Cooperation between two suppliers and a common retailer

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ABSTARCT

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Over past few years, supply chain coordination has been widely studied and numerous practitioners and researchers proposed many models on this field. Although many previous studies addressed channel competition considering a scenario with an exclusive retailer with only one producer's brand, in real world the retailers sell various products with different brands. This study was to analyze the relation between two suppliers and a common retailer by taking various degree of product sustainability into account. The market is considered to be duopoly. This thesis describes modifying and implementation of a supply chain coordinator tool in order to enhance the profit earned by any of the parties involved in this supply chain.

In this thesis we present a cooperation and collaboration model in a supply chain consisting of two suppliers with a common retailer. We establish the conditions for cooperation in such scenario with popular supply chain contracts. Even though other methods have been reviewed under various scenarios, we confine our interest to apply a coordinating contract and analyse the results. The type of the contract that can coordinate the supply chain is debatable and it needs to be analyzed depending on the limitations. The methodological approach taken in this study is modifying a contract in order to coordinate the supply chain and leads to better off for all parties.

First we consider the classical model then the whole sale price contract is applied. Later in order to enable the supply chain coordination, facility sharing contract and franchise contract have been modified and implemented. Finally by illustrating the results of implementing each contract, a framework is presented. In this study the linear demand function is used because of tractability in providing analytical results while in real case the nonlinear demand function is widely used.

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Introduction

A supply chain is a system of associations, people, activities, information, and resources involved in transporting a product or service from a supplier to customer. Supply chain activities involve the transformation of raw materials and components into a finished product that is delivered to the end customer (Nagurney, 2006).

Smooth functioning of this system cannot be viable without the cooperation of the supply chain members. Efficiency of supply chain depends upon the close coordination of key decision makers such as suppliers, manufacturers, retailers, etc.

In this thesis we confine our interest to a simple supply chain with two suppliers and a retailer. A simplified supply chain helps us in understanding the cooperation mechanism among its partners in a much smoother way. We assume that the first supplier is a local producer and sells the product locally through a retailer. Another supplier is foreign/outside producer and is interested in entering in the local market. The local supplier produces the product with a low production cost compared to the outsider one. The demand of the product depends on the price; hence the outside supplier attempts to reduce the production cost and increase the profit. We assume that both producers manufacture similar products, however, production cost and reputation of the foreign producer (and thus retail price) are higher than the local producer. Both products are sold in the same market. We are interested in analyzing if the cooperation between two competitive producers could benefit the overall supply chain, and if yes, then what could be the shape of such collaboration. (Figure (1-1))

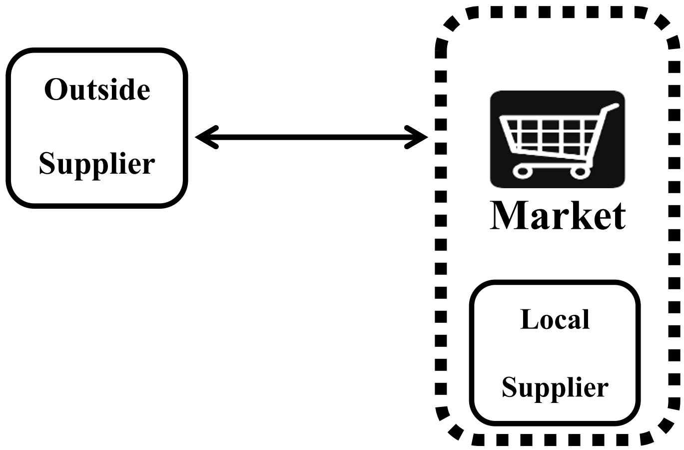

Figure 0-1 Realistic supply chain

We explore two models:

1) The classical model: Figure (1-2) demonstrates the classical model that consists of two competitive suppliers producing similar products and the products are sold through a common retailer. Supplier A produces product A and supplier B produces product B.

2) The partnership model: The second scenario is assuming a close partnership among one of the suppliers and the retailer. In this scenario we are interested in investigating the action of supplier B and possible collaboration.

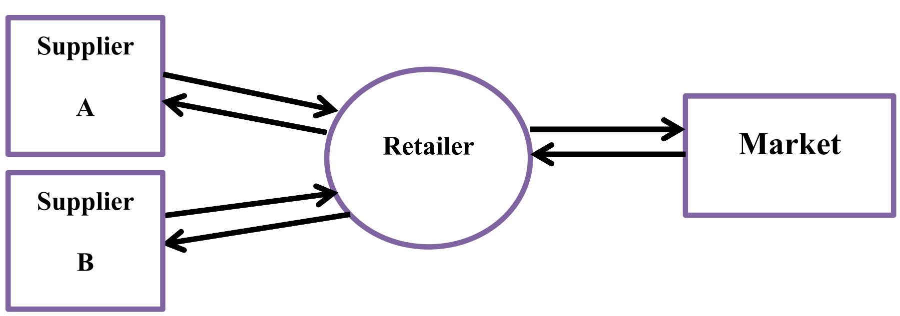

Figure 0-2

The incapable supplier inevitably hopes to find a way to encourage the leading supplier to compromise and collaborate. To make an incentive, a coordination mechanism should be offered that is capable to reduce the production cost and profitable for all members. Otherwise none of the supply members would accept the coordination strategy that may deteriorate their own profit. In order to coordinate the supply chain the application of coordination tools is applied.

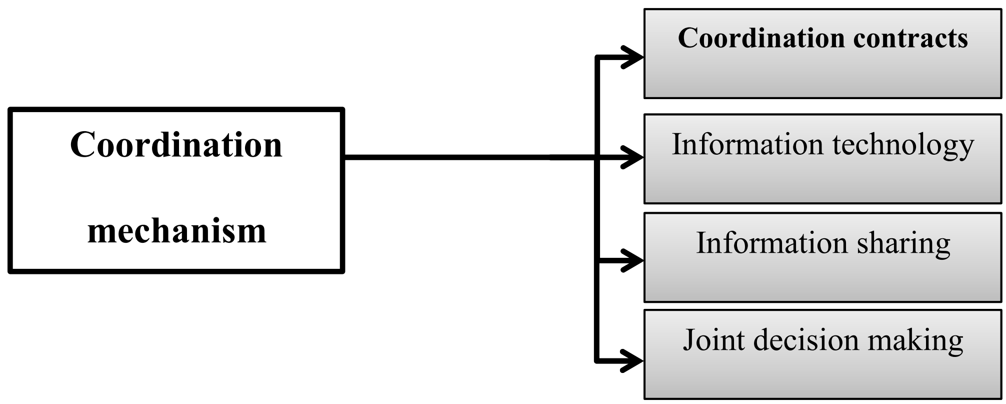

Figure 0-3 Coordination tools

As it is presented by Govindan et al. (2013), one of the tools to coordinate a supply chain is a coordinating contract that refers to comprehensive coordination mechanism used in both theory and practice.

The idea of supply chain coordination theory is very extensive and it incorporates different aspects of the relationship between the supply chain members. A vast literature regarding the coordination is suggested by Arshinder et al. (2008) and it is illustrated in Figure (1-3). Among four coordination mechanisms illustrated in Figure (1-3), we confine our interest to the first mechanism which is coordination contracts and we strive to analyze the impact of implementing the contract on the considered supply chain. Contracts are designed with the definition of all the parameters such as quantity, price, quality, and deadlines to improve supplier -buyer relationship. According to Arshinder et al. (2008) the objectives of applying a coordination contract are:

- Maximization of the entire supply chain profit
- Minimization of inventory related costs of overstock and shortage
- Fair risk sharing between the parties

Govindan et al. (2013) presented the coordinating contracts and classified them with respect to distinctive parameters. These contracts are applicable in forward supply chains or can also be modified and applied to achieve coordination in reverse supply chains which is not mentioned in this thesis.

Game theory analysis plays an important role in dealing with supply chain coordination and it is used as an approach to coordinate and by applying the concept of game theory, the players are able to identify whether they are better off by cooperation or by non-cooperative actions.

Based on Albrecht (2010), game theory applied to the supply chain can be divided to two main categories:

1) Cooperative games: The players want to coordinate while they are not competitors. Moreover, the supply chain members are willing to compromise. Thus they negotiate on a contract with defined parameters and if both parties comply with it, the contract is implemented. Otherwise they are considered as the second category.
2) Non-cooperative players: The players are competitive and each player works individually. They are not willing to cooperate (Albrecht, 2010).

According to Albrecht (2010), in the cooperative game the responsibility of the supply chain members is to decide which type of contract is applicable and modify the contract in such a way that both players are satisfied with the contractual terms. Not being agreed on the contractual terms leads to non-cooperation situation and the players will be rivals.

As Guardiola et al., (2007) illustrated the second option for the players who do not comply on a contract but willing to cooperate is the coalition approach where the definitions of cooperative game theory are applied without a predefined procedure to be followed which has not been considered in this study.

Li and Wang (2007) demonstrated the effect of cooperative actions between the players and indicated that:

- Total supply chain profit is higher at cooperation than at non-cooperation;
- The optimal order quantity of the buyer is higher at cooperation than at non-cooperation;
- The wholesale price of seller to buyer is lower at cooperation than at non-cooperation.

The aim of the project is to provide a conceptual theoretical framework based on each supplier's profit function and the total supply chain's profit and we attempt to formulate each supplier's profit under different coordinating contracts.

This thesis will be organized as follow; In order to properly explore this topic and explain the case; first we introduce the critical articles that cover this problem. We discuss important terms and topics related to the supply chain in chapters 2. Chapter 3 illustrates the implementation of two contracts and condition. In chapter 4 we implement a comparative numerical example in order to analyze the impact of implementing each contract. Finally chapter 5 presents the conclusion and areas for further research.

2. Literature Review

In the areas of supply chain collaboration, the research interest can broadly be classified in three following streams:

1) Channel competition and coordination
2) Supply Chain Collaboration
3) Supply chain coordination (coordinating contracts)

In this chapter we provide the review under these sections;

1.1 Channel competition and coordination

Channel coordination has been widely studied in last two decades in marketing area. In general, channel competition can be classified into upstream competition and downstream competition. Upstream competition refers to the competition among the upstream partners such as suppliers, buyers and manufacturers. On the other hand, downstream competition addresses the competition between low level of the supply chain e.g. retailers and sellers.

One of the earliest studies in the field of channel competition has been conducted by Jeuland and Shugan (1983). They present a frame work where the competition was studied in a channel with different system structure and demand. The other researches have conducted series of studies on this field and one of the most relevant ones to this thesis was contributed by Choi (1991). He stablished a model with two competing suppliers and a common retailer.

In 2010 Pan et al. (2010) conducted a research on a supply chain with two suppliers and one retailer and they showed the effect of supply chain infraction on the retailer and his decisions for choosing the resources. Also different power structure channel was considered and they defined a specific condition when it is better for the suppliers to work under revenue sharing contract and the same for the retailers under linear demand function. We can consider the mentioned paper, the closest study to this thesis.

Ingene and Parry (1995) analyzed the downstream competition and indicated a model with competing retailers and they attempted to coordinate the supply chain using the coordinating contract. In 1997 a similar model was presented by Padmanabhan and Png (1997) with competing retailers and a common supplier. Recently in 2008, Yao et al. (2008) carried out a model with one supplier and two competing retailers and with stochastic demand.

Choi (1996) analyzed both upstream and downstream competition and in his work the system structure was important parameter that affects the supply chain efficiency. The authors differentiated the Horizontal or Vertical system consequence on the supply chain and their main finding indicated that while (horizontal) product differentiation helps suppliers, it hurts retailers. Conversely, while (horizontal) store differentiation helps retailers, it hurts suppliers.

The general result from numerous papers state that the manufacturers may prefer exclusive dealing due to reduced competition at the retailer level, even though welfare and industry profits may be higher with common agency (Kök, 2010).

This thesis can be considered in the upstream competition level under deterministic demand that will be more explained in the following sections.

1.2 Collaboration

As Daugherty et al. (2006) presented, nowadays suppliers must find a way to collaborate with the other suppliers in the supply chain if they hope to survive, evolve and flourish. Decomposing old barriers and entering into such open relationships with easy exchange of information is not easy for many businesses. Practitioners, academics and consultants have stated the importance of strategic collaboration. Within a supply chain setting, collaboration involves two or more independent players working together to achieve greater success together than working independently.

In many scenarios, collaboration of the supply chain members can help to strengthen the entire supply chain and all suppliers involved in the collaboration can reap greater profit from jointly working. Daugherty et al. (2006) stated that there are many possible improvements. For instance, improved customer service, better inventory management, more efficient usage of resources, reduced cycle times and increased information sharing. Many studies have been done regarding how to implement collaborative arrangements and what's required if supply chain partners want to integrate their operations and work together for the same goal. According to Daugherty et al. (2006), inter-organizational or cross-enterprise supply chain collaboration pays attention on sharing of information, joint development of strategic plans and synchronizing operations. But the most success is probable when collaborative partners integrate human, financial, and technical resources to create a better business model (Bowersox et al., 2003).

Daugherty et al. (2006) stated that collaboration requires that the diverse entities work together by sharing processes, technologies, and information to enhance the value for the whole group and their customers. The other factor that has an important impact on the collaboration is trust. Lack of trust is an important barrier to stablish a collaborative partnership. Collaboration without trust among the supply chain suppliers cannot be obtained in an easy way (Daugherty et al., 2006). Albeit the process of trusting in a business is difficult, it is necessary to trust and share the information because collaboration is just possible when the information is divulged to collaborative partners. The best way to initiate trust is to first be sure that it's not going to happen immediately. Thus, all members are obligated to prove through daily interactions over time as an effort to limit the damages caused by lack of trust. They should keep promises and strive to meet the expectations. Performance enhancements are expected from collaborative relationships and if this were not the result, suppliers would hardly take the trouble of working together and incur the cost of integration. Demonstrating the collaboration as an intriguing method is not an easy task for a supplier who is seeking to encourage another supplier to integrate. There are certain issues that arise in an incentive process. Daugherty et al. (2006) demonstrated many notable parameters that are required to be considered when collaboration is implemented.

1.3 SC coordination

Coordination theory is based on the game theoretical approach, which means that the success of one individual is affected by the choices made by the other participants in the game (Myerson, 1991). By considering this fact, Cachon (2003) studied the set of supply chain optimal actions as a unique Nash equilibrium and investigates the behavior of different coordination contracts. In general a system with some suppliers that are seeking to maximize their profit, can earn less than an integrated system. Thus it can be an incentive for the suppliers to comply on coordination that leads to increase the total profit. But obtaining a Pareto improvement is not always possible in a supply chain. As it is explained earlier, one of the main approaches to obtain coordination is implementing a coordinating contract.

Cachon (2001) conducted a series of review on SC coordination by contracts that have been cited many times on stream of supply chain and he mentioned all types of coordinating contracts and emphasized the terms of implementation of each one on the channel.

There are many types of coordinating contracts in literature but the most used ones can be listed as: Whole sale price (WP), Quantity discount (QD), Buy Back (BB) and Revenue Sharing (RS) contracts. By implementing a contract properly, supply chain members can enhance the efficiency of the supply chain and improve their profit and the total profit of the supply chain.

What is the coordinated supply chain? According to Cachon (2003) a supply chain is coordinated when the set of supply chain actions is in a Nash equilibrium, i.e., none of the members has a profitable set of actions. In the ideal case, all the optimal actions should be a unique Nash equilibrium. However, there are certain drawbacks associated with the use of each contract. Also in most of the cases, contracts with lower complexity are more preferable if the contract's efficiency is high (Cachon, 2003). The contract designer may prefer to suggest the simpler but high efficiency contract even though the mentioned contract may not conclude to optimize the supply chain. Contract's efficiency refers to the ratio of the supply chain profit when the contract is implemented to the supply chain's optimal profit.

A supply chain is said to be coordinated when the total expected profit is improved after the contract is implemented. Also a Pareto efficient contract is a situation when all the members are no worse off with the existing contract than any other contracts. Thereby the so-called win-win condition is considered. SC contracts are a useful tool to make the members behave coherently and improve the channel performance (Giannoccaro, 2004). Moreover these contracts have an important role on the risk which is taken by any SC members. In the other words, the risk is shared among the members (Tsay, 1999). Particularly in our case under each contract that we considered, the risk is taken by the retailer or the supplier based on the terms of the contract.

An important review that investigates the relationships within the SC has been carried out by Tsay et al. (1991) and they considered abundant topics in contractual scheme.

Contract implementation

Cachon (2003) proposed the sequence of the decision process for implementing a contract; In this sequence, the first step is to identify the potential motivation in the supply chain and define a contract that can be applicable and improve the entire supply chain profit although the terms of the contract would be changed with respect to the each member's characteristics. The set of parameters for the contract are defined.

Furthermore for each type of coordinating contract, the possible range of profit allocations is evaluated and finally the contract implementation and the impact on the supply chain are examined.

For simplifying the evaluation process of choosing the type of contract which is efficient to be implemented, Cachon (2003) suggested the following assessment criteria for contract implementation:

- Supply chain coordination, indicates that after implementing the coordinating contract, none of the supply chain members should have the incentive to deviate from the supply chain actions.
- Administrative costs, indicating that administrative cost that is concluded from the explained details in the contract definitions, is an important criteria for an efficient contract.
- Risk and benefits sharing are considered as an important feature of any contract that should be allocated in a fair way. Moreover, the fair division of the total profit of supply chain affects the performance of the contract.

Administrative cost plays an important rule when the coordinating contract is implemented and evaluated. The main achievement is minimizing the cost, however the administrative cost cannot be omitted and it is directly related to the type of the coordinating contract that embraces the transactions (Govindan et al., 2013).

According to Govindan et al. (2013), the simpler contracts force the supply chain members to confront with less administrative cost in compare to the more complicated contracts.

For instance, wholesale price contracts and quantity discount contracts are costly in analogous way, while revenue sharing, buyback and quantity flexibility contracts imply a higher cost which is concluded from the higher level of detail and additional required material and informational flows.

Govindan et al. (2013) explained that there are a set of parameters taken into consideration when designing a model of coordination by contracts for instance: supply chain structure, the incentive/coordination part, the theory applied in analyzing the model, the type of demand approach, and the time horizon. The coordinating contracts can be designed to improve the condition of the supply chain members in the cases of two-echelon supply chains (with the number of participants n and with $n = 2$) and multi-echelon supply chains (with $n \geq 3$). This thesis in considered in a multi-echelon supply chain due to three participants in the supply chain.

Each contract is studied in two different scenarios: when the demand is deterministic and when the demand is considered as a stochastic parameter. It is obvious that this difference for the demand has an important effect on all the supply chain members and the strategy they choose to have for the production. It affects all the parameters related to production, for instance: lead time, safety stock etc.

Demand

In this study we discuss a particular supply chain under deterministic demand and we assume that the manufacturer's demand is known at the time of the order, meaning that the demand forecast at the start of production process is the actual demand during every order. During the on-order time, demand for the manufacturer is said not to be changed. All parties know the demand and it is not considered as private information. Ignoring this assumption forces the manufacturer into greater uncertain.

However, in a realistic scenario demand is never constant and known at the time of an order. Demand (D) will follow a probability distribution of some sort. Corbett

(2000) explained that demand uncertainty strengthens the incentive conflicts between two parties, as in general they will have opposing objectives. When the manufacturer is not certain about the demand, he should use some tools to predict the demand and order based on this information. Forecasting is used to predict demand, and as time approaches the forecasted date, demand can be better approximated.

In order to explore this situation we make the following assumptions about demand;

(1) We assume that demand is known by both parties.

(2) We assume that all possible demands can be met by regular production.

(3) We assume no possibility of buy-back contracts. Once the supplier delivers the order to the retailer, products may not be bought back by the supplier at a negotiated cost.

It is important to mention that implementation of a contract model needs a high degree of cooperation among all the SC members during the designing phase. However, there is no contrast with decentralized decision-making where the SC members need to know each other concerns about their unit price. Furthermore, the desirability of the contractual scheme by the various chain members plays an important role. This deals with adjusting the contract parameters so as to make all decisions well accepted by the players.

In each supply chain there are multiple actions that should be done, and usually they are not in the best interest of the supply chain members because they are concerning about maximizing their own profit. And mostly this concern conducts to the poor performance. However, the supply chain can be coordinated by setting some relations and fixed transferred payments between the members.

The supplier that wants to offer a contract should consider the most favorable contract which the other supplier will accept. Moreover suppliers are likely to offer many supply chain scenarios to entice the rest and finally all the supply chain members will agree on the most profitable one. The one they stipulate, they set the details and rules.

Another definition in supply chain refers the type of profit that is earned by the retailers or manufacturers. Reservation profit is the profit that the members of the supply chain will gain and for implementing new action if the profit is below the reservation profit, they will not participate in the supply chain (Cachon, 2003).

Incremental profit is the difference between the supply chain's maximum profit and the reservation profit. This type of profit is a useful measure because among all the possible contracts, this upper bound can be helpful to decide if a contract is beneficial for any of the members or not (Cachon et al., 2010).

1.3.1 **Whole Sale Price (WP)**

Whole sale price (WP) is the classic contract that has been widely used in the supply chain coordination filed. Under this classic model, all the risk of overage of the products is accrued by the retailer and the supplier is not facing any compensation for the unsold units. On stream of wholesale price research, this contract has been studied under stochastic and deterministic demand. In 1988 Shugan and Jeuland (1988) studied WP under deterministic demand. Then it was contributed by (Choi, 1991 and 1996). Petruzzi and Dada (1999) studied WP with considering stochastic demand. In 1999 Lariviere (1999) indicated that whole sale price cannot coordinate the supply chain. Recently Pan et al., in 2009 stablished a model based on WP with stochastic demand.

More related research to this thesis have been done by Trivedi (1998), Lee and Staelin (1997) and Albeniz and Roels (2007) who studied channels consist of multiple manufacturers and a common retailer by considering wholesale price contract.

In this thesis WP is used as a criterion for analyzing the efficiency of the other supply chain contract and for comparative result.

1.3.2 Revenue Sharing contract (RS)

Supply chain coordination with revenue sharing contract has been well studied (see Cachon (2003) and references therein). In RS contract, the supplier or manufacturer charges the retailer W per unit purchased plus the retailer gives the supplier/manufacturer a certain percentage of his revenue from that unit. Because all the revenue is shared, the salvage revenue can also be shared, however in this thesis only the regular revenue is shared. If f is the retailer's share of revenue generated from each unit then $(1 - f)$ is the fraction of the revenue that the supplier earns. RS contracts have been applied successfully in the video cassette rental industry (2002). The introduction of revenue sharing coincided with a significant improvement in performance at Blockbuster: Warren and Peers (2002) report that Blockbuster's market share of video rentals increased from 24% in 1997 to 40% in 2002. Not surprisingly, this has led to litigation against Blockbuster and the movie studios, alleging that revenue-sharing contracts have hurt competition in the industry (Wall Street Journal 2002). Indeed, evidence shows that the new terms of trade helped the industry in aggregate: Mortimer (2000) estimates revenue sharing increased the industry's total profit by 7%.

