Pricing and Sourcing Strategies for Competing Retailers in Supply Chains under Disruption Risk

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Highlights

- Sourcing and pricing decisions of competing retailers under supply disruption
- Game theoretic analysis of a retailer competing against a reliable supply chain
- Price adjustment as a risk contingency strategy resulting in profit improvement
- Competitive dynamics shaped by market size, procurement cost and disruption risk
- Framework derived based on combining pricing and sourcing strategies

Pricing and Sourcing Strategies for Competing Retailers in Supply Chains under Disruption Risk

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Abstract: Supply disruption has become a critical concern for businesses around the world. The extant literature has dealt with the sourcing decision for a price-taking retailer. In this paper, we study how a retailer can use pricing decisions along with sourcing strategies under disruption risk while competing against another retailer with a more reliable supply chain. The retailer uses two decision levers namely, price adjustment, and split of order between reliable but expensive supplier and/or cheap but unreliable supplier to compete in the end market. Our analyses show that the competitive dynamics is shaped by the cost structure of the players, relative market potential and disruption risk. We find that the retailer focuses on reliable supplies with less price adjustment when it enjoys procurement cost advantage and higher market potential. On the other hand, as the procurement cost advantage and market potential shifts to the competitor; the retailer opts for cheaper but risky supplies and relies on drastic price adjustments. These results have important managerial implications and provide critical guidelines for retailers involved in pricing and sourcing decisions under the threat of supply disruptions.

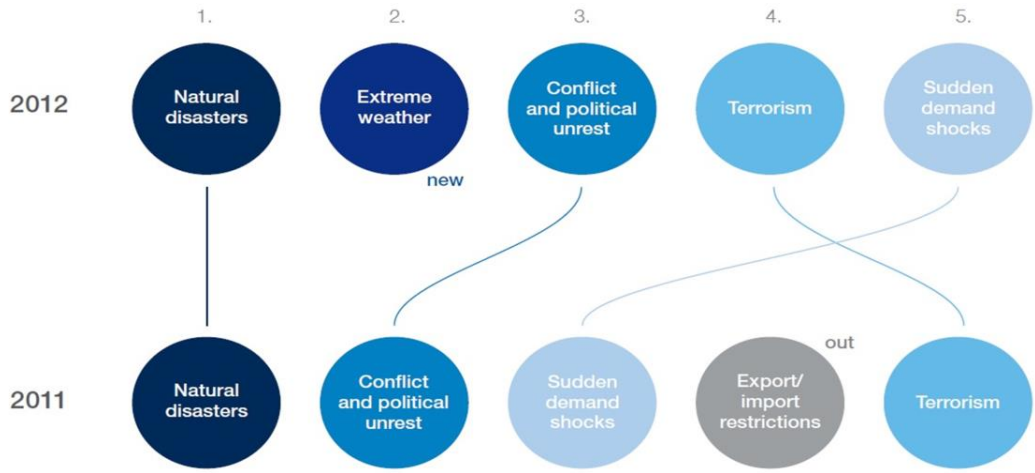
Keywords: Strategic Planning, Supply Chain Risk Management; Supply Disruption; Sourcing Strategies; Pricing Decisions

Introduction

Modern supply chains are complex networks that are spread across the globe where supply disruption risks exist in every link (Choi, Narasimhan, & Kim, 2012). A recent WEC-Accenture report (Bhatia; Lane & Wain, 2013) identifies natural disaster as primary threat followed by extreme weather, conflict and political unrest, terrorism and sudden demand shock as major causes for supply disruptions. The threat perception has changed over the years as shown in Figure 1. The report also stresses the importance of resilient supply chains. Resilience is defined as the ability of a supply chain to return to the state it was in before the disruption occurred. Reliability and resilience of suppliers are important criteria for long-term success of a retailer competing in end market. Supply disruptions often lead to lower return on sales and assets, loss of competitive advantage, market share and goodwill, which in turn impacts profitability (Hendricks & Singhal, 2005). Supply chain glitches result in higher costs and inventories with an immediate effect on revenues and market share. Supply chain glitches also cause loss of shareholders value where smaller firms are affected more than the larger firms (Hendricks & Singhal, 2003).

