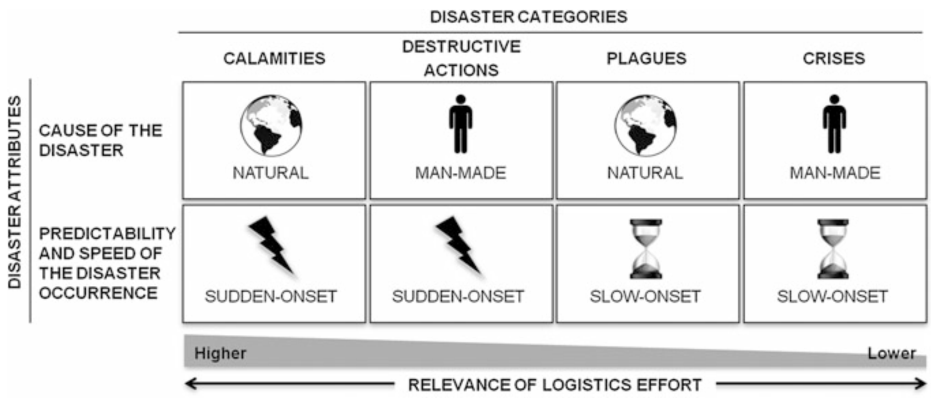

Figure 2. 1 Types of Disasters (Cozzolino, 2012)

There are many actors that take role in a disaster relief operation, which can be classified as non-governmental organizations, military, business firms, and United Nations. The relationship between non-governmental organizations and business firms, which is aimed to be used for this study, is specified as 'humoneytarian' which is represented in Fig 2.1 (Larson, 2011). These types of partnerships are also called as diagonal or vertical partnerships which occur between two firms from different sectors or areas (Cozzolino, 2012). Many non-governmental relief organizations engage with private sector companies such as suppliers and transportation providers to satisfy the large quantities of relief items. It is not easy to manage the relationships between non-governmental organizations (NGO's) and commercial companies but these types of relations may be strategic as both sides have mutual benefits such as sharing expertise and resources (Balcik, et al., 2010).

Figure 2. 2 A Typology of Relationships (Larson, 2011)

Coordination of procurement becomes a vital issue as the demand for relief products is very unpredictable and both resource scarcity and oversupply are possible. There are also some special characteristics of relief material supply chain which differentiates it from commercial supply chain which is also represented in Table 1.1 such as; being non-profit based, high-stakes, unreliability, incomplete historical data and uncertain demand pattern (Beamon, 2004). There are also other challenges when compared to commercial supply chains such as; lack of recognition of the importance of logistics, lack of professional staff, inadequate use of technology, lack of institutional learning and limited collaboration which means that some duplications may occur as a result of lack of coordination. Generally, none of the major relief organizations know each other's objectives or projects, thus they struggle for the same purposes and waste both time and resource (Thomas & Kopczak, 2005). Moreover, information of inventory is not integrated and properly kept, product expiry dates require high attention for perishable goods, demand is uncertain for both in time and space, there is a very little theory to support decisions made (Taylor, 2011).

Table 2. 1 Comparison of Commercial and Humanitarian Logistics (Ertem, et al., 2010)

Topic	Commercial logistics	Humanitarian logistics
Main objective	Maximize profit	Save lives and help beneficiaries
Demand pattern	Fairly stable and can be predicted with forecasting techniques	Irregular with respect to quantity, time, and place. Demand is estimated within the first hours of response
Supply pattern	Mostly predictable	Cash is donated for procurement. Unsolicited donations, and in-kind donations need sorting, prioritizing to decrease bottlenecks
Flow type	Commercial products	Resources like evacuation vehicles, people, shelter, food, hygiene kits, etc.
Lead time	Mostly predetermined	Approximately zero lead time, demand is needed immediately
Delivery network structure	Established techniques to find the number and locations of warehouses, distribution centers	Ad-hoc distribution facilities or demand nodes, dynamic network structure
Inventory control	Safety stocks for certain service levels can be found easily when demand and supply pattern are given	Unpredictable demand pattern makes inventory control challenging. Pre-positioned inventories are usually insufficient
Technology and in-formation systems	Highly developed technology is used with commercial software packages	Less technology is used, few software packages that can record and track logistics data. Data network is non-existent
Performance measurement method	Based on standard supply chain metrics	Time to respond the disaster, fill rate, percentage of demand supplied fully, meeting donor expectation
Equipment and vehicles	Ordinary trucks, vehicles, fork-lifts	Robust equipment are needed to be mounted and demounted easily
Human resources	Commercial logistics is a respected career path	High employee-turnover, based on voluntary staff, harsh physical and psychological environment
Stakeholders	Shareholders, customers, suppliers	Donors, governments, military, NGOs, beneficiaries, United Nations etc.

The infrastructure of humanitarian supply chains shows a similar characteristic when compared to classical supply chains. Habib, et al. (2016) defines humanitarian supply chains as in below Figure 1.3.

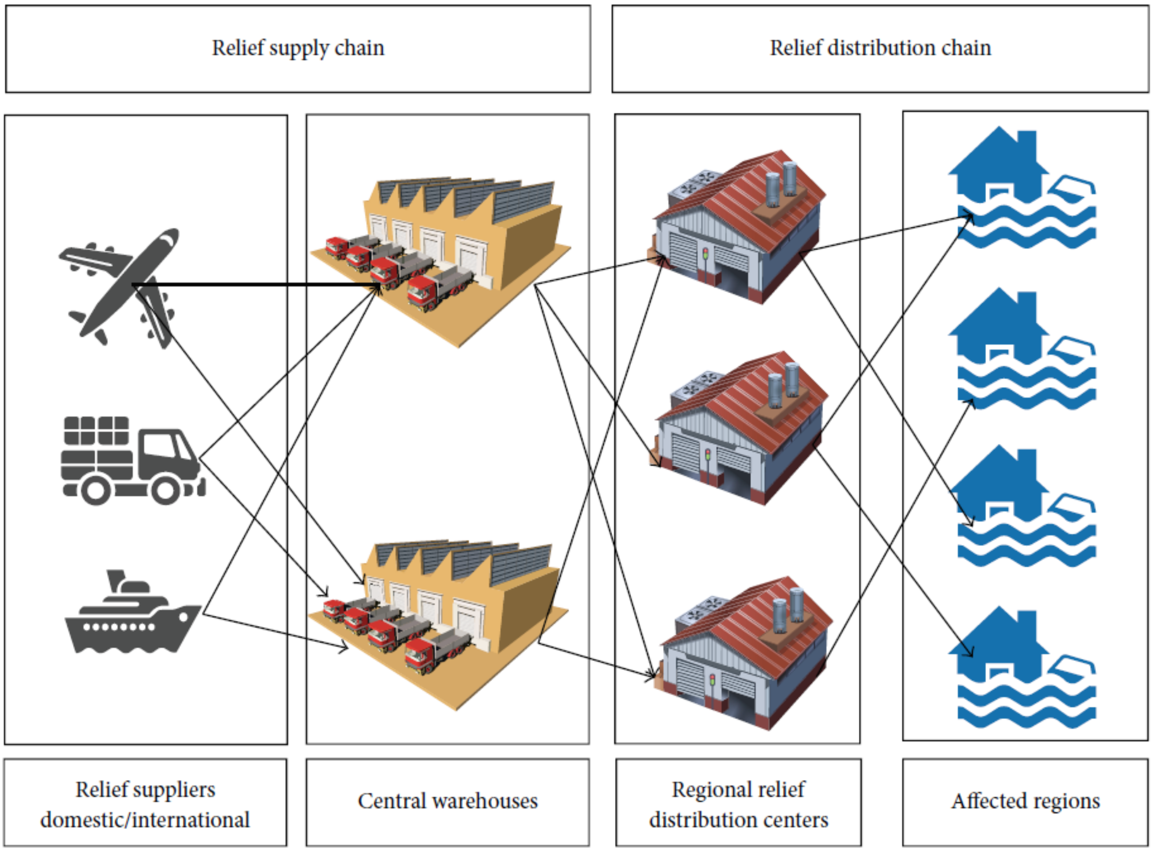

Figure 2. 3 Conceptual Humanitarian Supply Chain (Habib, et al. (2016)

Habib, et al. (2016) defines the conceptual humanitarian supply chains as in above Figure 2.3. First half of the total supply chain represents the relief supply chain part and second half shows relief distribution chain. The first link of the supply chain begins with relief suppliers (commercial partners) and when they supply products, these products are generally stocked in central warehouses which are reflected as holding cost in this study. Generally, this holding cost becomes so low as there are some incentives for humanitarian organizations. Then the goods are cross docked to regional relief distribution centers to be distributed affected people. By just looking at this figure, one can see how complex and complicated it is to coordinate humanitarian supply chains as it also includes too much variability.

Type of products that are going to be procured is also important. Types of products are classified in different ways in literature. Balcik, Beamon, & Smilowitz (2008) state that there are two type of products based on their demand characters; type 1 items are required right after the disaster strikes, and the demand is generally huge, it may not be possible to cover all the demand, then it is not backordered and becomes lost sale. Tents, blankets, tarpaulins, jerry cans, mosquito nets can be given as examples for type 1 products. Type 2 items are regularly consumed goods that the demand becomes more visible by time. If this type of demand is unsatisfied then it will be backordered rather than it is lost. Depending on the disaster type and phase the products needed change a lot. Basically; after a disaster strikes; the advance emergency kit is procured by NGO's which consists of water carrier, shelter, stove, hygiene kit, blankets, and kitchen set (Taylor, 2011). In this study, it is intended to evaluate both typical goods such as advance emergency kits and perishable goods with different contracts or different parameters which are improved specially for the product characteristics.

As it is specified; actions that are taken change a lot corresponding to the phase of disaster response. Kumar & Havey (2013) state that; there are sequential phases of disasters management such as, mitigation& preparedness, response and recovery/ rebuild which are evaluated in other resources as pre-disaster, response and post-disaster. In preparedness phase, the risks are evaluated and assessed and other resources are planned in advance for disaster response. In response phase, some goods are procured such as medics, food, water, shelter and also supply chain is built and logistics actions are made. In post-disaster phase; cleaning the debris, rebuilding the infrastructure and thinking on the lessons learnt and taking actions as a result of the experiences are the main issues. Generally, procurement becomes an element of the first two phases. But the contracts are more applicable in the planning phase which is pre-disaster phase.

A well optimized supply chain by contract coordination has a Nash equilibrium which means that no firm has a chance to deviate from supply chain optimal actions in order to have more profit than the other level. It is also important that there should be a unique action that has to be taken as for preventing firms from coordinating on suboptimal actions (Cachon, 2003). A contract can also be defined as a system that improves supply chain performance by dividing the risks between system members and also increasing the total profit (Govindan, et al., 2012). There are many types of contracts in the literature which can be used for different circumstances. For example, for newsvendor model mostly used contracts are wholesale contracts, buyback contracts, revenue-sharing contracts, quantity-flexibility contracts, sales-rebate contracts, and quantity-discount contracts (Cachon, 2003).

In classical newsvendor model, which is also called as newsboy and single-period model, is one of the fundamental models in the literature used for specifying the optimal order quantity for perishable goods. Prices are assumed to be fixed and demand is generally stochastic. Supply chain consists of two firms; one is supplier and one is retailer. Retailer faces the newsvendor problem that he has to specify his order quantity before the selling season starts.

As a second step, supplier prepares and presents a contract to retailer and, retailer decides whether she will accept the contract or not. If the retailer accepts the contract supplier becomes responsible of producing and delivering the specified quantity q to retailer before the selling season. Then the demand occurs and transfer payments are made between the supplier and the manufacturer based upon the agreed contract. Both firms are assumed to be risk neutral and both firms have the same full information (Cachon, 2003). With the help of these parameters the equations can be set as follows.

$$\pi_r(q) = pS(q) + vI(q) - g_r L(q) - c_r q - T \quad (2.1)$$

$$= (p - v + g_r)S(q) - (c_r - v)q - g_r\,\mu - T \quad (2.2)$$

$\pi_r(q)$ shows the profit function of the retailer which consists of five components. The first component represents the price obtained from the expected sales, and the second is for the salvage value of the left inventories for the retailer. The third component is the goodwill cost which can also be accepted as the penalty cost when lost sales occurs, next one is the cost of materials that are ordered from the supplier and finally the transfer cost which will be evaluated in each contract differently according to the contract’s character. Another equation can be written for the supplier as follows.

$$\pi_s(q) = g_S S(q) - c_S q - g_S \mu + T \tag{2.3}$$

Apart from the profit function of the retailer; the supplier also has a cost for producing the amount of orders given by the retailer and also a penalty cost. The transfer cost is paid by the retailer to the supplier so it becomes revenue for the supplier.

Finally, the profit function for the supply chain is expressed by the following equation.

$$\pi(q) = \pi_r(q) + \pi_s(q) = (p - v + g)S(q) - (c - v)q - g\mu \tag{2.4}$$

Profit of the centralized supply chain can be obtained by the addition of the two sides of the contract. In order to have a meaningful solution from these equations one can say that it is important to prove that these functions are concave. Otherwise when the first derivative is taken the solution will be meaningless. It is also shown clearly by Cachon (2003) that the second derivative of the supply chain profit function respect to the order quantity is less than zero which means the function is concave. Furthermore, the first derivative respect to the order quantity gives the optimum order quantity for the supply chain which maximizes the profit.

$$S'(q^0) = \bar{F}(q^0) = \frac{c-v}{p-v+g} \tag{2.5}$$

From this equation the optimum quantity that maximizes the supply chain profit is represented by the parameters of the system. By changing the transfer payment, the system can be balanced and some possible profit allocations between sides of the contract can be determined.

Another important point is that the side that prepares the contract is not important as the well-being of supply chain is thought rather than the benefits of sides.

2.1 Wholesale-Price Contract

This contract type is applied to newsvendor model and supplier charges the retailer *w* per unit purchased. This cost reflects to the model as a transfer payment. In that case naturally, wholesale price must be less than the marginal cost of supplier. However, it means that the wholesale price contract can coordinate the supply chain if the supplier gets a non-positive profit which causes the supplier to require for higher wholesale prices. (double marginalization) Thus, wholesale price contract is usually not considered as a coordinating contract. But when the administrative costs of preparing a more complex contract exceed the potential profit increase of supplier, she may prefer wholesale contract. Because wholesale contract is more applicable and simple when compared to other contract types (Cachon, 2003).

In wholesale contract the transfer payment is specified as $T_w(q,w) = wq$, which directly allocates a cost for each quantity that will be paid by retailer to the supplier. The profit functions are the same with the classical newsvendor except for the transfer payment, thus one can say that the optimal quantity which maximizes the profit of retailer's profit function becomes

$$F(q_r^*) = 1 - \frac{w - c_r - v}{p - v + g_r} \tag{2.6}$$

It's clear that this equation is obtained from the first derivative of retailer's profit function by changing the transfer payment in classical newsvendor problem. As it is also important to specify the wholesale price, one can derive easily $w(q)$ from equation 2.7 as follows

$$w(q) = (p - v + g_r)\bar{F}(q) - (c_r - v) \tag{2.7}$$

Similar to the profit function of the retailer, supplier's profit function can also be written by adding the transfer payment to the classical newsvendor model of the supplier.

$$\pi_s(q, w(q)) = g_S S(q) + (w(q) - c_S)q - g_S\mu \tag{2.8}$$

By taking the first derivative of this equation with respect to q the optimum quantity of the supplier will be obtained.

$$\pi_s\big(q_S^*, w(q_S^*)\big) = (p - v + g_r)\bar{F}(q)\left(1 + \frac{g_s}{p - v + g_r} - \frac{qf(q)}{\bar{F}(q)}\right) - (c - v) \tag{2.9}$$

As a result of these equations, the retailer will demand for lower wholesale price while the supplier tries to increase the wholesale price. Another point which was also mentioned before is that the wholesale contract can coordinate the system only when the supplier's profit is non-positive which makes the supplier to ask for greater wholesale prices and causes double marginalization. Although this type of contract may be seen useless, it is one of the most basic contracts and prepares a basis for other contracts.

In literature, there is a wide variety of studies that include wholesale price contracts and also studies which compares other contracts with wholesale contracts. A study which compared wholesale price contract with revenue sharing contract was held by Ouardighi (2014). Because of the characteristic of wholesale contract double marginalization problem came up and in order to solve this problem revenue sharing contract was used. As a result, he made a comparison between optimum wholesale contract and revenue sharing contract in a two stage non-cooperative game.

Another study which used a game theoretic approach and combined it with wholesale and revenue sharing contract can be shown as Chakraborty, et al. (2015) which studied a supply chain with two competing manufacturers which is directly linked to a retailer. They studied it as a Stackelberg game which the retailer is the leader based on a newsvendor model. As a second step manufacturers were specified as Stackelberg leaders. Wholesale price model was used and for coordinating the supply chain revenue sharing model was used.

2.2 Buyback Contract

In this type of contract, the supplier charges w per unit purchased just like the wholesale price contract, but then she pays the retailer b per unit remaining at the end of the selling season. It is clear that the buyback price should be less than the wholesale price as the retailer should not get profit from these remaining inventories. The remaining units are not sent back to the supplier physically; except for the situation that supplier's net salvage value is greater than the retailer's net salvage value (Cachon, 2003). Corresponding transfer payment becomes $T_b(q,w,b) = wq - bI(q) = bS(q) + (w-b)q$ with the light of the given information. By adding this transfer payment to general profit function of the retailer it can be shown as

$$\pi_r(q,w,b) = (p - v + g_r - b)S(q) - (w_b - b + c_r - v)q - g_r\mu \qquad (2.10)$$

A substitution is made in order to simplify the model by using parameter λ such that $\lambda \geq 0$,

$$p - v + g_r - b = \lambda(\mathrm{p - v + g}) \tag{2.11}$$

$$w_b - b + c_r - v = \lambda(\mathrm{c - v}) \tag{2.12}$$

For buyback contracts a special parameter λ is used for expositional clarity and, it helps to see the profit share of the retailer and the supplier. λ is less than or equal to one and while λ increases profit share of the retailer also increases. Both profit functions can be structured again with parameter λ.

$$\pi_r(q, w_b, b) = \lambda(\mathrm{p - v + g})\mathrm{S(q)} - \lambda(\mathrm{c - v})\mathrm{q} - \mathrm{g_r}\mu \tag{2.13}$$

$$\pi_s(q, w_b, b) = (1 - \lambda)\pi(\mathrm{q}) - \mu(\lambda \mathrm{g_S} - (1 - \lambda)\mathrm{g_r}) \tag{2.14}$$

As it can be seen from these equations' parameter λ directly allocates the share of profit between retailer and supplier.

2.3 Revenue-sharing Contract

By a revenue sharing contract the supplier charges the retailer w per unit purchased and after the selling season the retailer gives the supplier a percentage share of his revenue which also includes the salvage value. φ is used as the fraction of retailer which represents the share that he keeps for himself and thus (1- φ) becomes the share that the retailer sends to the supplier. This type of contract is usually used for video rental industry (Cachon, 2003). Because of that parameter φ, revenue-sharing contracts may be accepted similar with buyback contracts. The respective transfer payment can be shown as follows

$$T_r(q, w_r, \varphi) = (w_r + (1 - \varphi)v)q + (1 - \varphi)(p - v)S(q). \tag{2.15}$$

Retailer's profit function is

$$\pi_r(q, w_r, \varphi) = (\varphi(p - v) + g_r)S(q) - (w_r + c_r - \varphi v)q - g_r\mu. \tag{2.16}$$

Similar to buy back contract a substitution is made by λ.

$$\varphi(p-v)+g_r=\lambda(\mathrm{p}-\mathrm{v}+\mathrm{g}) \tag{2.17}$$

$$w_r+c_r-\varphi v=\lambda(\mathrm{c}-\mathrm{v}) \tag{2.18}$$

With the help of these substitutions the following profit functions for retailer and supplier respectively can be obtained.

$$\pi_r(q,w_r,\varphi)=\lambda\pi(\mathrm{q})+\mu(\lambda\mathrm{g}-\mathrm{g_r}) \tag{2.19}$$

$$\pi_s(q,w_r,\varphi)=\pi(q)-\pi_r(q,w_r,\varphi)=(1-\lambda)\pi(q)-\mu(\lambda\mathrm{g}-\mathrm{g_r}) \tag{2.20}$$

As mentioned before; revenue sharing contract is very similar to buy back and even equal under some circumstances. Again λ becomes responsible for allocating the profit share between sides of contract.