As well as other contracts, RS is studied by Giannoccaro and Pontrandolfo in 2004 under deterministic demand and under stochastic demand (Wang et al., 2004; Cachon and Lariviere, 2005; Yao et al., 2008; Qin and Yang, 2008). Despite its numerous merits Cachon and Lariviere (2005) identify several limitations of revenue sharing to (at least partially) explain why it is not prevalent in all industries. In particular, it is characterized cases in which revenue sharing provides only a small improvement over the administratively cheaper wholesale price contract. Additionally, revenue sharing does not coordinate a supply chain with demand that depends on costly retail effort. In 2004, Giannoccaro et al., published a paper in which they worked on RS which is used in coordinating a decentralized three stage SC. They trace stochastic demand and devoted a major attention to the fine tuning of contracts parameters in order to obtain the win-win condition.

In 2005, Pasternack demonstrated that RS is an attractive way to achieve channel coordination but if the manufacturer wants to stay to the current pricing structure for the products while RS is implemented, there is a possibility that without the side payment form the vendor, the manufacturer's expected profit would decrease (Pasternack, 2005). Bernstein and Federgruen (2005) show that, a nonlinear version of the price-discount contract does coordinate this setting. A second limitation of revenue sharing, which is probably more significant than the first, is the administrative burden it imposes on the suppliers. Under revenue sharing, the supplier must monitor the retailer's revenues to verify that they split appropriately. The gains from coordination may not always cover these costs. To explore this idea, Cachon and Lariviere (2005) studied the performance of the supply chain under a wholesale price contract, which clearly has a lower administrative cost than revenue sharing. They demonstrate that there is considerable variation in supply chain performance under a wholesale price contract and conclude that revenue sharing's administrative burden may explain why it is not implemented in some settings.

Cachon and Lariviere (2005) suggest that revenue-sharing contracts are very effective in a wide range of supply chains. They analyzed revenue sharing in downstream competition and it has been proved that revenue sharing can coordinate the supply chain with competitive retailers in terms of sales volume better than the other contracts. They indicated that revenue sharing generally does not coordinate competing retailers when each retailer's revenue depends on its quantity, its price, and the actions of the other retailers, e.g., competing price-setting newsvendors with each retailer's demand depending on the vector of retail prices. For this setting, more complex contracts are needed, e.g., additional parameters or nonlinear components.

Finally, revenue sharing does not coordinate a supply chain when non contractible and costly retailer effort influences demand. Nevertheless, Cachon and Lariviere (2005) show that the supplier may still choose to implement revenue sharing if the impact of effort is sufficiently small.

1.3.3 **Franchise contract (FC)**

The franchise contract was first applied in USA at the end of the nineteenth century. According to Velentzas et al. (2013), this contract has been carried out as a marketing tool: the act of using another supplier's successful business model. The franchise is an alternative to build chain store for the franchisor to distribute goods that avoids the investment.

As noted by Agallopoulou (2010), franchise contract can be divided into four main groups and the particular type of this contract that can be applied on this study is production or industrial franchising. This type of contract refers to yielding the license to manufacture or alter certain products with respect to the main instructions and sell them with the franchisor's trade brand.

1.3.4 **Summary**

To sum up the literature, the most relative studies to this thesis can be summarized as follow:

1. Choi (1991) investigated a channel of two competing manufacturers and a common retailer under different power structure scenarios. Authors stablished the model under linear and nonlinear demand functions and the results were reverse under these two types of demand (Choi, 1991).
2. Cachon and Kök (2010) studied competing manufacturers who sell their product through a single retailer. Authors implemented WP, quantity discount and two-part tariffs and the results of applying these three coordinating contracts have been compared based on product substitutability and other parameters (Cachon et al., 2010).
3. Pan et al., (2010) presented that considered a supply chain consists of two manufacturers and a retailer. They discussed the effect of applying wholesale

price versus revenue sharing contract under different channel power structures and the preference of the players under specific condition (Pa et al., 2010).

Table 1 Literature review

Author (year)	Type of contract	Type of Demand function	Power structure	Channel type	Main finding
Choi (1991)	_	Linear and non-linear demand function (stochastic)	Manufacturer-Stackelberg Vertical Nash Retailer-Stackelberg	Two competing supplier and a common retailer	Under linear demand function: price and profit increase as products are less differentiated, better off for manufacturer with exclusive dealer and opposite for the retailer. Reverse result under non-linear demand function. Better off for all members when no one dominants the supply chain.
Choi (1996)	_	Linear demand function (stochastic)	Manufacturer-Stackelberg Vertical Nash Retailer-Stackelberg	Duopoly Manufacturers duopoly Retailers	While (horizontal) product differentiation helps manufacturers, it hurts retailers. Conversely, while (horizontal) store differentiation helps retailers, it hurts manufacturers.
Cachon and Lariviere (2005)	FS Wholesale -price Buyback QF	Linear demand function (stochastic)	_	Competing retailers	FS can coordinate a supply chain with single supplier and retailer. Also it can coordinate a supply chain with competing retailers. They compare the coordinating contracts.

Cachon and Kok (2010)	Wholesale -price Quantity discount two-part tariff	Linear demand function (stochastic)	_	Competing manufacturers and a common retailer	Quantity discount and two-part tariff force manufacturer to compete more aggressively.
Pan et al., (2010)	Wholesale price Revenue sharing	Linear demand function (stochastic)	Retailer dominated Manufacturer dominated	Two manufacturers and a common retailer	In a two manufacturers–one retailer channel it is beneficial for either one or both manufacturers to use a RS contract under the manufacturer-dominated scenario. While in a manufacture–two retailers channel, it is beneficial for either one or both retailers to use a RS contract under the retailer-dominated scenario.
This thesis	Wholesale -price FS Modified Franchise	Linear demand function (Deterministic)	_	Two competing suppliers and a common retailer	

According to the mentioned literature, the contribution of this thesis is using modified revenue sharing and franchise contract in order to be applicable to a specific scenario. The modified revenue sharing and franchise contract with deterministic demand have not been presented before. In addition, we mention the partnership of retailer and a supplier that leads to better profit for the channel under specific circumstances. The partnership of the retailer and the supplier is illustrated as collaboration between these parties to achieve better off.

3. Formulation of the supply chain

1.4 Introduction

We confine our interest to investigate the coordination mechanism of two competing suppliers and see if a contract can be helpful in realizing such coordination. We first study the classical model with two competing suppliers and a common retailer and then design a contract to investigate the coordination mechanism. For analytical simplicity we use deterministic demand function and thus shortage and left over of stock is not applicable to our models. Each supplier is assumed to produce only one product and a common retailer is the only channel to sell those products. We consider two scenarios – in the first scenario, we assume all the three members of the supply chain are independent. The first setting is a classical setting and several researchers investigated the coordination mechanism in similar settings. In the second scenario, our main research topic, we consider the first supplier is part of the retailer and second supplier wants to sell the product through this retailer.

Choi (1991) stated that all parties will be better off when no one dominates the market and none of the members has a leading role in the supply chain. The whole industry as well as the customers is better off when none of the channel members are in dominant position. According to above paper, the total profit of the system when there is no leader is more than a channel with stackelberg leader because the selling prices are lower and the profit is higher for all parties.

1.5 Two suppliers through a common retailer

This model has been first studied by Choi (1991). The author considered two competitive producers with a common retailer and demonstrated that depending on the demand function, the results for coordination would be different for each party in various scenarios. The author discussed various channel structures under linear and non-linear demand functions. According to the above research, under linear demand function the supplier is better off by dealing with exclusive retailer while the retailer is willing to deal with several producers. The results are different under the non-linear demand function. The importance of choosing the correct demand function is indicated in the papers referring the channel coordination.

In this chapter, first we discuss a scenario where two competitive suppliers produce their products with varying degree of substitutability. The final product is shipped from each supplier to the retailer. We first present a wholesale price contract in which each supplier sells the product to the retailer at a given wholesale price and then retailer set the retail price for each product.

For ease of exposition, we name product A and product B produced by supplier A and supplier B, respectively. Also we assume all the information related to the suppliers and retailer is available to all parties. We do not distinguish between these two suppliers from the aspect of being competitive because we assume both brands are well known.

Each supplier is expected to seek higher profit and get the better pay off by considering the market and minimizing the production cost. The optimum selling price can be obtained easily by analyzing the linear demand function. It is observed that when the production cost is fixed, by using the related expression, both suppliers can moderate their whole sale price and optimize their revenue albeit there are many other parameters that influence the profit which are not our object of study here.

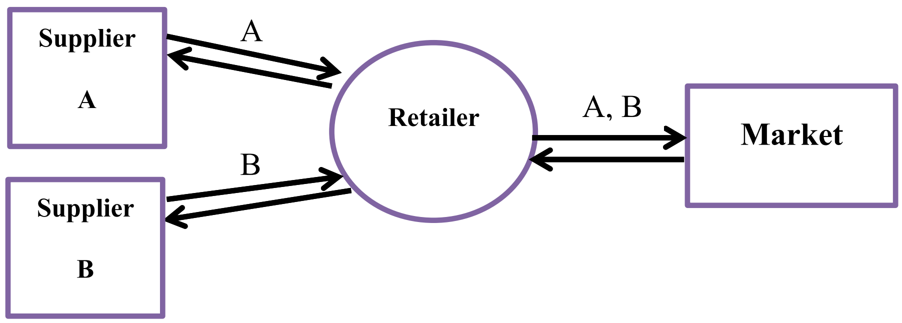

Figure 0-1 Primary Model

Figure (3-1) demonstrates the primary model that we consider which consists of two suppliers, a retailer and the market. The suppliers are producing products A and B and the retailer releases the products in the market.

As it was mentioned before, in order to simplify the model, we assume the following conditions:

1. Unlimited capacity for each supplier
2. Duopoly market

Primary Model

In order to formulate the model, we first describe the demand function and then the profit function. Choosing the best demand function plays an important role in channel coordination and there is a noticeable difference in supply chain efficiency when linear demand function is used or non-linear demand function is considered (Choi, 1991). For simplicity we use a linear demand function.

Although many practitioners have applied the stochastic demand function, to make the model easier we consider deterministic demand for both products. Thus salvage value and shortage costs have not been considered in this thesis.

To model the classical problem, we use the following notations:

i: index for the manufacturers $i = A, B$

C_i: Production cost

α_i: Market size of the *i*th manufacturer

β_i: *i*th supplier's sensitivity

γ_i: *i*th supplier's competitor's sensitivity

D_i: Market demand of the *i*th product

F_i: Profit of the *i*th manufacturer

F_R: Profit of the Retailer

The decision variables are:

P_i: Retail price of the *i*th product

W_i: Whole sale price of the *i*th product

We use the following duopoly static demand function that captures the product differentiations and each product's selling price:

$$D_i(P_i, P_j) = \alpha_i - \beta_i P_i + \gamma_i P_j \qquad \text{for } i = A \text{ and } j = B \qquad (1)$$

The parameter α_i represents the initial market share of the *i*th product. β_i shows the own-price sensitivity of each supplier and this parameter is directly related to the popularity of the product. In other words, when the product is very well-known and popular between the customers, this parameter is small because when the selling price increases, still there is high demand for the product and the increment in selling price does not have a huge effect on the demand.

To show the impact of the competitor's price, γ_i is defined and each dollar increasing in the competitor's selling price, leads to more demand for other product. Also product substitutability is characterized by γ_i and with higher values of γ_i, the product substitutability is higher ; so the products are closer and can be easily substituted. Hence this parameter has an immense effect on demand. Also these parameters are assumed to satisfy $\beta_i > \gamma_i > 0$ according to Jeuland and Shugan (1988). In the experimental section, these two parameters are set to be between zero and one. When $\beta_i - \gamma_i$ decreases and γ_i approaches β_i, the products are more substitutable and less differentiated, hence there is more potential price competition between the suppliers (Choi, 1991). However, in our model beside the product differentiation, we use this parameter to show the reaction of the supplier to his competitor's selling price.

We assume that the above demand model is symmetric and this indicates a case where both players have equal competing power in a duopolistic market place (Yao et al., 2008).

Figure (3-2) indicates the results obtained from the profit function based on linear demand function. As it can be seen from this plot, the profit function is concave; thus we can solve the problem and find the optimal point.

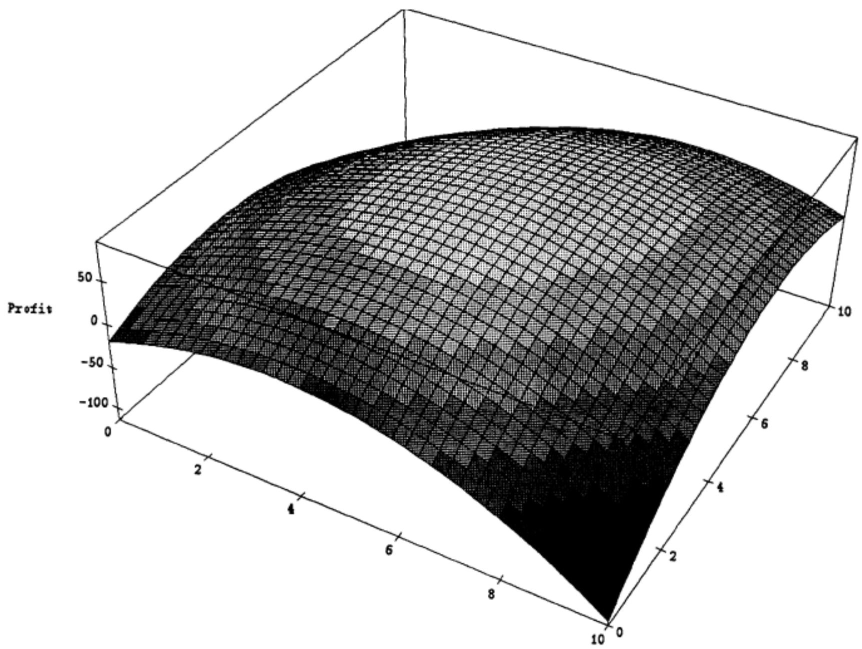

Figure 0-2 Concavity of profit function [adopted from Choi, 1991]

Weakness of the demand function

Albeit the mentioned demand function indicates the market share and effect of selling prices in an appropriate way, there are some limitations using this function in some special scenarios. Imagine the first selling price is too high, even higher than the average selling price, and the second selling price is also very high. It is logical that when the selling price is much more than the normal price, there will not be any customer who is willing to buy the product even if the product is a very well-known brand. However dealing with this demand function, there is still demand for this product that is not rational.

Moreover, although this linear demand function has been widely used in the literature, there is another weakness about this type of function. As it is noted earlier, when the difference between γ and β is very small, the products are less differentiated and when $\beta_i - \gamma_i$ is near zero, the products are nearly perfect substitutes. The demand function is rewritten as:

$$D_i(P_i, P_j) = \alpha_i - \beta_i(P_i - P_j) \qquad \text{for } i = A \text{ and } j = B \qquad (2)$$

If the selling prices are equal, then the demand function would be independent of the selling prices and the market share is exclusively the only affective parameter on demand. This is not logically feasible since the vendors would be able to choose infinite selling prices and still have demand. As a result, the profit for all the parties increases when the products are less differentiated regardless of the channel structure. And it is logical for the supplier to prefer an exclusive retailer rather than a common one with other suppliers when the products are so similar (Choi, 1991).

These are some limitations of using the linear demand function; however we adopted it for ease of use and better insights. The following part interprets the profit earned by each supply chain member at the end of the season.

1.5.1 **Case 1: No Retailer, two suppliers (Hypothetical case)**

In this hypothetical case, we assume that there is no retailer and only two suppliers sell their products directly to the market, then whole sale price will not exist and suppliers have all the information of the customers and they can sell their product directly through other ways such as selling through online websites. However this case is hypothetical and it cannot be applied to real world. (Figure (3-3))

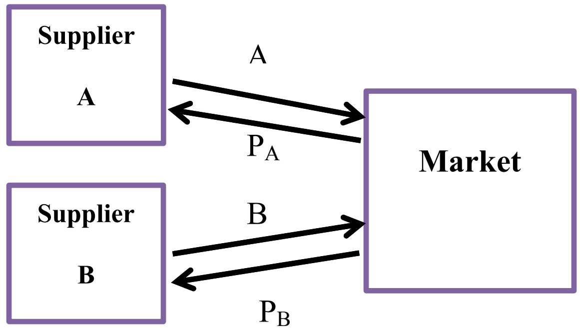

Figure 0-3

Profit of the suppliers

Profit of each supplier without the existence of the retailer can be defined as:

$$F_i(P_i, P_j) = D_i P_i - D_i C_i \qquad \text{for } i = A \text{ and } j = B$$
$$F_i(P_i, P_j) = (\alpha_i - \beta_i P_i + \gamma_i P_j)(P_i - C_i) \qquad \text{for } i = A \text{ and } j = B \qquad (3)$$

And the total profit is given by:

$$\text{Total profit} = F_i(P_i, P_j) + F_j(P_i, P_j) \qquad \text{for } i = A \text{ and } j = B \qquad (4)$$

The above profit function indicates the total profit of each supplier depends upon the demand, selling price and the production cost. Due to the concavity of the profit function, equating the first order derivative to zero yields the optimal sales price:

$$\frac{\partial F_i(P_i, P_j)}{\partial P_i} = \alpha_i - 2\beta_i P_i + \gamma_i P_j + \beta_i C_i \qquad \text{for } i = A \text{ and } j = B \qquad (5)$$

$$P_i^* = \frac{2\beta_i \alpha_j + \gamma_j \alpha_i + \gamma_j \beta_i C_i + 2\beta_i \beta_j C_j}{4\beta_i \beta_j - \gamma_i \gamma_j} \qquad \text{for } i = A \text{ and } j = B \qquad (6)$$

The following expression provides the optimal demand for each supplier:

$$D_i^*(P_i, P_j) = (\alpha_i - \beta_i P_i^* + \gamma_i P_j^*) \qquad \text{for } i = A \text{ and } j = B \qquad (7)$$

From (6) it can be easily deduced that for a price to be valid the following should hold:

$$4\beta_i\beta_j - \gamma_i\gamma_j > 0 \qquad \text{for } i = A \text{ and } j = B \qquad (8)$$

The above inequality implies the relation between own-price sensitivity and the competitor's price sensitivity. If we assume $\beta_A = \beta_B$ and $\gamma_A = \gamma_B$, then we obtain the condition $\beta > \frac{\gamma}{2}$ for these two parameters which demonstrates that the value of own-price sensitivity should be more than half of the competitor's price sensitivity.

In the next section we discuss the case consists of two suppliers and a common retailer.

1.5.2 **Case 2: Competing suppliers selling through a common Retailer (CSAR)**

In this model we assume that each supplier sells its products to end consumer through a common retailer. For clarity of expression, we use 'He' to represent the first supplier and 'She' to represent the second supplier. We first analyze the relationship using the classical wholesale price contract. Figure (3-4) illustrates a system consists of two suppliers selling product A and B to the retailer at a wholesale price W_i per unit. Then the retailer sets the selling prices P_A and P_B for products A and B, respectively.

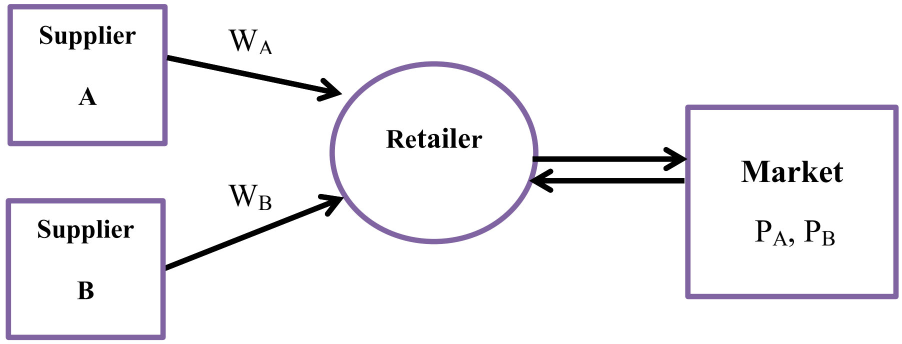

Figure 3-4 Whole Sale price

Retailer's profit

Profit function for the retailer based on the whole sale price and linear demand function is given by:

$$F_R(P_i,P_j)=(\alpha_i-\beta_i P_i+\gamma_i P_j)(P_i-W_i)+(\alpha_j-\beta_j P_j+\gamma_j P_i)(P_j-W_j) \quad \text{For } i=A \text{ and } j=B \quad (9)$$

As discussed before, salvage or shortage are not considered due to deterministic demand. Total profit function of the retailer is literally the retailer's reaction function to the supplier's whole sale price. Total profit and the optimal selling prices can be derived from the first order conditions of (9):

$$\frac{dF_R(P_A,P_B)}{dP_A}=\alpha_A-2\beta_A P_A+\gamma_A P_B+W_A\beta_A+\gamma_B P_B-W_B\gamma_B$$

And the derived equation of the total profit with respect to P_B is given by:

$$\frac{dF_R(P_A,P_B)}{dP_B} = \alpha_B - 2\beta_B P_B + \gamma_B P_A + W_B\,\beta_B + \gamma_A P_A - W_A\gamma_A \tag{10}$$

Second order derivatives provide the hessian matrix:

$$\begin{bmatrix} \dfrac{\partial^2 F_R}{\partial {P_A}^2} & \dfrac{\partial^2 F_R}{\partial P_A \partial P_B} \\ \dfrac{\partial^2 F_R}{\partial P_A \partial P_B} & \dfrac{\partial^2 F_R}{\partial {P_B}^2} \end{bmatrix} = \begin{bmatrix} -2\beta_A & (\gamma_A + \gamma_B) \\ (\gamma_A + \gamma_B) & -2\beta_B \end{bmatrix} \tag{11}$$

By considering the condition we set for β and γ (i.e. $\beta > \gamma > 0$), the determinative of the second order derivatives of equation (9) is negative. Therefore we can obtain the maximum of the profit function.

Equally competitive suppliers

The main objective is to achieve the optimum selling price that can maximize the total profit of the supply chain. However, to do the primary calculations, it is presumed that the own-price sensitivity parameter and the competitor's price sensitivity parameter are equal for both suppliers. In other words, the suppliers are equally competitive and have same market share $(\beta_A = \beta_B, \gamma_A = \gamma_B)$.

The above assumptions, simplifies equation (10) considerably as follow:

$$\begin{aligned} \frac{dF_R(P_A,P_B)}{dP_A} &= \alpha - 2\beta\, P_A + 2\gamma\, P_B + W_A\,\beta - W_B\gamma \\ \frac{dF_R(P_A,P_B)}{dP_B} &= \alpha - 2\beta\, P_B + 2\gamma P_A + W_B\,\beta\, - W_A\gamma \end{aligned} \tag{12}$$

After equating (12) to zero, on further reduction, we obtained the expressions for the summation and the subtraction of the sales prices:

$$P_A + P_B = \frac{(W_A + W_B)}{2} - \frac{\alpha}{\gamma - \beta}$$
$$P_A - P_B = \frac{(W_A - W_B)}{2} \tag{13}$$

According to equation (13), the optimal selling price that is the reaction of the retailer to the whole sale price, when $\gamma_A = \gamma_B$ and $\beta_A = \beta_B$ can be shown as:

$$P_i^*(W_i) = \frac{W_i}{2} - \frac{\alpha}{2(\gamma - \beta)} \qquad \text{For } i = A, B \tag{14}$$

We can see that the selling price is directly related to the whole sale price. It should be noted that the above selling price can be used only for the particular scenario where the suppliers are equally competitive and equally own price sensitive ($\gamma_A = \gamma_B$ and $\beta_A = \beta_B$).