Sourcing has become a crucial strategic decision in mitigating supply disruption risks. Retailers/ Manufacturers often place their orders either with one supplier (single-sourcing) or two suppliers (dual-sourcing). The structure of two suppliers from different geographies is commonly used in supply chain

Figure 1: Causes of Supply Disruptions



Source: Supply Chain Risk Radar survey results. World Economic Forum, 2012.

disruption literature (Ju, Gabor, & van Ommeren, 2015; Allon & Van Mieghem, 2010; Tomlin, 2006). This assumption is used because many firms source from low-cost suppliers in developing countries. Sourcing from foreign supplier in a developing country brings cost advantages but also exposes supply chain to disruptions. Supply disruption is attributed to shipment delays, customs delays, quality problems to name a few (Fang & Shou, 2015). In recent times, firms have been adopting sourcing strategies that comprise a mix of supplies; a cheaper supplier in a developing country and a more reliable production unit near the end market. This strategy helps to hedge against potential supply disruptions and at the same time control costs. In 2009, a Hyundai manufacturing plant in India suffered a prolonged worker's strike that disrupted overall production. Following this incident, Hyundai decided to move part of their production to Europe. Till 2014, Hyundai was exporting around 45% of the cars manufactured in India to Europe. In 2014, they decided to supply car models to Europe from their plants in Turkey and Czechoslovakia.[1] Hyundai wanted a more stable supply source near the market (Europe) to compete and improve its presence in Europe.

Another phenomenon recently observed is the increase in end-market prices because of supply disruptions. In 2004, a devastating shortage of flu vaccine occurred in the US. Around 46 million doses produced by Chiron, one of the two retailers, had samples that contained bacterial infection (Yu, Zeng, &

[1] Gupta S. D. (Aug 08, 2014). As Hyundai changes strategy, India's status as auto export hub in question. *Business Standard*. Retrieved from: http://www.business-standard.com/, accessed on July 28, 2015.

Zhao, 2009). The resulting shortage of drug led to rationing and increase in prices from $60 to $800[2]. In another instance, in 2011, the tsunami that followed a massive earthquake in Japan caused disruption in global production of semiconductors. This calamity led to shortages of parts for Nikon and Canon resulting in increased prices for cameras (Fang & Shou, 2015). The price of camera spiraled because of less or no supplies from one of the two suppliers. In both the cases, the retailers suffered from supply shortages and that resulted in price rise. The lack of supplies often results in an increase in prices. This leads to an important research question: how sourcing affects the competitive dynamics in a system? Retailers often offer substitutable products in the end-market where prices determine consumers' choice. The impact of supply chain glitches on competitors and pricing as a decision variable have not been explored in detail (Hendricks & Singhal, 2003). When faced with lower supplies, retailer has an option to increase prices. However, this strategy may not be that effective if retailer is competing in the end-market. Competitors can take advantage of retailers affected by supply disruption and capture the market share. In our paper, we look at Bertrand competition between two price-setting retailers and analyse how pricing can be used as an important lever under supply disruptions. We are interested in sourcing and pricing decisions of a retailer exposed to supply disruption risk while competing in end-market. The competition is further shaped by relative procurement cost, market-potential and price-elasticity. More specifically, we look at the following research questions:

- What should be the sourcing configuration of a price-setting retailer under Bertrand competition under different consumer price elasticities when supplies are unreliable?
- How can pricing be used to maximize profit in a competitive scenario when a firm does not receive supplies from one of the suppliers and the competitor has reliable supplies?
- How is a reliable supply chain affected by the sourcing structure of a competing retailer adopting single/dual sourcing strategies?

We study two competing retailers engaged in competition in a one-period, single-product model. In present times, there are multiple instances where two firms dominate market for a product. Airbus and Boeing in the passenger aircraft market, Intel and AMD in chips for computing devices, Canon and Nikon in the digital single lens reflex (SLR) camera market are notable examples from different industries. Very often, competing firms use different set of suppliers. In case of duopoly, supply disruption at one of the firms results in little or no supply in the end-market, thus benefitting the competitor and inducing price rise of the product. In our model, both the retailers set prices that determine their end-market demand. In case of disruption, retailers have the option of charging a higher price to cover the loss due to lower supplies. In our model of two competing retailers, one of the retailers has two sourcing options; (a) cheaper but unreliable (foreign supplier), and (b) reliable but

[2] Grady D. (Oct 17, 2004). With Few Suppliers of Flu Shots, Shortage Was Long in Making. *The New York Times*. Retrieved from: http://www.nytimes.com, accessed on July 28, 2015.