2.4 Quantity-flexibility Contract

By a quantity-flexibility contract the supplier charges the retailer *w* per unit purchased, but then compensates the lost sales and unsold units. Another point of view is that the retailer takes a credit from the supplier which can be expressed as $(w_q+c_r-v)\min(I,\delta q)$, here I represents the leftover inventory; q is the number of units purchased; and δ is a contract parameter which is between 0 and 1. So the limit for the compensated number of unsold units is set by the parameter δ (Cachon, 2003).

Transfer payment for quantity-flexibility contract is as follows.

$$T_q(q,w_q,\delta)=w_q q-(w+c_r-v)\int_{(1-\delta)q}^{q}F(y)dy \tag{2.21}$$

This transfer payment contains the wholesale price paid by the retailer, and after the selling season ends the inventories left are compensated by the supplier. Salvage value is not included as the retailer still has the ability to get the salvage value after the season. The compensated amount of left inventory is limited by a portion of δ. As a result of this profit function of retailer becomes

$$\pi_r\big(q, w_q, \delta\big) = (p - v + g_r)S(q) - \big(w_q + c_r - v\big)q + \big(w_q + c_r - v\big)\int_{(1-\delta)q}^{q} F(y)dy - \mu g_r. \quad (2.22)$$

And the profit function of the supplier is

$$\pi_s\big(q, w_q(\delta), \delta\big) = g_s S(q) + \big(w_q(\delta) - c_s\big) - (w_q(\delta) + c_r - v)(F(q) - (1 - \delta)F\big((1-\delta)q\big). \quad (2.23)$$

When δ is set to zero, it means that the retailer will earn the least supply chain optimal profit. Otherwise when δ is set to 1, the supplier gets the least profit.

2.5 Sales-rebate Contract

By a sales-rebate contract the supplier charges the retailer w per unit, and gives the retailer an r rebate per unit sold above a threshold unit which is equal to t. It means that when $q > t$ the retailer pays w for every unit which are below t units, and above the units the price becomes *w-r* (Cachon, 2003).

With respect to this definition the transfer payment becomes

$$T_s(q, w_s, r, t) = \begin{cases} w_S q & q < t \\ (w_s - r)q + r(t + \int_t^q F(y)dy) & q \geq t. \end{cases} \quad (2.24)$$

This function shows clearly that when the ordered quantity is less than t the only transfer payment is w_S, otherwise because of the rebate that is obtained by the quantity the wholesale price will decrease by r. By adding this transfer payment to the model, the profit function of the retailer can be represented as

$$\pi_r(q, w_s, r, t) = (p - v + g_r)S(q) - (c_r - v)q - g_r\mu - T_s(Q, W_S, r, t). \quad (2.25)$$

The transfer payment will be written according to the quantity ordered by the retailer. Another function is supplier’s profit function.

$$\pi_s(q, w_s(r), r, t) = -g_s\big(\mu - S(q)\big) - c_s q + T_s(q, w_s(r), r, t) \qquad (2.26)$$

The optimum quantities are obtained by calculating the first derivative of these functions and also by evaluating the supply chain profit. It is known that the sales rebate contract cannot coordinate the supply chain by voluntary compliance.

2.6 Quantity-discount Contract

There are many types of quantity-discount contracts in the literature. Cachon (2003) considers all units contract. In this type of contracts transfer payment is taken as $T_d(q) = w_d(q)q$ where $w_d(q)$ is the per unit wholesale price that decreases in q.

Under these circumstances the profit function of retailer becomes

$$\pi_r\big(q, w_d(q)\big) = (p - v + g_r)S(q) - (w_d(q) + c_r - v)q - g_r\mu \qquad (2.27)$$

As it can be seen clearly this equation is obtained by adding the respective transfer function to classical newsvendor function. Again, by making a substitution with λ, a general profit function can be obtained.

$$\pi_r\big(q, w_d(q)\big) = \lambda(\mathrm{p} - \mathrm{v} + \mathrm{g})\mathrm{S}(\mathrm{q}) - \lambda(\mathrm{c} - \mathrm{v})\mathrm{q} - \mathrm{g_r}\mu \qquad (2.28)$$

Parameter λ will again act like a ratio that allocates the profit of supply chain between sides just like buyback and revenue sharing contract.

There are also many other hybrid and special contract models depending on the character of supply chain. In this study, appropriate contract models will be applied for humanitarian supply chains.

3. LITERATURE RESEARCH

Literature is reviewed briefly in two areas; relief material management and supply chain coordination with contracts, as there is a gap in the literature about humanitarian supply chain coordination with contracts.

3.1 Relief Material Management

Beamon & Kotleba (2006) worked on a stochastic inventory control model which decides on the optimal order quantities and reorder points for relief response. Whybark (2007) studied the inventories that are held for disaster relief and described the characteristics of these inventories through three stages; acquisition, storage and distribution. Tzeng, Cheng, & Huang (2007) constructed a multi-objective model for relief delivery systems which evaluates three objectives by; minimizing total cost, minimizing total travel time and maximizing the minimal satisfaction during the planning period. An empirical study was also conducted for cities Taichung, Nantou City, and Nantou County which were hit by a major earthquake on September 21, 1999, and results were examined. Balcik, Beamon, & Smilowitz (2008) studied a vehicle based distribution system which corresponds to distribution of relief supplies to demand locations by using mixed integer programming. In that study, the routes for each vehicle based on their capacities are specified and some tests problems were also implemented. Mete & Zabinsky (2010) proposed a stochastic optimization model to be used for medical supplies for two stages; storage and distribution which will be applicable for many disaster types. They also added a case a study by using different earthquake scenarios. Chandraprakaikul (2010) collected 33 papers and analyzed the studies which are conducted about humanitarian supply chain in 2010 and gathered some data which can be seen clearly in Table 3.1 and Table 3.2. These tables show the research methodologies key terms that are used in chosen studies. This study can be held as a theoretical study and classified as both coordination and purchasing which will be one of the rare studies.

3.2 Supply Chain Coordination with Contracts

There are many studies that were implemented for supply chain coordination with contracts. Yao, Leung, & Lai (2008) investigated a newsvendor model with one manufacturer and two competing retailers which have stochastic demand and they set the manufacturer as the Stackelberg leader who offers the revenue sharing contract. As a result of the study they found out that revenue sharing contract is better for coordination when compared to price-only contract while searching and equilibrium in a Bayesian Nash game. Partha, Sarmah, & Jenamani (2011) combined revenue sharing and quantity discount contracts and managed to coordinate a two level supply chain. They have taken demand as a function of price and stock. As a result, they proved that stock dependency has a positive effect on order quantity.

Table 3. 1 Classification by Methodology (Chandraprakaikul, 2010)

Research Methodology	**Appearance frequency**	**Percentage**
Analytical		
Conceptual/theoretical	16	48%
Mathematical Modelling	7	21%
Empirical		
Case Study/field study/interview	9	27%
Experimental Design	1	3%
Survey	0	0%

Table 3. 2 Top Key Terms (Chandraprakaikul, 2010)

Key Term	**Number**	**Sample**
Coordination	3	Tatham and Kovacs (2010), Balcik et al.(2010)
Challenges in humanitarian logistics	4	Kovacs and Spens (2009), Chandes and Pache (2010)
Customer Service	1	Oloruntoba and Gray (2009)
Distribution	1	Balcik (2008)
Facility location	1	Balcik and Beamon (2008)
Humanitarian relief logistics model	9	Pettit and Beresford(2005), Tovia(2007), Maon et al. (2009)
Inventory management	5	Beamon and Kotleba (2006), Taskin and Lodree (2009)
Performance management	5	Schulz and Heigh (2009), Beamon and Balcik (2008)
Promoting humanitarian logistics	2	Whiting and Ostrom (2009), Kumar et al. (2008)
Purchasing	2	Trestrail et al. (2009)

Xiong, Chen, & Xie (2011) introduced a composite contracts which consists of a buyback and quantity flexibility contract. They conclude that as long as one of the component contracts coordinates the supply chain the composite contract also coordinates. Secondly, if there are constraints about the parameters of the contracts composite contract can behave more flexible compared to the component contracts. Thirdly, composite contract is more flexible about allocating the risk between levels of supply chain. Xu & Bisi (2012) worked on wholesale contract with retail price postponement with one supplier and one retailer system and derived unique optimal solutions. Chen, Zhang, & Sun (2012) held a study on the pricing strategy of a dual channel supply chain and specified the manufacturer as Stackelberg leader. They searched for the conditions which both the supplier and manufacturer prefer dual channel supply chain. They applied wholesale price contract but saw that the only side that has benefit by that contract is the retailer not the manufacturer. So they also applied a contract with a complementary agreement such as profit sharing agreement and as a result the system is optimized, which means that both sides have benefit because of the applied contract type.

Furthermore; Wang, Wang, & Su (2013) studied on a one retailer one supplier system which is coordinated by a wholesale price contract. Selling cost is not known by the retailer but he can spend some resources in order to get some information as the contract is prepared by the supplier. They specified an upper bound for information gathering cost which makes it meaningful to get information and they implemented some sensitivity analysis in order to understand the effect of information gathering cost on order quantity. Jörnsten, Nonas, Uboe, & Sandal (2013) considered a newsvendor model with discrete demand by developing a mixed contract. As a next step they tried to prove that the mixed contract that they have developed is superior to real option contract in case the manufacturer has a bound for the variance that she is willing to accept. Oliveira, Ruiz, & Conejo (2013) proposed a model for electricity markets which considers multiple generators and retailers. They compared supply chain coordination techniques on two different market structures and concluded that two-part tariff is the best contract to reduce double marginalization and increase efficiency Murphy & Oliveira (2013) examined the pricing of option contracts for petroleum reserve and aimed this contract to be used by both the government and refiners. As a result of this study one point that they found was the options increase by oil prices and decrease by total inventory held.

Palsule-Desai (2013) made a research on Bollywood- Indian movie industry and decided to develop a game theoretic model for revenue sharing contracts which divides the profit share between players. Their purpose was to determine if revenue sharing contracts are more preferable than revenue independent contracts or not for the specified area. Kim, Park, & Shin (2013) focused on a quantity flexibility contract and developed a linear programming model which includes several key parameters from the buyer's side. There are many more articles in literature which are related to supply chain coordination by contracts the ones that are reviewed are represented in Table 2.3. Hu, Lim, & Lu (2014) worked on a one retailer one manufacturer system which both have stochastic demand. They applied option contract and studied the optimal ordering policy for the supply chain and made a sensitivity analysis in order to understand the impact of parameters on these policies.

The most related study in the literature is implemented by Liang, et al. (2012). This study offers an option contract for relief supply chain management and takes the system as a one buyer one supplier supply chain. They designed a two stage option contract and then as a second step they also developed a binomial option pricing model for screening the values for different levels of supply chain such as from the buyer side and supplier side. Then they made a sensitivity analysis and looked at the effects of parameters and added a numerical example. This article becomes important as it is the only study that studies contract management in the same field with this study.

Another related study is Chakravarty (2014) which does not work on contract management but construct models about humanitarian supply chain deeply. This study determines on response time, relief material quantities, amount of prepositioned inventory by applying a two stage proactive approach. Disaster is chosen as natural sudden onset disaster which is specified as hurricanes. The study aims to show the impact of rapid response on human survival and deciding on the optimal mix of inventories for both prepositioned inventory and post disaster inventories. There are many important points about this study which also helps for our study while deciding on parameters.

Table 3. 3 Comparing Studies in Literature with Proposed Study

	Upstream Member	Downstream Member	Contract Type	Implementation Area	Game theoretic approach	Product type	Demand
Yao, Leung, & Lai (2008)	one manufacturer	two competing retailers	Revenue sharing	Commercial	Manufacturer as Stackelberg leader / Bayesian Nash Game	a newsvendor product	additive function as in Zabel's(1970) paper is used
Partha, Sarmah, & Jenamani (2011)	one manufacturer	one retailer	Revenue sharing & quantity discount	Commercial		Short life cycle products	price sensitive and stock dependent
Xiong, Chen, & Xie (2011)	one supplier	one retailer	Buyback& quantity flexibility	Commercial		not specified	Normal distribution is used for the numerical example
Xu & Bisi (2012)	one supplier	one retailer	Wholesale	Commercial	Manufacturer as Stackelberg leader	not specified	General dist. For manufacturer - linear, exponential, isoelastic for the retailer
Chen, Zhang, & Sun (2012)	one supplier	one retailer	Profit sharing vs.wholesale	Commercial	Manufacturer as Stackelberg leader	IT technology	price dependent
Wang, Wang, & Su (2013)	one supplier	one retailer	Wholesale	Commercial		new product	linear function of price
Jörnsten, Nonas, Uboe, & Sandal (2013)	one supplier	one retailer	Mixed contract vs. Option contract	Commercial		newspaper	discrete demand
Oliveira, Ruiz, & Conejo (2013)	one supplier	multiple retailers	Two part tariff	Electricity market		Electricity trading	linear function of price
Murphy & Oliveira (2013)	one supplier	multiple retailers	Option	Petroleum market		oil	isoelastic
Palsule-Desai (2013)	one supplier	one retailer	Revenue sharing vs. Revenue independent contracts	Bollywood- Indian movie industry	Game theoretic model	video rental- movie industry	convex decreasing such as an exponential decay
Kim, Park, & Shin (2013)	Multiple suppliers	one retailer	quantity flexibility	Commercial		single type of product	conditional probability distribution
Hu, Lim, & Lu (2014)	one supplier	one retailer	Option	Commercial		a newsvendor product	symmetric demand information, normal distribution is used
Liang, Wang, & Gao (2012).	one supplier	one retailer	Option	Humanitarian Supply Chain		one kind of relief material (food,drinking water or daily necessity)	by history statistics
Proposed Study	one suppler / multi supplier	one retailer / multi retailers	Some existing contracts will be applied and a new contract will be developed	Humanitarian Supply Chain		non perishable goods	by applying different scenarios with the help of a tool the distribution of demand can be obtained

For example, for valuing human life, two approaches are used in literature such as HC (Human Capital) and WTP (Willingness to Pay). HC is an approach which estimates the future income potential of an individual and WTP is an approach that shows the amount of money that a community is ready to pay for surviving an individual's life. In that study second approach was used and a parameter was specified for this purpose as v1. Another important point is the perishable demand which means; the number of people that survive after a disaster will decrease by time; especially for the post disaster phase. The demand is also specified by a function which is determined by the intensity of the disaster. The distribution of disaster intensity is taken as Weibull distribution in this study as the disasters which have lower intensities occur more often than disaster with greater intensities. This study does not provide a contract that was prepared for humanitarian supply chain but gives an idea about parameters and models that helps to determine on optimal values for quantities, response time and so on.

In a current literature research which has been held by Habib, et al. (2016) includes similar methods and sources as in this study.

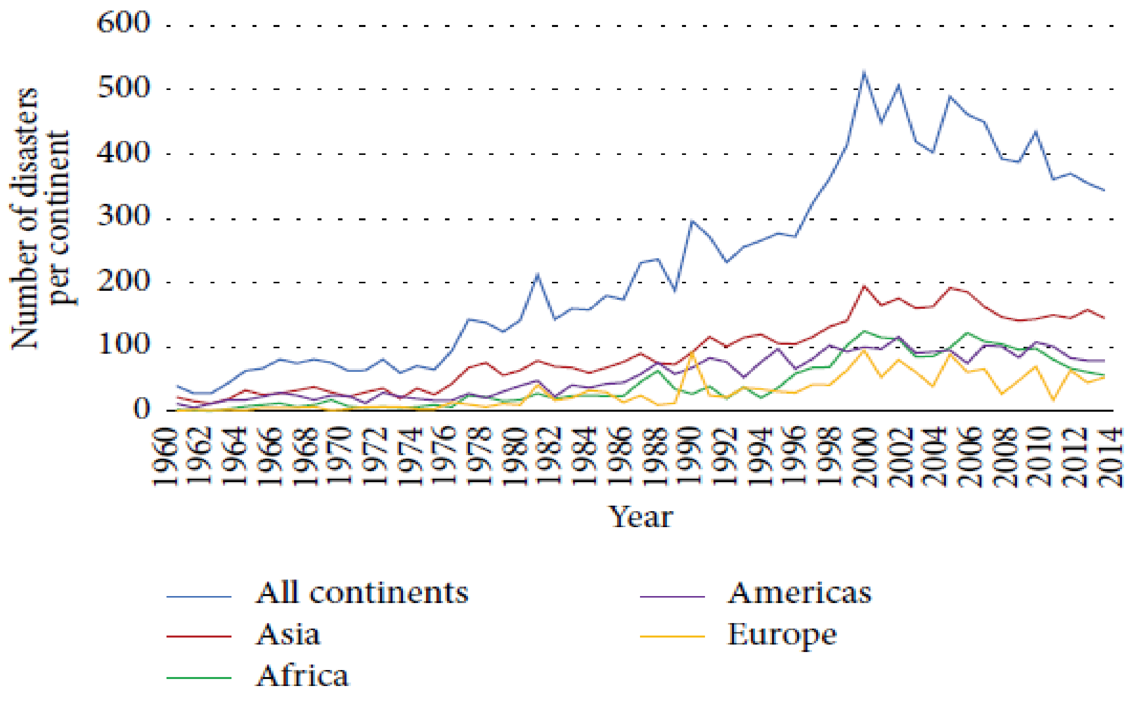

Figure 3. 1 Number of Disasters Between 1960-2014 per Continent

In Figure 3.1 they used the disaster data from ‘emdat.com’ which shows the disaster per continent for a period between 1960-2014. This figure shows the increasing trend of disaster all over the world. Similar to this figure; in this study; total number of affected people by disasters between 1980-2015 for Turkey is used to represent total demand. Their literature review also holds the most current studies which deal with optimization models, vehicle routing distribution models and reverse logistics models. However, no study on contract management can be seen as a current study.

Another study that holds a multi-objective optimization model for optimizing total operation cost, effectiveness, development and agility of the supply chain is studied by Peters, et al. (2016). They applied this optimization model for WFP and used a mixed integer linear programming for simultaneously optimizes multi objective functions. As a result of the study they state that they could make an improvement for operational cost of humanitarian supply chain of Yemen and Iraq.

Alem, et al. (2016) studied a two stage stochastic optimization models on logistic model for disaster relief based on stochastic network models. Main concerns of the model are, budget allocation, fleet sizing, procurement, varying lead times over a multi-period horizon. In addition, they also proposed a special heuristic method to get a solution or result to given proposed model. As a fact of nature, the construction of models and solution methods are different from the methods that are held in this study. But as a provided current study it gives an opportunity to gain an insight on related subject.

A similar study to the content of this study is held by Toyasaki, et al. (2016). They held a horizontal cooperation between humanitarian organizations. They also specified some important insights by making discussions with managers of logistic management of disaster relief organizations. For instance, they gave important information for this study also, about storage costs of humanitarian organizations. They stated that members of humanitarian organizations can store as many items as they need by free of charge; with no minimum limit of quantity to be stored. This also supports the infinitesimally small holding cost used in this study. They also preferred to base their models on newsvendor model. They stated that as a result of volatility and unpredictability, prepositioned stock is a must to meet the whole demand. The main optimization for humanitarian organizations is stated to be cost optimization by means of expected inventory cost. They applied a non-cooperative complete information game on this optimization model. The main difference of the given model is that it seeks for coordination between horizontal humanitarian organizations; but it still serves as a really useful study by means of information about same field.