Supplier's optimal profit

By using equation (14), the optimal profit of each supplier can be calculated based on the selling price. As indicated earlier, profit is the total revenue that the supplier obtains subtracted from the total production cost:

$$F_i^*(P_i, P_j) = (W_i - C_i)(\alpha - \beta P_i^* + \gamma P_i^*) \qquad \text{For } i = A \text{ and } j = B \tag{15}$$

As indicated above, the optimal supplier's profit is obtained based on the whole sale price and the production cost. If we can substitute P_i^* in the profit function (15), the profit function for the ith supplier can be rewritten as:

$$F_i^*(W_i, W_j) = (W_i - C_i)\left[(\alpha - \beta(\frac{W_i}{2} - \frac{\alpha}{2(\gamma - \beta)}) + \gamma(\frac{W_j}{2} - \frac{\alpha}{2(\gamma - \beta)})\right] \tag{16}$$

For $i = A$ and $j = B$

For simplifying the profit function, we do another substitution:

$$A = \frac{\alpha}{2(\gamma - \beta)} \tag{17}$$

It should be considered that substitution ($A = \frac{\alpha}{2(\gamma - \beta)}$) is applicable only for this scenario. They are equally competitive, equal price sensitivity and have the same market share. The profit function for the ith supplier due to the above substitution will be changed to:

$$F_i^*(W_i, W_j) = (W_i - C_i)\left[\alpha - \beta\frac{W_i}{2} + \beta A + \gamma\frac{W_j}{2} - \gamma A\right] \qquad \text{For } i = A \text{ and } j = B \tag{18}$$

Thus expression (18) states the profit function based on the whole sale price and the selling price is not used in the mentioned function.

Whole sale price, retail price and production cost

If we want to determine the supplier's whole sale price, it is possible to consider the first order derived function of supplier's profit with respect to the whole sale price (Choi, 1991).

$$\frac{\partial F_i^*(W_i, W_j)}{\partial W_i} = \alpha - \beta W_i + \frac{\beta}{2}C_i + A\beta + \frac{\gamma W_j}{2} - \gamma A \qquad \text{For } i = A \text{ and } j = B \tag{19}$$

Substituting A in equation (19) allows us to obtain the whole sale price for product A and B:

$$W_i^*(W_j, C_i) = \frac{\alpha + \gamma W_j}{2\beta} + \frac{C_i}{2} \qquad \text{For } i = A \text{ and } j = B \qquad (20)$$

The function above illustrate that in order to obtain positive profit, the whole sale price should be higher than half of production cost. Otherwise the profit of the supplier will be negative that is not a feasible solution for the equation.

By using function (19), it is possible to investigate the relation between the whole sale price and the production cost:

We can consider the common parts and simplify the equations:

$$\alpha + A\beta - \gamma A = \beta W_A - \frac{\gamma W_B}{2} - \frac{\beta}{2} C_A$$

$$\alpha + A\beta - \gamma A = \beta W_B - \frac{\gamma W_A}{2} - \frac{\beta}{2} C_B$$

Because the left side is common, we can make the right side equal:

$$\beta W_A - \frac{\gamma W_B}{2} - \frac{\beta}{2} C_A = \beta W_B - \frac{\gamma W_A}{2} - \frac{\beta}{2} C_B$$

$$\frac{\beta}{2}(C_B - C_A) = \frac{\gamma}{2}(W_B - W_A) + \beta(W_B - W_A)$$

The subtracted wholesale price and production cost can be written as:

$$(W_B - W_A) = \frac{\beta}{\gamma + 2\beta}(C_B - C_A) \qquad (21)$$

The above expression indicates the relation between the whole sale price and the production cost and it is obvious that although the other parameters have an impact on the whole sale price, higher production cost leads to higher whole sale price. Furthermore, in this equation β and γ for supplier A and supplier B are equal. It means that we consider both suppliers equally competitive in this particular case.

Exclusive profit function

We can rewrite the profit function for supplier A in another way based on the wholesale price:

$$F_A(W_A, W_B) = (W_A - C_A)\left[\alpha + \beta A + \gamma \frac{W_B}{2} - \gamma A - \beta \frac{W_A}{2}\right]$$

In order to simplify the function, the first order derivative is used:

$$\frac{\partial F_A(W_A, W_B)}{\partial W_A} = \alpha - \beta W_A + \frac{\beta}{2} C_A + A\beta + \frac{\gamma W_B}{2} - \gamma A$$

$$\alpha - \beta W_A + \frac{\beta}{2} C_A + A\beta + \frac{\gamma W_B}{2} - \gamma A = 0$$

OR

$$\alpha + A\beta + \frac{\gamma W_B}{2} - \gamma A = \beta W_A - \frac{\beta}{2} C_A$$

By using the last part of above equations, the profit function is adjusted to a simpler function:

$$F_A(W_A, W_B) = (W_A - C_A)\left[\beta W_A - \frac{\beta}{2} C_A - \beta \frac{W_A}{2}\right]$$

$$F_A^*(W_A) = \frac{\beta}{2}(W_A - C_A)^2 \tag{22}$$

The same for the second supplier:

$$F_B^*(W_B) = \frac{\beta}{2}(W_B - C_B)^2 \tag{23}$$

Expression (23) indicates that under wholesale price contract the profit can be obtained when the wholesale price and production cost are accessible for both parties.

It is worth mentioning that the 1st and 2nd derivative of the profit functions of the suppliers are both negative hence the supplier's profit function is concave and there is a unique solution that maximizes the profit.

Retail price and wholesale by considering the parameters

Solving (22) and (23), whole sale price is given by:

$$W_i = \frac{\alpha}{2\beta-\gamma} + \frac{\beta(2\beta C_i + \gamma C_j)}{(2\beta-\gamma)(2\beta+\gamma)} \qquad \text{For } i = A \text{ and } j = B \qquad (24)$$

The above function indicates that the whole sale price of the supplier is positively related to the production cost of both products A and B (Choi, 1996).

Replacing the whole sale price in the functions (14) provides the retail price:

$$P_i = \frac{\alpha(3\beta-2\gamma)}{2(2\beta-\gamma)(\beta-\gamma)} + \frac{\beta(2\beta C_i + \gamma C_j)}{2(2\beta-\gamma)(2\beta+\gamma)} \qquad \text{For } i = A \text{ and } j = B \qquad (25)$$

If we consider the same production cost for each supplier, the problem becomes symmetric and it is easier to analyze $(C_A = C_B = C)$. The whole sale price and selling price for each supplier will be given by:

$$W_i = \frac{\alpha + \beta C}{2\beta - \gamma} \qquad \text{For } i = A, B \qquad (26)$$

$$P_i = \frac{\alpha(3\beta - 2\gamma) + \beta C(\beta - \gamma)}{2(2\beta - \gamma)(\beta - \gamma)} \qquad \text{For } i = A, B \qquad (27)$$

By considering $\beta_i > \gamma_i > 0$, the above prices are always positive so by assigning the mentioned selling price, positive profit will be obtained (Choi, 1996).

Different characteristics

In this part we investigate another scenario where the characteristics of each supplier are unique and they have various feature. In contrast to the last part that the suppliers were considered equally competitive, equally sensitive to own price and had equal market share, here all the parameters are different for each supplier. As we obtained the selling price for the first case, it allows us to indicate the optimum selling price given by the derived equations (9) and (10). The derived function will provide us the optimal selling prices for both suppliers:

$$P_i^* = \frac{(\gamma_i + \gamma_j)(\alpha_j + W_j\beta_j - W_i\gamma_i) + 2\beta_j(\alpha_i + W_i\beta_i - W_j\gamma_j)}{4\beta_i\beta_j - (\gamma_i + \gamma_j)^2} \qquad \text{For } i = A \text{ and } j = B \quad (28)$$

And for the supplier B is given by:

$$P_j^* = \frac{(\gamma_i + \gamma_j)(\alpha_i + W_i\beta_i - W_j\gamma_j) + 2\beta_i(\alpha_j + W_j\beta_j - W_i\gamma_i)}{4\beta_i\beta_j - (\gamma_i + \gamma_j)^2} \qquad \text{For } i = A \text{ and } j = B \quad (29)$$

The optimal selling price function is feasible if the condition $4\beta_i\beta_j > (\gamma_i + \gamma_j)^2$ is satisfied. The mentioned condition is satisfied if $\beta_i > \gamma_i$ and $\beta_j > \gamma_j$ (Jeuland and Shugan, 1988). The condition stipulates that the demand of each product is more sensitive to his own-selling price rather than the competitor's selling price. This inequality exists for supplier

B as well. It is noticeable to mention that when $\beta_i - \gamma_i > 0$ and this difference decreases, it means that the price sensitivity is getting closer to the competitor's price sensitivity. In other word when γ_i is increasing, two products can be substituted easily by the customers and it leads to more competition in selling prices. Each dollar increase in the selling price of the competitor's product, highly affects the demand of the other product.

In order to show the effect of each parameter on the selling price, a numerical example has been used and the graphs are shown in Appendix A1. To sum up, the main parameters have the following impact:

1) Effect of γ (product substitutability): The figures show the positive effect of product similarity on selling prices of product A and B that leads to more competition. These differences can be explained in part by the proximity of β and γ. When β is fixed, the profit of supplier A and supplier B is increasing by augmentation of γ. (See Appendix A1.1)
2) Effect of β (own price sensitivity): The overview of effecting price sensitivity on the selling and wholesale price proves that when the market is so accurate about the product's selling price, each dollar increasing has a huge impact on the demand. When β increases the profit of supplier A and supplier B decrease. (See Appendix A1.1)

1.5.3 **Partnership of supplier A and the retailer (CR&S)**

Prior to commencing this section, it is notable that although close partnership is always hard to implement and not all the suppliers and retailers agree on it, we consider the second scenario a partnership case while the goal is to determine whether partnership can coordinate the supply chain and make better profit or not.

In real world there are numerous famous retailers that collaborate with an exclusive brand. That means they sell one specific brand at the store, also they play as the retailer for the other brands even though the products could be the same. The following list is some examples of some famous retailers who have their own exclusive brand and also sell the other brands:

- Canadian tire: Canadian tire is a big retailer that sells the products under the brand "Master Craft" which is specifically produced for Canadian tire and also many other products with different brands are provided in the store.
- Pharmaprix: Shoppers (Pharmaprix) is Canada's largest retail pharmacy chain and it uses the brand "Life" that is only sold at the Shoppers and many other brands of food, cosmetics etc. are sold at this retailer.
- Some other examples of great retailers: Costco, Maxie & Cie, IGA, Jean Coutu etc.

In all the mentioned retailers, the specific brand is just available at the designated retailer exclusively and not at the other retailers. For instance Kirkland product (which is produced exclusively for Costco) cannot be found at another retailer.

We try to investigate the impact of partnership on our basic model and for the purpose of analysis, supplier A has an alliance with the retailer and they work together for the shared profit while supplier B is working separately and has her own profit.

Hence we assume that supplier A and the retailer agree on partnership and they can be stated as very close partners. Notice that the whole sale price contract is still implemented and all of the terms are arbitrarily applied. This assumption is conducted into a situation where coordination exists between supplier A and the retailer and relatively they can be considered as one element in the supply chain. However, when supplier A and the retailer work as one component, it would be an obvious observation that in particular, the analysis of the above scenario concludes to an incentive for supplier B to be involved by reason of obtaining more profit. The coordination between the retailer and supplier A exists because the profit will be enhanced by applying partnership.

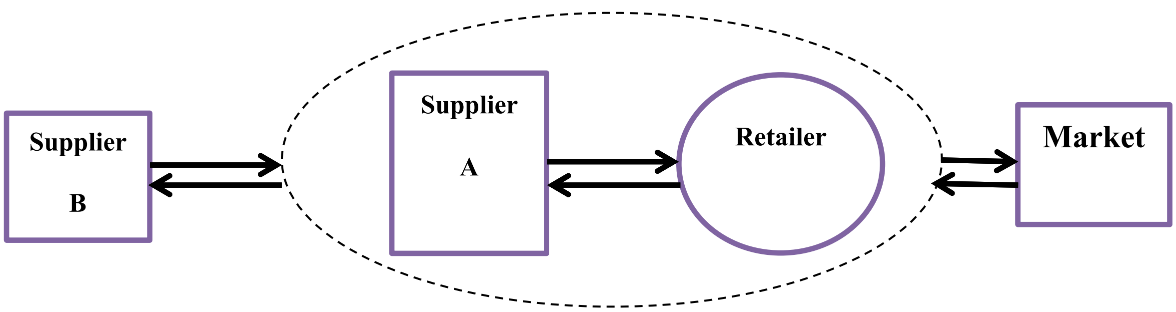

Figure 0-5 partnership of Supplier A and retailer

Since supplier A and the retailer are close partners, the whole sale price for product A does not exist any longer and it is replaced by C_A which is the production cost. Albeit the whole sale price of product B still remains and the retailer is charged W_B for each unit (Figure (3-5)).

Retailer's profit

According to the explanation under wholesale price contract, the retailer earns his own profit which is the profit of selling product A (that is produced by supplier A). In addition, he receives the profit from selling product B in this particular scenario. The wholesale price of the product A is replaced by the production cost. Thus, the profit function under deterministic linear demand function is given by:

$$F_R(P_A, P_B) = (P_A - C_A)(\alpha_A - \beta_A P_A + \gamma_A P_B) + (P_B - W_B)(\alpha_B - \beta_B P_B + \gamma_B P_A) \tag{30}$$

Regarding to function (30), the first part refers to the profit out of selling product A and the second part belongs to the other supplier's product (product B). By considering the equally competitive and equal sensitivity to own-price, after substituting $A = \dfrac{\alpha}{2(\gamma - \beta)}$, the profit function for the retailer under linear demand function is given by:

$$\begin{aligned} F_R(W_B) &= \beta C_A{}^2 - \frac{\beta C_A{}^2}{2} - C_A\alpha - C_A A\beta - \frac{C_A \gamma W_B}{2} + C_A \gamma A \\ &= C_A\left[-\alpha - A\beta - \frac{\gamma W_B}{2} + \gamma A\right] + \frac{\beta C_A{}^2}{2} \end{aligned} \tag{31}$$

The profit function (31) indicates that the profit of the retailer can be obtained independently from the selling price if all the variables are known. As it was explained earlier, the whole sale price of product A is not used and is replaced by the production cost due to the partnership of the retailer and supplier A.

Supplier B's profit

The profit function for supplier B does not change and it is considered the same profit function as no-partnership scenario that is given by:

$$F_B(P_A, P_B) = (W_B - C_B)(\alpha_B - \beta_B P_B + \gamma_B P_A) \tag{32}$$

Supplier B produces product B and she incurs the production cost, then it is sold to the retailer by $\$W_B$ per unit. By taking equally competitive and equally sensitive to the price into account, the changes will follow the same as the last section and the only difference is the replacement of the whole sale price of product A with the production cost since the partnership has been applied. After using the substitution of $A = \dfrac{\alpha}{2(\gamma - \beta)}$, the profit function is changed to:

$$F_B(W_B) = C_B\left[-\alpha - A\beta - \frac{\gamma C_A}{2} + \gamma A\right] + \frac{\beta W_B^2}{2} \tag{33}$$

Function (33) allows us to obtain the profit function when the wholesale price and production cost are provided.

Optimal selling price

In order to obtain the optimal selling price for products A and B, the first order derived function of retailer's profit is used. The selling price is set by the retailer and it is yield to all the supply chain members. The optimal selling price for product A is given by:

$$P_A^* = \frac{(\gamma_A + \gamma_B)(\alpha_B + W_B\beta_B - C_A\gamma_A) + 2\beta_B(\alpha_A + C_A\beta_A - W_B\gamma_B)}{4\beta_A\beta_B - (\gamma_A + \gamma_B)^2} \tag{34}$$

The same calculation has been done for product B and the selling price is interpreted as:

$$P_B^* = \frac{(\gamma_A+\gamma_A)(\alpha_A + C_A\beta_A - W_B\gamma_B) + 2\beta_A(\alpha_B + W_B\beta_B - C_A\gamma_A)}{4\beta_A\beta_B - (\gamma_A+\gamma_B)^2} \tag{35}$$

Equations (34) and (35) show the optimal selling prices of each product and again the condition of $4\beta_A\beta_B > (\gamma_A+\gamma_B)^2$ should be held to obtain positive selling price. The mentioned condition is satisfied if $\beta_A > \gamma_A$ and $\beta_B > \gamma_B$ (Jeuland and Shugan, 1988).

The effect of the main parameters on the profit based on our numerical example in chapter 4 is categorized as follow:

1) Impact of γ (competitor's price sensitivity): increasing the competitor's price sensitivity is positively affecting the selling prices of product A and B. However, partnership conducts into lower selling price for supplier A. The profit of supplier A and supplier B are increasing by increasing γ. However it can be seen that supplier B is better off when there is no partnership of supplier A and retailer (Appendix A1.2).

2) Impact of β (own price sensitivity): Increase in own price sensitivity has negative effect on demand and profit, respectively (Appendix A1.2).

The above parts belong to the implementation of the wholesale price contract on the system with partnership. Next part investigates if applying other contracts can coordinate the supply chain or not. First we study facility sharing contract inspired by revenue sharing. Next, a modified franchise contract is discussed.

First set of analysis has been done on partnership and non-partnership of supplier A and the retailer. We found that close association of supplier A with the retailer is always beneficial. Therefore we apply the facility sharing contract on the partnership of supplier A and retailer scenario (CR&S).

1.5.4 **Offering a new coordinating contract**

In the context of supply chain coordination, as it was mentioned earlier, each player seeks to maximize his own profit and this approach can be achieved by coordination through a contract. In this specific case, we assume that product B is a famous brand. However, the production cost is higher compared to producing A by supplier A. Supplier A is the prevailing member and he is not willing to change his approach unless the profit enhances.

In the following section we confine our interest to modify and apply two very similar contracts with an inconsiderable difference. The first contract that is offered to be replaced by the whole sale price contract is a facility sharing contract inspired by revenue sharing contract in supply chains.

1.5.4.1 Facility sharing contract (FS)

Consider supplier A is able to produce with lower production cost in contrast to supplier B. By assuming that supplier A has unlimited production capacity, we can define a facility sharing contract as follows; Supplier A will produce his own product (A) and produces his competitor's product (B). Since supplier A is privileged with lower production cost, product B can be produced by supplier A with lower price.

The transaction consists of a payment from supplier B to supplier A for producing product B. Let's define the payment by S^{FS} which is very close to the production cost of supplier A and supplier B pays S^{FS} dollar for each unit of B produced by supplier A $(S^{FS} \geq C_A)$.

So Supplier A agrees on producing his competitor's product with the same production cost of A. But in return, supplier A is given a fraction (θ) of the revenue from selling product B. It is notable that supplier B is the one who is in charge for making decision about the order quantity and she is the player who occur the lost and also takes the risk. Supplier B claims the order size and supplier A produces and sells product B through the retailer. Both products are being sold through the same retailer in a mutual market. The low price for S^{FS} is a type of deduction and discount that is given to supplier B by supplier A in return of fractional revenue. The figure below indicates the contract implementation on the supply chain:

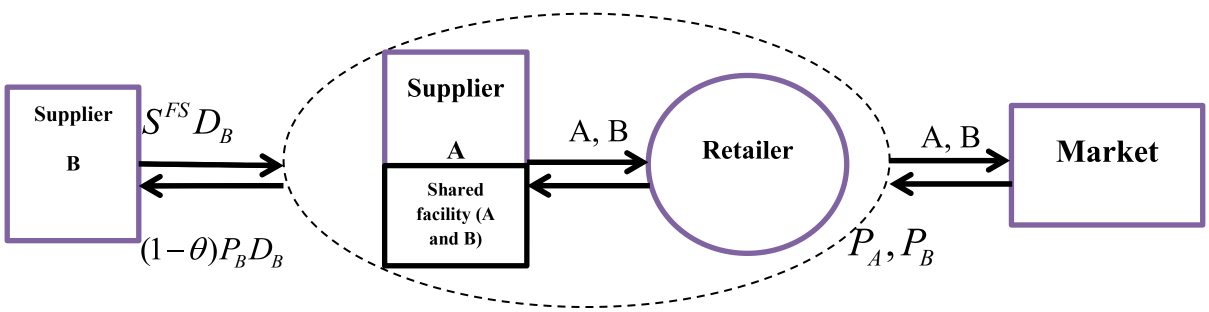

Figure 0-6 Implementation of Facility Sharing on the channel

To model the problem, we define the following extra notations:

θ: Shared fraction of the revenue

F_i^{FS}: Profit of supplier i after Facility sharing contract

F_R^{FS}: Profit of the Retailer after Facility sharing contract

S^{FS}: Selling price of product B from supplier A to supplier B

Linear demand function is considered similar to previous sections:

$$D_i(P_i, P_j) = \alpha_i - \beta_i P_i + \gamma_i P_j \qquad \text{for } i = A \text{ and } j = B$$

We consider the revenue from selling product B is shared exclusively and salvage value does not exist.

The explicit definition is provided by analyzing the profit function for each supplier with respect to the terms of facility sharing contract.

Supplier A's profit function

As it was mentioned before we consider supplier A and the retailer as very close partners. Hence we consider a combined profit for them:

F_A^{FS} = own profit (product A) – production cost of B + payment received from Supplier B for product B + fraction of the revenue of selling product B

By using the previously mentioned notations, the profit function is given by:

$$\begin{aligned} F_A^{FS}(P_A, P_B) = {} & (P_A - C_A)\left[\alpha_A - \beta_A P_A + \gamma_A P_B\right] - C_A\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] \\ & + S^{FS}\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] + \theta * P_B\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] \end{aligned} \tag{36}$$

Supplier B's profit function

The profit for supplier B is given by:

$F_B^{FS}(P_A, P_B) =$ – purchasing cost from supplier A+ revenue from product B- fraction of the revenue shared with supplier A

By using the previously mentioned notations, the profit function is given by:

$$F_B^{FS}(P_A, P_B) = -S^{FS}\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] + (1-\theta) P_B \left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] \tag{37}$$

Optimal selling prices

Each supply chain member seeks to enhance the profit and due to the concavity of profit function we are able to obtain the optimal selling prices. The first order derived function of the retailer's profit with respect to P_A and P_B is written as:

$$\begin{aligned} \frac{\partial F_A^{FS}}{\partial P_A} &= \alpha_A - 2\beta_A P_A + \gamma_A P_B + C_A \beta_A + (S^{FS} - C_A)\gamma_B + \theta P_B \gamma_B \\ \frac{\partial F_A^{FS}}{\partial P_B} &= \gamma_A P_A - C_A \gamma_A - \beta_B S^{FS} + C_A \beta_B + \theta \alpha_B - 2\beta_B \theta P_B + \theta P_A \gamma_B \end{aligned} \tag{38}$$

Equating (38) to zero provides the optimal selling prices:

$$P_A^* = \frac{(\alpha_A + C_A\beta_A + (S^{FS} - C_A)\gamma_B) 2\beta_B \theta + (\gamma_A + \theta\gamma_B)(\theta\alpha_B - C_A\gamma_A - \beta_B S^{FS} + C_A \beta_B)}{4\beta_A \beta_B \theta - (\gamma_A + \theta\gamma_B)^2} \tag{39}$$

And the selling price of product B can be obtained by:

$$P_B^* = \frac{(\alpha_A + C_A\beta_A + (S^{FS} - C_A)\gamma_B)(\gamma_A + \theta\gamma_B) + 2\beta_A(\theta\alpha_B - C_A\gamma_A - \beta_B S^{FS} + C_A \beta_B)}{4\beta_A \beta_B \theta - (\gamma_A + \theta\gamma_B)^2} \tag{40}$$

Comparing the above optimal selling prices with the selling prices under WP contract, the impact of two new parameters on the selling prices is obvious. The mentioned selling price is positive if the condition of $4\beta_A\beta_B\theta > (\gamma_A + \theta\gamma_B)^2$ is hold, otherwise the selling price is not a feasible solution for this problem.