more expensive (domestic supplier) and the second supplier has a reliable supply source. Song & Zipkin (1996), Tomlin (2006), Yang et al. (2012) among others, have assumed no supplies from the foreign supplier in case of disruption and we use the same assumption as well. We study the competitive dynamics between retailer and the competing retailer, who is referred as the competitor in this paper henceforth. The competitor is an integrated firm with a more reliable supply chain. We determine the cutoff probabilities for optimal sourcing strategies for the retailer. We also optimise for the prices to be charged in both the supply disruption and no disruption cases for different sourcing strategies for both the retailer and the competitor and the split of order for the retailer in case of dual-sourcing. We further define price-adjustment as a practice by retailer(s) to charge higher prices in the end market when one or more retailers receive less supplies due to supply disruption.

Competitive dynamics is shaped by the interplay between market availability, procurement cost and probability of disruption at the suppliers' end. Retailer adjusts prices and uses combination of cheaper but risky and/or expensive yet reliable sourcing to counter supply disruption risks while competing in the end-market. The broad findings are as follows: on one hand, retailer focuses on reliable supplies with less price adjustment when the procurement cost advantage and higher market potential is with the retailer; on the other, as the procurement cost advantage and market potential shifts to the competitor, retailer opts for cheaper but risky supplies and relies on drastic price adjustments. The competitor's profit function follows a non-monotonic relation with the probability of disruption of the retailer's supplies.

The remainder of the paper is arranged as follows. Section 2 provides a brief review of the literature. Section 3 describes the analytical models. Sections 4, 5 and 6 provide a theoretical analysis of the models. Section 7 provides a detailed numerical analysis and results. In section 8, detailed discussion and conclusion of the paper with possible future research directions have been outlined.

2. Literature Review

Our present work draws upon three streams of literature: sourcing strategies, supply disruption risk management and competitive dynamics in supply chains under disruptions.

There is an extensive literature on sourcing strategies. The literature on sourcing strategies identifies three types of strategies based on the number of suppliers from whom the buyer would source, who are selected from among many qualified suppliers: (1) single sourcing, (2) dual-sourcing and (3) multiple sourcing. Single sourcing has several disadvantages. Yu et al.(2009) mention that dependence on single source exposes the buying firm to greater risk. Minner (2003) highlights the importance of multiple sourcing to counter the risk of exchange rate volatility, supply disruptions due to machine breakdown, labour strikes or political instability. Burke et al. (2007) report that single sourcing is optimal when the supplier capacity is more than the total demand. The retailer is not able to take advantage of diversification benefits when supplier capacity is large. In all other cases, multiple sourcing

is optimal. We refer the readers to Bozarth, Handfield, & Das (1998) and Yu et al.(2009) and references therein for a comprehensive review of the evolution of sourcing strategies.

Supply Chain Risk Management (SCRM) literature and specifically supply disruptions has been categorized into three broad areas, (1) yield uncertainty i.e., the difference between the order placed and the order received, (2) lead-time uncertainty and (3) supplier disruption where supplier will supply either the full order in case of no disruption and nothing in case of disruption (Fang & Shou, 2015). Yano & Lee (1995) provide a comprehensive review of the yield uncertainty literature. They look at the split of order between two suppliers in case of varying yield uncertainty and cost differentials. Anupindi & Akella (1993), Gerchak & Parlar(1990), Parlar & Wang (1993), Deo & Corbett, (2009) & Fang & Shou (2015) are some significant research works where the authors have used yield uncertainty model. The supplier disruption model is widely used in the dual sourcing literature. Parlar & Berkin (1991), Snyder & Shen (2006), Song & Zipkin (1996), Tomlin (2006), Yang, Aydin, Babich, & Beil(2009) & Yu et al.(2009) have made significant contribution to this stream of research. Gupta, He, & Sethi (2015) studied the impact of disruption on competing retailers. Their main focus was on the timing of order and capacity reservations as risk mitigation options. The industry examples that motivate the research in this paper are closest to the third area of SCRM. Tomlin (2006) discusses the difference between risk mitigation and contingency strategies. Yang, Aydin, Babich, & Beil (2012) develop a model where supplier reliability is private information and supplier can either choose to opt for backup production or pay a penalty. They use mechanism design to select which supplier to source from while factoring in the trade-off between the expensive backup option and supplier reliability. Wang, Gilland, & Tomlin (2010) compare the benefits of dual sourcing and process improvement. In case of random capacity, it is more beneficial to invest in process improvement than dual sourcing for low cost difference between the suppliers. It is better to invest in dual sourcing than process improvement when the difference in reliability is high. For random yield, dual sourcing and process improvement are favoured under high cost and reliability differences respectively.