Tofighi, et al. (2016) implemented a two-echelon network design problem which covers multiple warehouses. A two stage stochastic modeling was developed and in the first phase location of these stated warehouses were specified. In the second phase minimization of distribution time was considered. Also according to priority of the items weighted distribution time was also optimized. In addition, total inventory cost and shortage cost was aimed to be minimized. A tailored differential evolution algorithm was used to get an efficient result as the problem is quite complex.

Madjid, et al. (2017) applied a vehicle routing optimization model which decides on the location of warehouses. The product type held was perishable products that are being distributed in post disaster phase and the routing of relief vehicles was also a concern which has been optimized in this model. The model itself is a mixed integer linear programming model and the heuristic method used for getting results was genetic algorithm. Multi objectives were set in this model such as, minimizing total cost of procurement in pre disaster phase, minimizing the cost of pots disaster phase by means of transportation and other efforts, and finally minimizing the total time that is spent for disaster relief. As a special method epsilon constraint method has been used. Similar to this study, the performance of the solution methods were compared with the help of ANOVA analysis.

A recent study held for coordination of humanitarian supply chain by quantity flexibility contract (Nikkhoo, et al., 2018). Study implemented quantity flexibility contract on a multi echelon supply chain which is composed of NGO, supplier and effected areas. It has been found out that this contract type coordinates the supply chain for all parties and provides a basis to eliminate significant loss. By applying an existing contract model in literature this study has similarities with this study by means of methodology and aim.

4. METHODOLOGY

In this study relief supply chain coordination by contracts is intended to be carried out. The contract model can be either one of the contract models that are implemented in the literature or a new contract type which is suitable for humanitarian supply chain coordination. Most probably the existing models in the literature will be evaluated in the first phase and a new hybrid model will be constructed.

Supply chain will be considered as a one buyer one supplier supply chain which consists of a non-governmental organization as buyer and commercial firms as suppliers. The system can also be taken as two-stage system with multi retailers or multi suppliers. It is known that the gap in literature is more significant for multistage supply chain coordination with contracts.

The disaster type will be taken as sudden-onset natural disaster and the demand will be stochastic which can be assumed as perishable by time as the number of surviving people will decrease by time as. In the first phase general distribution can be used in the model and then other distributions can be attached to the model with the help of literature and databases provided by relief management organizations. The product type that is going to be considered will be advanced emergency kit (water carrier, shelter, stove, hygiene kit, blankets and kitchen set).

Before looking at the equations developed for the basic model, one can have an idea by looking at the flow diagram by Figure 4.1.

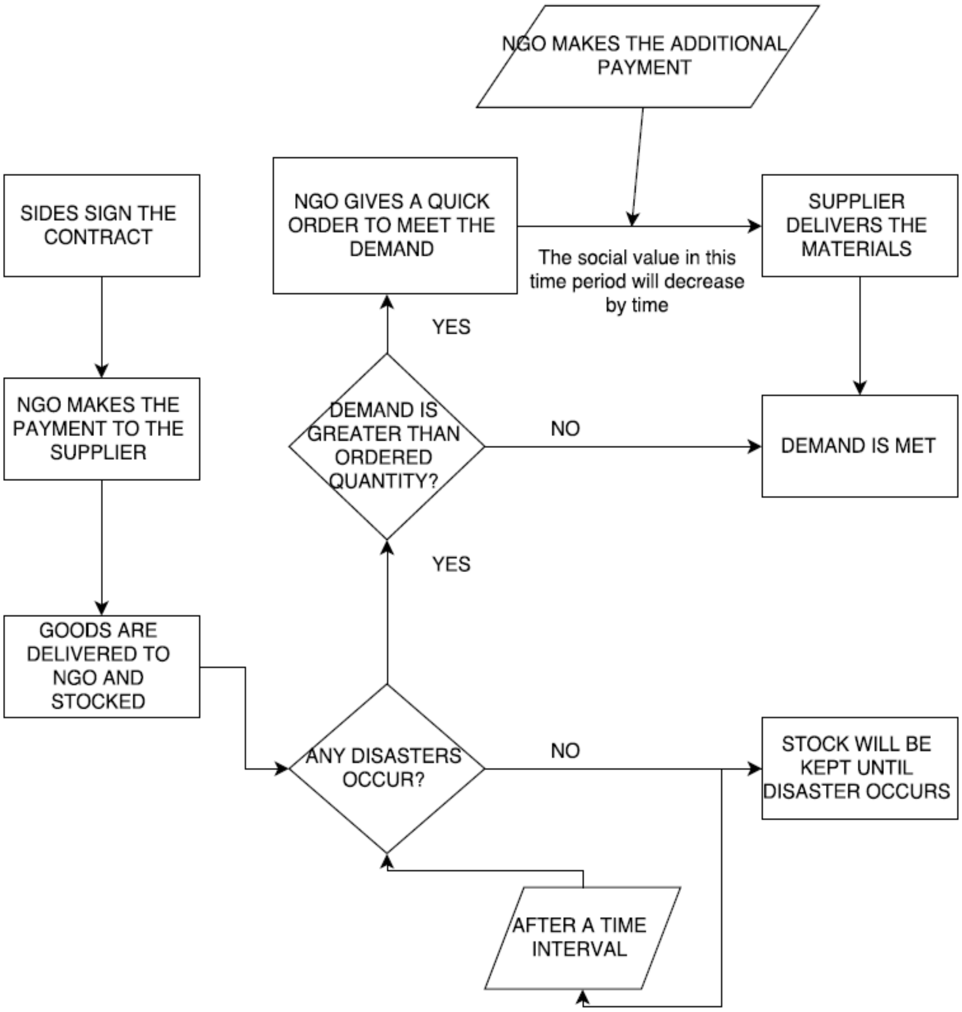

Figure 4. 1 Flow Chart of Intended Model

In Figure 4.1 the flow chart of the intended contract can be seen as above. This flow chart only includes the process for the basic model improved as a beginning. As it can be seen it begins with the signing of the contract as a usual process. Second step is the payment of NGO to the supplier and then the goods are delivered to NGO and stocked before the disaster. If any disaster occurs these stocks are used for meeting the demand and if the stocks are not enough, then a quick order is given again by the NGO and an additional payment is made for this additional order. In the given lead time the demand decreases as the number of surviving people will decrease in the given time period. It's also important that if supplier has enough capacity for this additional demand or not. When these additional orders are also met the process ends. On the other hand, if no disaster occurs the contract will expire or be renewed by the sides and the stocks will be kept until a disaster occurs.

For the intended contract model, at first a basic model was constructed which shows the general characteristics of the respective supply chain.

4.1 General Assumptions of the Study

Before going into details of the model structure, general assumptions applied to all models can be followed in this section.

Table 4. 1 General Assumptions of the Study

$$w_1 > w_2 > b > b_S > t_e > \emptyset > t > h \approx 0$$

$$\emptyset < o + e < w_1$$

$$w_1 > w_2 > b > b_S > t_e > \emptyset > e > t > h \approx 0$$

$$0<\Omega<1$$

These relations are based on logical explanations in accordance with the humanitarian supply chain characteristics. It becomes clear that revenue parameters w_1 and w_2 are much higher than other parameters as they represent the value of human life. Backorder value is not a very close value to these revenue parameters, but still higher than other parameters as the backorder cost of loosing one life and missing a requirement by disaster victims should be higher than other costs. Backorder of supplier is also high according to this explanation made. These parameters are followed by express transfer cost, cost of NGO paid per disaster kit, normal transfer cost. Holding cost is a very low and neglectable for nonprofit organizations as they get many incentives for warehouse activities.

First assumption is followed by general assumption of option contract. This is a logical constraint for option contract which makes both sides eager to attend. The new cost paid by the NGO should be higher than decentralized case and should be less than the revenue obtained by NGO.

Last assumption is the exercise price added version of first assumption lines after application of option contract parameters. Last line is also added after application of reimbursement contract which clarifies that reimbursement share is a value between 0 and 1.

4.2 Structure of Decentralized Model

The first equation that will use these parameters is developed to represent the profit function of NGO which can also be seen as below. *T* parameter shows the transfer payment as the contract is not developed yet. It will be characterized when the contract model that will be applied is chosen. The profit function of the nongovernmental organization can be seen in Equation 4.1.

$$\pi_{NGO}^{D} = w_1 min[E[X], q] + w_2[E[X] - q]^+ + \delta_{NGO}\{-\emptyset q - tq - h[q - E[X]]^+ - (b + t_e + \emptyset)[E[X] - q]^+ + b_s[E[X] - q - c]^+\} + (1 - \delta_{NGO})\{(-\emptyset q - tq - hq)\} - T$$
(4.1)

The first part of the function represents the social value obtained by the demand met. As it can be seen clearly; min function is used, which indicates that if the demand is less than t given order the social value will be obtained by demand, otherwise order quantity will specify the total social value that will be gained. Next part shows the case that backorder occurs. In that case, an express delivery order will be given by NGO. But in that time period that goods are delivered, social value will decrease by time. It clarifies that w_2 will be less than w_1, as both number of victims and satisfaction levels will decrease by time. Third part of the equation shows the case when disaster occurs. For this purpose, a general parameter of δ_{NGO} is used; as only one forecast that will be made by the NGO can be used by both sides of the contract. Here it seems more appropriate to accept that NGO makes the forecast with the help of more experience. It should also be kept in mind that the decision maker is NGO. When we look inside of the parentheses; first of all, we see cost of orders that will be paid to supplier, transportation cost of prepositioned inventory, holding cost of inventory if the quantity ordered is more than demand, backorder and express transportation cost if demand is more than the quantity ordered before the disaster, backorder price that will be paid by supplier if additional quantities cannot be met because of supplier's capacity. The second parentheses show the case of no disaster, and first part again shows the cost of orders given, secondly transportation cost of orders and finally the holding cost of goods.

Parameters that are used for supplier's equation are nearly the same with NGO's. Profit function for the supplier can be shown as below in Equation 4.2. The function of supplier is important when developing centralized model.

$$\pi_S^D = \delta_{NGO}(\emptyset max[E[X], q] - c_S \max[E[X], q] - H_S q - b_S[E[X] - q - c]^+) + (1 - \delta_{NGO})(\emptyset q - c_s q - H_S q) + T$$

(4.2)

Equation for the supplier is represented in two parts. First part shows the case if disaster happens, and second part shows the case of no disaster. Again the forecast of NGO will be used as δ_{NGO}. The first component of first parentheses is the price of goods that are ordered and paid by NGO and again max function is used as entire demand will be met. Second component of the equation is the cost of producing the amount that will be required, other one is holding cost of the goods ordered and finally backorder cost of additional goods if they cannot be delivered on time if capacity of the supplier is not enough. Second parentheses are again for the case of no disaster occurs, so first component is the price of the order, second one is the cost of production and finally holding cost of the inventory carried. Transportation cost is not included in supplier's cost function. It is thought that all transportation is provided by a third party freight company. Transfer cost is again left to be updated when the contract is specified.

As a final step, centralized model is obtained by adding given two profit equations of NGO and supplier which is shown in Equation 4.3.

$$\pi_{SC}^D = \pi_{NGO}^D + \pi_S^D = w_1 E[X] - w_1[E[X] - q]^+ + w_2[E[X] - q]^+ - \delta_{NGO}\emptyset q - \delta_{NGO} h[q - E[X]]^+ - \delta_{NGO} b[E[X] - q]^+ - \delta_{NGO} t_e[E[X] - q]^+ - tq - hq + \delta_{NGO} hq + \delta_{NGO}\emptyset E[X] - \delta_{NGO} c_s E[X] + \delta_{NGO} c_s[E[X] - q]^+ - c_s q - H_s q + \delta_{NGO} c_s q$$

(4.3)

After obtaining these equations the purpose will be basically getting optimum values for these equations except for the supplier's, as the decision maker is set as NGO. Optimum values are being obtained by differentiating equations with respect to order quantity. By also getting second derivatives of these equations, one can decide if these mentioned equations are convex or concave, therefore checking second derivative is also important.

As a next step, centralized solution will be compared to decentralized solution and an appropriate contract model will be chosen in order to equalize centralized and decentralized order quantity. Thus, efficiency of the contract will be hundred percent and the supply chain will be coordinated.

In order to be able to take the derivative of the equations, first of all they must be linearized. The linearized form of NGO's profit equation can be seen below as Equation 4.4.

$$\pi_{NGO}^{D} = w_1 E[X] - w_1 \int_q^\infty xf(x)dx + w_1 q\bar{F}(q) + w_2 \int_q^\infty xf(x)dx - w_2 q\bar{F}(q) - \delta_{NGO} hqF(q) + \delta_{NGO} h \int_0^q xf(x)dx - \delta_{NGO} b \int_q^\infty xf(x)dx - \delta_{NGO} bq\bar{F}(q) - \delta_{NGO} t_e \int_q^\infty xf(x)dx + \delta_{NGO} t_e q\bar{F}(q) - \delta_{NGO} \emptyset \int_q^\infty xf(x)dx + \delta_{NGO} \emptyset q\bar{F}(q) + \delta_{NGO} b_s \int_{q+c}^\infty xf(x)dx - \delta_{NGO} b_s q\bar{F}(q) - tq - hq + \delta_{NGO} hq - T \tag{4.4}$$

And linearized form of the whole supply chain can be seen below in Equation 4.5.

$$\pi_{SC}^{D} = w_1 E[X] - w_1 \int_q^\infty xf(x)dx + w_1 q\bar{F}(q) + w_2 \int_q^\infty xf(x)dx - w_2 q\bar{F}(q) - \delta_{NGO} \emptyset q - \delta_{NGO} hq\bar{F}(q) + \delta_{NGO} h \int_0^q xf(x)dx - \delta_{NGO} b \int_q^\infty xf(x)dx + \delta_{NGO} bq\bar{F}(q) - \delta_{NGO} t_e \int_q^\infty xf(x)dx + \delta_{NGO} t_e q\bar{F}(q) - tq - hq + \delta_{NGO} hq + \delta_{NGO} c_s \int_q^\infty xf(x)dx - \delta_{NGO} c_s q\bar{F}(q) - c_s q - H_s q + \delta_{NGO} c_s q + \delta_{NGO} \emptyset E[X] - \delta_{NGO} c_s E[X] \tag{4.5}$$

As a next step, derivatives of these linearized equations are taken and following optimum quantity equations are obtained for each side of the contract.

Optimum quantity which maximizes NGO's profit can be seen in Equation 4.6 below. This equation is positive and denominator part is not equal to zero under general assumption in this study.

$$q_{NGO}^{D} = \frac{-w_1\bar{F}(q) - w1 + w_2\bar{F}(q) + \delta_{NGO} hf(q) + \delta_{NGO} b\bar{F}(q) - \delta_{NGO} t_e \bar{F}(q) - \delta_{NGO} \emptyset \bar{F}(q) + \delta_{NGO} b_s cf(q+c) + \delta_{NGO} b_s - \delta_{NGO} b_s \bar{F}(q) + t + h - \delta_{NGO} h}{\delta_{NGO} hf(q) + 2\delta_{NGO} bf(q) - 2\delta_{NGO} \emptyset f(q) - \delta_{NGO} b_s f(q+c)} \tag{4.6}$$

Lemma 4.1 Optimum quantity q_{NGO} is a strictly positive value.

Proof. First of all, it is known that w_1 is a big value which represents social value of saving one life. So when we compare it to other parameters we can directly accept that it is greater, which can also be seen as follows $w_1 > b > t_e > h$. It was mentioned that holding cost for NGO is relatively small and can be even accepted as zero as most of the companies provide almost free stocking areas for them and they have also many other stimulations. As a result, it can be accepted as the smallest value. For the backorder cost of NGO, it can be said that it has a greater value when it is compared to express transportation and holding cost but it is still less than social value of saving one life.

It becomes clear that numerator part of equation becomes negative under general assumption.

Under general assumption it can be seen clearly that the denominator part of equation (4.6) will get a negative value which can be seen in equation (4.7).

$$2b < 2\emptyset + b_s \tag{4.7}$$

As both numerator and denominator are negative, Lemma 4.1 is proven.

■

Additionally, optimum quantity for supply chain can be expressed as follows which can also be seen from Equation 4.8.

$$q_{SC}^{D} = \frac{-w_1\bar{F}(q)+w_2\bar{F}(q)+\delta_{NGO}\emptyset+\delta_{NGO}h\bar{F}(q)+\delta_{NGO}b\bar{F}(q)-\delta_{NGO}t_e\bar{F}(q)-\delta_{NGO}\emptyset\bar{F}(q)+\delta_{NGO}b_s cf(q+c)+\delta_{NGO}b_s\bar{F}(q)+t+h-\delta_{NGO}h}{2\delta_{NGO}hf(q)+2\delta_{NGO}bf(q)-\delta_{NGO}b_sf(q+c)+\delta_{NGO}b_sf(q)}$$

(4.8)

Lemma 4.2 Optimum quantity q_{SC} is a strictly positive value.

Proof.

Under general assumption of this study, with some further assumption it can be concluded that SC quantity is strictly positive.

$$b_s(q + c) - b_sf(q) - 2bf(q) > 0 \tag{4.9}$$

Equation 4.9 provides a basis for negativity of denominator part of the equation. It is clear by general assumption that numerator part is negative due to w_1.

As both numerator and denominator becomes negative, entire equation will be positive and Lemma 4.2 is proven.

■

After obtaining those optimum quantity equations for supply chain profit and NGO's profit it should also be clarified if those profit functions have a relative maximum value at given quantity q or not. Thence, second derivative test must be applied to those given equations and if the second derivative can be taken, it must be checked whether they take positive or negative value.

First of all, as objective function for NGO and supply chain is constructed on the basis of maximization it becomes clear that concavity rule must be checked for the second derivative.

According to second derivative test rule; accepting that q has a critical point which means the first derivative of function f according to q is equal to zero, second derivative will show if the equations have a minimum or maximum value for given quantity q. Namely, if second derivative exists, then f has a relative maximum value if $f''(q) < 0$ and has a relative minimum value if $f''(q) > 0$. If second derivative cannot be obtained, then it means that the second derivative test is not informative for this case.

In light of foregoing, the second derivatives with respect to q of both equations are obtained. As a result, following equations are obtained.

Lemma 4.3 Second derivative of SC profit function has negative value.

Proof.

$$f''(q)_{SC} = -w_1 f(q) + w_2 f(q) + \delta_{NGO} h f(q) + 3\delta_{NGO} b f(q) - \delta_{NGO} t_e f(q) - \delta_{NGO} \emptyset f(q) + 2\emptyset b_s f(q) \tag{4.10}$$

In equation above the second derivative of supply chain profit function with respect to intended optimum quantity q can be seen. To accept that this equation will take a value which is less than zero, some assumptions should be made such as Equation 4.11.

$$w_1 + \delta_{NGO} t_e + \delta_{NGO} \emptyset > w_2 + \delta_{NGO} h + 3\delta_{NGO} b + 2\delta_{NGO} b_s \quad (4.11)$$

In addition to general assumption, Equation 4.11 also acts as a basis to provide negativity for second derivative of SC profit function.

Within the light of all information that are obtained from general assumption, one can say that Equation 4.11 will get a value below 0, $f''(q) < 0$ which directly means the function has a relative maximum value for the given quantity q. Thus, it is accepted that profit function of whole supply chain has a maximum value for the given optimum quantity q. As a result, Lemma 4.3 is proven.

■

The same process is also applied for the profit function of NGO that can also be seen as follows.

$$f''(q)_{NGO} = -w_1 f(q) + w_2 f(q) + \delta_{NGO} h f(q) + 3\delta_{NGO} b f(q) - \delta_{NGO} t_e f(q) - 3\delta_{NGO} \emptyset f(q) - 2\delta_{NGO} b_s f(q) \quad (4.12)$$

Similar to SC profit function it is also observed whether corresponding equation is negative as follows.