In chapter 4, we applied the facility sharing contract on a designated numerical example. We also compared the profit of each member under wholesale price contract and facility sharing contract under various scenarios. The results show a significant augmentation in supplier B's profit since the production cost is highly reduced after implementing revenue sharing contract.

Next section contributes to a modified franchise contract. New parameters are used and the effect of each parameter is discussed.

1.5.4.2 Modified Franchise (FC)

The second suggested contract that can contribute the supply chain coordination is defined based on franchise contract. In this contract, there is a franchisee and a franchisor who agree on particular obligations.

This type of contract refers to yielding the license to manufacture or alter certain products with respect to the main instructions and sell them with the franchisor's trade brand. To enable the franchise contract for our case, we modified and changed it in some terms. The modified franchise contract is so close to facility sharing and there is only a small difference that will be explained in following sections.

The retailer is willing to pay a lower whole sale price for product B and supplier B wants to reduce her production cost. Since product B is also a good brand, we assume that supplier A is the franchisee for brand B. Thus supplier A produces product A and also produces products with brand of B. Supplier A obtains the permission to use the competitor's (Supplier B's) brand and in return, supplier A will pay supplier B a fixed fraction of the revenue from selling product B as a fee.

Supplier B can also produce B and sell it in other markets, however, we do not consider it here. In this agreement, supplier B does not concern about the order size due to defining order size by supplier A and all the risk of shortage or lost will be occurred by supplier A. Although in both facility sharing and franchise contracts, product B is produced by supplier A and sold through the retailer, one of the main features that distinguishes these two contracts is the risk which is taken by supplier B in facility sharing implementation and by supplier A when franchise contract is applied. Also in the franchise contract supplier B does not pay for product B at all and she just receives the fraction of revenue from the sold units of B as a fee for the brand, while under facility sharing contract, supplier B pays for product B that is produced by supplier A.

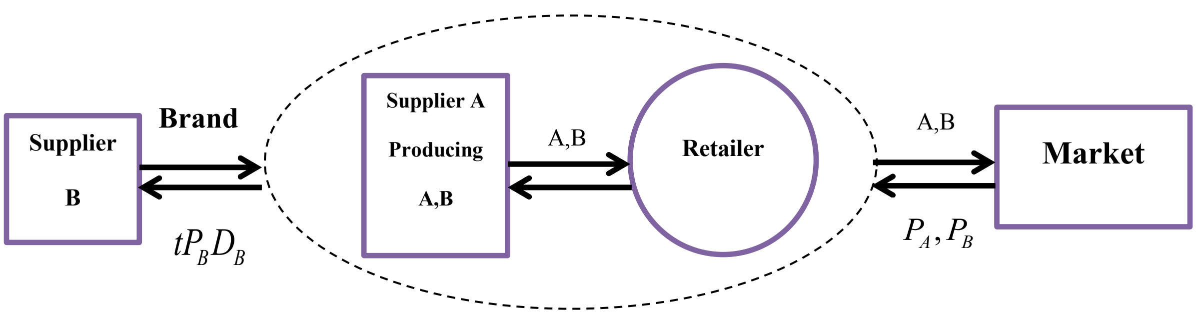

Figure 0-7 Implementation of Franchise

It is notable that the franchise contract is implemented due to unlimited capacity of the suppliers. We consider a new parameter t that indicates the fee which is paid by supplier A to supplier B and in our model, t is considered between 0 and 1. Supplier B receives total fee from supplier A at the end of the selling season.

To model the transaction between two parties, the following extra notations are used:

t : Fee given to supplier B per each unit

F_i^{FC} : Profit of the *i*th supplier after Franchise contract

F_R^{FC} : Profit of the Retailer after Franchise contract

By using the above notations, the profit function for the supply chain's members can be expressed as follow.

Supplier A's profit function

Due to the deterministic demand, the order quantity and the demand are the same; we do not consider the batch size and just the demand is mentioned in the model. Thus there is no shortage or overage for any of the products and the order size is exactly equal the foreseen demand in our case.

$F_A^{FC}(P_A, P_B)$ = own profit (from product A) – manufacturing product B + fraction of the revenue from selling product with the brand B

$$\begin{aligned} F_A^{FC}(P_A, P_B) = {} & (\alpha_A - \beta_A P_A + \gamma_A P_B)(P_A - C_A) + \\ & (-C_A + (1-t)P_B)(\alpha_B - \beta_B P_B + \gamma_B P_A) \end{aligned} \tag{41}$$

Supplier B's profit function

The profit function for the supplier B is defined basically as the brand name fee. As it is mentioned earlier, supplier B is producing B but sells in other possible markets and we do not consider her profit with respect to the other markets. So the profit refers to the fee is given by:

$$F_B^{FC}(P_A, P_B) = tP_B(\alpha_B - \beta_B P_B + \gamma_B P_A) \tag{42}$$

Optimal Selling prices

Since supplier A's profit function is concave, we can obtain the optimal selling prices by considering the derived profit function with respect to P_A and P_B :

$$\begin{aligned} \frac{\partial F_A^{FC}(P_A, P_B)}{\partial P_A} &= \alpha_A - 2\beta_A P_A + \gamma_A P_B + \beta_A C_A - C_A \gamma_B + (1-t) P_B \gamma_B \\ \frac{\partial F_A^{FC}(P_A, P_B)}{\partial P_B} &= (1-t)\alpha_B - 2(1-t)\beta_B P_B + \gamma_A P_A + (1-t) P_A \gamma_B - \gamma_A C_A + \beta_B C_A \end{aligned} \tag{43}$$

Selling prices for each supplier can be calculated as follow when all the parameters are known for both parties:

$$P_A^* = \frac{2(1-t)\beta_B(\alpha_A + \beta_A C_A - C_A \gamma_B) + (\gamma_A + (1-t)\gamma_B)((1-t)\alpha_B - \gamma_A C_A + C_A \beta_B)}{4\beta_A \beta_B (1-t) - (\gamma_A + (1-t)\gamma_B)^2} \tag{44}$$

And the same expression for supplier B:

$$P_B^* = \frac{2\beta_A((1-t)\alpha_B - \gamma_A C_A + C_A \beta_B) + (\gamma_A + (1-t)\gamma_B)(\alpha_A + \beta_A C_A - C_A \gamma_B)}{4\beta_A \beta_B (1-t) - (\gamma_A + (1-t)\gamma_B)^2} \tag{45}$$

Condition:

1. According to the first and second derivatives with respect to P_A, P_B and t, the function is concave only when the following condition is satisfied:

$$\begin{aligned} &4\beta_A \beta_B (1-t) - (\gamma_A + \gamma_B (1-t))^2 \geq 0 \text{ and } 0 \leq t < 1 \\ &\text{or} \\ &4\beta_A \beta_B (1-t) \geq (\gamma_A + \gamma_B (1-t))^2 \qquad \text{and } 0 \leq t < 1 \end{aligned} \tag{46}$$

2. Supplier A will accept the contract with supplier B only if he receives better profit at the end of the season. Thus the following condition should be held:

$$tP_B > C_B \tag{47}$$

Thus if all the parameters are known, the selling prices that optimize the profit function can be achieved. If we plot the optimum selling price in the profit function, the optimum profit function with respect to the demand for each supplier is obtained.

Table 2 summarizes profit functions and optimal selling prices for the wholesale price, facility sharing and franchise contract. In order to demonstrate the efficiency of any of these three contracts in our particular case, we need to establish an experimental analysis to compare the profit obtained for each of the supply chain members under similar circumstances. Notice that all of the models provided for our specific scenario are under linear demand and the demand is considered as a deterministic factor. The following chapter contributes a numerical example based on the primary assumptions and the sensitivity analysis has been done to indicate the impact of the main parameters on the profit. Finally the profit of each member is compared and distinguished under three contracts.

Table 2 Profit functions under different contracts under CR&S

Supply Chain members	Whole sale price contract (WP)	Facility sharing Contract (FS)	Franchise Contract (FC)
Supplier A's profit	$(P_A - C_A)\left[\alpha_A - \beta_A P_A + \gamma_A P_B\right]$ $+(P_B - W_B)\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$	$-S^{FS}\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] + (1-\theta)P_B\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$	$P_B t\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$
Supplier B's profit	$(W_B - C_B)\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$	$(P_A - C_A)\left[\alpha_A - \beta_A P_A + \gamma_A P_B\right] - C_A\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$ $+S^{FS}\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right] + \theta * P_B\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$	$(P_A - C_A)\left[\alpha_A - \beta_A P_A + \gamma_A P_B\right]$ $+(-C_A + (1-t)P_B)\left[\alpha_B - \beta_B P_B + \gamma_B P_A\right]$

Table 2 Optimal selling prices of product A and product B under different contracts

Supply Chain members	Whole sale price Contract (WP)	Facility sharing Contract (FS)	Franchise Contract (FC)
Optimal selling price of product A P_A^*	$\frac{(\gamma_A+\gamma_B)(\alpha_B+\mathrm{w}_B\beta_B-C_A\gamma_A)}{4\beta_A\beta_B-(\gamma_A+\gamma_B)^2}+\frac{2\beta_B(\alpha_A+C_A\beta_A-\mathrm{w}_B\gamma_B)}{4\beta_A\beta_B-(\gamma_A+\gamma_B)^2}$	$\frac{(\alpha_A+C_A\beta_A+(S^{FS}-C_A)\gamma_B)2\beta_B\theta}{4\beta_A\beta_B\theta-(\gamma_A+\theta\gamma_B)^2}+\frac{(\gamma_A+\theta\gamma_B)(\theta\alpha_B-C_A\gamma_A-\beta_BS^{FS}+C_A\beta_B)}{4\beta_A\beta_B\theta-(\gamma_A+\theta\gamma_B)^2}$	$\frac{2(1-t)\beta_B(\alpha_A+\beta_AC_A-C_A\gamma_B)}{4\beta_A\beta_B(1-t)-(\gamma_A+(1-t)\gamma_B)^2}+\frac{(\gamma_A+(1-t)\gamma_B)((1-t)\alpha_B-\gamma_AC_A+C_A\beta_B)}{4\beta_A\beta_B(1-t)-(\gamma_A+(1-t)\gamma_B)^2}$

Optimal selling price of product B P_B^*	$\frac{(\gamma_A+\gamma_B)(\alpha_A+C_A\beta_A-\mathrm{w}_B\gamma_B)}{4\beta_A\beta_B-(\gamma_A+\gamma_B)^2}+\frac{2\beta_A(\alpha_B+\mathrm{w}_B\beta_B-C_A\gamma_A)}{4\beta_A\beta_B-(\gamma_A+\gamma_B)^2}$	$\frac{(\alpha_A+C_A\beta_A+(S^{FS}-C_A)\gamma_B)(\gamma_A+\theta\gamma_B)}{4\beta_A\beta_B\theta-(\gamma_A+\theta\gamma_B)^2}+\frac{2\beta_A(\theta\alpha_B-C_A\gamma_A-\beta_B S^{FS}+C_A\beta_B)}{4\beta_A\beta_B\theta-(\gamma_A+\theta\gamma_B)^2}$	$\frac{2\beta_A((1-t)\alpha_B-\gamma_A C_A+C_A\beta_B)}{4\beta_A\beta_B(1-t)-(\gamma_A+(1-t)\gamma_B)^2}+\frac{(\gamma_A+(1-t)\gamma_B)(\alpha_A+\beta_A C_A-C_A\gamma_B)}{4\beta_A\beta_B(1-t)-(\gamma_A+(1-t)\gamma_B)^2}$

4. Experimental Results and Analysis

In this chapter, we aim for investigating the effectiveness of implementing two presented contracts (facility sharing and franchise) on the supply chain under investigation. Each contract is applied on the supply chain and the profit of each supplier is compared with the profit under wholesale price contract. Also, we are looking for the impact of demand function parameters on each supplier's profit under different contracts. It is critical to emphasise that, the comparison is done by considering the profit under each contract provided in chapter 3.

As we explained in chapter 3, we basically consider two different scenarios:

1) Competing suppliers selling through a common retailer (CSAR)
2) Partnership of supplier A and the retailer (CR&S)

The main goal is to analyze the profit of each supplier under the above scenarios. The first scenario is the classical model which consists of coordination among two competitive suppliers and a common retailer when whole sale price contract exists between the suppliers and the retailer.

The second scenario consists of a partnership between the dominant supplier and the retailer. In this part, we implement facility sharing and franchise contract. Each contract deals with some specific parameters and in order to show the effect of each parameter, we use a numerical example (Table 3) and some assumptions have been considered to limit the results.

The first set of results are concerned with comparing the profit of each supplier under scenarios CSAR and CR&S in order to show the efficiency of partnership on the supply chain performance. Then, we mainly focus on CR&S and two contracts are implemented. All the formulations have been coded in excel and also the results have been checked in C++.

1.6 Numerical example data and assumptions

In this section, we provide details on the numerical example that has been implemented. The numerical example that we considered is based on the following primary assumptions:

1) Primary market share of product A is greater than product B ($\alpha_A > \alpha_B$).
2) Own price sensitivity parameter is always greater than the competitor's price sensitivity parameter ($\beta > \gamma$).
3) The production cost for supplier B is greater than supplier A ($C_B > C_A$).
4) The whole sale price of supplier B is greater than supplier A ($W_B > W_A$).
5) The whole sale price is always greater than production cost ($W > C$).

We consider the following values for the parameters presented in table 3:

Table 3 Parameters used in numerical example

Variables	Supplier A	Supplier B
primary market share (α)	60 units	50 units
Own price sensitivity (β)	0.9	0.9
Competitor's price sensitivity (ϒ)	0.02	0.02
Production cost	8 $	15 $
Wholesale price	10 $	15.5 $

1.7 Analyzing CSAR and CR&S scenarios

To get better insight into the effect of competition parameter (γ) and own price sensitivity (β) on the profit of each supplier, in each part we fix one of the two parameters and change the other one. The findings based on several experiments are summarized in table 4. Graphical representation of these results is presented in Appendix A1.1.

Table 4 Choice of no-partnership vs. partnership system at different competition levels

competition (ϒ)	Low competition	High competition
Supplier A (product A)	partnership with retailer	partnership with retailer
Supplier B (product B)	No significant difference	Better off when supplier A has no alliance with the retailer

Table 4 demonstrates each supplier's better off under the two different scenarios which are CSAR and CR&S; supplier A is better off under CR&S (partnership) whether there is high competition between the suppliers or low competition. While this alliance leads to worse off for supplier B when the competition is high and under low competition scenario, there is not a significant difference in supplier B's profit under the two schemes.

The result provided in table 4 confirms that close association of supplier A with retailer is always beneficial for this supplier as also pointed out by Daugherty et al. (2006) and Bowersox et al. (2003).

Giving the previous circumstances (CSAR and CR&S), by considering different levels of own price sensitivity parameters, likewise the previous results, we conclude that with the partnership, supplier A see improvements in its profit at the cost of supplier B's profit (Appendix A1.1). Our numerical experiment indicates that it is difficult for supplier B to compete with supplier A when the latter forms an alliance with the retailer. In this situation, Supplier B will be willing to form an alliance with the competing supplier A. Since both suppliers are in competition, such relationship will be governed by some kind of contracts such as these investigated in this thesis.

We choose the following abbreviation to indicate the implemented coordinating contract: WP (Wholesale price), FS (Facility sharing), and FC (Franchise contract).

Table 5 indicates the parameters of facility sharing and franchise contracts that have been used in the numerical example.

Table 5 Facility sharing and Franchise contract parameters

Variable	Supplier B
Facility sharing parameter θ	0.6
Facility sharing parameter S^{FS}	8.01$
Franchise parameter t	0.2

1.8 Analysis of partnership using facility sharing and wholesale price contract

In this section we analyze the supply chain coordination using facility sharing and whole sale price contracts. We compare the effectiveness of the contract by comparing the profit of each supplier after implementing them.

Recall from chapter 3, in this contract supplier A accepts to produce product B and θ represents the fraction of the revenue that supplier A keeps and (1-θ) will be given to supplier B.

In order to assess the effect of γ and β, similar to the previous section, we consider one parameter is changing and the other is fixed. So we can demonstrate the consequence of implementing facility sharing in various cases compared to the system with the wholesale price contract.

In order to limit the experiments, we just consider two different ranges for θ and according to the result; we believe that these ranges can provide a good insight. We study $0 < \theta < 0.5$ and $0.5 < \theta < 1$:

Case 1) θ>0.5: This case implies that, a significant portion of the revenue (more than 50%) from product B will be shared with Supplier A.

Case 2) θ<0.5: This case implies that a small portion of the revenue (say less than 50%) from product B is shared with Supplier A.

1.8.1 Comparative study with respect to competitor's price sensitivity

In this part we consider the effect of competitor's price sensitivity on the profit of the suppliers. The graphs are shown in the Appendix (A2.1) and the results are summarised in table 6. In the above numerical example we fixed $\beta_A = \beta_B = 0.9$.

Case 1) θ>0.5

Based on several experiments, when there is low competition, supplier A is better off under FS contract. The reason is that he is given more than half of the revenue from selling product B and because of low competition; the competitor's price is not affecting the other product's demand significantly. Supplier B is better off under facility sharing contract too, because the implementation of this contract leads to reduction of production cost and selling price of product B. Although more than half of the revenue of selling product B will be given to supplier A, still there is an incentive for supplier B due to reduction of the production cost and selling price.

When the competitor's price sensitivity is high (High competition), supplier A is better off under facility sharing again because of the big share of revenue from selling product B. Likewise supplier B is better off under FS(Appendix A2.1).

Case 2) θ<0.5

If less than half of the revenue from sharing product B is given to supplier A, the graphs show different result. When the competition is low, supplier A earns better profit by not implementing facility sharing contract, because he is given less than 50% of the revenue under FS and producing product A and B is not as profitable for him under this contract. On the other hand, because supplier B receives more than half of the revenue, she is better off under FS contract.

Under high competition, again it is more profitable for supplier A to perform under the wholesale price contract. For the second supplier the result is the same as before and facility sharing is more efficient for her (Appendix A2.1).

1.8.2 Comparative study with respect to own price sensitivity

This part investigates the effect of own price sensitivity (β) on the performance of FS and WP contract. The graphs are shown in the Appendix A2.2 and the results are summarised in table 6.

Case 1) θ>0.5

When more than half of the revenue from selling product B is given to supplier A and own price sensitivity parameter is small, supplier A is better off under WP. Facility sharing performs better for supplier A only when more than 90% of the revenue from selling product B is given to him. Otherwise wholesale price is more profitable. The reason is when the price sensitivity is low, the augmentation in selling price does not significantly affect the demand. Thus under low own price sensitivity, supplier A is having good profit under WP and producing product B is only profitable when a very big share of the revenue from selling B is given to supplier A.

In contrary, by considering low own-price sensitivity, Supplier B is considerably better off under FS. Even though supplier B receives less than half of revenue from selling product B, still the product cost reduction has an effective impact on the revenue. Under this assumption from figure (7-8) in Appendix A2.1, we see a dramatic fall in supplier B's profit under FS (Figure (7-9)) due to the change in selling price of product B. Selling price of product B under FS is less than WP contract when competition price sensitivity is small. By increasing γ , selling price of product B under WP is less than WP contract.

Case 2) θ<0.5

When small fraction of selling product B is given to supplier A, after several experiments, we conclude that it is not beneficial for supplier A to implement FS contract and he is better off under WP contract whether β is small or high. In both situations, because of the small fraction, whole sale price is more beneficial for supplier A. Conversely, supplier B is better off under FS by considering low and high owns price sensitivity because a considerable portion of selling product B belongs to supplier B.

1.8.3 **Conclusion**

Table 6 Supply chain's members better off under with FS vs. WP

SC members	Own Price Sensitivity / Competitor's Price sensitivity	**High price sensitivity** $\beta_A = \beta_B$		**Low price sensitivity** $\beta_A = \beta_B$	
		θ **<0.5**	θ **>0.5**	θ **<0.5**	θ **>0.5**
supplier A	**High competition**	-	FS	-	If $\theta \geq 0.9$ then FS
	Low competition	-	FS	-	If $\theta \geq 0.9$ then FS
supplier B	**High competition**	FS	FS	FS	FS
	Low competition	FS	FS	FS	FS

Table 6 reflects each supplier's better off under the assumption of implementing facility sharing contract or not implementing this contract. Furthermore, it is worth mentioning that the obtained result can be totally changed under nonlinear demand function and also by changing any of the assumptions mentioned earlier.

As it can be observed in table 6, supplier B cannot compete with the local supplier when product B is expensive. Hence the only way to compete with supplier A is implementing a profitable facility sharing contract. According to several experiments, the profit of Supplier B has been significantly increased under FS since in this case the production cost of B is decreased. This leads to reduction in the selling price and consequently improvement in the demand and profit for supplier B.

Oppositely, it is not always profitable for supplier A to implement FS. Specifically when small percentage of the revenue from selling product B is given to supplier A. Supplier A has a big market share and he will agree on FS only if it leads to more profit for him. When less than half of the revenue from selling product B is given to supplier A, he is better off under WP because FS leads to less selling price and more demand for product B which is not pleasant for supplier A and less than half of the revenue from selling product B cannot cover the expenses.

To sum up, we can consider 4 mutual scenarios when both suppliers are better off under the same contract. Facility sharing leads to better off for supplier A and supplier B when:

1) The own price sensitivity is high and $\theta > 0.5$, considering low competition.

2) The own price sensitivity is high and $\theta > 0.5$, considering high competition.

3) The own price sensitivity is low and $\theta \geq 0.9$, considering low competition.

4) The own price sensitivity is low and $\theta \geq 0.9$, considering high competition.