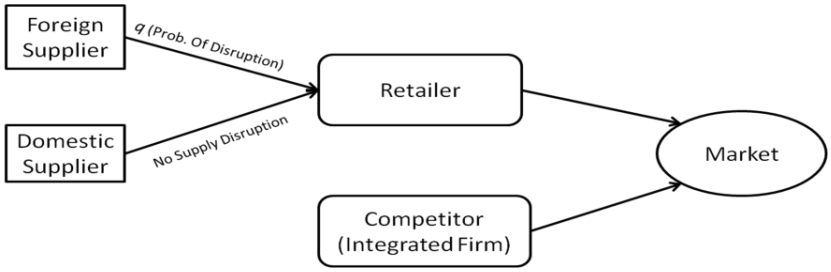
Most of the papers in disruption literature have looked at supplier competition, and only a few have studied retailers' competition. Babich et al. (2007) discuss the effect of competing suppliers in case of one buyer. They derive that the buyer can extract more profit with an increased correlation of suppliers' default risks, and suppliers will extract more profit if their default risk has a negative correlation. Deo & Corbett (2009) model the supplier decision to enter a market under Cournot competition between existing suppliers in the face of yield uncertainty in the production process. Qi, Shi, & Xu (2015) investigate the effect of supplier's competition when suppliers are competing on pricing and reliability. One of the findings is that the supplier should go for high wholesale price and reliability. All the papers mentioned above are mainly about the supplier's competition. Tang & Kouvelis (2011) were one of the first to model retailers' competition in the face of suppliers with varying yield uncertainty. They use yield uncertainty as an exogenous variable. Further, they use Cournot game setting to analyse the implications of dual sourcing and diversification and the implications it has on

retailer's profit. Chen & Guo (2013) looked at retailer competition in the presence of supply uncertainty. They look at sourcing as a more strategic choice when there is a common supplier. Their paper mainly focuses on the optimality of different sourcing strategies namely single and dual sourcing in the presence of yield uncertainty for competing retailers. He, Huang, & Yuan (2015) also looked at the pricing and ordering decision for competing retailers in the presence of supply disruption. They use a common supplier and spot market for the competing retailer. They compute a reliability threshold value to decide on the sourcing option. Fang & Shou (2015) compare the value of centralization on retailer's competition in case of yield uncertainty of supplier. The decision between single sourcing and dual sourcing has been explored in case of a price-taking retailer. We look at these decisions in the face of competing retailers. We use Bertrand game as we model price as a decision variable and price adjustment strategies to cope with supply shortages due to disruptions. We further examine how difference in procurement costs impact the competitive dynamics amongst retailers under supply disruption. To the best of our knowledge, our paper is one of the first attempts at modeling pricing as a decision variable under the risk of supply disruption in a duopoly where one of the retailers chooses an optimal pricing and sourcing strategy to compete with another firm that has a more reliable supply source.

3. Model and Analyses

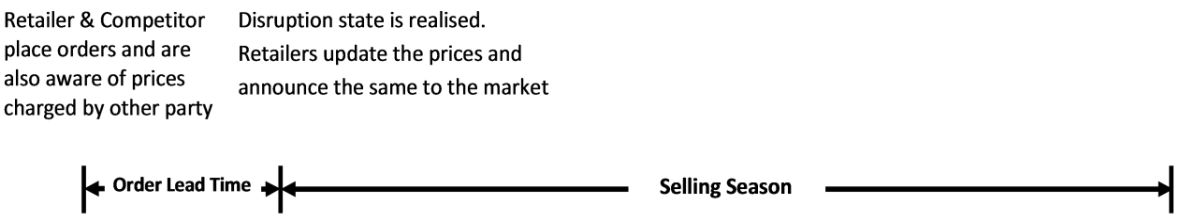
We study a duopoly market in a single period setting, where one of the retailers (R) has two suppliers, one low cost, but unreliable foreign supplier, and another expensive but reliable domestic supplier. The foreign supplier has a 'q' probability of disruption and will not supply anything in case of disruption. This assumption implies that orders are received from the foreign supplier in bulk at the beginning of the selling horizon and not in batches during the selling season. Hence, disruption results in no supplies from the foreign supplier. The domestic supplier is reliable and faces no supply disruption risks. The other competing retailer (referred to as competitor, C) is an integrated firm that produces the product internally and is not exposed to supply disruptions. This assumption is important when a retailer attempts to understand the implication of single sourcing vis-a-vis dual-sourcing when competing against a reliable supply chain. All parties are assumed to be risk-neutral, and there is no information asymmetry. The cost of procurement from the different suppliers and the realised state of supplies from the foreign supplier is known to both the retailers. Procurement cost for a retailer from a supplier would mean the total direct cost per unit incurred by the retailer in acquiring the product. The procurement cost will include the sum of purchase cost, logistics cost, handling and labor costs for acquiring the product (He et al., 2015; Inderfurth, Kelle, & Kleber, 2013). Also, the competitor can ramp up its supplies if required and cater to market demand within a very short lead time. The suppliers do not have capacity constraints. The model is depicted pictorially in Figure 2.