Lemma 4.4 Second derivative of NGO profit function has negative value.

Within the light of the foregoing, first part of the equation becomes the greatest value with negative sign.

In this context, the profit function of NGO also has a relative maximum value for the given optimum quantity q.

Lemma 4.4 is also proven.

■

As a result, both of the equations are concave and have a maximum value for optimum quantities which directly indicates that the functions that were constructed can be used for further improvements and they are on a steady foundation.

4.3 Evaluation of the Current Supply Chain Situation

After validating profit functions are concave, another issue is to check the relationship between the optimum quantities of supply chain and the decision maker. Cachon (2003) states that a simple contract is applicable if the contract has a high efficiency which means the decision maker will take the biggest share and the supply chain optimal profit will be really close to the supply chain profit when contract is applied. In order to apply a logical contract model to the given supply chain one should look whether decision maker's and supply chain's optimal quantity are the same or one of them is bigger. So in order to get a balance between these quantities a more realistic contract can be applied and the time will be saved.

Lemma 4.5 NGO's optimal quantity is greater than supply chain optimal quantity.

Proof. By having assumption above, one can say that if NGO's quantity is still higher than supply chain quantity after increasing supply chain's quantity function, then it means that NGO's optimal quantity is higher for sure. First, NGO's optimum quantity equation's sign is changed for both numerator and denominator to make it more similar to SC optimal quantity equation.

Thus, to make these two equations more similar we can add the following to supply chain's quantity function.

$$\Delta = \frac{-w_1+\delta_{NGO}hf(q)+\delta_{NGO}b_s-\delta_{NGO}b_s\bar{F}(q)-\delta_{NGO}\emptyset-\delta_{NGO}h\bar{F}(q)-\delta_{NGO}b_s\bar{F}(q)}{2\delta_{NGO}hf(q)+2\delta_{NGO}bf(q)-2\delta_{NGO}b_sf(q+c)+\delta_{NGO}b_sf(q)} > 0 \qquad (4.13)$$

After adding Equation 4.13 to the optimal quantity of supply chain, the numerator parts will be equal. It can also be seen properly with the help of the following assumption that

Equation 4.13 has positive value, thus it can be concluded that supply chain's optimal quantity will increase after adding this equation.

As a result, supply chain's optimal quantity equation will be as the following:

After adding Δ value to SC function, numerator parts of two equations become equal. Therefore, denominator parts of the equations are checked in order to understand relation. In equation 4.14 denominator part of SC function can be seen after addition of Δ.

$$2\delta_{NGO}hf(q) + 2\delta_{NGO}bf(q) - \delta_{NGO}b_s f(q+c) + \delta_{NGO}b_s f(q)$$
(4.14)

It is known that as long as the numerators are equal lower denominator will mean that the equation has a higher value. Difference between the denominators of supply chain equation and NGO's can be seen in Equation 4.15. h is a close value to 0, so neglected in below relation.

$$-2\delta_{NGO}\emptyset f(q) < \delta_{NGO}\mathrm{b}_s f(q)$$
(4.15)

It can be concluded that Equation 3.16 gets a negative value under general assumption. Because of this information, it becomes clear that NGO's optimum quantity is higher than SC quantity. In other words, although a quantity which is higher than 0 is added to SC quantity NGO's quantity is still higher.

Lemma 4.5 is proven.

■

In conclusion, optimum quantity value for supply chain coordination is less than optimum quantity that optimizes NGO's profit function. Unsurprisingly, the current system is not coordinated as these quantities are not the same. In order to coordinate this supply chain a contract model must be applied to system which will lessen the quantity that will be ordered by NGO.

It is also a logical solution for this model, as NGO will try to give an order as much as it can to increase the profit that it will get from the social value that it will get by meeting the demand. It also has a significant backorder cost that becomes a really important factor while giving orders as it is directly related to human life. And social value is stated as a significantly important value. To get a balance between NGO and supplier, first the existing contract models will be evaluated and then if necessary, a new contract model may be applied. While choosing the contracts the focus point will be reducing the order quantity that NGO gives. The contracts will be adapted to the given model by changing the transfer payment parts that were left to be changed before.

4.4 Option Contract

Option contract is a special type of contract that can be used to make a supply chain more efficient and coordinated by avoiding the risks and lessen uncertainty by postponing decision phase of buyer (Liang, et al., 2012).

A first step to option contract was provided by Kleindorfer and Saad (2005) which separated the price of the contract into two parts which are reserve fee and executive fee. In another study that was held by Cucchiella and Gastaldi (2006) option contract was used as a risk management tool which was also an important focus on option contracts (Cucchicella & Gastaldi , 2006).

In literature there are many applications of Option contract for commercial supply chains. For instance, Jörnsten K. , Nonas et al. (2013) studied a classical newsvendor model with discrete demands and they used a mixed contract which means the retailer can give an order which is a combination of q units and Q real options on the same items. They concluded that this mixed contract model can be more efficient than option contract under specific circumstances. It was also found out with the help of option contracts that; a loss averse retailer's order quantity may increase with respect to retail price and decrease with respect to option price and exercise price. This result was obtained for a two-stage supply chain for one period which includes a risk neutral supplier with short life cycle products and a risk averse retailer that has stochastic demand and orders via option contracts (Chen, et al., 2014). Another study was held by Hu, et al., (2014) for a one retailer one manufacturer supply chain with stochastic demands. They also applied partial backordering to usual process; after retailer exercises his orders and then decide on the backorder quantity. Optimal ordering policy is decided in this study and some numerical examples were represented.

Apart from commercial supply chains option contracts are also used several times for humanitarian supply chains. Liang, et al. (2012) used option contracts for relief material supply chains. They accepted relief supply chain as a one retailer – one supplier system and by making some assumptions they used binomial lattice for the pricing model and with the help of this method they coould used different price values for each side of the contract. They concluded that there is a feasible price range for option contract that can coordinate relief supply chain and satisfy both sides. Another study was held by Wang, et al. (2015) which compared three different contract models and decided on one of them. They studied pre-purchasing approach, instant purchasing and option contract. As a result they concluded that option contract is the most efficient of all and achieved a Pareto improvement. These studies can also act like a pioneer for this study as they proved that option contract is a reasonable choice for this kind of supply chain.

While applying option contract to the basic contract model that was represented in this study the implementation procedure will be similar to the traditional usage. Before disaster strikes the intended order will be given by NGO by paying a unit premimum price *o*. If disaster strikes, then the contract will be triggered and for each quantity that will be ordered by NGO exercise price will be paid per unit which is *e*. Apart from the traditional contract there are also some other special issues. Once NGO pays the premimum price *o* to the supplier the inventory will be holded by supplier and the holding cost will be applied to supplier. And transportation cost will be just take part in the exercising part as the inventories will be held by the supplier and if no disaster occurs those units will not be transported. Another point can be about express transportation for excess demand. If NGO needs to give an express demand then again the same procedure with the intended basic contract model can be applied. There should be a logical constraint for specified option contract model such as; $\emptyset < o + e < w_1$. This means; to satisfy the supplier the total price that will be obtained for one unit should be better than the classical price amount $\emptyset$ to persuade the supplier. And also for NGO the cost that will be paid to the supplier should be less than the social value obtained by meeting the demand of one victim. Otherwise non of the sides will be eager to accept the contract.

The whole process again begins with signing the contract and NGO specifies the quantity that will be kept by the supplier until the contract is triggered. A unit premium price *o* is paid to the supplier for reserved quantities. After that, supplier holds this quantity in his inventory until the contract is triggered. It becomes supplier's responsibility to meet this specified quantity when contract is triggered.

If disaster strikes the contract is triggered and some scenarios may occur. If demand is less than given order quantity, NGO exercises a quantity that is equal to demand and pays a unit price *e* for each unit. If demand is greater than the quantity, NGO exercises all the quantity that was specified in contract and again pays exercise price and also pays additional price for the excess quantity, which is $\emptyset$ for the cost and additional express transportation cost.

It is also possible that disaster does not strike, in that case option price and inventory will be kept by supplier until contract period is over.

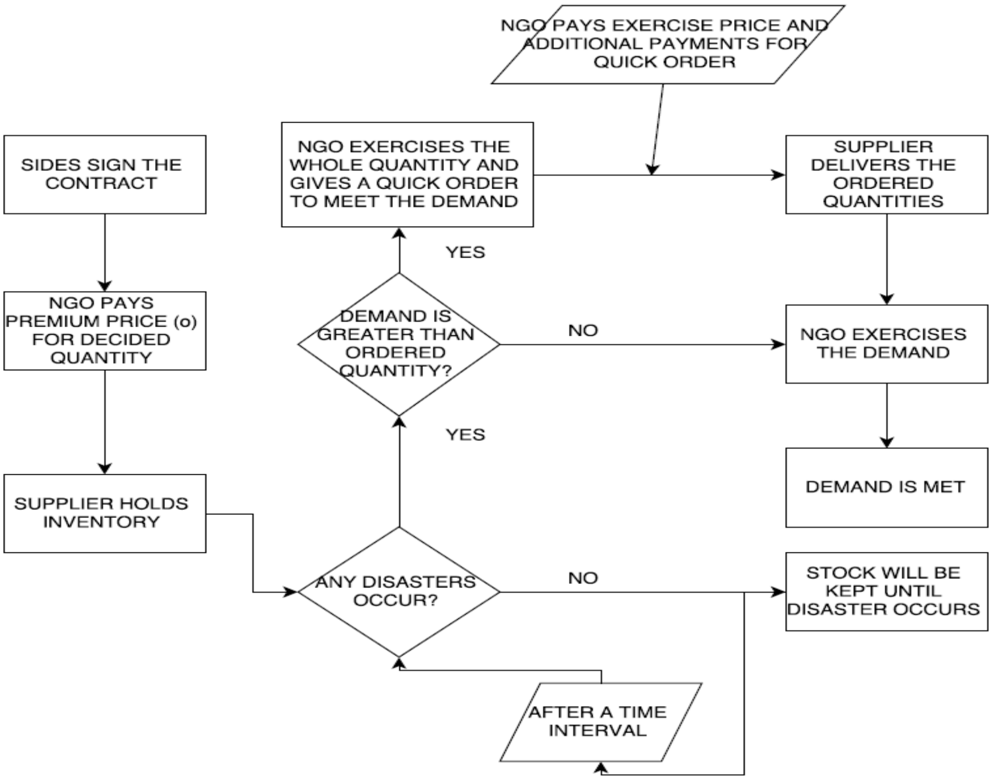

Figure 4. 2 Flow Chart of Option Contract Model Applied to Intended Model

4.4.1 Application to Basic Model

The parameters that have been stated in the former part are applied to the basic model that was developed. Both the NGO's and supplier's profit functions are revised and the new parameters are added in a logical way. Correspondingly, the profit equations of NGO and supplier become as the following.

$$\pi_{NGO}^{O} = w_1 min[E[X], q] + w_2[E[X] - q]^+ + \delta_{NGO}\{-oq - (e + t)(min[E[X], q]) - (b + t_e + Ø)[E[X] - q]^+ + b_s[E[X] - q - c]^+\} + (1 - \delta_{NGO})\{(-oq)\}$$

(4.16)

First part of the profit function for NGO does not change but next parts are revised slightly. For example, the first element after the probability that the disaster strikes means the option price will be paid to the supplier for the forecasted quantity that will be reserved by NGO and held by the supplier. Next parenthesis represents the costs related to the quantities that will be exercised thus minimum function is used. Express transportation part can be applied as the same, thus this part is not revised. Backorder part also remains the same but the last element of the equation changes as if disaster does not strikes the only cost will be the option price that has been paid to the supplier. Holding costs are ignored for NGO as the inventories are held by the supplier until disaster strikes.

$$\pi_S^O = \delta_{NGO}(oq + emin[E[X], q] - c_s max[E[X], q] - H_S q - b_S[E[X] - q - c]^+ + Ø[E[X] - q]^+) + (1 - \delta_{NGO})(oq - c_s q - H_S q)$$
(4.17)

Supplier profit function is also revised as can be seen in Equation 4.17. The first element again represents the option cost that will be obtained from NGO for the first specified quantity that is ordered. Second part is for the exercise price that will be paid by NGO for exercised quantity after disaster strikes; this quantity may be also equal to demand id demand is less than specified quantity. In addition to this, in case of demand is higher than option priced quantity an express shipment will be made to NGO, which will have a cost of Ø per unit. Another changed part is located in no disaster part of the equation. If no disaster happens the only price that supplier get will be the option price and for both of the situations until disaster strikes, supplier has to hold the first quantity that was specified and paid by NGO.

To be able to see more clearly, transfer cost is defined. Corresponding equation can be seen in Equation 4.18. This transfer cost becomes useful to analyze the effect on given profit equation and enables to be understood if profit function becomes higher or not as a result of contract application.

$$T^O = -\delta_{NGO} emin[E[X], q] - \delta_{NGO} tmin[E[X], q] - oq + 2\delta_{NGO}Øq + 2\delta_{NGO}tq + \delta h[q - E[X]]^+ - Øq - tq - hq + \delta_{NGO}hq$$
(4.18)

For better understanding, it can be evaluated whether this transfer cost has a greater value than 0 or not. If the value is greater than 0, then it becomes clear that profit value of NGO will decrease as a result of the application of this contract. Again with help of general assumption and logical constraint of option contract namely; $Ø < o + e < w_1$ it is concluded that transfer cost function is less than 0 in both conditions ($q > X$ *and* $X > q$). As a result of this interpretation, it is seen that transfer cost decreases NGO's profit under all circumstances which means affects the supplier's profit positively in this case. This result may lead to a willingness of supplier to agree on the contract.

To get the optimal option price first, one should take the first derivative of given NGO profit function. Then by equalizing it to supply chain optimal quantity equation the option price which will coordinate the stated supply chain will be obtained.

Theorem 4.4.1.1 Optimal quantity for given option contract model is

$$q_R^O = \frac{-w_1\bar{F}(q)+w_2\bar{F}(q)+\delta_{NGO}e\bar{F}(q)+\delta_{NGO}t\bar{F}(q)-\delta_{NGO}b\bar{F}(q)-\delta_{NGO}t_e\bar{F}(q)-\delta_{NGO}\emptyset\bar{F}(q)+\delta_{NGO}b_s cf(q+c)-\delta_{NGO}b_s\bar{F}(q)-o}{-\delta_{NGO}b_s f(q+c)-\delta_{NGO}b_s qf(q)} \quad (4.19)$$

Proof. Given optimal quantity in Equation 4.19 can be proven as below

First, Equation 4.16 is linearized as follows

$$= w_1E[X] - w_1[E[X]-q]^+ + w_2[E[X]-q]^+ - \delta_{NGO}oq - \delta_{NGO}eE[X] + \delta_{NGO}e[E[X]-q]^+ - \delta_{NGO}tE[X] + \delta_{NGO}t[E[X]-q]^+ - \delta_{NGO}bE[[X]-q]^+ - \delta_{NGO}t_e[E[X]-q]^+ - \delta_{NGO}\emptyset[E[X]-q]^+ + \delta_{NGO}b_s[E[X]-q-c]^+ - oq + \delta_{NGO}oq$$

$$= w_1x - w_1\int_q^\infty xf(x)dx + w_1q\bar{F}(q) + w_2\int_q^\infty xf(x)dx - w_2q\,\bar{F}(q) - \delta_{NGO}e\mu$$
$$+ \delta_{NGO}e\int_q^\infty x\,f(x)dx - \delta_{NGO}eq\bar{F}(q) - \delta_{NGO}t\mu + \delta_{NGO}t\int_q^\infty x\,f(x)dx$$
$$- \delta_{NGO}tq\bar{F}(q) - \delta_{NGO}b\int_q^\infty x\,f(x)dx + \delta_{NGO}bq\bar{F}(q) - \delta_{NGO}t_e\int_q^\infty x\,f(x)dx$$
$$+ \delta_{NGO}t_eq\bar{F}(q) - \delta_{NGO}\emptyset\int_q^\infty x\,f(x)dx + \delta_{NGO}\emptyset q\bar{F}(q)$$
$$+ \delta_{NGO}b_s\int_{q+c}^\infty x\,f(x)dx + \delta_{NGO}b_sq\bar{F}(q) - oq$$

Then first derivative of this linearized equation is taken with respect to quantity q.

$$= w_1\bar{F}(q) - w_2\bar{F}(q) - \delta_{NGO}e\bar{F}(q) - \delta_{NGO}t\bar{F}(q) + \delta_{NGO}b\bar{F}(q) + \delta_{NGO}t_e\bar{F}(q) + \delta_{NGO}\emptyset\bar{F}(q) - \delta_{NGO}b_s(q+c)f(q+c) + \delta_{NGO}b_s\bar{F}(q) - \delta_{NGO}b_s qf(q) - o$$

Because of these equations optimal quantity can be obtained by Equation 4.19.

Thus, Theorem 4.4.1.1 is proven.

■

As a next step, concavity test is applied in order to understand if obtained quantity function has a maximum value as it is important to know if option contract for the given model is suitable or not.

Second derivative for quantity q of option contract can be seen as follows in equation 4.20.

$$f''(q)_{NGO} = -w_1qf(q) + w_2qf(q) + \delta_{NGO}eqf(q) + \delta_{NGO}tqf(q) - \delta_{NGO}bqf(q) - \delta_{NGO}t_eqf(q) - \delta_{NGO}\emptyset qf(q) - \delta_{NGO}b_sf(q+c) - \delta_{NGO}b_sqf(q) - \delta_{NGO}b_sf(q) \quad (4.20)$$

In the equation above the second derivative of profit function with respect to intended optimum quantity q can be seen. To accept that this equation will take a value which is less than zero, some assumptions should be made.

Lemma 4.6 Second derivative of NGO's profit function has negative value.

Proof. First, it is known that $w_1$is a big value which represents social value of saving one life. The general assumption that was made before can be updated for option contract as in the last line of general assumption table.

In addition to information that was provided before, parameter e which is used as exercise cost is accepted to be less than normal buying cost of given product.

As a result of these information one can say that Equation 4.19 will get a value below 0, $f''(q) < 0$ which directly means the function has a relative maximum value for the given quantity q. Thus, it is accepted that profit function of NGO for option contract model has a maximum value for the given optimum quantity q.

As a result, Lemma 4.6 is proven.

■

Therefore, further steps can be applied as all the necessary validations are completed. After making all the validations, optimum option price can be decided in order to coordinate the contract.

Optimum option price can be decided by equalizing the obtained optimum quantity equation of option contract to basic model's supply chain optimal quantity function. This option price coordinates the supply chain and gives the optimum profit.

The option price obtained by balanced equations as stated can be seen in numerical analysis section with numerical examples.

In addition to optimal option price, there are some circumstances that win win situation takes place. These circumstances can be seen as in below equations.

For NGO to get a better profit below balance should be obtained between parameters as in Equation 4.21.

$$\delta_{NGO} e E[X] + \delta_{NGO} e[E[X] - q]^{+} + \delta_{NGO} t E[X] + \delta_{NGO} t[E[X] - q]^{+} + oq < \delta_{NGO} h[q - E[X]]^{+} + \emptyset q + tq + hq$$

(4.21)

And for supplier below condition should be provided to provide a better profit value in Equation 4.22.

$$\delta_{NGO} e - \delta_{NGO} e[E[X] - q]^{+} + oq - \emptyset q > 0$$

(4.22)

These two conditions should be both provided to make NGO and supplier to agree on option contract. In our case, as our NGO is the decision maker it may be thought that NGO has a priority when compared to supplier.

4.5 Cost Sharing (Reimbursement) Contract

Many government contracts are based on cost sharing contracts that are based on reimbursement procedure. As a nature of fact, it is almost impossible to forecast or decide on how much service and products obtained will cost when a disaster strikes. Therefore, the cost that will be reimbursed will be transferred and decided after some time passes or contract ends. Without any doubt, a forecast will be made by government and a budget will be arranged before the contract starts.