Next part is related to comparing supplier A and supplier B's profit under franchise contract compared to the whole sale price contract.

1.9 Analysis of partnership using franchise and whole sale price contract

This part investigates the profit of each supply chain's member under WP contract and franchise contract (FC). By applying the franchise contract, supplier A plays as a franchisee and uses the brand of the other supplier (Brand B).

Supplier A produces product A and also uses the brand of product B. In order to moderate the channel, supplier A pays supplier B a fraction of the revenue from selling product B as a fee at the end of the season which is defined by t and it is consider between 0 and 1. It is worth pointing out that when the franchise contract is implemented, there is the possibility for supplier B to sell its product to other markets, however we only consider the transaction as the fee given to supplier B by supplier A and the rest of selling to other markets is not considered here.

Repeatedly we categorize the effect of main parameters and illustrate the impact of changing each parameter by fixing the others. It is sensible that implementing franchise contract would be an incentive for supplier B since she is seeking to maximize its profit.

The most important parameter that impacts the profit under the franchise contract is t. According to the results, by increasing t supplier B is more interested in implementing franchise contract because the augmentation of t leads to more revenue for her; on the other hand, supplier A is seeking to set the least possible value for the fee (t).

In order to obtain better insight, we consider two different situations for the fee on the revenue of selling product B:

Case 1) t < 0.5: it implies that less than 50% of selling product B will be given to Supplier B and the rest is kept by supplier A.

Case 2) t > 0.5: it implies that more than 50% of selling product B will be given to Supplier B and the rest is kept by supplier A.

1.9.1 Comparative study with respect to product differentiation (competitor's price sensitivity)

In this part we consider the effect of competitor's price sensitivity on the profit of suppliers. The graphs are shown in the Appendix A3.1 and the results are summarised in the table 7. We fixed $\beta_A = \beta_B = 0.9$.

Case 1) t < 0.5

Supplier B is better off under modified franchise since the production cost for her is too high to effectively compete with supplier A. According to the results, supplier B is better off even when she is given a small percentage of the revenue from selling product B under low or high competition. Supplier A is only better off under modified franchise contract when t<0.2 and he keeps a significant percentage of the revenue from selling product B. Although producing A and B under franchise contract affects the demand of production A, when the fee for supplier B is low, franchise is profitable for supplier A. If we consider 0.2<t<0.5, Supplier A is better off under wholesale price contract.

Case 2) t > 0.5

Based on multiple experiments we observed that when the fee for supplier B is high, it is not profitable for supplier A to implement modified FC. The reason is the high price sensitivity and small share for supplier A. Under high and low competition, supplier A would not be better off by applying the modified FC. While supplier B is better off when she receives more than half of the revenue from selling product B as fee. From the data in the Appendix A3 it is apparent that supplier B is better off under low or high competition when the modified franchise is implemented. Modified franchise contract causes the reduction in the selling price of product B because under this contract, product B is manufactured by supplier A under a lower production cost. On the other hand, the demand of product A is decreased under franchise contract. Thus when supplier A pays a big fraction of the revenue from selling product B to supplier B as a fee, he is worse off under this contract.

1.9.2 Comparative study with respect to own price sensitivity

Case 1) t<0.5

When price sensitivity is low, supplier A is still better off under wholesale price and it is not profitable to act as a franchisee for the other brand. And with low or high competition supplier A will apply wholesale price. Whereas Supplier B is better off when she sells his brand and receives the fee instead of producing product B with high production cost.

Case 2) t >0.5

When the suppliers are not very sensitive to their own selling price, supplier A is worse off under modified franchise contract when competition is high or low. Product A has a big share of market and due to low production cost, it is not profitable for supplier A to apply franchise contract when more than half of the revenue from selling product B is given to supplier B as the fee. While supplier B is much better off under franchise contract whether the price sensitivity is high or low as a result of high production cost. The graphs are shown in Appendix A3.2.

1.9.3 **Conclusion**

Applying franchise contract is expensive for all members; however we do not consider the implementation expenses. According to the graphs FC leads to better profit for the supply chain members in some particular scenarios. The results obtained from the analysis are summarized in table 7. This result may not be valid under different hypothetical or other special cases.

Table 7 Supply chain's members better off under integrated system with FC vs. WP

SC members	**Own Price Sensitivity** / **Competitor's Price sensitivity**	**High price sensitivity** $\beta_A = \beta_B$		**Low price sensitivity** $\beta_A = \beta_B$	
		t **>0.5**	t **<0.5**	t **>0.5**	t **<0.5**
supplier A	**High competition**	-	If $t<0.2$ then FC	-	-
	Low competition	-	If $t<0.2$ then FC	-	-
supplier B	**High competition**	FC	FC	FC	FC
	Low competition	FC	FC	FC	FC

As it can be observed in table 7, the comparison of the result reveals that supplier A would apply franchise contract only when the own price sensitivity is high and also he is better off particularly if he keeps a significant share of the revenue from selling product B. When supplier A and B are not sensitive to their own price it is not profitable for supplier A to act as a franchisee and buy supplier B's brand even if he receives a big share.

By considering all scenarios we conclude that supplier B is always better off to sell her brand rather than producing product B with high production cost. It is profitable for supplier B to sell her brand when they are very sensitive to their own price or under low sensitivity.

1.10 Comparing WP, FS and FC

1.10.1 **Equal characteristics ($\beta_A = \beta_B$ and $\gamma_A = \gamma_B$)**

In this section, we compare the results of implementing each of the contracts under different scenarios and the conclusion provides a framework to choose the best contract under different circumstances. In order to establish a framework that compares the efficiency of wholesale price, facility sharing and franchise contract we consider the mutual areas for both suppliers. Then we can illustrate the best of these three presented contract that can be applied on our case based on the primary assumptions that we consider.

Following graphs are provided to indicate the impact of each variable on profit of supplier A and supplier B under three different contracts. The profit is based on the optimal selling price for each product.

We study two different scenarios with respect to the percentage of the shared revenue:

Scenario 1) A Big Share of selling product B is given to Supplier A (High own price sensitivity)

Let's assume that under facility sharing contract more than half of the revenue from selling product B is given to supplier A ($\theta > 0.5$). Also, under the franchise contract more than half of the revenue from selling product B is kept by supplier A and the rest is given to supplier B as the fee ($t < 0.5$).Figure (4-1) indicates the effect of increasing competition on supplier A's profit under the three contracts. In this graph we consider $\beta_A = \beta_B = 0.9$. It can be seen that when supplier A is very sensitive to his own price (increase in selling price highly affects the demand), and more than half of the revenue from selling product B is kept by him, facility sharing contract results in better profit compared to franchise contract and whole sale price contract (Appendix A4.1.1).

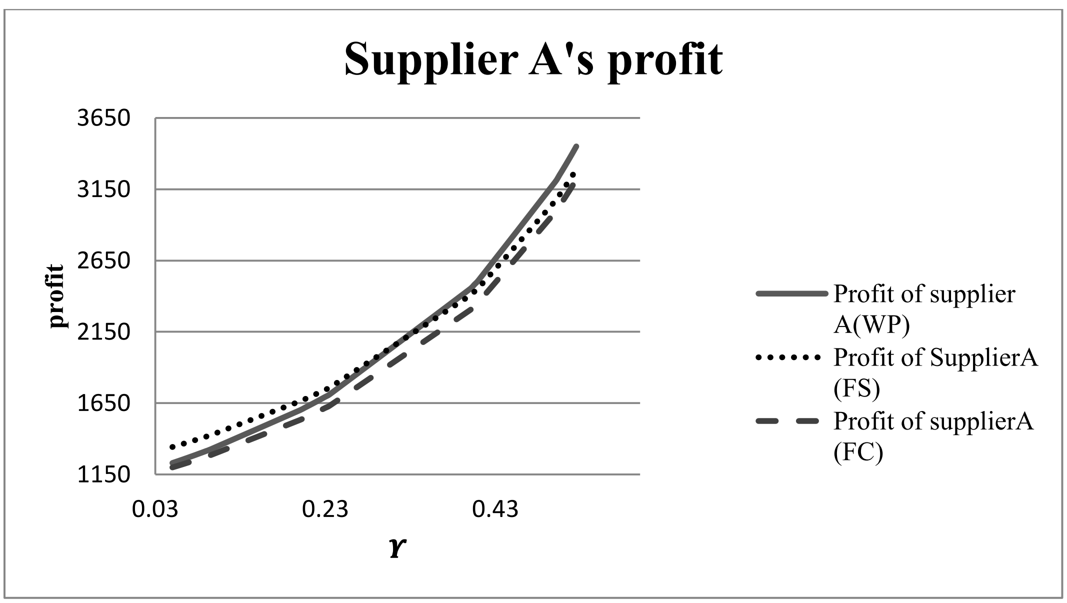

Figure 0-1 The effect of competition parameter on supplier A's profit

When the competition rate is low, supplier A is better off under FS, however there is not a significant difference between three contracts. While by increasing the competition rate, the difference between the contracts is significant. Franchise leads to the least profit because it is not profitable for supplier A to buy product B's brand while the price sensitivity is high.

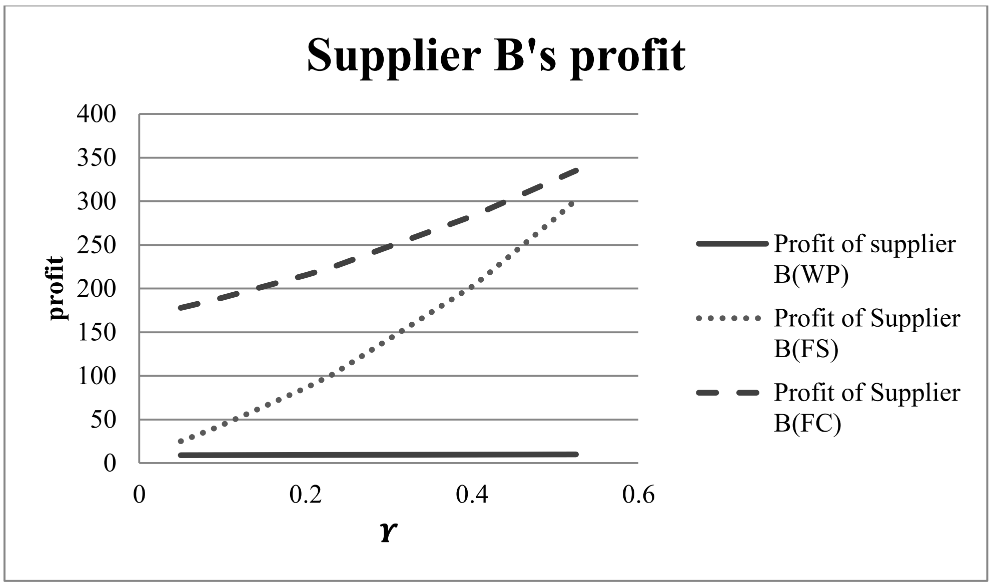

Figure 0-2 The effect of competition parameter on supplier B's profit

Supplier B is better off under franchise contract and she has the lowest profit under wholesale price contract since production cost is high. By increasing the competition, the difference of the profit under franchise and facility sharing is reduced. Figure (4-2) shows that supplier B has better profit when she accepts supplier A as her franchisee since she does not face high production expenses. Facility sharing is also profitable for supplier B and wholesale price contract leads to the least profit under high or low competition.

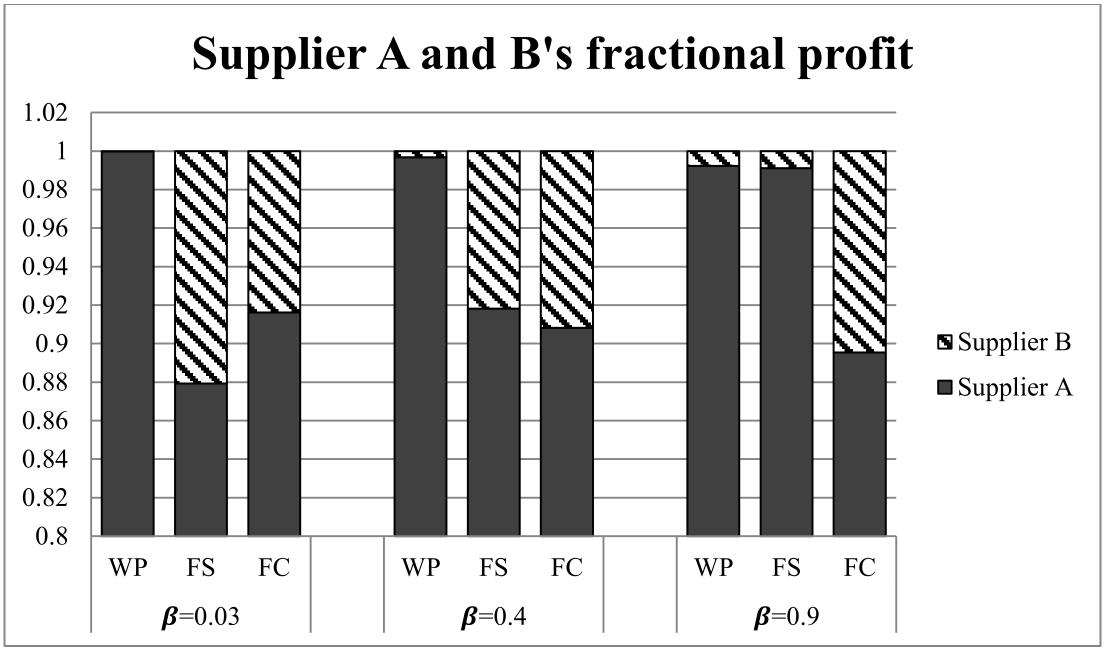

Figure 0-3 Supplier A and B's fractional profit under low competition

Figure (4-3) demonstrates the fractional profit for each supplier under three different contracts. It demonstrates the profit under three different values for own price sensitivity when the competition is low. The profit for each supplier is given by $\frac{\text{Profit of supplier A}}{\text{Total profit}}$ and $\frac{\text{Profit of supplier B}}{\text{Total profit}}$ under three contracts.

According to figure (4-3), supplier A is better off under whole sale price because the competition is low and he can sell with a reasonable selling price. Supplier A’s profit under facility sharing is as good as wholesale price only when the price sensitivity is high. Franchise causes worse off for supplier A. Supplier B is better off under franchise contract due to high production cost and she has the least profit under the wholesale price contract.

Figure (4-4) reports the profit for each supplier by considering high own price sensitivity under three levels of competition. The graph presents the effectiveness of facility sharing on supplier A's profit. Supplier B is better off when she sells her brand under franchise contract. In this graph supplier B's profit under WP and FS is not shown properly due to very small profit values. It can be seen that both suppliers are better off by increasing competition and facility sharing is profitable for supplier B when competition is high.

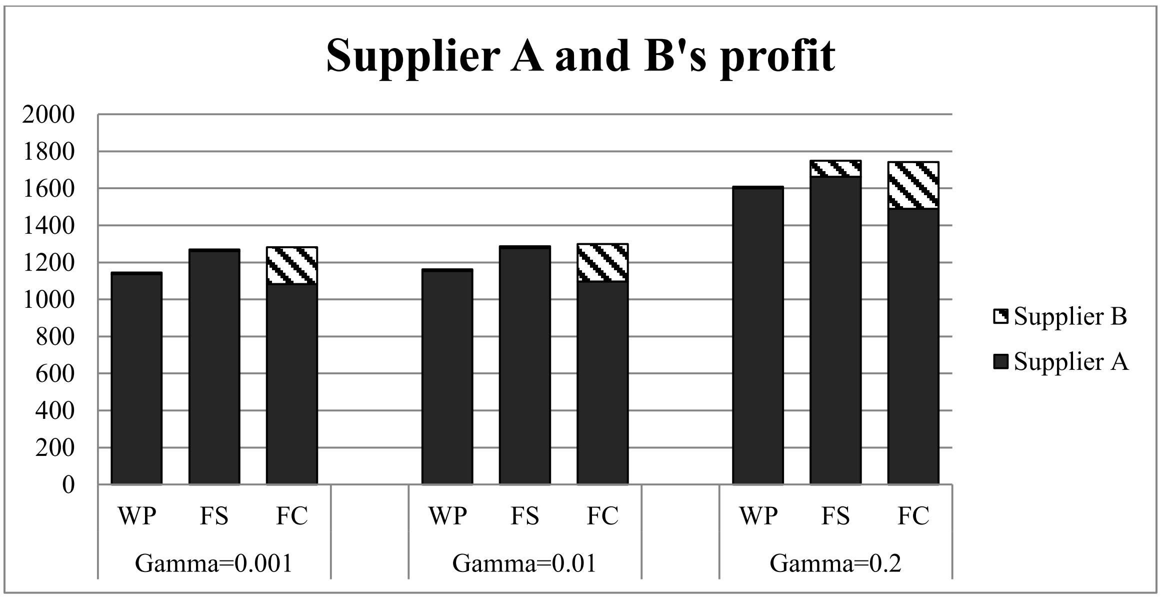

Figure 0-4 Supplier A and Supplier B's profit under high own price sensitivity

Figure (4-5) demonstrates the retail prices of each product under high price sensitivity and low competition. As we mentioned before, the goal of suggesting a coordinating contract is reduction in the production cost and the selling price. Therefore, in the results we can see a small difference is product A's retail price, while there is a significant change in product B's retail price under different contracts. The retail price of product B is reduced under franchise and facility sharing contracts compared to the wholesale price contract.

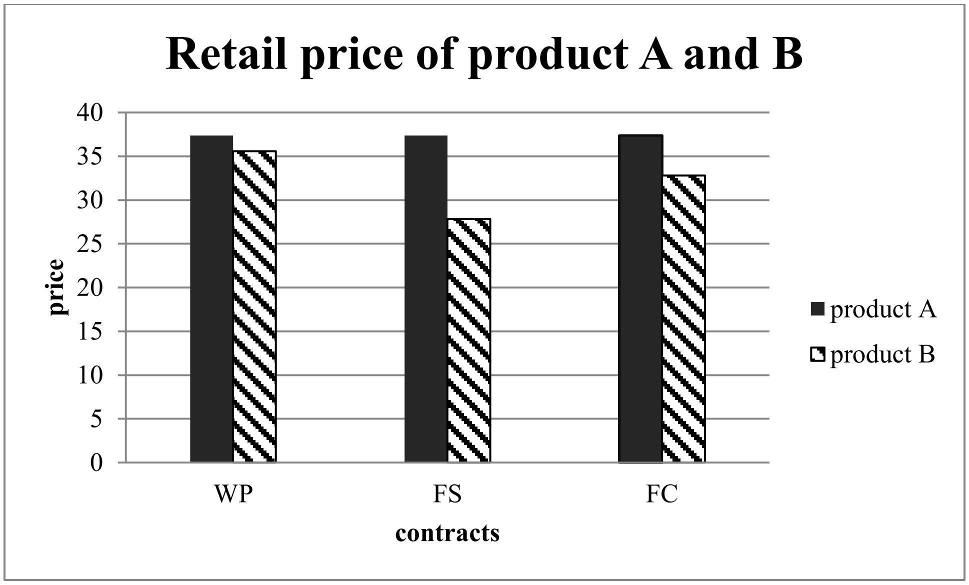

Figure 0-5 Retail price of product A and B under high price sensitivity and low competition

In order to present better implication, we consider the effectiveness of facility sharing and franchise contract with respect to whole sale price in table (8) when we set high own price sensitivity $(\beta_1 = \beta_2 = 0.9)$. The effectiveness is defined by the profit of the supply chain member over the profit under whole sale price:

Effectiveness of facility sharing contract= $\dfrac{\text{Profit under } FS}{\text{Profit under } WP}$

Effectiveness of Franchise contract = $\dfrac{\text{Profit under } FC}{\text{Profit under } WP}$

We consider 3 different values for γ : low competition, moderate competition, high competition.

Table 8 The effect of changing competitor's price sensitivity on profit effectiveness

	Supplier A's profit			Supplier B's profit		
Contract	**Whole Sale Price**	**Facility sharing efficiency** $\frac{F^{FS}}{F^{WP}}$	**Franchise efficiency** $\frac{F^{FC}}{F^{WP}}$	**Whole Sale Price**	**Facility sharing efficiency** $\frac{F^{FS}}{F^{WP}}$	**Franchise efficiency** $\frac{F^{FC}}{F^{WP}}$
γ =0.001	1	1.11>1	1.01>1	1	0.92<1	14.92>1
γ =0.1	1	1.07>1	0.99<1	1	4.73>1	16.6>1
γ =0.7	1	0.93<1	0.94<1	1	29.5>1	34.13>1

From table 8, it is obvious that when γ is very small (0.001), meaning that the sensitivity to the competitor's selling price is low and the demand is not significantly affected by the other supplier's selling price, FS causes better off for supplier A and worse off for supplier B. While supplier B is much better off under FC. By increasing competition FC leads to less profit for supplier A and oppositely supplier B is better off under FC.

When competition is very high (γ =0.7), FS and FC work very good for supplier B. On the other hand, these two contracts make less profit for supplier A comparing to the wholesale price contract.

Scenario 1) A Big Share of selling product B is given to Supplier A (Low own price sensitivity)

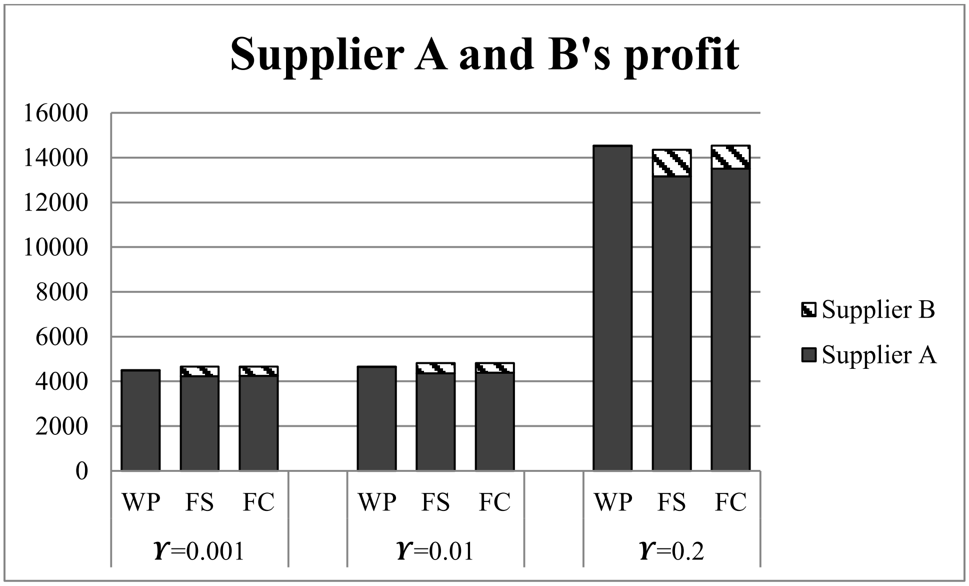

Figure 0-6 Supplier A and Supplier B's profit under low own price sensitivity

According to figure above, although a big share of revenue from selling product B belongs to supplier A ($\theta > 0.5$ and $t < 0.5$), because of low own price sensitivity supplier A is better off under WP compared to FC and FS (Appendix A4.1.2). Thus under this specific assumptions, FC and FS are profitable for supplier A, while they are profitable for supplier B.