Figure 2: Pictorial representation of the Model



The timeline of the events is shown in Figure 3. The retailer, conscious of the prices that would be charged by the competitor, decides on the sourcing strategy considering the probability of disruption of her foreign supplier. On similar lines, the competitor also decides on her prices and produces the goods. When the disruption status is realised, both the retailers update their prices and announce that in the market. In case of disruption, the competitor determines the additional quantity to be supplied in the market and delivers it with an updated price.

Figure 3: Timeline of events



We have assumed a linear price-dependent demand structure. This demand structure has been widely used in academic literature, notably by Anderson & Bao (2010), Deo & Corbett (2009) and Dixit (1979) among others.

Demand:

$$D_1 = a_1 - b_1 p_1 + p_2$$
$$D_2 = a_2 - b_2 p_2 + p_1$$

where, a_1 and a_2 are the market potential of the retailer and the competitor, respectively, and b_1 and b_2 are own price elasticities of the retailer and the competitor, respectively. Following practice, we assume cross-price elasticity to be one. We also assume own-price elasticity is greater than cross-price elasticity, i.e., $b_1, b_2 > 1$ as used in the papers by Anderson & Bao(2010), Biswas, Avittathur, & Chatterjee (2016). Prices set by the retailer and the competitor are denoted by p_1 and p_2, respectively.

It is interesting to study, the sourcing configuration of a retailer when she is competing against a more reliable supply chain. The problem analysis is from a game theoretic perspective to understand the dynamics of the pricing decision under supply disruption in a duopoly setting. Please refer to Table 1 for all the notations and variables used in the analytical models.

Table 1*:* Notations and Variables

$P^{j}_{j,k}$	Prices Charged in $i = \begin{cases} SF - Single\ sourcing\ from\ Foreign\ supplier, \\ SD - Single\ sourcing\ for\ Domestic\ supplier, \\ DS - Dual\ sourcing \end{cases}$ by, $j = \begin{cases} R = Retailer, \\ C = Competitor \end{cases}$ in cases of $k = \begin{cases} N = No\ disruption\ scenario, \\ D = Disruption\ scenario \end{cases}$
c_1	Cost per unit of Foreign supplier
c_2	Cost per unit of Domestic supplier
c	Per unit cost of manufacturing for the competitor
q	Probability of disruption of Foreign supplier $0 < q < 1$
α_l	The split of order to Foreign supplier in dual sourcing for case l = 1, 2 and 3. Also, $0 \le \alpha_i \le 1$, $\alpha_l = 1$ implies SF and $\alpha_l = 0$ implies SD
$\pi^{i}_{l,j}$	Expected profit in case l for player j for sourcing strategy i where l denotes the different cases based on differences in procurement cost structure of the retailer and the competitor

We also assume that the demand will be positive in case the retailer was offering a product at price c_1 and c_2 in case it was a monopolist, i.e., $a_1 - b_1 c_2 > 0$. This also implies that the expression will be positive for c_1 as $c_1 < c_2$.

In case of dual sourcing, the orders are placed with both the suppliers, i.e., $0 < \alpha_l < 1$. Also, the subscript l is used to represent three different procurement cost structures of the retailer with respect to the competitor. We discuss the cases in detail in subsequent sections. Next, we present the profit functions of both the players.