There are multiple forms of reimbursement contracts, but the one that will be held in this study is basic cost sharing contract. Other cost sharing contracts are namely; cost plus fixed fee (CPFF), Cost plus incentive fee (CPIF), Cost plus award fee (CPAF) contracts.

Cost sharing contract is based on a share percentage of cost between sides that is agreed on. This cost share may also be thought as an incentive that NGO suggests the supplier because of saved lives of disaster victims. It is known by previous sections that a symbolic profit is defined for a saved life by government. In this case, it can also be accepted like this profit is shared with supplier.

Generally, suppliers make discounted prices and try to provide a better service by means of transportation, price, quality etc. on a disaster intervention. Because of these services a significant cost appears to happen and it becomes harder to get a win-win situation. By sharing and reimbursing the cost; government suggests a kind of incentive to supplier which makes it easier to approve the contract by both sides.

But of course as a result of shared costs, the responsibility of commercial side (supplier) also increases accordingly. In health sector, reimbursement contracts are used widely also based on tender agreements. In case commercial side cannot supply required quantities, there may be serious consequences like tender ban or high amounts penalty costs.

In more detail the flow chart of this contract type is on next page which may make it easier to understand the process more clearly.

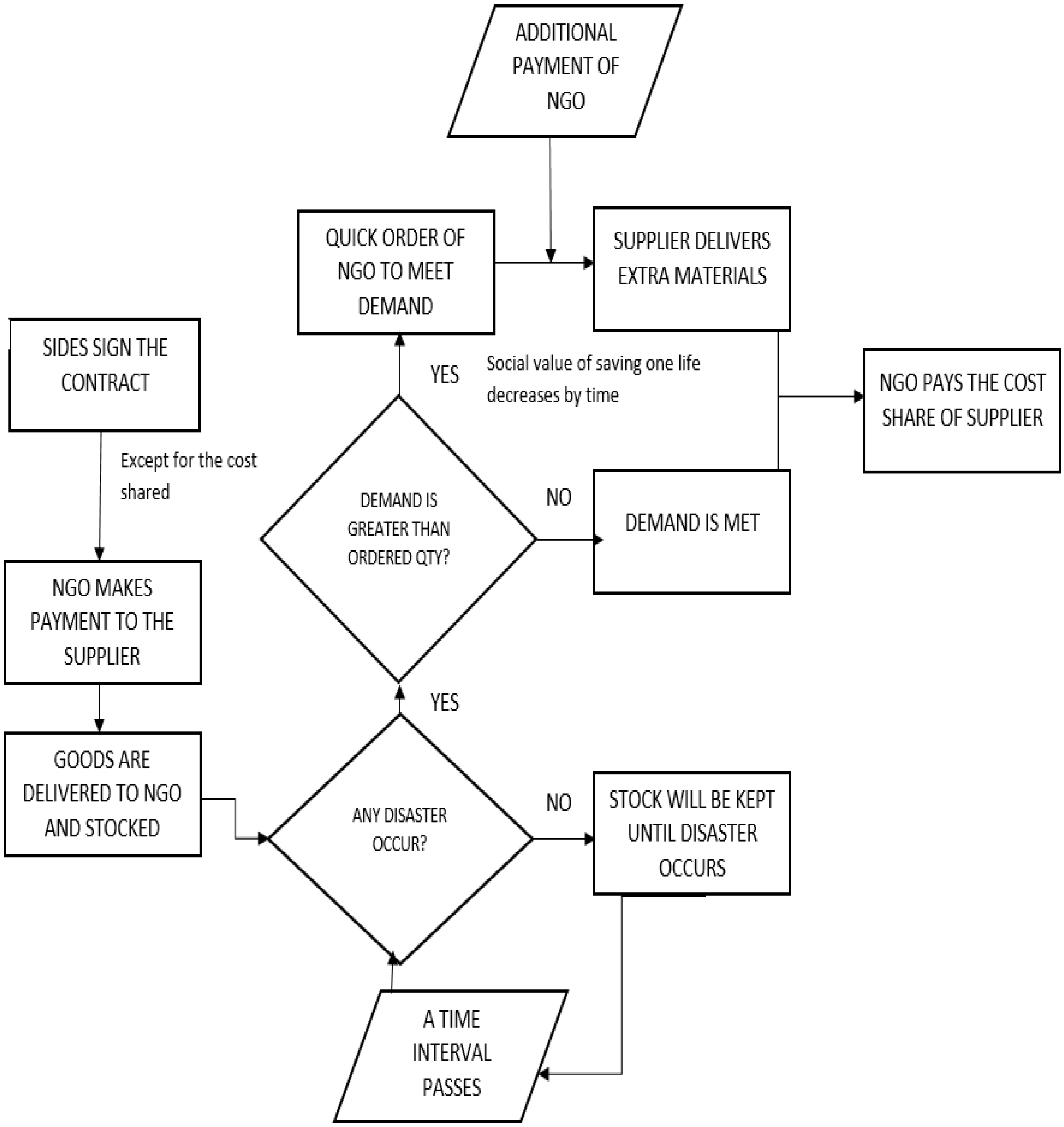

Figure 4. 3 Reimbursement Contract Flow Chart

In literature, there are many examples of cost sharing (reimbursement) contracts and are also many applications in commercial health sector. Ghosh and Shah (2014) studied a green sensitive consumer demand supply chain and decided whether it will be better for the retailer to decide on a cost sharing contract or not. They also considered a bargaining model which makes the study more realistic. Manufacturer incurs total cost of greening process; therefore, an incentive should be put for manufacturer to agree on this relation.

Reimbursement contracts are applied on healthcare industry for medicines and medical devices. Government and the commercial suppliers agree on a reimbursement procedure and government makes a reimbursement after the products are used from consignment or direct purchase. There are not so many cost sharing contract examples by means of supply chain coordination purpose, but there are many qualitative studies held in literature for this contract type. It may also be evaluated as a type of revenue share contract which is held before in previous sections of this study.

Morgan et al. (2013) stated reimbursement contracts are used in Canada pharmaceutical industry which offers several advantages such as making the payment after seeing the performance of medicines, create some changes on policies within the contract period. They held a study which is out of scope of this study but still helps to have an insight on the topic.

4.5.1 Application of Reimbursement Contract

The parameters that have been stated in former part is applied to basic model that was developed. Both the NGO's and supplier's profit functions are revised and new parameters are added in a logical way. Correspondingly, profit equations of NGO and supplier becomes as the following equation.

$$\pi_{NGO}^{R} = w_1 min[E[X], q] + w_2[E[X] - q]^+ + \delta_{NGO}\{-\emptyset q - tq - h[q - E[X]]^+ - (b + t_e + \emptyset)[E[X] - q]^+ + b_s[E[X] - q - c]^+\} + (1 - \delta_{NGO})\{(-\emptyset q - tq - hq)\} - \Omega(\mathrm{b_s}[E[X] - q - c]^+ + c_s \max(E[X], q) + H_s q) \quad (4.23)$$

As one can see, the first part up to Ω symbol, all the profit function remains as the same for NGO. No change has been made as basic model stays the same and nothing changes except for cost sharing application. The different part is after Ω symbol, which is set as the share that will be paid for supplier's cost. In more detail, NGO will pay Ω percentage of supplier's cost after all the products are delivered and post disaster phase comes. This share is the incentive or reimbursement that is made to supplier that is stated in previous section. Thus, the transfer cost for this type of contract becomes as in equation below.

$$T = \Omega(\mathrm{b_s}[E[X] - q - c]^+ + c_s \max(E[X], q) + H_s q) \tag{4.24}$$

For transfer cost function, the cost of supplier is taken and multiplied with the share that will be accepted by NGO to be paid. This amount is subtracted by NGO's profit function.

A similar change has also been made for supplier's profit function as can be seen in Equation 4.25, below;

$$\pi_S^R = \delta_{NGO}(\emptyset max[E[X], q]) - c_s \max[E[X], q] - H_s q - b_s[E[X] - q - c]^+) + (1 - \delta_{NGO})(\emptyset q - c_S q - H_s q) + \Omega(\mathrm{b_s}[E[X] - q - c]^+ + c_s \max(E[X], q) + H_s q)$$

(4.25)

In Equation 4.25, the profit part of the equation for supplier remains the same while the transfer cost of NGO is added as revenue.

Theorem 4.5.1.1 Optimal quantity for given reimbursement contract model is

$$q_{NGO}^R = \frac{-w_1\bar{F}(q) - w_1 + w_2\bar{F}(q) + \delta_{NGO}h\bar{F}(q) + \delta_{NGO}b\bar{F}(q) - \delta_{NGO}t_e\bar{F}(q) - \delta_{NGO}\emptyset\bar{F}(q) - \Omega b_s cf(q+c) - \Omega b_s\bar{F}(q) + \Omega c_s + \Omega H_s}{2\delta_{NGO}hf(q) + 2\delta_{NGO}bf(q) - \delta_{NGO}b_s f(q+c) + \delta_{NGO}b_s qf(q) + \Omega b_s f(q+c) - \Omega b_s f(q)}$$

(4.26)

Proof.

As a usual following step, nonlinear profit functions are converted into linear forms which makes it easier to get optimum quantity value for given equations. In following equation one can see the linearized form of profit function of NGO.

$$
\begin{aligned}
\pi_{NGO}^{R} = w_1 E[X] - w_1 \int_q^\infty x f(x) dx + w_1 q \bar{F}(q) + w_2 \int_q^\infty x f(x) dx - w_2 q \bar{F}(q) \\
- \delta_{NGO} h q \bar{F}(q) \\
+ \delta_{NGO} h \int_0^q x f(x) dx \\
- \delta_{NGO} b \int_q^\infty x f(x) dx - \delta_{NGO} b q \bar{F}(q) \\
- \delta_{NGO} t_e \int_q^\infty x f(x) dx + \delta_{NGO} t_e q \bar{F}(q) \\
- \delta_{NGO} \emptyset \int_q^\infty x f(x) dx + \delta_{NGO} \emptyset q \bar{F}(q) \\
+ \delta_{NGO} b_s \int_{q+c}^\infty x f(x) dx - \delta_{NGO} b_s q \bar{F}(q) - t q - h q + \delta_{NGO} h q \\
- \Omega b_s \int_{q+c}^\infty x f(x) dx + \Omega b_s q \bar{F}(q) - \Omega \mathrm{c_s} q - \Omega \mathrm{H}_s q
\end{aligned}
$$

Basically, the transfer function of stated reimbursement model is added to profit function of NGO. As a following step, first derivative of profit function is obtained to be able to get optimum quantity value.

First derivative of transfer function is added properly to first derivative of NGO’s profit function properly, which gives the optimum quantity result.

Just like other contract applications that have been applied before, it should be proven at first if optimum quantity obtained is positive or not.

Lemma 4.7 Optimum quantity q_{NGO} is a strictly positive value.

Proof.

First, it is proven that the optimum quantity obtained for first basic model application is strictly positive. Therefore, it becomes appropriate to prove that added transfer function does not affect the optimum quantity’s positivity.

As transfer function is relatively simple, it is almost clear and in just several steps proof can be completed as below;

First derivative of transfer function that is added to basic model is as follows;

$$T' = 2\Omega b_s q f(q) - \Omega b_s - \Omega b_s F(q) \tag{4.27}$$

And the way it affects optimum quantity is as below;

$$\Delta q = \frac{-\Omega b_s c f(q+c) - \Omega b_s \bar{F}(q) + \Omega c_s + \Omega H_s}{\Omega b_s f(q+c) - \Omega b_s f(q)} \tag{4.28}$$

Here by accepting general assumption, As it is known *F(q)* is a value between 0 and 1 which makes it relatively smaller than other values. Therefore, second and third element of numerator part becomes greater that first element which makes numerator positive. For denominator also as first element is multiplied by stock quantity it will provide greater value than second element and this makes denominator positive also. As both numerator and denominator are positive the effect of addition of this equation will be positive. It is already accepted that decentralized model's quantity equation is positive. Adding a positive value to a positive function again provides a basis for positive function.

Lemma 4.7 is proven.

■

Lemma 4.8 Second derivative of NGO profit function has negative value.

It was stated before that the first derivative of transfer function that is added to NGO's profit function was like;

$$T' = -\Omega b_s (q+c) f(q+c) + \Omega b_s \bar{F}(q) - \Omega b_s q f(q) - \Omega c_s - \Omega H_s$$

And second derivative of this function will be;

$$T'' = -\Omega b_s q f(q) - 2\Omega b_s f(q)$$

Second derivative of transfer function becomes clearly negative as all the elements have negative signs. It was proven in Lemma 4.8 before that NGO's profit function has a negative value for the second derivative when basic model is applied. As this transfer cost affects the total equation with a minus sign it becomes clear that NGO's profit function's second derivative is still negative.

In this context, the profit function of NGO also has a relative maximum value for the given optimum quantity q.

Lemma 4.8 is also proven.

■

Thus, NGO's profit equation is concave and has a maximum value for the optimum quantity.

In addition to that, analytical expression of reimbursement share percentage Ω is as below;

$$\Omega = \frac{\begin{array}{c} w_1\bar{F}(q) + w_1 - w_2\bar{F}(q) - \delta_{NGO}h\bar{F}(q) + 2\delta_{NGO}hqf(q) + 2\delta_{NGO}bqf(q) - \delta_{NGO}b\bar{F}(q) + \delta_{NGO}t_e\bar{F}(q) + \delta_{NGO}\emptyset\bar{F}(q) \\ -\delta_{NGO}b_s(q+c)f(q+c) - \delta_{NGO}b_s\bar{F}(q) + \delta_{NGO}b_sqf(q) - t - h - \delta_{NGO}h \end{array}}{-b_s(q)f(q+c) - b_s\bar{F}(q) + b_sqf(q) - c_s - H_s} \tag{4.29}$$

Under below circumstance, reimbursement contract provides a win-win solution for both sides.

$$(\mathrm{b_s}[E[X] - q - c]^+ + c_s \max(E[X], q) + H_s q) > \Omega(\mathrm{b_s}[E[X] - q - c]^+ + c_s \max(E[X], q) + H_s q) > 0 \tag{4.30}$$

This equation is mainly based on comparison with reimbursement contract to decentralized case, and to summarize from above equation, reimbursement contract provides a win win situation when Ω takes a value between 0 and 1.

4.4 Numerical analysis

First of all, in order to make numeric analysis clearer and more coherent some assumptions are made and the parameters are generated between specified interval values not to violate any of these assumptions.

For each parameter 30 random values are generated to be able to observe the trend and changes of profit functions and searched parameters.

One of the most important decisions made is the distribution of demand value. While deciding, real life data is used that is obtained by (emdat.com). The data contains the number of people that are affected by disasters between 1980 and 2015 with some additional information. Used data obtained from the stated web site can be found in APPENDIX A. Total affected people number represents the basis for demand in this study which makes demand information more realistic.

After getting data, as a following step the number of total affected people is analyzed and the distribution of the data is searched. For deciding on the distribution, StattAssist 5.6 is used. By applying the analysis below, this tool enables to decide on the distribution that fits the data most and additionally gives the parameters of specified distribution.

The distribution of demand data is chosen as gamma distribution with stated tool by application of following tests.

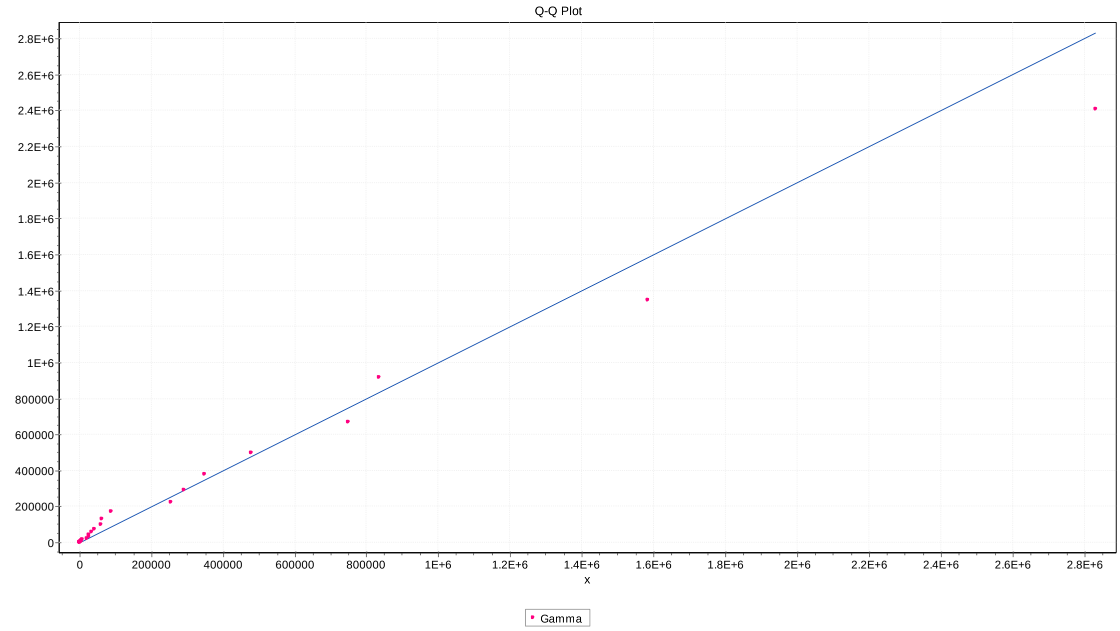

Figure 4. 4 Q-Q Plot of Randomly Generated Parameters

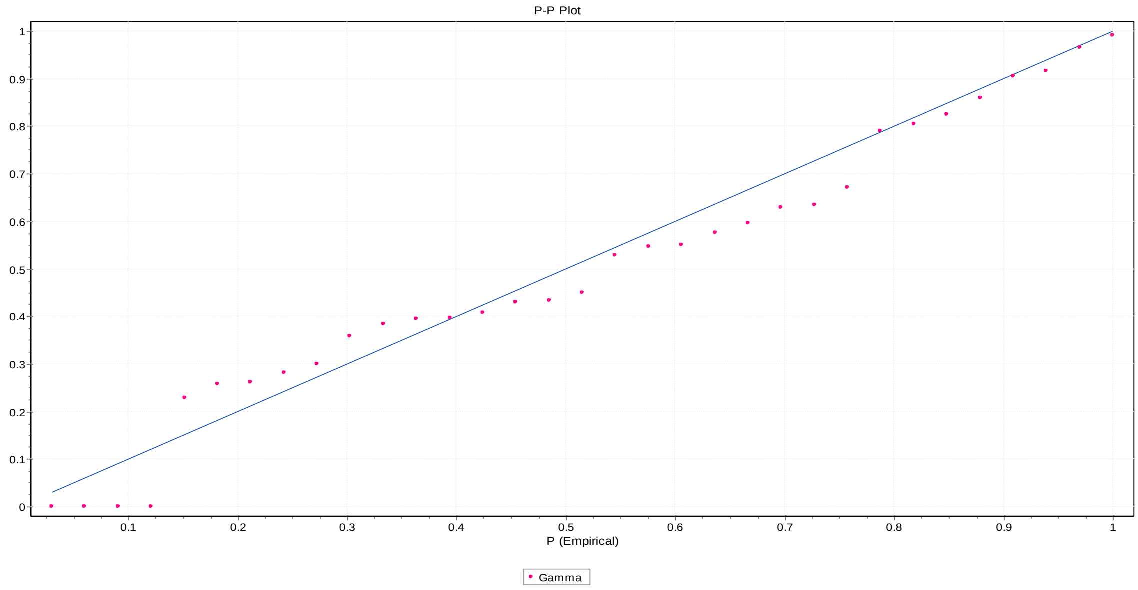

Figure 4. 5 P-P Plot of Randomly Generated Parameters

In Figure 4.3 and 4.4 QQ and PP plot the coherence of the data can be seen with gamma distribution. Quantile-Quantile Plot (QQ plot) shows the quantile of two data sets. When two sets come from the same distribution the stated data points should fall approximately on 45-degree line that can be seen in Figure 4.3 and 4.4. While vertical axis shows the quantile of the first data set, horizontal axis shows quantile of data set two. This plot makes it easier to see if a given data fits to a distribution or not and used by many of the software.