Scenario 2) A Big Share of selling product B belongs to Supplier B (High own price sensitivity)

We assume that under FS, less than half of the revenue from selling product B is given to supplier A ($\theta < 0.5$). Also, under FC contract, less than half of the revenue from selling product B is kept by supplier A and the rest is given to supplier B as the fee ($t > 0.5$).

Based on several experiments summarized in Appendix A4.2.1 and figure (4-7), when a small percentage of the revenue from selling product B is given to supplier A, he is worse off under facility sharing and franchise contract.

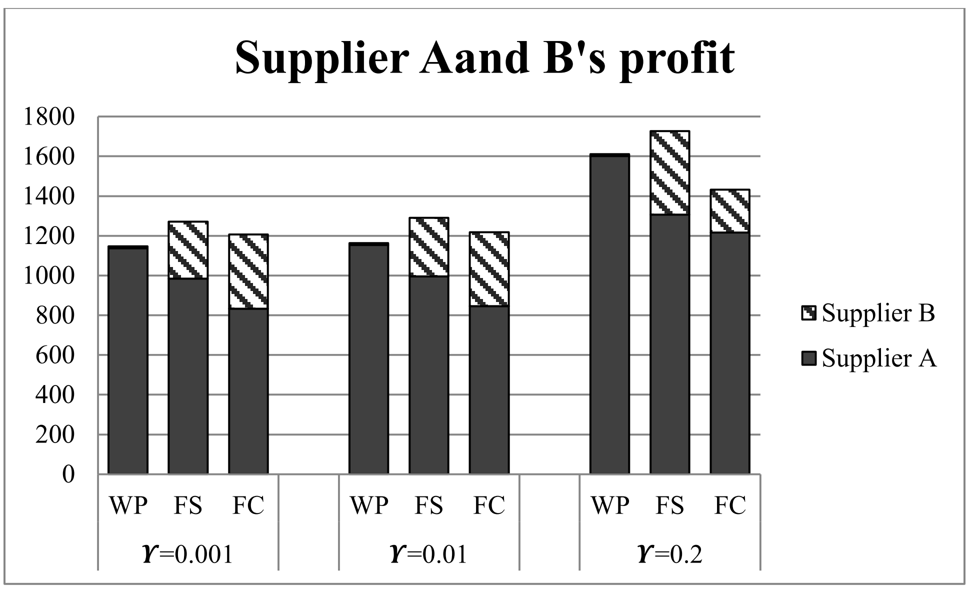

Figure 0-7 Supplier A and supplier B's profit under high own price sensitivity

Scenario 2) A Big Share of selling product B belongs to Supplier B (Low own price sensitivity)

As it can be seen in figure (4-8), when supplier A is payed less than half of the revenue from selling product B, it is not profitable for him to implement facility sharing or franchise contract because these contracts lead to more demand and profit for supplier B (Appendix A4.2.2).

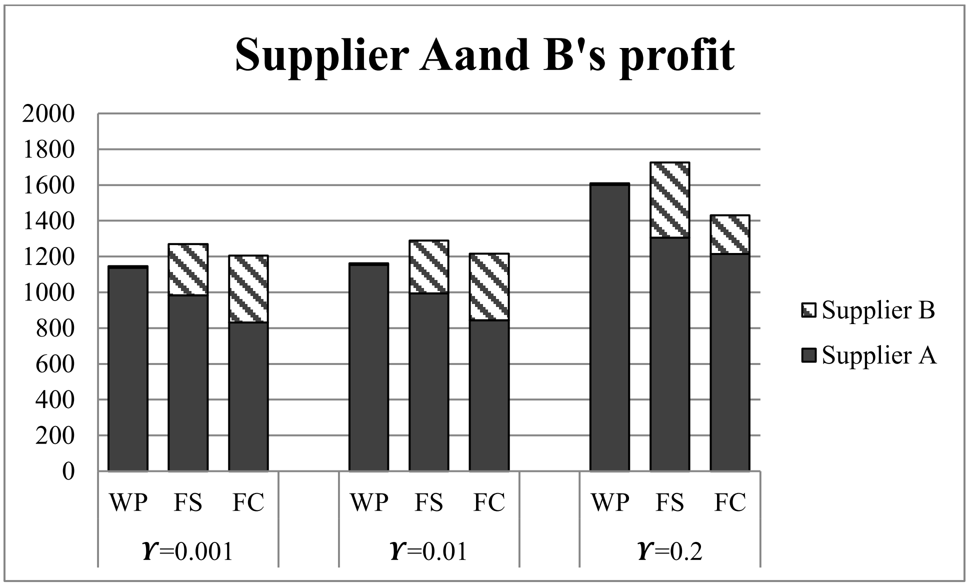

Figure 0-8 Supplier A and Supplier B's profit under low own price sensitivity

1.10.2 **Different characteristics ($\beta_A \neq \beta_B$ and $\gamma_A \neq \gamma_B$)**

Up to this section, we particularly focused on a supply chain with equal characteristics for the suppliers. But in this part we study different characteristic for each supplier in table 9. We assume that $\theta > 0.5$ and $t < 0.5$.

Table 9 The effect of different characteristics on supplier A and B's profit

Parameters / scenarios	$\beta_A > \beta_B$	$\beta_A < \beta_B$	$\gamma_A < \gamma_B$	$\gamma_A > \gamma_B$
Partnership vs. No-Partnership	Same Result	Same Result	Same Result	Same Result
WP vs. FS vs. FC	1	Same Result	2	Same Result

As it can be seen from table 9, in terms of comparing the profit of each supplier under the scenarios of partnership and no partnership, the results for the profit of the suppliers are the same as the profit under equal characteristics.

While in table 9, case 1 and 2 are the cases that the results are quietly different. We explain about each different case:

1. When $\beta_A > \beta_B$, it means that supplier A is more sensitive to his own price compared to supplier B. Under equal β, supplier A is better off under facility sharing, while when we consider $\beta_A > \beta_B$ the results show that supplier A's profit

under wholesale price is more than the profit under FS and FC. Thus when supplier A is very sensitive to his own price, FS and FC are not profitable for him and wholesale price leads to better off. Also when we consider equal β for the suppliers, supplier B is better off under franchise contract, while under the assumption of $\beta_A > \beta_B$, facility sharing is more profitable than franchise contract. Thus supplier A will not implement FS or FC when he is more sensitive to his own price.

2. When $\gamma_A < \gamma_B$, we see different results for supplier A's profit when β is small. When supplier A's competitor's price sensitivity parameter is smaller than supplier B's competitor's price sensitivity, franchise contract leads to better off for supplier A comparing to WP, while under the assumption of equal characteristic WP is better than FS and FC. We conclude that when supplier A is not very sensitive to his own price and his competitor's price, franchise contract can be implemented on the supply chain. When we assume high price sensitivity for the suppliers, the results are the same.

Next chapter provides a summary on the results and the future research.

5. Conclusion and Future Research

1.11 Conclusion

In this study we discussed a supply chain consists of two competitive suppliers and a common retailer. The dominant supplier is the local one and he can produce the product under low production cost. While the other supplier is the foreigner who faces the low demand due to high production cost and transportation cost. We aimed to determine if there is a coordinating contract that can be applied on this supply chain.

First we analyze the classical model under linear deterministic demand functions and considered the wholesale price contract. Then we assumed a case where the dominant supplier and the retailer became close partners and analyzed the relationship. Subsequently, we analyzed the relationships under popular supply chain contracts. We suggested a modified facility sharing contract which was inspired by the revenue sharing contract. The profit function and optimal selling prices for each supplier has presented. Then we used the concept of franchise contract and another contract was discussed. Whole sale price was used in order to analyse the effectiveness of the suggested contracts.

Finally a numerical example is used to show each contract's effect on the mentioned supply chain. By changing the main parameters, we showed the scenarios that each contract is profitable for the suppliers. The aim of this thesis was to assess the effectiveness of two suggested coordination contracts based on the profit of each supplier.

Based on multiple experiments we generally confirmed that partnership of the retailer and local supplier makes better profit for the members compared to the decentralized system. While the outsider supplier is worse off when the retailer and local supplier become close partners. This result has been proved in several papers.

The study shows that between wholesale contract, facility sharing contract and franchise contract, wholesale price causes the least profit for the foreign supplier since her production cost is too high so she seeks to reduce this production cost.

The investigation of different levels of competition and own price sensitivity showed that supplier B is better off under franchise contract in most of the scenarios. We can conclude that in our hypothetical case, the outsider supplier cannot reduce her production cost unless she agrees on coordination with the local supplier. In this thesis, the coordination can be achieved by implementing facility sharing contract or franchise contract.

Supplier A is mainly better off under wholesale price contract. But there are some specific scenarios that facility sharing works better for supplier A:

1) When the price sensitivity is high and more than half of the revenue from selling product B is given to supplier A and the competition between two brands is low.
2) When the price sensitivity is high more than half of the revenue from selling product B is given to supplier A and the competition between two brands is high.
3) When the price sensitivity is low and almost the total revenue from selling product B is given to supplier A, considering low competition.

4) When the price sensitivity is low and almost the total revenue from selling product B is given to supplier A, considering high competition.

5) Under the assumption of different characteristics, when supplier A is more sensitive to his own price comparing to the other supplier ($\beta_A > \beta_B$), even if he is offered a big share of revenue from selling product B, he is better off under whole sale price rather than FS and FC.

6) Under the assumption of different characteristics, when $\gamma_A < \gamma_B$ and price sensitivity is low, franchise is profitable for supplier A and supplier B.

Based on the results, although franchise contract leads to better pay off for supplier B, it cannot be profitable for supplier A comparing to wholesale price.

1.12 Future research

In this work we were limited to deterministic linear demand. It will be interesting to see in future scope of such collaborations under linear and multiplicative stochastic demand. In addition, we did not consider different channel powers in this study, a greater focus on channel structures could produce interesting findings regarding the presented supply chain.

We study two popular coordinating contracts. Another possible area of future research might be modifying other contracts such as two-part tariff, quantity discount, etc.

We considered a linear demand function. This study can be repeated by applying a nonlinear demand function.

Bibliography

Abel P. Jeuland,Steven M. Shugan. (2008). Managing Channel Profits. *Marketing Science, 27*, 52–69.

AGALLOPOULOU, P. (2010). *BASIC CONCEPTS OF GREEK CIVIL LAW.* Greece: Sakkoulas.

Albrecht, M. (2010). Supply Chain Coordination Mechanisms: New Approaches for Collaborative Planning. In M. Albrecht, *Lecture Notes in Economics and Mathematical Systems.* Springer.

Andy A. Tsay, S. N. (1999). Modeling Supply Chain Contracts: A Review. In S. N. Andy A. Tsay, *Quantitative Models for Supply Chain Management* (pp. 299-336). Springer US.

Arshinder, Kanda, A., Deshnukh, S.G. (2008). Supply chain coordination: perspectives,empirical studies and research directions. *International Journal of Production Economics*, (pp. 316-335).

Bowersox,Closs,Stank. (2003). HOW TO MASTER CROSS-ENTERPRISE COLLABORATION. *SUPPLY CHAIN MANAGEMENT REVIEW,* (pp. 18-27). Evanston: Northwestern University, Evanston.

Cachon & A. Gürhan, Kök. Gérard P. (2010). Competing Manufacturers in a Retail Supply Chain:On Contractual Form and Coordination. *Management Science, 56*, (pp. 571-589).

Cachon, G. P. (2003). Supply Chain Coordination with Contracts. In S. G. A.G. de Kok, *Handbooks in Operations Research and Management Science* (Vol. 11, pp. 229-340). Boston, MA.

Choi, S. (1996). Price competition in a duopoly common channel retailer. *Journal of Retailing, 72(2)*, (pp. 117-134).

Choi, S. C. (1991). Price Competition in a Channel Structure with a Common Retailer. *Marketing Science* , (pp. 271-296).

Ding, D., Chen, J.,. (2008). Coordinating a three level supply chain with flexible return policies. *Omega 36*, (pp. 865–876).

F.J. Arcelus,Satyendra Kumar,G. Srinivasan. (2008). Evaluating manufacturer's buyback policies in a single-period two-echelon framework under price-dependent stochastic demand. *Omega36,International Journal of Management Sciences*, (pp. 808–824).

Hahn, K.H., Hwang, H., Shinn, S.W.,. (pp. 770–780). A returns policy for distribution channel coordination of perishable items. *European Journal of Operational Research 152*, 2004.

Hajnalka Vaagen, S. W. ((2008)). Product variety arising from hedging in the fasion supply chain. *Int. J. Production Economics*, (pp. 431–455).

Hongli Wang ,Yan Ren. (2012). Supply Chain Coordination under Buyback Contract with Multiple Newsvendors. In *Recent Advances in Computer Science and Information Engineering* (pp. 23-32). Springer Berlin Heidelberg.

Hon-Shiang Lau , Amy Hing-Ling Lau. (1999). Manufacturer's pricing strategy and return policy for a single-period commodity. *European Journal of Operational Research 116*, (pp. 291-304).

Huachun Xiong a, 1. B. (2011). A composite contract based on buy back and quantity flexibility contracts. *European Journal of Operational Research*, (pp. 559–567).

Ilaria Giannoccaro, P. P. (2004). Supply chain coordination by revenue sharing contracts. *production economics*, (pp. 131-139).

Indranil Bose a, Paul Anand b,*. (2007). On returns policies with exogenous price. *European Journal of Operational Research 178*, (pp. 782–788).

James D. Dana, J. K. (September 2001). REVENUE SHARING AND VERTICAL CONTROL IN THE VIDEO RENTAL INDUSTRY*. *THE JOURNAL OF INDUSTRIAL ECONOMICS*, (pp. 223–245).

Jing Hou , Amy Z. Zeng , Lindu Zhao . (2010). Coordination with a backup supplier through buy-back contract under supply disruption. *Transportation Research Part E: Logistics and Transportation Review*, (pp. 881–895).

John Velentzas, Georgia Broni. (2013). The Business Franchise Contract As A Distribution Marketing System: Free Competition And Consumer's Protection. *Procedia Economics and Finance, 5*, (pp. 763 – 770).

Kannan Govindan a,b,*,1, Maria Nicoleta Popiuc b, Ali Diabat c. (2013). Overview of coordination contracts within forward and reverse supply. *Journal of Cleaner Production*, (pp. 319-334).

Kannan Govindan a,b,*,1, Maria Nicoleta Popiuc b, Ali Diabat c. (2013). Overview of coordination contracts within forward and reverse supply. *Journal of Cleaner Production*, (pp. 319-334).

Karen Donohue, Y. Z. (2011). Buyback versus Revenue-sharing Contracts:Influence of Loss Aversion and Payment Timing. *MSOM Annual Conference* (p. 3). Michigan: Ann Arbor.

Kewen Pan,K.K. Lai , Stephen C.H. Leung , Di Xiao. (2010). Revenue-sharing versus wholesale price mechanisms under different channe lpower structures. *European Journal of Operational Research, 203*, (pp. 532–538).

Kewen Pan,K.K. Lai,Stephen C.H. Leung,Di Xiao. (2010). Revenue-sharing versus wholesale price mechanisms under different channel power structures. *European Journal of Operational Research, 203*, (pp. 532–538).

Kök, G. P. (2010). Competing Manufacturers in a Retail Supply Chain:On Contractual Form and Coordination. *Management Science*, (pp. 571-589).

Lariviere, C. a. (2005). Supply Chain Coordination with Revenue-Sharing :Strengths and Limitations. *MANAGEMENT SCIENCE*, 15.

Lariviere, M. A. (1999). Supply Chain Contracting and Coordination with Stochastic Demand. In Sridhar Tayur, Ram Ganeshan, & Michael Magazine, *Quantitative Models for Supply Chain Management* (Vol. 17, pp. 197-232). Boston, MA: Springer US.

Luis A. Guardiola,Ana Meca,Judith Timmer. (2007). Cooperation and profit allocation in distribution chains. *Decision Support Systems*, (pp. 17-27).

Myerson, R. B. (1991). *Game Theory;Analysis of Conflict.* Harvard University Press.

Nagurney, A. (2006). *Supply Chain Network Economics: Dynamics of Prices, Flows And Profits* . Edward Elgar Pub.

Pan, K., K.K. Lai, L. Liang, S.C.H. Leung. (2009). Two-period pricing and ordering policy for the dominant retailer in a two-echelon supply chain with demand uncertainty. *Omega, 37*, (pp. 919-929).

Pasternack, B. A. (2005). Using Revenue Sharing to Achieve Channel Coordination for a Newsboy Type Inventory Model. In *Supply Chain Management: Models, Applications, and Research Directions* (pp. 117-136). Springer US.

Patricia J. Daugherty a,*, R. Glenn Richey b, Anthony S. Roath c,. (2006). Is collaboration paying off for firms? *Business Horizons*, (pp. 61-70).

Petruzzi, N.C., M. Dada. (1999). Pricing and newsvendor problem: A review with extensions. *Operations Research, 47(2)*, (pp. 183-194).

Qin, Z., J. Yang. (2008). Analysis of a revenue-sharing contract in supply chain management. *Internaitonal Journal of Logistics: Research and Applications, 11(1)*, 17-29.

Shugan, S., A. Jeuland. (1988). Competitive pricing behaviour in distribution systems. In T. Devinney, *Issue in Pricing: Theory and Research* (pp. 219-238). MA: Lexington Book.

Tsan-Ming Choi a,*, Duan Li b, Houmin Yan. (2008). Mean–variance analysis of a single supplier and retailer supply chain under a returns policy. *European Journal of Operational Research 184*, (pp. 356–376).

Tulika Chakrabortya, S. S. (n.d.). Coordination and Competition in a Common Retailer Channel: Wholesale Price versus Revenue-Sharing Mechanisms.

Wang, Y., L. Jiang, S.J. Shen. (2004). Channel performance under consignment contract with revenue sharing . *Management Science , 50 (1)*, (pp. 34-47).

Xiaohang Yue a,*, Srinivasan Raghunathan b. (2007). The impacts of the full returns policy on a supply chain with information asymmetry. *European Journal of Operational Research 180*, (pp. 630–647).

Xiuhui Li, Qinan Wang. (2007). Coordination mechanisms of supply chain systems. *European Journal of Operational Research 179*, (pp. 1-16).

Yingxue Zhao, T.-M. C. (2014). Buyback contracts with price-dependent demands: Effects of demand uncertainty. *European Journal of Operational Research*, (pp. 663–673).

Z. Yao , Stephen C.H. Leung , K.K. Lai . (2008). Analysis of the impact of price-sensitivity factors on the returns policy in coordinating supply chain. *European Journal of Operational Research 187*, (pp. 275–282).

Z. Yao , Stephen C.H. Leung , K.K. Lai. (2008). Manufacturer's revenue-sharing contract and retail competition. *European Journal of Operational Research*, (pp. 637–651).

APPENDIX

A1: Partnership vs. No Partnership

A1.1 Scenario 1: No Partnership (CSAR)

1) Effect of γ on supplier A and supplier B's profit

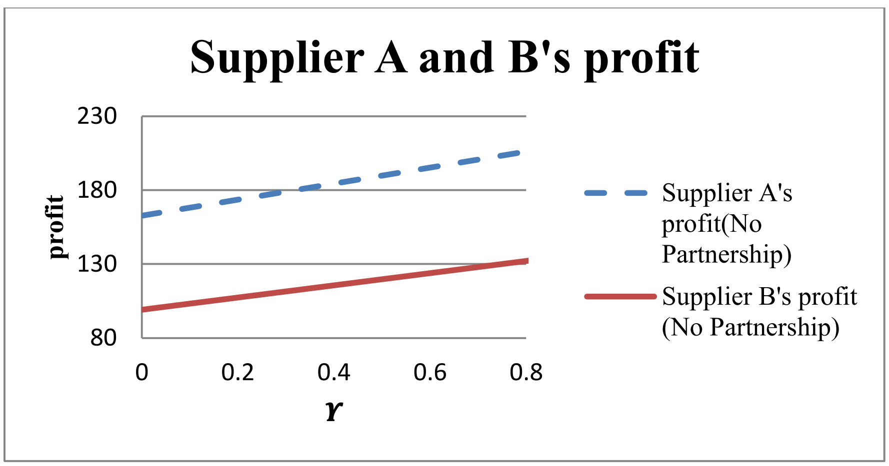

Figure 0-1 The effect of competition parameter on the profit of each supplier

From the graph above we can see that the profit has been increased by augmentation of product similarity and less product differentiation contributes to better off for both players.

2) Effect of $\boldsymbol{\beta}$ on supplier A and supplier B’s profit

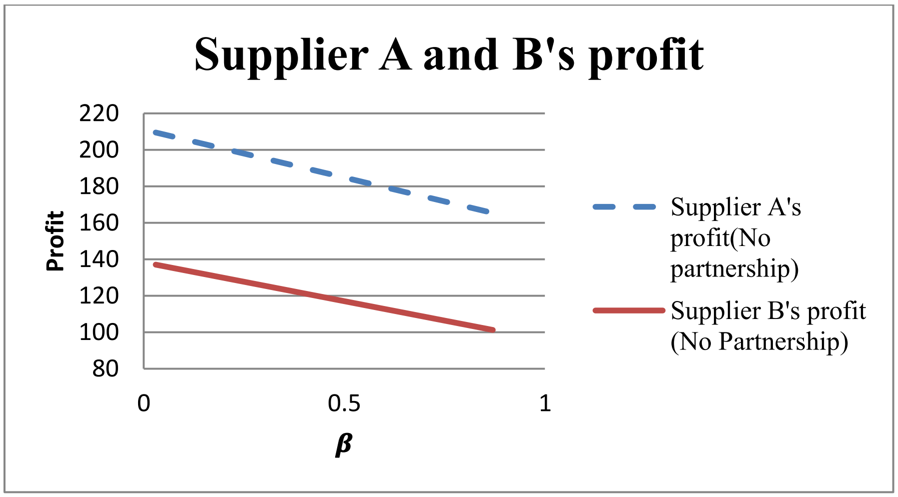

Figure 0-2 The effect of $\boldsymbol{\beta}$ on supplier A and supplier B’s profit

According to the graphs related to changing β , increasing price sensitivity in this system leads to less selling price for both competitors and also less profit for all the parties.