3.1 Expected Profit Functions Under Different Sourcing Strategies

The retailer has three different strategies at her disposal. She can go for single sourcing from either the foreign supplier or the domestic supplier, and dual sourcing. The profit functions of the retailer and the competitor under the three different sourcing strategies are described below:

3.1.1 Single sourcing from Foreign Supplier

In case of single sourcing from the foreign supplier, the retailer will not be able to deliver anything to the market if disruption occurs at the foreign supplier. The expected profit function of the retailer, in this case, will be:

I. $$\pi_{l,R}^{SF} = (1-q)(P_{R,N}^{SF} - c_1)(a_1 - b_1 P_{R,N}^{SF} + P_{C,N}^{SF})$$

The expected profit function of the competitor will be:

$$\pi_{l,C}^{SF} = (1-q)(P_{C,N}^{SF} - c\ )(a_2 - b_2 P_{C,N}^{SF} + P_{R,N}^{SF}) + q(P_{C,D}^{SF} - c)(a_2 - b_2 P_{C,D}^{SF} + P_{R,D}^{SF})$$

3.1.2 Single sourcing from Domestic Supplier

In case of single sourcing from the domestic supplier, the retailer gets assured supplies and her profit function will be:

II. $$\pi_{l,R}^{SD} = (P_{R,N}^{SD} - c_2)(a_1 - b_1 P_{R,N}^{SD} + P_{C,N}^{SD})$$

The profit function of the competitor will be:

$$\pi_{l,C}^{SD} = (P_{C,N}^{SD} - c)(a_2 - b_2 P_{C,N}^{SD} + P_{R,N}^{SD})$$

3.1.3 Dual Sourcing

In this case, the retailer places orders with both the suppliers. In the event of a disruption, she will only receive the order she placed with the domestic supplier. Hence, in case of disruption, supplies will be constrained by the fraction of the order that was placed with only the domestic supplier. Also, prices charged in case of disruption and no disruption will be different and will be based on the supplies received in each of the cases.

The objective function of the retailer will be:

$$\pi_{l,R}^{DS} = (1-q)\left[P_{R,N}^{DS} - \alpha_l c_1 - (1-\alpha_l)c_2\right](a_1 - b_1 P_{R,N}^{DS} + P_{C,N}^{DS}) + q(P_{R,D}^{DS} - c_2)(a_1 - b_1 P_{R,D}^{DS} + P_{C,D}^{DS})$$

III. *s.t.*,

$$(1-\alpha_l)(a_1 - b_1 P_{R,N}^{DS} + P_{C,N}^{DS}) \geq (a_1 - b_1 P_{R,D}^{DS} + P_{C,D}^{DS})$$

The expected profit function of competitor will be:

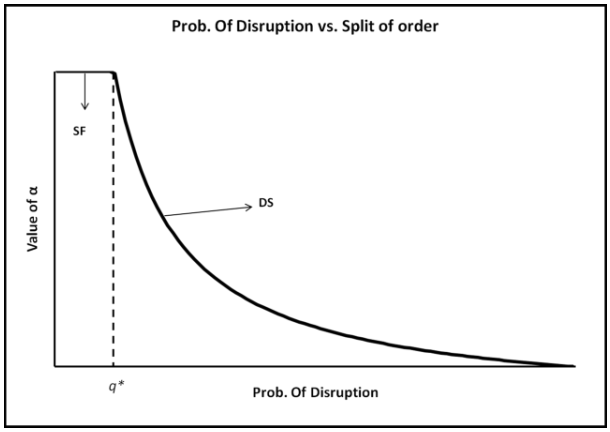
$$\pi_{l,C}^{DS} = (1-q)(P_{C,N}^{DS} - c)(a_2 - b_2 P_{C,N}^{DS} + P_{R,N}^{DS}) + q(P_{C,D}^{DS} - c)(a_2 - b_2 P_{C,D}^{DS} + P_{R,D}^{DS})$$

Proposition 1. The expected profit functions in I, II and III are concave in retailer's prices for given value of competitor's prices and vice-versa.

Proof: See Appendix A.

For notational simplicity, $\alpha_l = 1$ will denote SF. This helps us in establishing the continuity of the value of α_l. For low values of q, we find SF to be the dominant strategy. At $q = q^*$, which we define as the critical probability, the retailer moves from SF to DS. This critical probability q^* differs based on the difference in the procurement cost structure. We also find that α_l is non-increasing in the probability of supply disruption. The properties of q^* has been explored in details in the subsequent sections. How the optimal sourcing strategy changes with q^* is represented diagrammatically in Figure 4.