Probability-probability plot (PP plot) is also used for same purpose. PP plot compares data sets' cumulative distribution functions and again helps one to understand if the two data sets have same distribution or not. Just like QQ plot if the two distributions are the same the data points fall along the 45-degree line.

Within the light of this information it can be seen that the data points fall along closely to the 45-degree line and in a way can be a proof for stating demand value has a gamma distribution.

Apart from these graphical and visual tests, there are also some statistical tests that software applies. These are generally applied statistical tests which are used to understand if the data fits to a specific distribution. These tests are; Kolmogorov Smirnov, Anderson Darling and Chi-Squared. Stated software ranks the results obtained for these three tests and decides on the most appropriate distribution.

In below table 4.2 results of the stated tests for searched distributions can be found. As stated the software decides on the most suitable distribution that fits the data by getting a ranking in between according to the results obtained by statistical tests.

Table 4. 2 Statistical Test Results

#	Distribution	Kolmogorov Smirnov		Anderson Darling		Chi-Squared	
		Statistic	Rank	Statistic	Rank	Statistic	Rank
1	Beta	0,19906	17	15,34	39	N/A	
2	Burr	0,22449	20	51,108	43	N/A	
3	Burr	0,17603	14	24,023	40	N/A	
4	Cauchy	0,38184	33	12,251	36	3,1633	4
5	Chi-Squared	0,75758	49	-3,5788	1	82,964	43
6	Chi-Squared	0,75758	50	N/A		82,964	41
7	Dagum	0,16905	11	7,0187	20	3,4808	8
8	Dagum	0,16987	12	7,1817	23	3,9701	11
9	Error	0,40998	36	6,8106	16	17,67	32
10	Error Function	0,5	43	7,5387	27	4,1221	12
11	Exponential	0,49973	41	40,378	42	53,152	40
12	Exponential (2P)	0,49973	42	40,378	41	53,152	39
13	Fatigue Life	0,16805	9	7,1629	21	5,125	17
14	Fatigue Life	0,16805	10	7,1629	22	5,125	18
15	Frechet	0,16755	8	7,2495	24	3,9662	10
16	Frechet	0,27063	24	9,3493	29	7,1367	22
17	Gamma	0,21883	18	7,5058	26	5,3966	20
18	Gamma	0,12121	1	5,4676	6	2,4112	2
19	Gen. Extreme Value	0,22843	21	2,8215	4	3,7585	9
20	Gen. Gamma	0,16714	6	6,5694	10	4,1624	14
21	Gen. Gamma	0,22429	19	7,8328	28	5,6923	21
22	Gen. Pareto	0,25218	23	2,5748	3	2,8509	3
23	Gumbel Max	0,38584	35	5,766	7	9,6039	24
24	Gumbel Min	0,42538	39	10,504	32	17,412	31
25	Hypersecant	0,38275	34	6,515	9	15,19	30
26	Inv. Gaussian	0,27475	27	11,666	35	10,519	27
27	Inv. Gaussian	0,48522	40	169,36	49	29,365	35
28	Johnson SB	0,41815	38	4,2929	5	1,4132	1
29	Kumaraswamy	0,16743	7	15,199	38	N/A	
30	Laplace	0,40998	37	6,8106	17	17,67	33
31	Levy	0,2708	25	11,419	33	10,36	25
32	Levy	0,2708	26	11,419	34	10,36	26
33	Log-Logistic	0,16064	2	6,8079	15	3,3671	7
34	Log-Logistic	0,28798	28	9,607	30	17,724	34
35	Logistic	0,37208	31	6,4906	8	14,021	29
36	Lognormal	0,16461	4	6,8764	18	3,2768	5
37	Lognormal	0,16461	5	6,8765	19	3,2768	6
38	Normal	0,35901	30	6,6792	12	12,601	28
39	Pareto 2	0,17903	15	6,6811	13	4,2007	15
40	Pearson 5	0,5253	45	116,02	46	45,873	38
41	Pearson 5	0,5253	44	116,02	45	45,873	37
42	Pearson 6	0,16345	3	6,7011	14	4,7915	16
43	Pearson 6	0,17329	13	7,3681	25	4,1326	13
44	Power Function	0,23441	22	2,2684	2	7,6902	23
45	Rayleigh	0,73924	47	150,57	47	91,691	44
46	Rayleigh	0,67233	46	105,54	44	82,964	42
47	Rice	0,73924	48	150,57	48	91,691	45
48	Student's t	0,87877	51	418,43	50	N/A	
49	Uniform	0,38107	32	13,372	37	N/A	
50	Weibull	0,18878	16	6,5883	11	5,318	19

As can also be seen from table 4.2, most suitable distribution is chosen to be gamma distribution by the tool which can be seen in row 18. It is also possible to see each statistical test in more detail. For getting a clearer and robust idea about chosen distribution, detailed tables of statistical tests for gamma distribution can be seen in following table 4.3. Of course not all the tests give the best result for gamma distribution but for an overall look the best results are obtained for Gamma distribution.

Before explaining about the statistical test results in more detail it will make it clearer to give brief information on set hypotheses.

H_0: The data follows a specified distribution

H_1: The data does not follow the specified distribution

In more detail, a null hypothesis is set for testing if the data fits the stated distribution. In this study; the data is tested for gamma distribution. While null hypothesis accepts the stated data is follows gamma distribution, alternative hypothesis claims that data does not follow gamma distribution. For a specified confidence level; it is decided whether it there is enough evidence to reject null hypothesis or not. In table 4.3 below, last row of each statistical tests shows whether it is possible to reject the null hypothesis or not.

Table 4. 3 Statistical Test Results for Gamma Distribution

Gamma [#18]					
Kolmogorov-Smirnov					
Sample Size Statistic P-Value Rank	33 0,12121 0,67271 1				
α	0,2	0,1	0,05	0,02	0,01
Critical Value	0,18171	0,20771	0,23076	0,25801	0,27677
Reject?	No	No	No	No	No
Anderson-Darling					
Sample Size Statistic Rank	33 5,4676 6				
α	0,2	0,1	0,05	0,02	0,01
Critical Value	1,3749	1,9286	2,5018	3,2892	3,9074
Reject?	Yes	Yes	Yes	Yes	Yes
Chi-Squared					
Deg. of freedom Statistic P-Value Rank	3 2,4112 0,49155 2				
α	0,2	0,1	0,05	0,02	0,01
Critical Value	4,6416	6,2514	7,8147	9,8374	11,345
Reject?	No	No	No	No	No

In table 4.3 above, results of statistical tests which decide on the distribution of given data can be seen. As stated before, not all applied tests give the best result for chosen distribution but in overall decision gamma distribution is the one which is represented by given statistical results.

According to Kolmogorov-Smirnov test, null hypothesis cannot be rejected in any confidence level. Result obtained from Kolmogorov Smirnov test for Gamma distribution seems to have the best result of all between other distributions. However, this is not the same situation for Anderson Darling Test. This test claims that there is enough evidence for rejecting null hypothesis and states that the fits to another distribution. But for Chi-squared test, which is also a widely known distribution fitting test, results seem to be valid for gamma distribution under all confidence levels. As a result, the statistical tool decides that Gamma distribution is the best fitting distribution for given data.

This inference which gets its roots from statistical tools is also logical when the trend and manner of demand occurs as a result of disasters is thought. In below figure 4.5, probability density function and cumulative density function of demand distribution can be seen respectively.

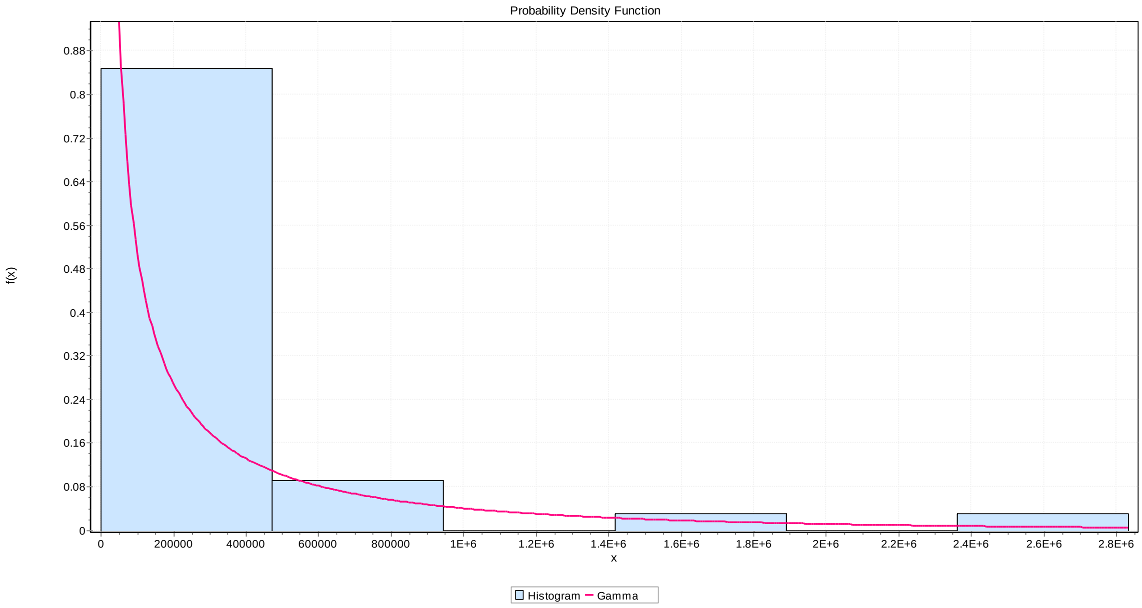

Figure 4. 6 Probability Density Function of Gamma Distribution

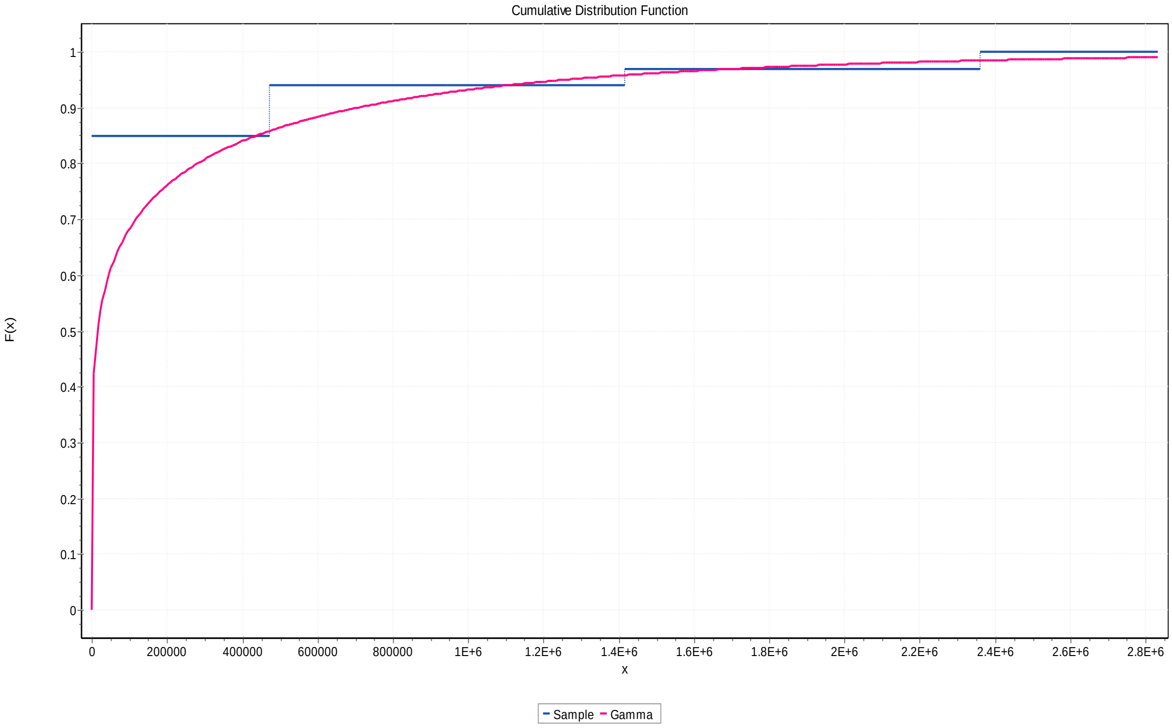

Figure 4. 7 Cumulative Density Function for Gamma Distribution

These two plots also serve as an analysis tool for proving that demand data fits to gamma distribution. The blue lines represent the sample demand data and the red lines are for gamma distribution. One can see the coherence between those data which makes it more reliable to use gamma distribution for demand.

The tool also decides on specifying the most suitable parameters of decided distribution. For used demand data specified parameters are provided as follows in table 4.4.

Table 4. 4 Parameters of Specified Gamma Distribution

Alfa	0.16973
Beta	1389100
Gamma	0

When applying numerical analysis these parameters are used for getting probability density and cumulative density functions. As general information about gamma distribution alpha is defined as scale parameter and beta is defined as shape parameter.

4.4.1 Design of experiments

Next step is defining the intervals in a consistent way with the assumptions made before. After specifying the intervals 30 random numbers are generated by random number generator of excel. Interval values used for each parameter can be seen as in table 4.5. Last two parameters are assumed to be fixed in this study in order to reduce complexity and logical values are chosen for them.

Table 4. 5 Randomly Generated Parameter Intervals

$\emptyset$	Unit cost of products paid to the supplier	40-60	per unit
$w1$	Social value of saving one life	300000-200000	per person
w_2	Social value of saving one life in case of backorder	180000-150000	per person
b	Backorder cost of products (which is very high)	70000-20000	per unit
h	Holding cost in case of overstock	0-20	per unit
δ_{NGO}	The probability of a disaster will occur which is forecasted by the NGO	0.85	fraction/year
$(1-\delta_{NGO})$	The probability of no disasters will occur in the contract period	0.15	fraction/year
t	Transportation cost	0-20	per unit
te	Transportation cost for express delivery	20-40	per unit
c	Capacity of the supplier	1500	unit/year
c_s	Cost of supplier for one unit product	30-50	per unit
Hs	Holding cost of supplier	30	per unit
bs	Backorder cost of supplier	20000	per unit

An important point to clarify about created scenarios is that there is no multicollinearity between the variables used in this study. This is proven by using some statistical methods. First of all, one of the indicators of multicollinearity is the correlation between parameters. For that reason, following table 4.56is prepared for making it clear that there is not a strong relation between parameters used. This is important to specify that each parameter used in this study is stand alone and specific. Parameters within intervals that are used in the study and the relations in between can be seen in following table 4.6.

Table 4. 6 Correlation Between Parameters

Variables	w1	w2	Ø	b	h	t	te	cs	Demand (x)
w1	**1,000**	0,000	-0,061	0,156	0,095	-0,011	0,241	0,214	0,286
w2	0,000	**1,000**	0,138	-0,014	-0,057	0,239	0,194	-0,334	-0,130
Ø	-0,061	0,138	**1,000**	-0,111	-0,286	0,018	0,006	-0,119	0,178
b	0,156	-0,014	-0,111	**1,000**	-0,117	0,024	0,273	0,198	0,069
h	0,095	-0,057	-0,286	-0,117	**1,000**	0,027	-0,072	0,153	-0,190
t	-0,011	0,239	0,018	0,024	0,027	**1,000**	0,104	0,147	-0,180
te	0,241	0,194	0,006	0,273	-0,072	0,104	**1,000**	0,075	-0,061
cs	0,214	-0,334	-0,119	0,198	0,153	0,147	0,075	**1,000**	-0,116
Demand (x)	0,286	-0,130	0,178	0,069	-0,190	-0,180	-0,061	-0,116	**1,000**

Within the light of this table one can say that there is no strong relation between parameters of this study and each parameter has a different mission and specification while deciding on the profits and quantities etc.

Another important indicator of multicollinearity between variables is VIF (Variance Inflation Factor). For being more concrete about this method, a more detailed definition can be made. VIF is a scale which shows how much the variation inflates by using following equation.

$$VIF_k = \frac{1}{1 - R_k^2} \tag{4.31}$$

This equation includes some common factors that are used for basic regression models. R^2 obtained by regressing k the factor over other factors used in analysis VIF value is obtained for each factor. In a way it represents if there is a high correlation between factors but in a more concrete way.

There is no specific upper limit for this scale factor but generally a VIF value that is close to 1 means there is no multicollinearity in between, a VIF value which is greater than 4 indicates a warning for further investigation and a VIF value which exceeds 10 means there is a multicollinearity between factors. R^2 value also helps to get an opinion about similarity between variables or parameters and also used for getting VIF value. In following table 3.6, stated VIF scale and R^2 values can be seen which makes it easier to make some interpretations.

Table 4. 7 Multicollinearity Indicators for Parameters

Statistic	w1	w2	Ø	b	h	t	te	cs	Demand (x)
R^2	0.238	0.269	0.146	0.152	0.159	0.130	0.177	0.286	0.243
Tolerance	0.762	0.731	0.854	0.848	0.841	0.870	0.823	0.714	0.757
VIF	1.312	1.369	1.171	1.180	1.189	1.149	1.215	1.401	1.321

In table 4.7, above R^2 values which corresponds to parameters used in this study can be seen. It is clear that these values are not high in a theoretical range. Another and most important indicator of multicollinearity is VIF. These factors also are in the range of 1-1.33 as stated before. This final check makes it clearer that there is no multicollinearity in between. This is important for the wellbeing of the study as each parameter should express a different characteristic while deciding on certain things. Otherwise, it would mean that some of the parameters used for this study express same things and does not serve as a different perspective.

In addition to given intervals there are also some fixed parameters. Probability density and cumulative density functions are generated in excel by using generated demand values and gamma distribution function. Generated parameters used for numerical analysis can be found in Appendix B.

4.4.2 Numerical analysis results

After setting all 30 parameter values and scenarios, as a next step decentralized scenario is monitored. Some interpretations can be made out of obtained values as in following tables.

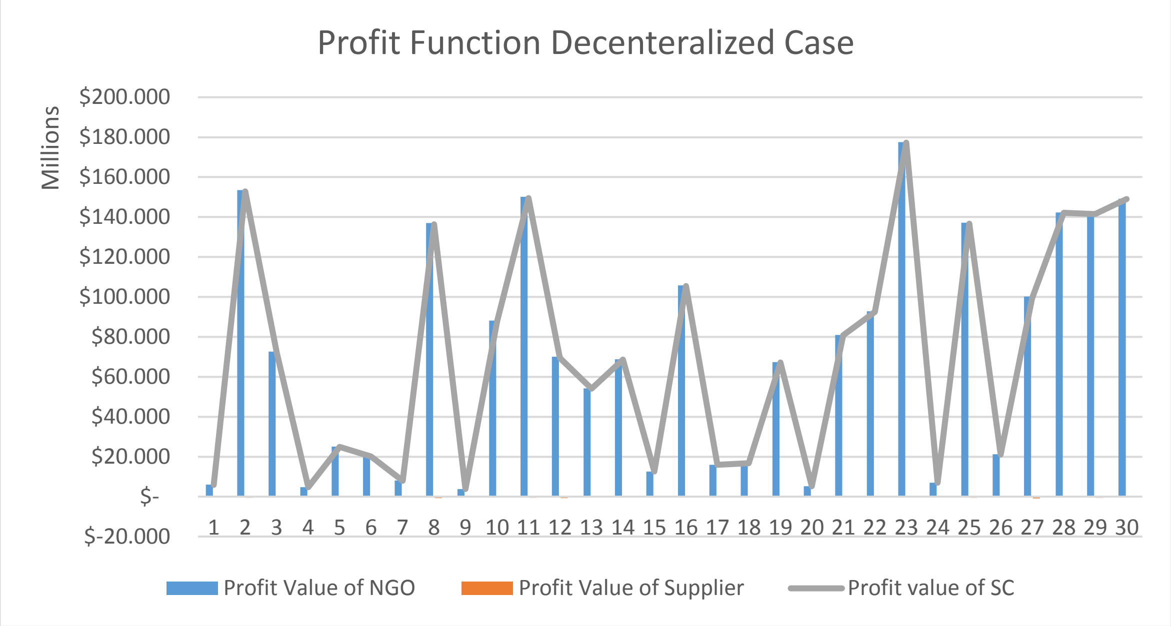

Figure 4. 8 Profit Function Values for Decentralized Case

Figure 3.7 shows the profit functions obtained for 30 different generated scenarios within stated profit functions. Blue bars show the profit of NGO, orange bars are for supplier's profit vales and the grey line shows the profit value of supply chain. By looking at the graph it is seen that supplier has no profit as the orange bars are not even visible and has no positive value. Vertical axis represents profit values and on the horizontal axis thirty different generated scenarios can be seen. As a matter of fact, there is no win-win situation for both sides.