A1.2 Scenario 2: Partnership of Supplier A and Retailer (CR&S)

1) Effect of γ on supplier A and supplier B’s profit

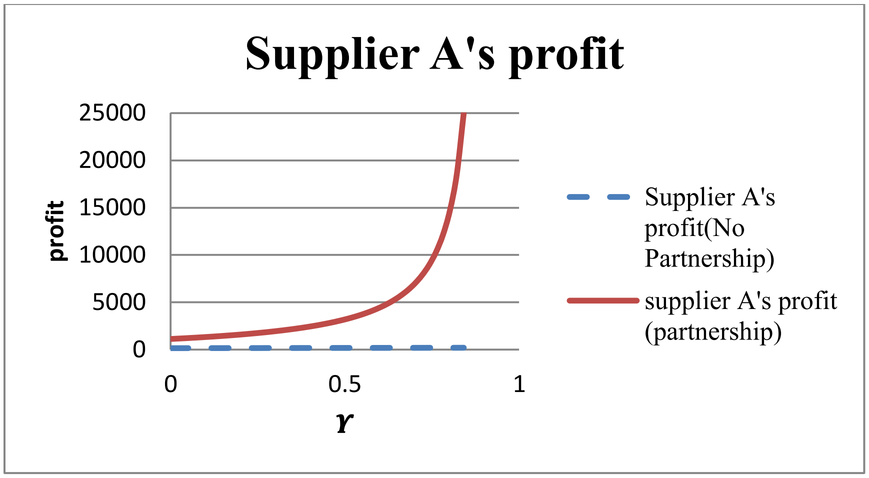

Figure 0-3 The effect of γ on Supplier A's profit before and after partnership

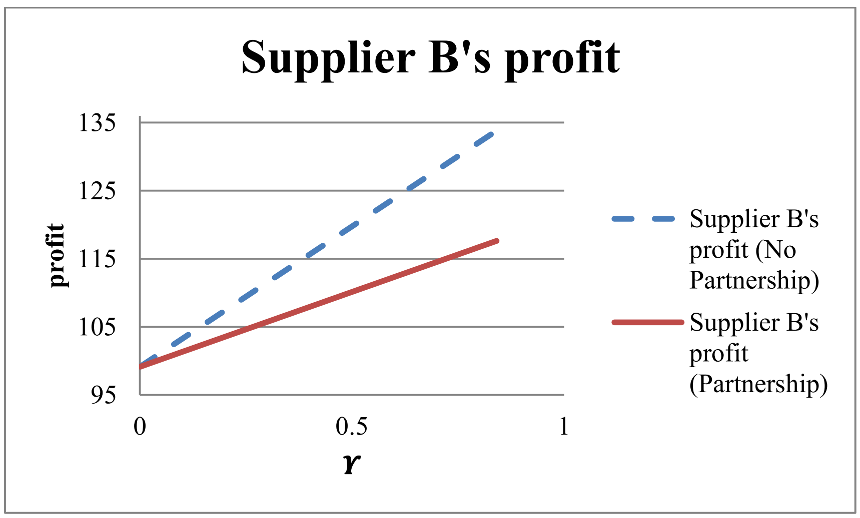

Figure 0-4 The effect of γ on Supplier B's profit before and after partnership

It is obvious that there is a sharp fall in supplier B's profit after partnership of Supplier A and retailer and the difference is increasing by increasing the product substitutability. Hence she prefers to stay in decentralized system in a scenario where there is high competition among the suppliers. As the product A and B are more differentiated, the profit difference is decreasing. The results of the correlational analysis that are presented in two figures above represent that by increasing the competition (i.e., less differentiated products) supplier B prefers to stay in the decentralized system.

A2: FS vs. WP

A2.1 Effect of Υ on supplier A and supplier B's profit

Scenario 1: When Supplier A gains more than 50% of the profit from selling product B

$\theta > 0.5$

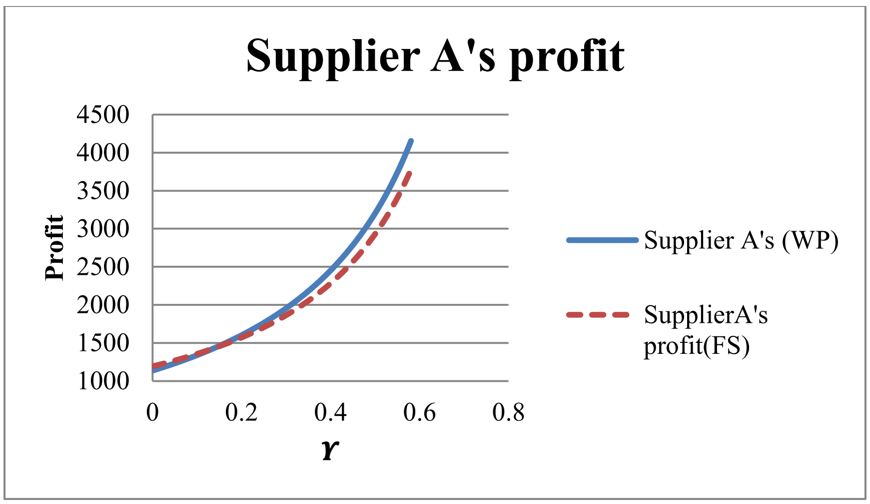

Figure 0-5 The effect of increasing Υ on Supplier A's profit under WP and FS

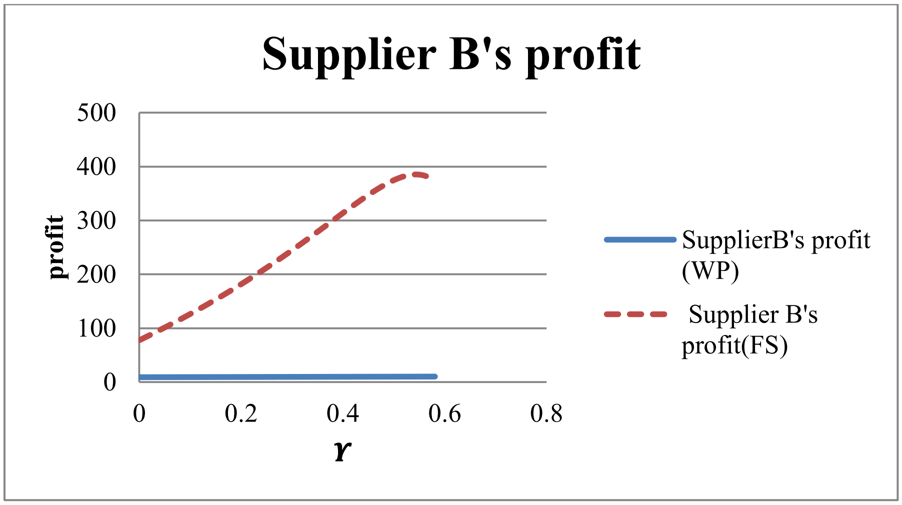

Figure 0-6 The effect of increasing **ϒ** on Supplier B's profit under WP and FS

Scenario 2: When Supplier A gains less than 50% of the profit from selling product B

θ<0.5

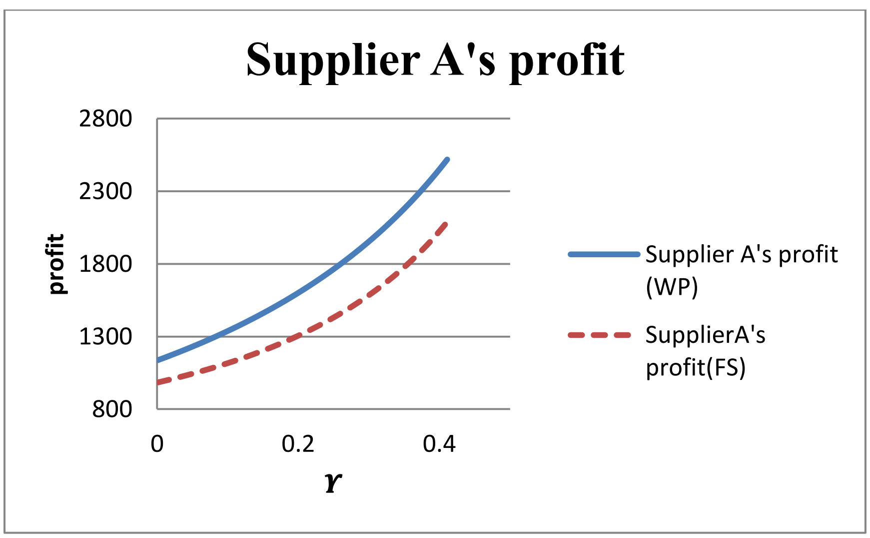

Figure 0-7 The effect of increasing **ϒ** on Supplier A's profit under WP and FS

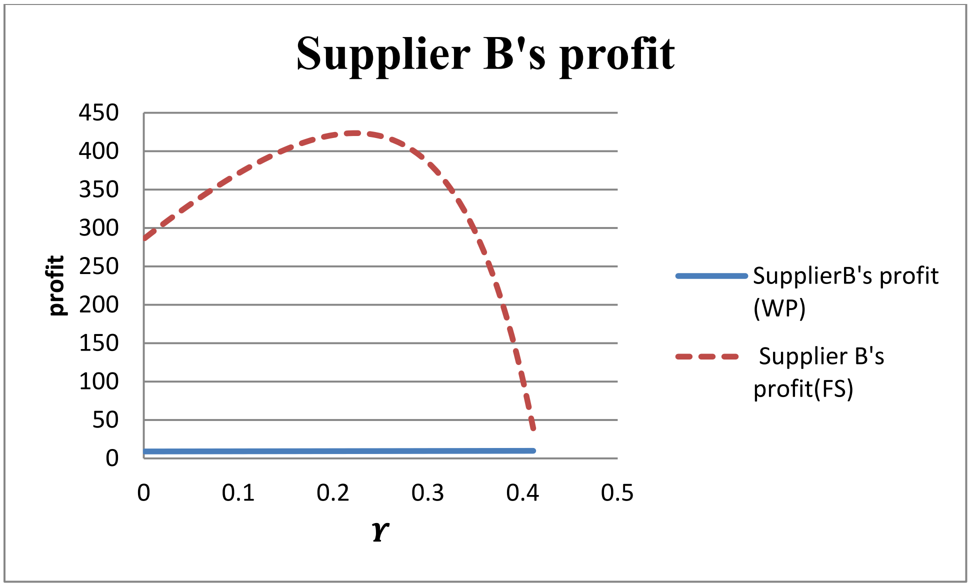

Figure 0-8 The effect of increasing $\boldsymbol{r}$ on Supplier B's profit under WP and FS

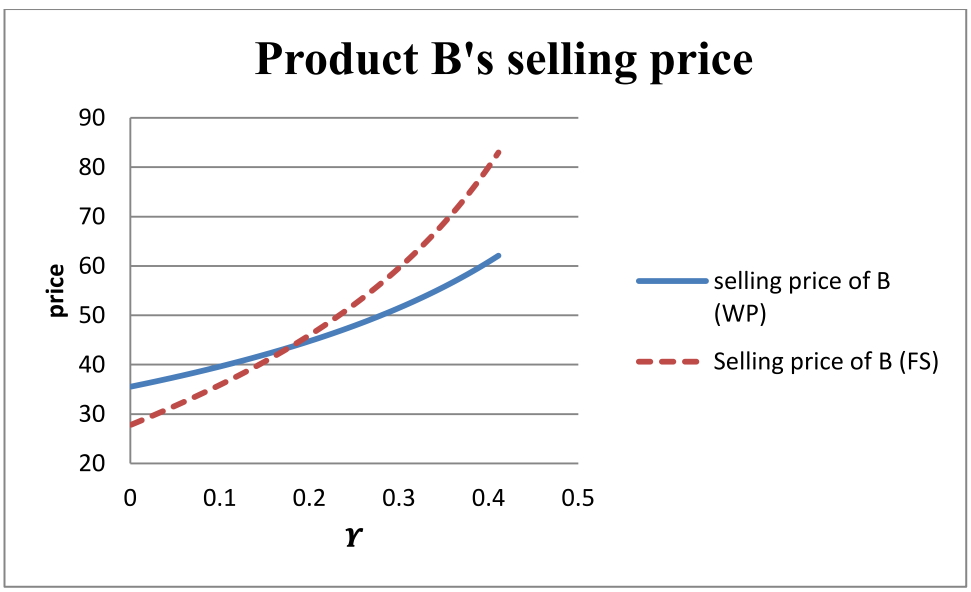

Figure 0-9 The effect of increasing $\boldsymbol{r}$ on product B's selling price under WP and FS

A2.2 Effect of β on supplier A and supplier B's profit

Scenario 1: When Supplier A gains more than 50% of the profit from selling product B $\theta > 0.5$

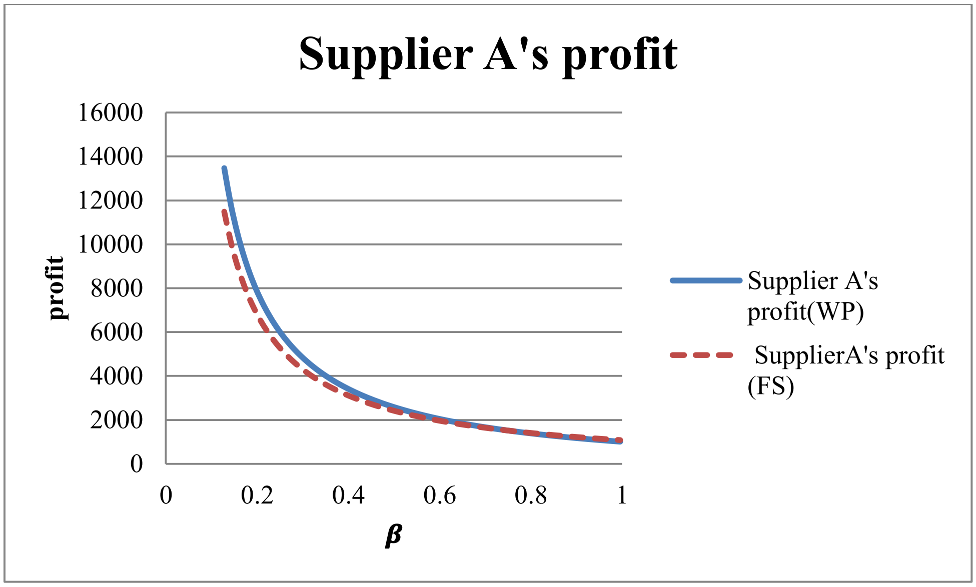

Figure 0-10 The effect of price sensitivity on Supplier A’s profit under WP and FS

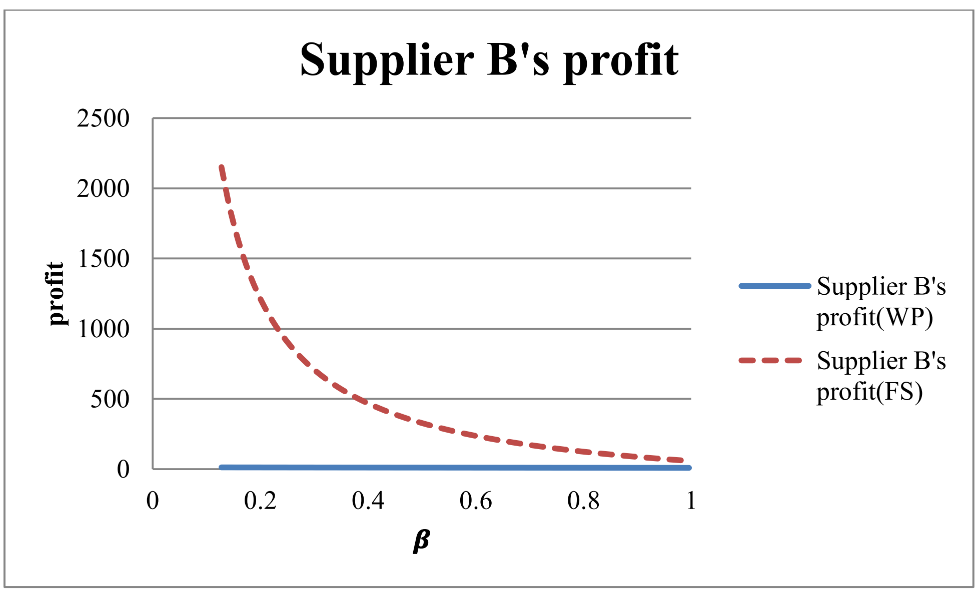

Figure 0-11 The effect of price sensitivity on Supplier B’s profit under WP and FS

Scenario 2: When Supplier A gains less than 50% of the profit from selling product B

θ<0.5

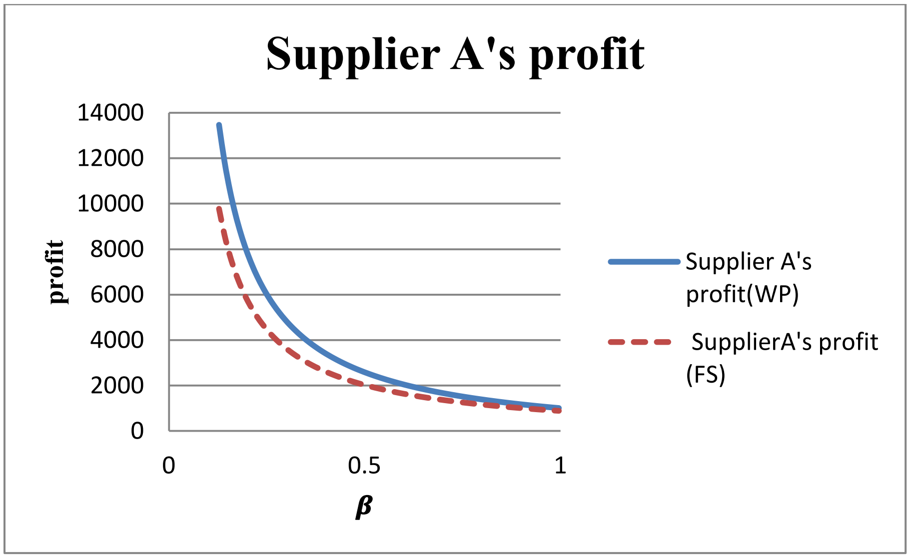

Figure 0-12 The effect of price sensitivity on Supplier A’s profit under WP and FS

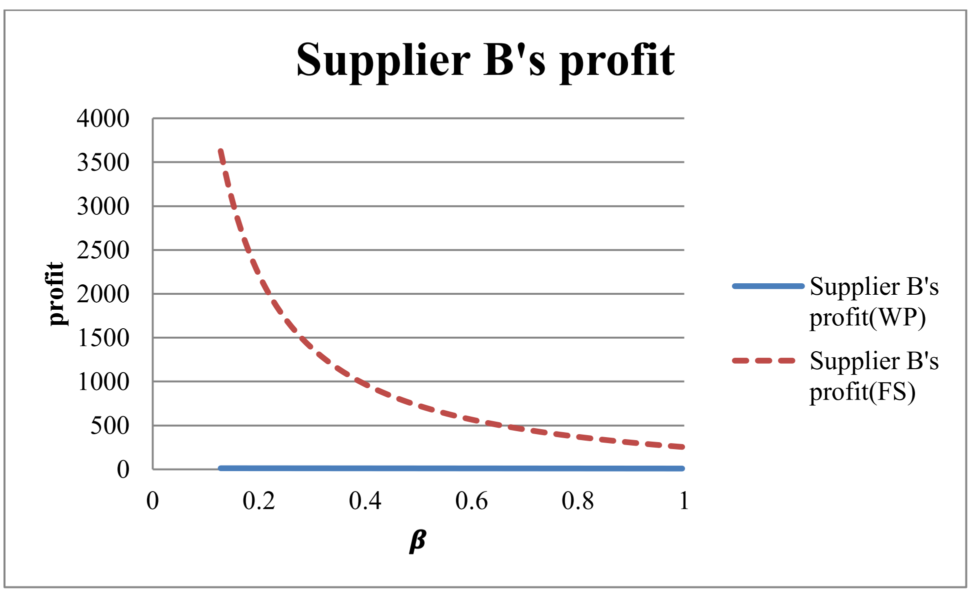

Figure 0-13 The effect of price sensitivity on Supplier B’s profit under WP and FS

A3: FC vs. WP

A3.1 Effect of $\boldsymbol{\Upsilon}$ on supplier A and supplier B's profit

Scenario 1: When Supplier A gains more than 50% of the profit from selling product B:

t <0.5

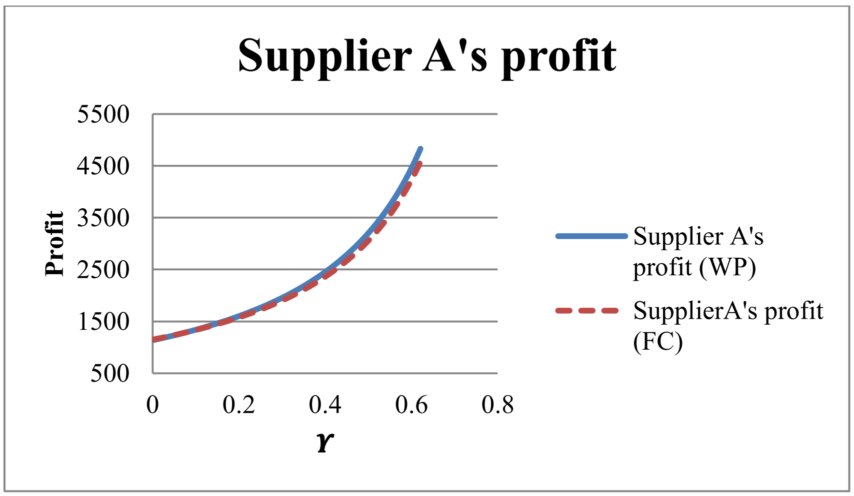

Figure 0-14 The effect of increasing competitor's price sensitivity on Supplier A's profit under WP and FC

Scenario 2: When Supplier A gains less than 50% of the profit from selling product B

t >0.5 ($t = 0.7$)