Unfortunately, one can see that decentralized situation is not optimized. While NGO gets most of the profit, supplier gets cost and therefore a consensus should be made between two parties. To be more realistic, this imbalance between sides occurs because of the value of NGO's high profit (value of human life). But on commercial side, a balance factor should be found between sides in order to make this agreement more profitable for both sides. This can be provided by creating a common parameter that can balance the supply chain profit between NGO and the supplier in a more balanced way.

As also stated in the study, by implementing one of the existing contract models to basic decentralized model may give a different insight, such as option contract. Structure of option contract and other details are explained in previous sections.

For adapting this contract to basic model, an additional parameter is set which is exercise price (e) within an interval 30-40 and option price o which is aligned with $\emptyset < o + e$ condition.

In order to get an optimum option price, the quantity which gives the optimum solution for decentralized profit function is equalized to option contract's quantity function and by leaving option price on right hand side an equation is derived. This equation gives option price to balance decentralized case and creates a win-win strategy. In following Figure 3.9, the new profit functions over same scenarios can be seen.

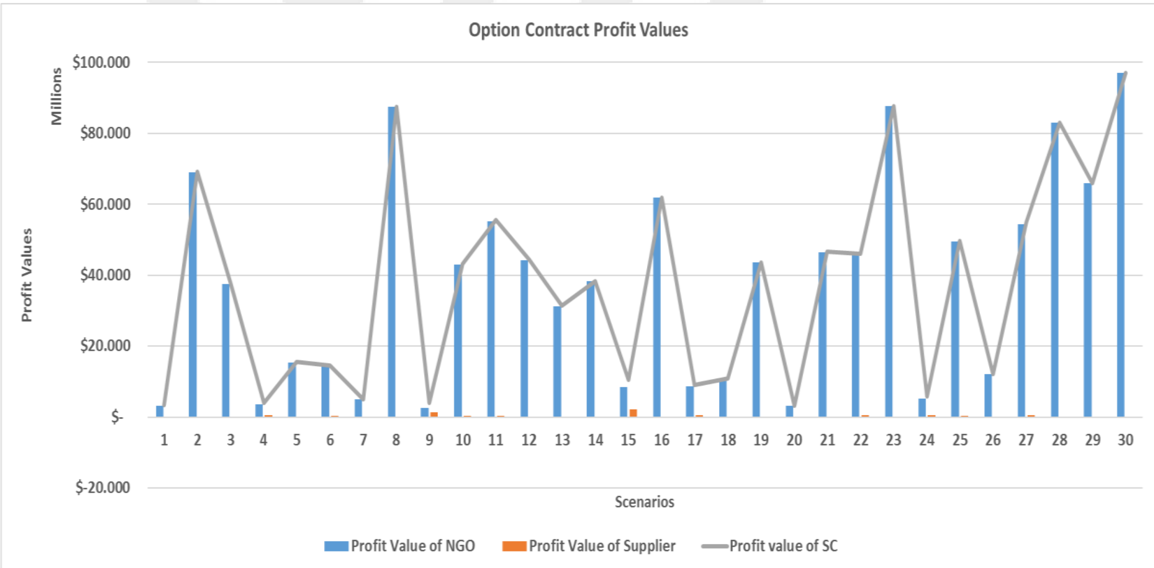

Figure 4. 9 Profit Function Values for Option Contract

In figure above, blue bars show profit value of NGO, orange bars for profit function value of supplier and grey line shows overall profit of supply chain which is the sum of supplier's profit and NGO's profit.

One can see that there has been an improvement for supplier's profit function value. This may cause a better consensus between sides. In decentralized case supplier's profit value was below zero which makes it more difficult to agree on a quantity. But in option contract it seems obvious that sides may agree on the same quantity under different circumstances when compared to decentralized case. The difference between NGO's and supplier's profit functions for decentralized and option contract case can be seen in following figures 4.10 and 4.11.

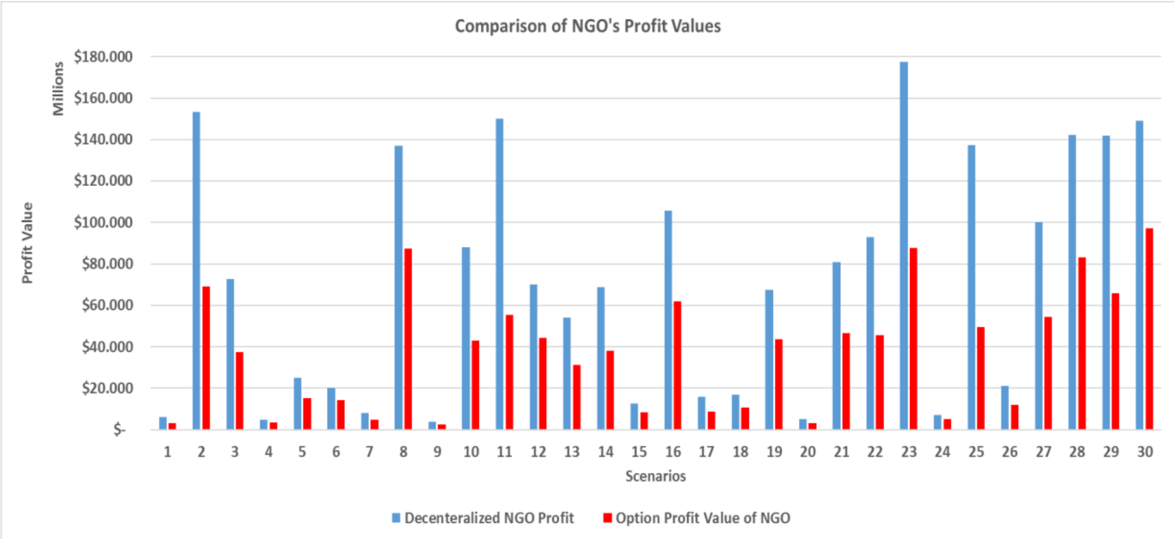

Figure 4 10 NGO Profit Function Comparison for Option Contract and Decentralized Case

In Figure 4.10, NGO's profit function under decentralized case and option contract case can be seen under thirty different scenarios. Blue bars show NGO's profit function value under decentralized case while red bars show the profit function value after option contract application. In most of the scenarios NGO gets again a significant part of the profit and there is a slight decrease of profit amount. But it is clear that, contract is a tool which is decided under a consensus of sides, and it is also important to take supplier's situation into account while deciding. Supplier's profit function after option contract application and the difference can be seen in following Figure 4.11.

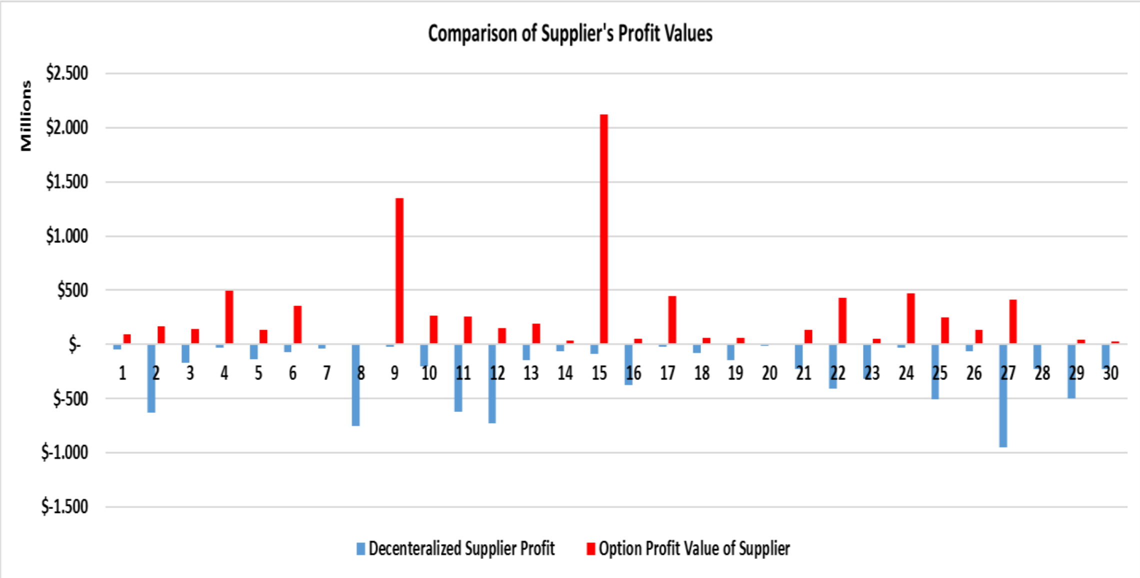

Figure 4. 11 Supplier's Profit Function Value Comparison for Option Contract and Decentralized Case

In Figure 4.11 above, blue bars show supplier's profit function value before option contract (decentralized case) and red ones show supplier's profit function value after application of option contract. In this figure, it becomes so obvious that supplier will not hesitate while deciding on option contract. Blue bars are mostly negative and sometimes not even visible when compared to red ones which make it clear that option contract is a far better choice than decentralized case for supplier side.

Thus, option contract is a relatively good choice for both sides. It's also useful as it helps both sides to decide on the same quantity under different circumstances. Of course, as demand may occur with different scenarios some changes in profit values may happen but in overall option contract seems to provide better circumstances especially for supplier. Therefore, supplier becomes eager to apply option contract and it is also possible for NGO to agree on option contract as there is a possibility of still getting a significantly high profit value and convincing supplier side. This makes option contract acceptable for both sides.

In Table 4.8, it can be seen how to profits behave according to scenarios.

Table 4. 8 Profit Behavior According to Scenario Parameters

Scenario	Option Price ($)	Decenteralized NGO Profit	Option Profit Value of NGO	Decenteralized Supplier Profit	Option Profit Value of Supplier
1	$ 45.029	$ 5.969.333.864	$ 3.209.182.572	$ -50.141.842	$ 93.860.631
2	$ 19.444	$ 153.463.360.321	$ 69.086.646.207	$ -626.826.247	$ 167.105.514
3	$ 22.351	$ 72.669.127.629	$ 37.496.514.090	$ -171.733.881	$ 143.902.565
4	$ 38.558	$ 4.696.826.987	$ 3.474.164.311	$ -26.275.106	$ 493.845.757
5	$ 24.987	$ 25.037.721.063	$ 15.375.349.679	$ -140.712.295	$ 136.807.646
6	$ 26.579	$ 20.117.357.792	$ 14.206.234.030	$ -72.088.144	$ 359.181.477
7	$ 34.378	$ 8.016.770.383	$ 4.893.672.473	$ -36.309.222	$ 8.918.308
8	$ 7.875	$ 137.057.332.185	$ 87.512.038.819	$ -754.327.089	$ 7.950.616
9	$ 52.817	$ 3.817.268.403	$ 2.541.499.727	$ -18.544.282	$ 1.353.220.518
10	$ 25.753	$ 88.120.717.703	$ 42.926.390.047	$ -203.976.211	$ 268.977.279
11	$ 24.280	$ 150.070.266.974	$ 55.232.009.264	$ -621.686.739	$ 260.946.696
12	$ 17.140	$ 70.133.277.716	$ 44.200.733.012	$ -731.836.833	$ 147.020.375
13	$ 24.331	$ 54.139.233.665	$ 31.214.452.234	$ -143.536.725	$ 192.388.709
14	$ 17.627	$ 68.755.767.477	$ 38.229.482.976	$ -61.734.621	$ 32.786.471
15	$ 64.891	$ 12.598.108.789	$ 8.350.622.909	$ -85.306.795	$ 2.123.124.559
16	$ 14.432	$ 105.786.310.849	$ 61.805.018.110	$ -376.743.689	$ 55.902.518
17	$ 45.262	$ 15.909.443.996	$ 8.666.896.660	$ -20.256.577	$ 442.940.622
18	$ 26.342	$ 16.828.050.118	$ 10.727.346.085	$ -77.230.831	$ 61.745.266
19	$ 13.803	$ 67.367.272.384	$ 43.595.323.769	$ -143.346.664	$ 57.593.051
20	$ 38.588	$ 5.148.481.245	$ 3.075.804.836	$ -15.047.202	$ 6.221.330
21	$ 17.422	$ 80.967.768.580	$ 46.512.423.462	$ -226.515.249	$ 135.453.782
22	$ 26.741	$ 92.810.923.001	$ 45.644.562.703	$ -404.070.076	$ 428.936.824
23	$ 14.579	$ 177.598.759.760	$ 87.597.946.351	$ -316.132.474	$ 55.468.712
24	$ 34.245	$ 6.957.442.385	$ 5.265.121.367	$ -31.379.358	$ 468.352.552
25	$ 26.236	$ 137.180.133.012	$ 49.477.829.836	$ -506.981.028	$ 252.144.488
26	$ 31.346	$ 21.195.570.166	$ 12.048.884.535	$ -65.411.321	$ 137.086.812
27	$ 24.165	$ 100.214.909.198	$ 54.461.749.598	$ -950.490.699	$ 417.253.672
28	$ 9.236	$ 142.296.359.573	$ 83.024.477.642	$ -229.711.998	$ -1.204.579
29	$ 16.044	$ 141.986.907.278	$ 65.864.802.074	$ -499.515.947	$ 41.537.644
30	$ 8.890	$ 149.207.013.153	$ 97.036.655.004	$ -227.965.361	$ 28.460.772

Many interpretations can be made within the light of table 4.8. First, as NGO begins to pay an option and exercise price to supplier as a fact of nature it becomes more difficult for NGO to get a better profit value when compared to decentralized situation. Another important point which has high effect on NGOs profit is the value of saving one life which is the revenue in NGOs profit function. It's naturally seen that for higher values of *w1* and *w2* NGO gets a better profit value. Option price and exercise price has a natural effect on profits as they are the main difference caused by the characteristic of contract and revenues also have a high impact as they have significantly high values compared to other parameters. In other words, option and exercise price is used to balance the effect of revenue parameters in this contract.

There are also some other findings and interpretations about obtained values. For instance, to balance the profit between sides the option price becomes a bit high. This is the result of high profit values of NGO as the value of human life is set for high values in this study. But this may show different patterns for each different country according to the value allocated for saving a human life. As a fact of nature of the applied option contract, once the option price gets higher, supplier makes better profit. Compared to NGO's profit supplier profit seems to be lower but compared to decentralized profit values it is clear that supplier will be more eager to apply option contract.

4.4.3 Numerical analysis for reimbursement contract

Based on the assumptions made for reimbursement contract same scenario parameters as used in previous applications are used. Reimbursement contracts are mainly applied in health sector commercial companies and government provides this share of cost as an incentive. Generally these agreements are made on tender basis which may cause tender bans in case of unavailable stocks for commercial supplier side. This represents a great risk for the supplier but provides a more reliable basis for humanitarian supply chain. Parameters of the contract remain the same and results are obtained from same scenarios just like in the first numerical analysis part.

The balance of profit values between sides can be seen in Figure 4.12.

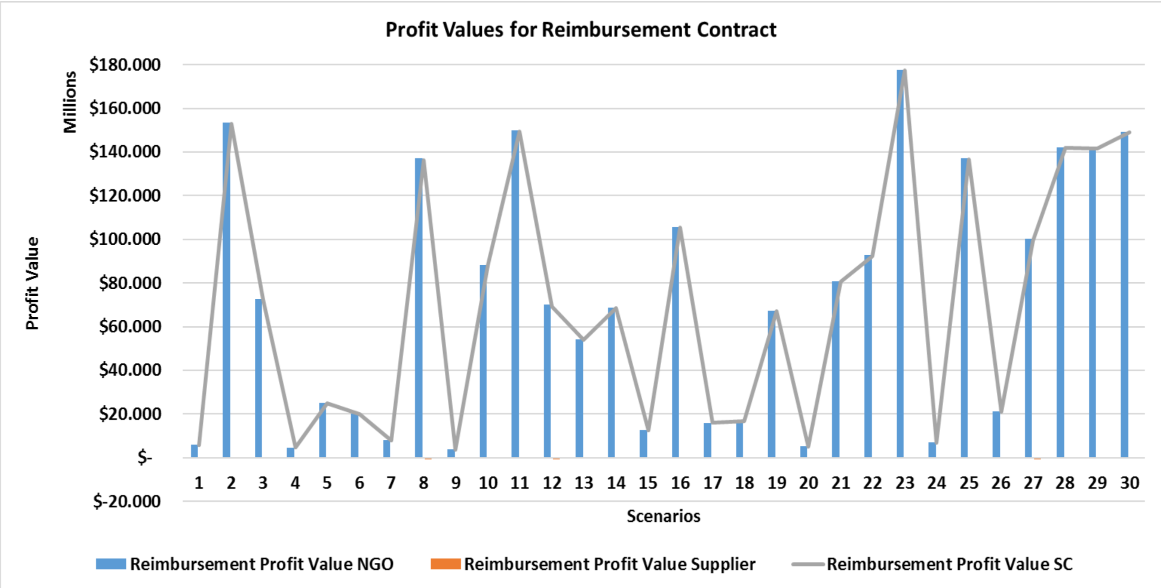

Figure 4. 12 Profit Function Values for Reimbursement Contract

While *x* axis shows 30 scenarios, *y* axis shows the profit values obtained according to set scenario values. Blue bars show the profit value for NGO and the orange bars represent profit value for supplier side. Grey line is set for the profit value for entire supply chain. Compared to decentralized case it may be stated that profit of supplier becomes a bit more visible and there is also an improvement when the entire supply chain's profit is observed. These comparisons will be made more widely in coming figures. Therefore, roughly an improvement for some of the scenarios can be seen from the figure.

Now, looking more deeply into each profit function for applied contract models following figures may be obtained.

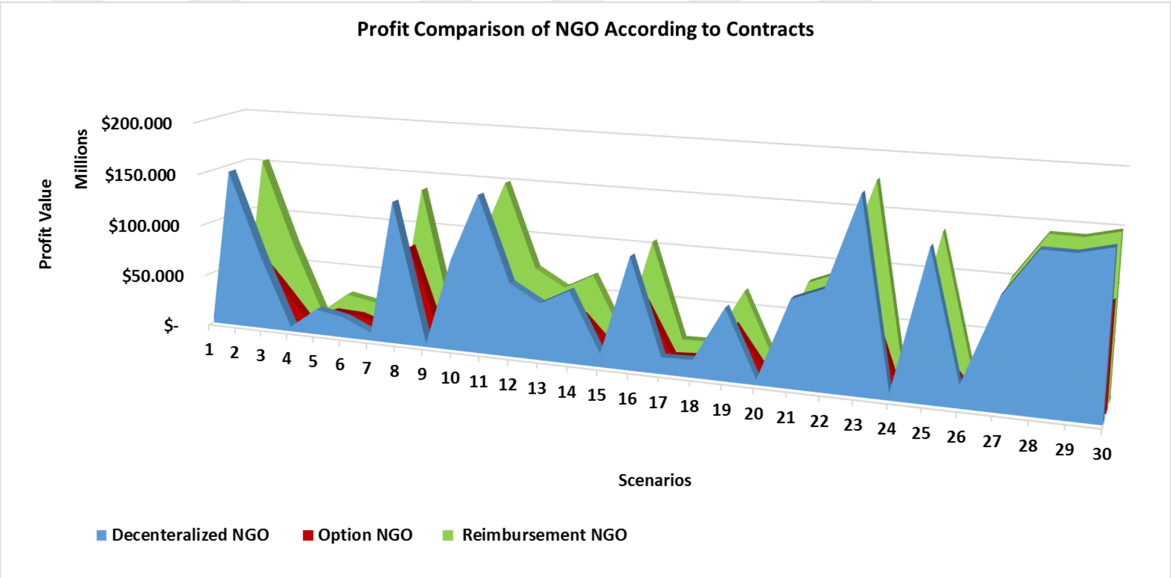

Figure 4. 13 NGO Profit Function Comparison for Decentralized, Option and Reimbursement Contracts

In Figure 4.13, NGO profit function comparison between applied contract models can be seen. Blue part represents the profit function value for decenteralized case, red part represents profit function of NGO for option contract and green part represents profit function value of NGO for reimbursement contract. Horizontal axis is for set scenarios and vertical axis represents the profit values obtained for NGO functions. As can be seen, there may be some fluctions according to the randomly generated parameter values. But mainly, one can say that the profit functions obtained for NGO give the best result for reimbursement contracts and then for option contract. This is also based on a logical explanation. In decenteralized case, with no effort of making the system better each side think for their own wellbeing, thus it becomes difficult to agree on a unique quantity or even provide a better profit for themselves. For option contract, NGO can make a better decision like paying less at first and keeping no inventory, and postponing the decision of the quantity will obtained for later. Therefore, a more realistic and healthy decision can be made. From the graphic, it can also be seen that for some of the scenarios option contract prepares a better basis for a more realistic approach.

For reimbursement contract, NGO accepts to give an incentive to supplier and share a specific share of supplier's cost. This also prepares a balance of backorder cost of supplier which represents the great responsibility of supplier. Therefore, for some scenarios supplier has to pay the penalty which return NGO as a significant revenue value and sometimes NGO pays the cost share which returns him more as a cost. This contract represents a great balance between sides and as can also be seen from the graph provides better profit value results for NGO when compared to option contract.

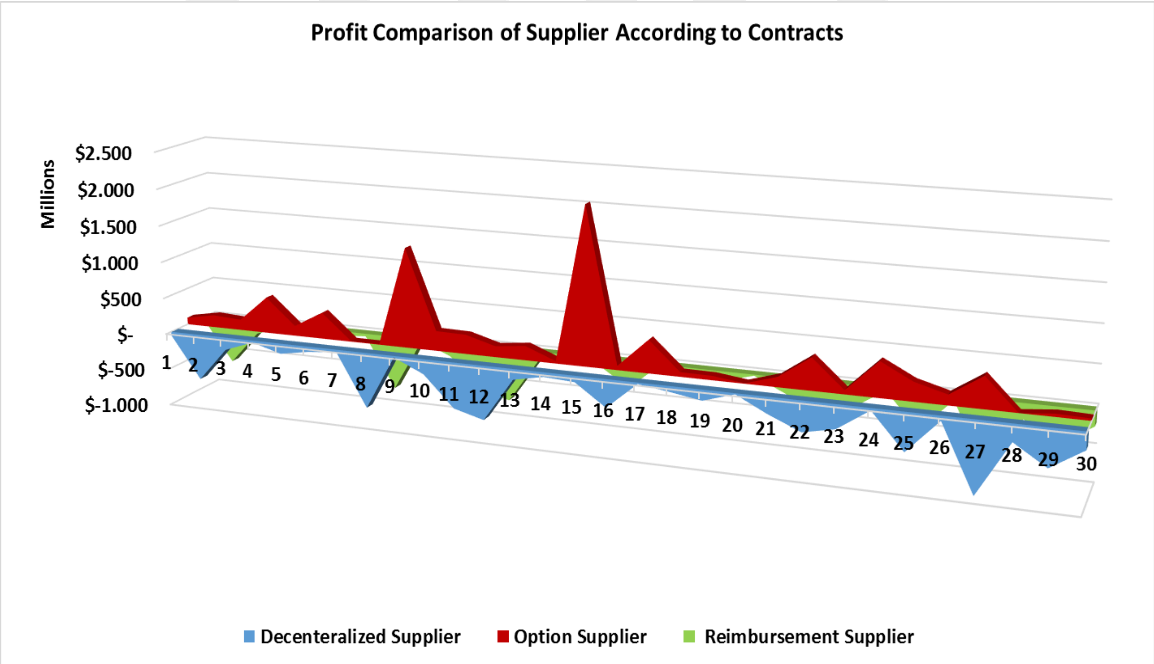

Figure 4. 14 Supplier Profit Function Value Comparison for Decentralized, Option and Reimbursement Contracts

Second comparison Figure 4.14, can be seen as above. Again horizontal axis represents different scenarios and vertical axis represents profit function of supplier for these scenarios as a comparison of contract models. This graph is also prepared for three different models namely, decenteralized, option contract and reimbursement contract.

Green part represents the profit values for supplier and red part is for option contract profit value of supplier. Decenteralized case is represented by blue part, red part is for option contract and green part represents reimbursement contract supplier profit values.

A similar interpretation can be made for supplier's profit function. In decenteralized case, supplier's profit has negative values which is represented in the negative side of the graph and almost invisible as decenteralized case's profit is very less when compared to other contract models. This is mainly because more than all supply chain profit is almost exactly allocated to NGO. Supplier is mostly responsible for the costs and NGO gets a big symbolic revenue from the lives saved.

When option contract is applied, NGO pays two different cost to supplier and makes a more realistic decision for quantity and gives supply chain optimum quantity as an order. This prepares a more realistic and logical base for each sides and supplier also has the ability to get a better profit value when compared to decenteralized case.

For reimbursement contract, supplier gets again a better profit compared to decenteralized case. This is mainly because the cost share incentive obtained by NGO. Compared to decenteralized case, profit value of supplier may be seen relatively good but still not enough to prepare a healthy basis for the agreement. Still in most of the scenarios supplier gets a negative portion of the profit. Compared to decenteralized case, the cost that supplier pays becomes less but it can be said that it is still not enough to make supplier eager on this agreement. By just looking at the graphs for all overall scenarios, if the decision of both sides taken, it may be concluded that option contract puts a more realistic approach for the sides to agree on the same quantity as it provides a better profit value for both sides in most of the cases and provides a win win situation compared to decenteralized case.

4.5 One-way ANOVA Comparison

ANOVA test is a useful test to understand whether given multiple data sets are significantly different from each other or not. ANOVA test is firstly found and applied by Ronald Fischer in 1928. This test is mainly based on hypothesis testing and composed of two hypothesis contradicting each other such as null hypothesis and alternative hypothesis. By using these two hypotheses the purpose is to prove that there is no enough evidence to prove that null hypothesis is wrong. This test is mainly a general form of t test which is applied for two samples and base it on a broader perspective between multiple groups.

In order to be able to get an understanding of significance, one should specify a significance level. Widely used significance levels are; 0.01, 0.05 and 0.10. Other values can also be used as significance values which are between 0 and 1. In this level the confidence level is used as 90%.

Making a comparison between P value and significance level one can decide if the means of given two data sets are significantly different or not.

Within the light of given information ANOVA test is applied to profit function obtained by each model to see whether there is a significant difference in between.

Therefore as a first step to begin t test, input parameters are calculated via excel. For that reason, mean value, standard deviation and sample numbers that are prepared for each profit function namely, NGO's profit function, supplier's profit function can be seen as below in Table 3.10. This table acts as a descriptive statistical analysis result which summarizes the main statistical values that will be used in the test. In addition to this descriptive statistics data analysis add-in of excel is also used for implementing One way ANOVA test.

One way ANOVA test basically represents if there is a difference between taken samples or not by comparing obtained P values.

Table 4. 9 Input Parameters for t test

Groups	***Sample Size***	***Average***	***Standard Deviation***
Decenteralized SC	30	$ 70.942.732.705	$ 56.974.406.155
Option SC	30	$ 38.037.725.499	$ 29.187.138.380
Reimbursement SC	30	$ 70.942.732.705	$ 56.974.406.155
Groups	***Sample Size***	***Average***	***Standard Deviation***
Decenteralized Supplier	30	$ -261.194.484	$ 260.871.311
Option Supplier	30	$ 279.264.353	$ 437.027.965
Reimbursement Supplier	30	$ -248.691.062	$ 253.214.919
Groups	***Sample Size***	***Average***	***Standard Deviation***
Decenteralized NGO	30	$ 71.203.927.188	$ 57.156.777.589
Option NGO	30	$ 37.758.461.146	$ 29.351.887.222
Reimbursement NGO	30	$ 71.191.423.767	$ 57.147.905.730

Input parameters that are used for t test can be seen as in Table 4.9. For each profit function another sub table is prepared. On the rows the values obtained for mean and standard deviation can be found. In addition to these, sample number has been specified as 30 as mentioned before.

Then ANOVA test is applied for profit function values of each group and analyzed by comparing the P values with 0.10 (as confidence level is set to 90%). First ANOVA table obtained for the profit function value of NGO can be seen as follows in table 4.10.

Table 4. 10 ANOVA Test Result for Profit Function of NGO

One way ANOVA result for NGO Profit Values	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	266621242355686000000	2,00	133310621177843000000	0,06	0,94	2,36
Within Groups	18349323053865100000000	87,00	210911759239829000000			
Total	18375985178100700000000	89,00				

By comparing calculated P value with statistical table P value (0,94>0,10) it is proven that there is enough proof to state that these three sample values have the same mean values for profit functions. Therefore, it can be concluded that for three of these contract values

NGO's profit value will not change significantly and in three of these cases NGO will be in same eagerness to agree on the contract quantity.

Table 4. 11ANOVA Test Result for Profit Function of Supplier

One way ANOVA result for Supplier Profit Values	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	$ 266.741.469.776.679.000.000	2,0	$ 133.370.734.888.339.000.000	45,9	0,0	2,4
Within Groups	$ 252.962.991.777.273.000.000	87,0	$ 2.907.620.595.141.070.000			
Total	$ 519.704.461.553.952.000.000	89,0				

Results are also obtained for Supplier's profit function for given three different model applications which can be seen in Table 4.11. This time, calculated P value is less than reference P value (0,0<0,10). Calculated P value is 0 in this case, which represents that there is no enough evidence to prove these three samples are equal. This may be interpreted as the supplier will have different eagerness level for each of the contracts. By having an overlook on the general pattern of profits between contracts one may understand on which contract the supplier will be more eager to agree on.

By again coming back to Table 3.9 some overview of outcomes may be obtained. As NGO is the first decision maker in this study, the priority of decision making is given to NGO on the first hand. By comparing mean profit values for each contract types, the best NGO profit value comes from reimbursement contract as the share of cost does not decrease the profit for NGO significantly. But on the other hand, there is no statistically significant difference for NGO to prefer one contract to other one. This may lead the situation to add a value on supplier's eagerness on the contract.

In that case, when an overall view is made for supplier's profit it may be concluded that the best case will be option contract by looking at average profit function value. Reimbursement contract has a relatively close value to decentralized case. Supplier will be more eager to agree on option contract quantity in all options. For both sides, when compared to decentralized case, option contract will provide a win-win basis and both sides will be eager on making an agreement on option contract.

5. CONCLUSION

Several contract types are studied in the literature for supply chain coordination. However, literature of humanitarian supply chain coordination is far behind of the commercial supply chains. Some studies evaluate the coordination of humanitarian supply chains, but till now there is only a few studies that focus on this subject. Generally, linear models are used and subjects such as routing and integration are taken into account.

In this study, main purpose is to apply a humanitarian supply chain dedicated model which mainly focuses on the most important parameters related to characteristic of humanitarian supply chain. Product type is specified as non-perishable goods which are provided to victims just after disaster strikes. Some special parameters are set in this model such as social value of saving one life (set as profit value for NGO).

In addition, other assumptions have been made for setting a statistical distribution to demand function based on real data obtained by “emdat.com”. And the data used in this study has been generated based on this assumption. It is also proven statistically that randomly generated data has no multicollinearity in between.

Base model has been developed aligned with the characteristic of humanitarian supply chains. Each parameter has been customized according to supplier and NGO’s cost and profit values. After setting all parameters a special model has been obtained for this study. As a next step it was proven that base model has a maximum optima point and there is a decentralized situation. Each side has their own optimum quantities and can not agree on a single quantity because of their own profit values.

Apart from the data used and the base model, the contract models chosen for this study are option contract and reimbursement contract. Option contract applications have been made in literature before based on different models. In this study, based on the developed model, option contract has been applied and the results have been analyzed. It was seen that option contract can coordinate the system and prepares a good basis for supplier also. And it is possible for the sides of the contract to agree on a unique quantity as they both get an acceptable profit. By looking at the mean value of 30 scenarios for NGO’s and supplier’s profit values, it may be concluded that this contract seems to be applicable for both sides as it does not lower NGO's profit too much and increases supplier's profit in most of the cases significantly.

After the application of option contract, a totally different model has been considered. This model is reimbursement (cost sharing) contract which is mainly applied in health industry. Most of the companies in health sector make agreements with hospitals and government based on reimbursement contracts. This gives a great responsibility to commercial side as there will be always a tender ban issue that may be faced in case of backorders. Therefore, this type of contract eliminates the risk of backorder situation that may be faced because of commercial side. But of course, as a return NGO agrees on sharing a specific percentage of costs of retailer. This helps sides to have balance of costs and serves to wellbeing of supply chain. Parameters of the based model stay the same; just a little adjustment has been made on generated parameter values in a way that no affect will be observed for optimum quantity of the base model.

Two contract models have been applied and for both of them it was proven that maximum optima can be obtained. In addition, it was proven that optimum quantity equations of these contracts are positive values. It can be said that there is a convenient base of application.

As a next step, by using generated data; for both contract models, values of characteristic parameters have been obtained. For option contract, this parameter was option cost and for reimbursement contract it was the percentage share of NGO that is paid to supplier. These parameters decide on the share of costs in both sides and coordinate the contract respectively.

By getting values for these parameters, profit functions were calculated for both sides, and an evaluation is made to see whether there has been an improvement of profit functions for the sides of the contract.

It was concluded that, both contract models are suitable for improving humanitarian supply chains. For better understanding a one way ANOVA test has been held for the results of thirty scenarios. According to the results of the test, there is not much difference between option and reimbursement contract for the NGO. This leads NGO to be eager on both contract types and take supplier's decision as an indicator also.

Same test is applied to supplier's profit values and option contract becomes a more suitable and profitable choice for supplier. A cost parameters itself becomes more efficient when compared to a cost share percentage. Both two contracts give better results for supplier when compared to decentralized case. Most probably supplier will have eagerness for both contracts, but when the contracts are compared to each other for these 30 scenarios option contract seems to provide a better profit state for supplier.

These outcomes leads both sides to agree on option contract, as supplier will have more willingness on this contract and it does not differ for NGO as the profit value does not show a significant change pattern. For both sides option contract provides a win-win situation when compared to decentralized case which makes it a logical choice.

In addition to what have been covered in this study some further subjects may also be added by means of theory and scope.

Besides non-perishable goods, perishable goods can also be taken into account as the only content of first aid kits are not just nonperishable goods. This will add a new perspective in the base model as there will be a shelf life concern also.

As a nature of fact, there are many other contract types that may be applied in addition to what have been implemented in this study. Other existing contracts may also be applied to see if they have a better impact or not on the coordination of this supply chain.

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7.APPENDIX

APPENDIX A   Data obtained by emdat.com

year	occurrence	Total deaths	Injured	Affected	Homeless	Total affected
1980	2	115		60000		60000
1981	1	10				0
1983	1	1346	1137	800000	33000	834137
1984	3	6	73	750200		750273
1985	3	13	14	665	65	744
1986	2	15	103	20750	250	21103
1987	2	41		150		150
1988	2	77	130	1305	685	2120
1990	2	69		4500		4500
1991	2	43	3	500		503
1992	2	914	3919	251000	95000	349919
1993	1	135				0
1994	2	30		8000		8000
1995	4	231	404	430200	48500	479104
1996	2		6	17500	9000	26506
1998	6	239	2663	2701590	128100	2832353
1999	6	17982	49792	880000	655000	1584792
2000	6	16	380	25000	350	25730
2001	7	50	176	3555		3731
2002	3	86	327	225000	30000	255327
2003	5	186	692	245240	45000	290932
2004	10	85	217	38435	50000	88652
2005	8	43	253	5950		6203
2006	4	83	15	63230		63245
2007	4	19		3150	36	3186
2008	1	2			300	300
2009	4	62	31	35106		35137
2010	2	64	106	3500	200	3806
2011	4	655	4306	6786	32075	43167
2012	1	13				0
2013	1	7				0
2014	1		324			324
2015	2	17		5000	1500	6500

APPENDIX B Randomly generated data used in study

w1	w2	Ø	b	h	t	te	cs	Demand (x	f(q)	F(Q)
207061	158336	55	62808	15	14	39	50	29450	3,2E-06	0,559
277994	162354	53	48118	14	8	28	48	558626	1,9E-07	0,876
237368	160828	43	48578	8	5	34	30	308481	3,7E-07	0,810
211498	156212	50	32476	11	10	25	42	22600	4E-06	0,535
208555	156720	42	38445	10	10	27	45	121292	9,1E-07	0,705
234552	173968	49	23005	10	3	35	31	87324	1,2E-06	0,669
208756	167599	43	49095	14	12	22	44	38778	2,5E-06	0,585
203902	153004	43	29416	20	1	25	35	682461	1,5E-07	0,896
256489	177911	47	31939	10	17	33	34	15192	5,5E-06	0,501
267547	166925	51	48935	5	16	40	37	332766	3,4E-07	0,819
287522	151089	46	58228	0	8	27	46	525845	2E-07	0,869
231115	161385	42	24554	17	20	28	50	309846	3,7E-07	0,811
243815	172098	55	42236	4	8	39	42	224354	5,1E-07	0,774
213057	159598	57	49983	5	0	29	34	325249	3,5E-07	0,816
273592	150479	42	47570	18	2	37	50	46535	2,1E-06	0,603
233416	168492	50	40147	4	0	32	41	457323	2,4E-07	0,854
245575	169467	56	57500	13	9	26	36	65412	1,6E-06	0,638
206927	164323	48	41526	11	11	38	47	82204	1,3E-06	0,662
206740	156461	59	30298	5	19	27	39	331567	3,4E-07	0,819
206742	164542	44	49989	17	5	38	33	25146	3,6E-06	0,545
228863	155156	49	31874	1	7	39	32	358121	3,1E-07	0,827
278132	157597	55	34207	13	17	40	45	339741	3,3E-07	0,821
268103	178334	47	56762	18	16	39	30	669535	1,5E-07	0,894
226869	171661	54	27689	19	19	35	40	31440	3E-06	0,565
286794	156676	46	67497	19	5	36	48	482033	2,2E-07	0,860
218626	176518	45	65828	2	13	40	47	97508	1,1E-06	0,681
286363	165372	51	22002	15	0	37	49	357549	3,1E-07	0,827
210680	163274	60	48876	4	3	39	41	682006	1,5E-07	0,896
246291	164735	46	61262	3	19	40	45	581232	1,8E-07	0,880
229474	170784	58	28859	6	7	21	34	661846	1,5E-07	0,893

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