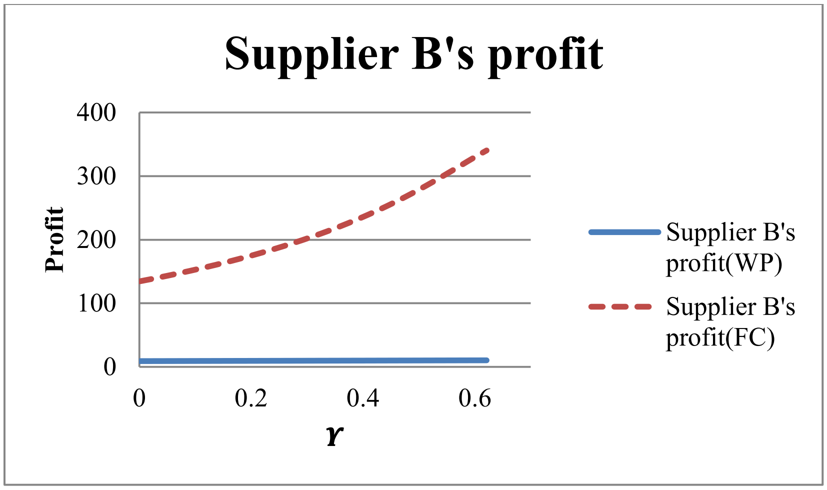

Figure 0-15 The effect of increasing Υ on supplier B’s profit under WP and FC

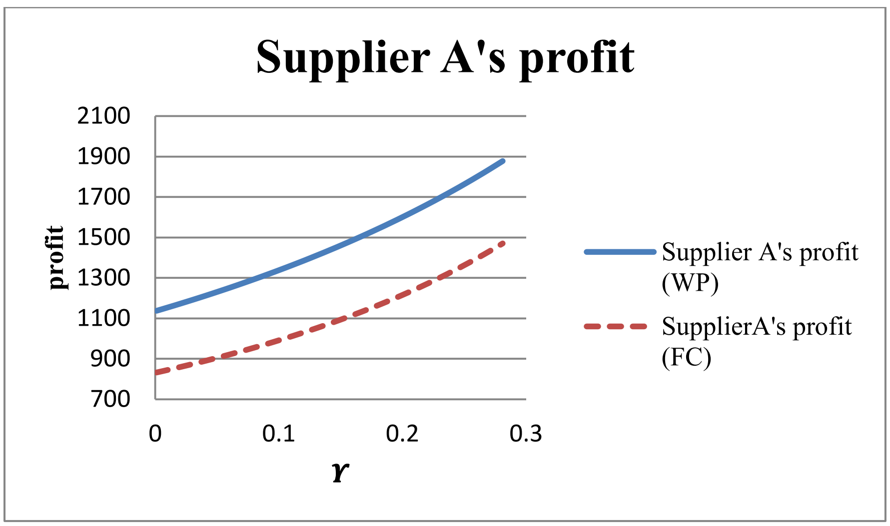

Figure 0-16 The effect of increasing Υ on Supplier A’s profit under WP and FC

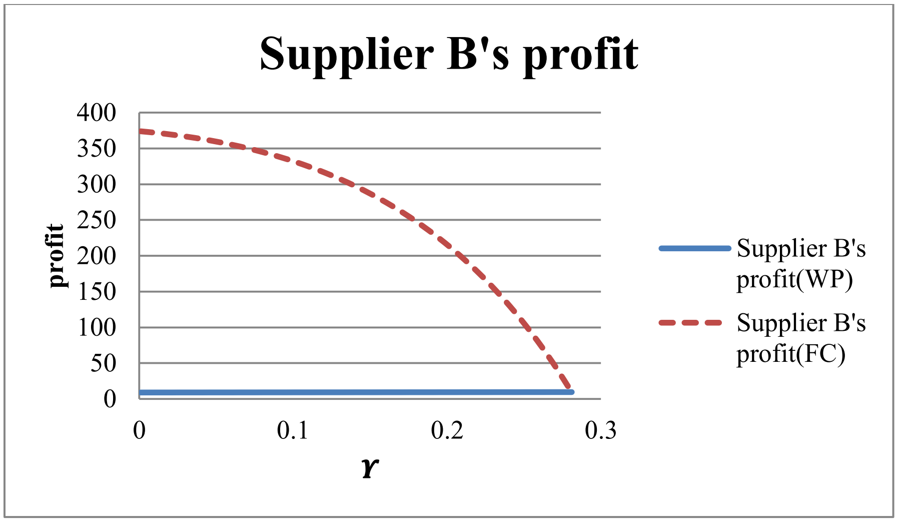

Figure 0-17 The effect of increasing $\boldsymbol{\Upsilon}$ on supplier B’s profit under WP and FC

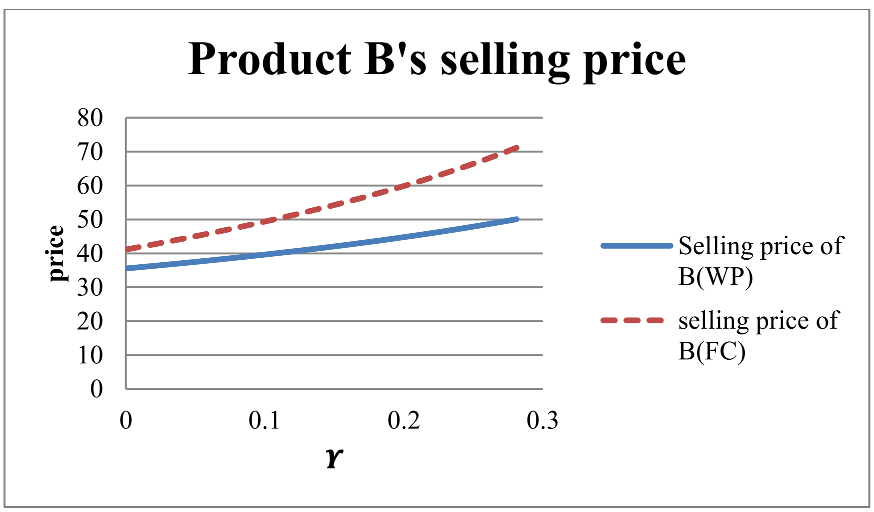

Figure 0-18 The effect of increasing $\boldsymbol{\Upsilon}$ on product B’s selling price before and after FC

A3.2 Effect of $\boldsymbol{\beta}$on supplier A and supplier B’s profit

Scenario 1: When Supplier A gains more than 50% of the profit from selling product B

$t < 0.5$ ($t = 0.2$).

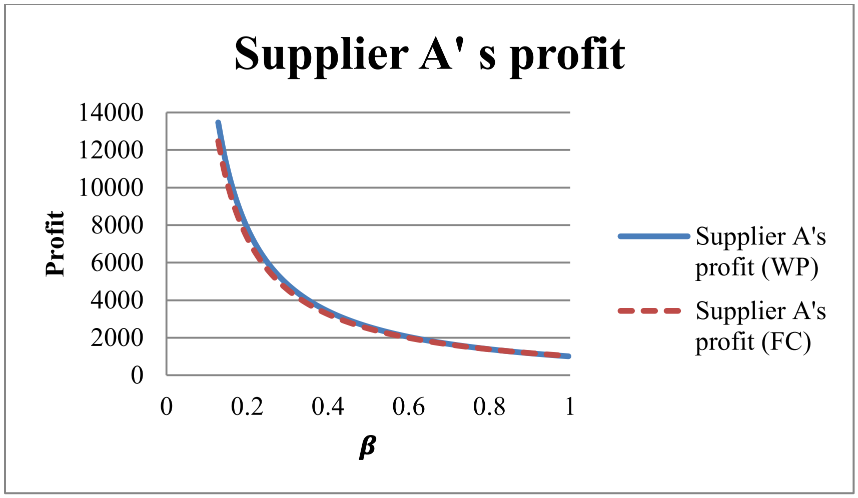

Figure 0-19 The effect of increasing own price sensitivity on Profit of Supplier A under WP and FC

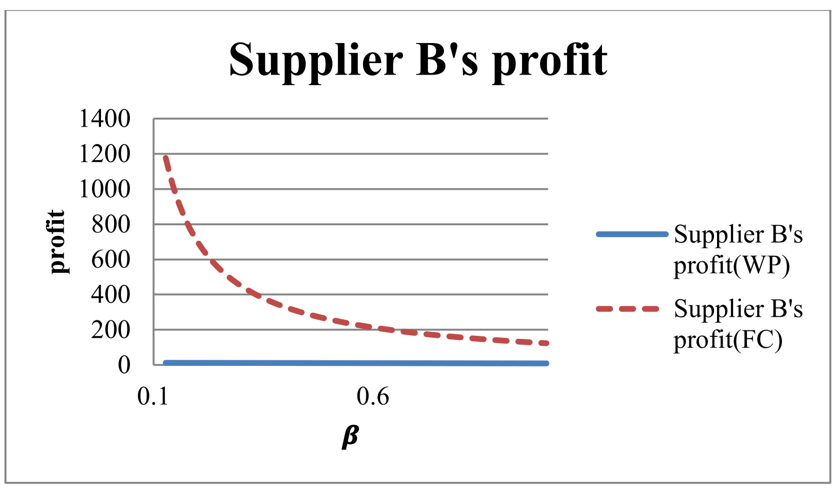

Figure 0-20 The effect of increasing own price sensitivity on Profit of Supplier B under WP and FC

Scenario 2: When Supplier A gains less than 50% of the profit from selling product B

$t > 0.5$ ($t = 0.7$)

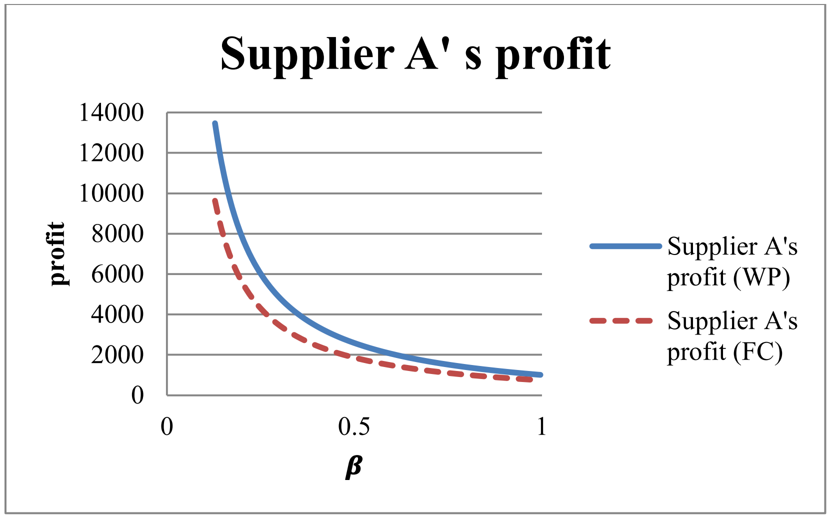

Figure 0-21 The effect of increasing own price sensitivity on Profit of Supplier A under WP and FC

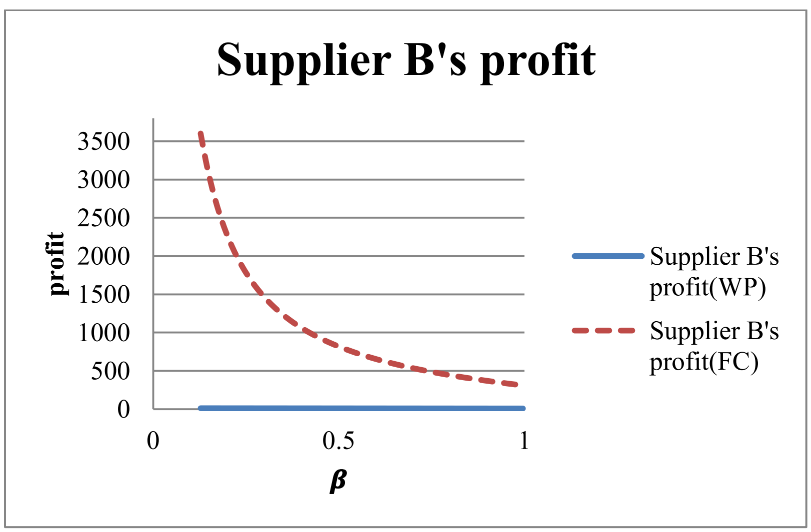

Figure 0-22 The effect of increasing own price sensitivity on Profit of Supplier B under WP and FC

A4: FS, FC vs. WP

A4.1 Scenario 1) A big Share of selling product B is given to Supplier A

A4.1.1 High price sensitivity

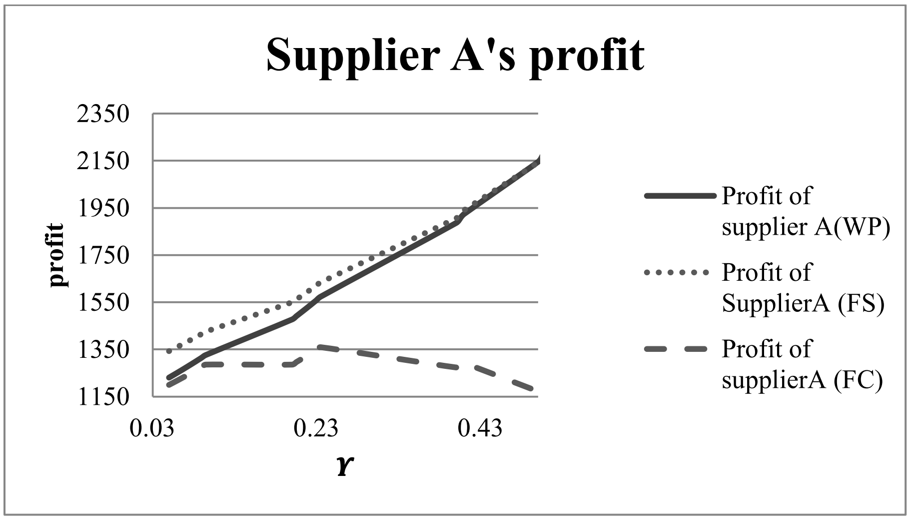

Figure 0-23 The effect of competitor's price sensitivity on supplier A's profit

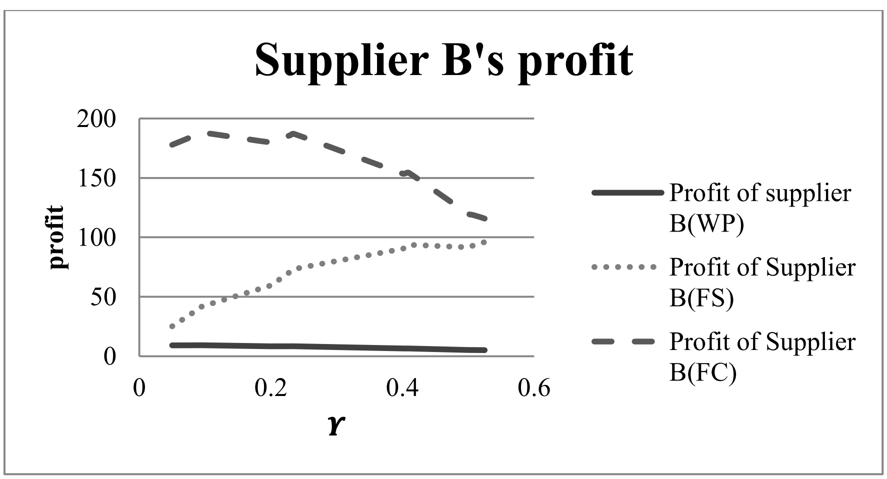

Figure 0-24 The effect of competitor's price sensitivity on supplier B's profit

A4.1.2 Low price sensitivity

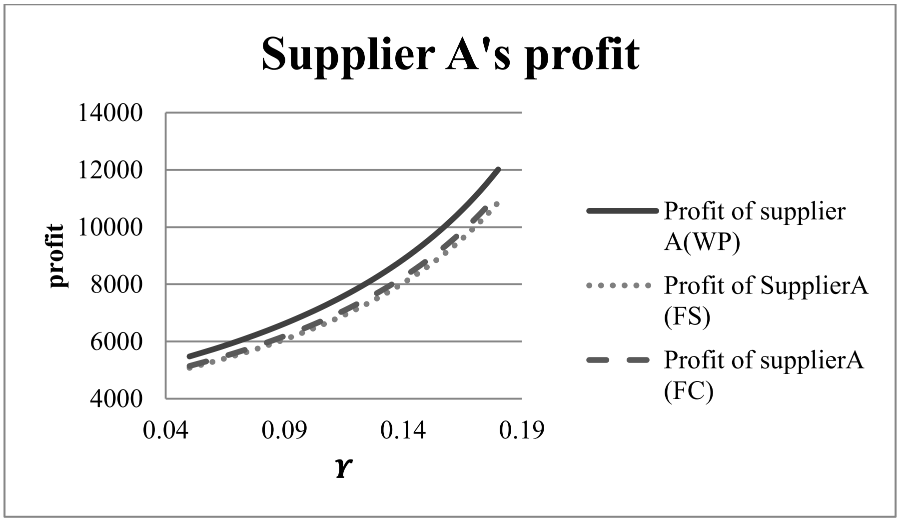

Figure 0-25 The effect of competitor's price sensitivity on supplier A's profit

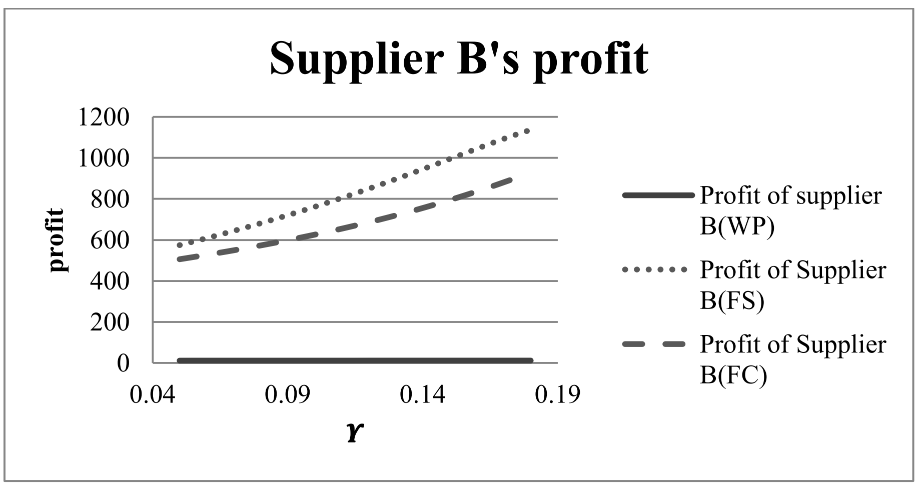

Figure 0-26 The effect of competitor's price sensitivity on supplier B's profit

A 4.2 Scenario 2) Small share belongs to supplier A

A 4.2.1 High price sensitivity

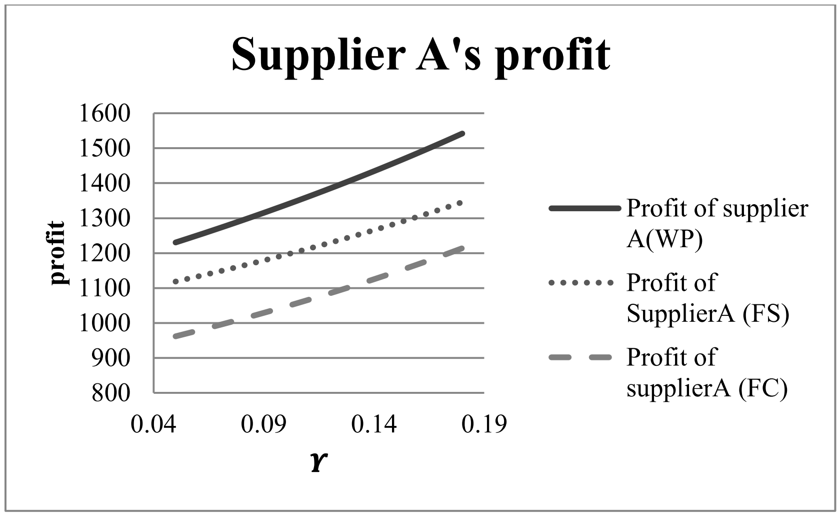

Figure 0-27 The effect of competitor's price sensitivity on supplier A's profit

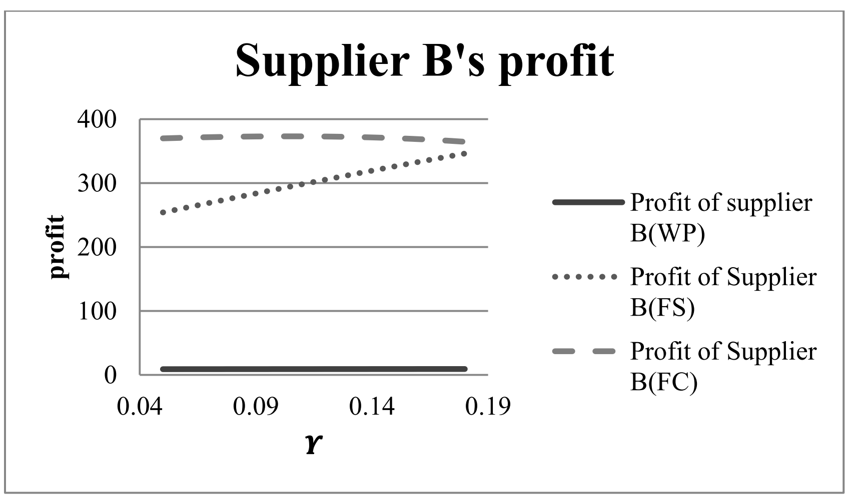

Figure 0-28 The effect of competitor's price sensitivity on supplier B's profit

A 4.2.2 Low price sensitivity

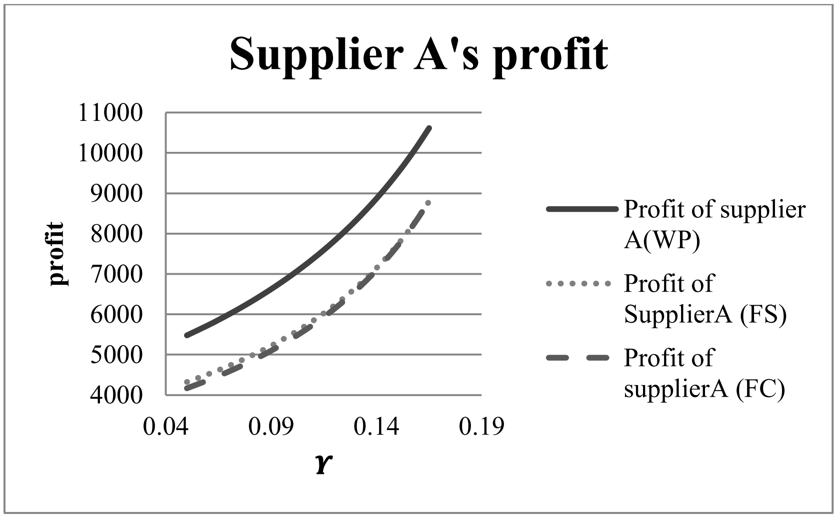

Figure 0-29 The effect of competitor's price sensitivity on supplier A's profit

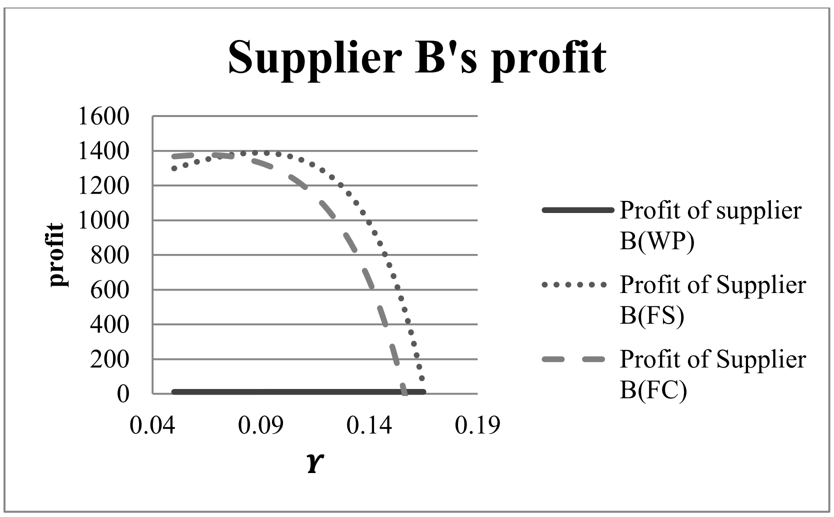

Figure 0-30 The effect of competitor's price sensitivity on supplier B's profit