Figure 4: Probability of Disruption vs. Split of Order to Foreign Supplier



The retailer has three sourcing strategies viz. single sourcing from domestic supplier (SD), single sourcing from foreign supplier (SF) and dual sourcing (DS), as mentioned above while competing against a retailer with a more reliable supply chain. The competitor may have different cost structure. Under the game theoretic dynamics, in a Stackelberg game, cost efficiency determines who acts as a leader in the decision making process. A firm with sufficient cost advantage gets a first-mover advantage in a duopoly (Amir & Stepanova, 2006). In their paper, van Damme & Hurkens (1999) argued that in a linear duopoly game, the firm with low cost will emerge as a leader in a Stackelberg game. This results in three cases based on the competitor's procurement cost: (i) the competitor's procurement cost is less than the retailer's cost of procuring from the foreign supplier, (ii) the competitor's procurement cost lies

between the retailer's cost of procuring from the foreign supplier and the domestic supplier and (iii) the competitor's procurement cost is more than the retailer's cost of procuring from the domestic supplier.

The first scenario leads to the competitor being the Stackelberg leader. Both the retailers go for a simultaneous move game in the second case and in the third case the retailer is the Stackelberg leader. In subsequent sections, a detailed analysis of the three cases mentioned above has been provided.

4. Competitor as Stackelberg Leader

In this case, $c < c_1 < c_2$, $c_1 = c + \beta_1, c_2 = c + \beta_1 + \beta_2$ where $\beta_1 \,\&\, \beta_2 > 0.$

Since, the competitor is more efficient in terms of the procurement cost; it acts as a Stackelberg leader. The retailer will optimize her profit function considering the prices of the competitor as given and based on the results obtained by the retailer; the competitor will optimise her profit function. The summary of the results can be found in Table 2 below. We have provided all the proofs in Appendix B.

Lemma 1: The expected profit function in case of dual sourcing can be optimized jointly for split of order, prices to be charged under normal and disruption cases for $q_1^* < q < 1$ where $q_1^* = \dfrac{b_1\beta_2(4b_1b_2 - 3)}{(2a_2b_1 - c - a_1 + 3b_1c_1 + 2b_1b_2(2a_1 + c) - 4b_1^2b_2c_1)}$ denotes the probability of disruption at which the retailer switches to DS from SF.

Proposition 2: The expected profit function of the retailer, when the competitor is Stackelberg leader, is optimised for the unique prices and split of order as mentioned below in Table 2. Also, the optimal value of dual variable for the constraint in case of dual sourcing of the retailer is $\mu_1^* = (1-q)\beta_2.$

Table 2: Optimum values of Prices and Split of Order for Case I

Strategy	Retailer		
	$P_{R,N}$	$P_{R,D}$	α
SF	$P_{R,N}^{SF} = \frac{(a_1 + P_{C,N}^{SF*} + b_1 c_1)}{2b_1}$	$P_{R,D}^{SF} = \frac{a_1 + P_{C,D}^{SF*}}{b_1}$	1
DS $For\ q_1^* \le q \le 1$	$P_{R,N}^{DS} = \frac{a_1 + b_1 c_1 + P_{C,N}^{DS*}}{2b_1}$	$P_{R,D}^{DS} = \frac{b_1\beta_2 + q(a_1 + P_{C,D}^{DS*} + b_1 c_1)}{2qb_1}$	$\alpha_1 = \frac{b_1\beta_2 - q(P_{C,D}^{DS*} - P_{C,N}^{DS*})}{q(a_1 - b_1 c_1 + P_{C,N}^{DS})}$

Table 2a

Strategy	Competitor	
	$P_{C,N}$	$P_{C,D}$
SF	$P_{C,N}^{SF*} = \frac{\upsilon}{2(2b_1 b_2 - 1)}$	$P_{C,D}^{SF*} = \frac{(a_1 - c + b_1 a_2 + b_1 b_2 c)}{2(2b_1 b_2 - 1)}$
DS $For\ q_1^* \le q \le 1$	$P_{C,N}^{DS*} = \frac{\upsilon}{2(2b_1 b_2 - 1)}$	$P_{C,D}^{DS*} = \frac{b_1\beta_2 + q\upsilon}{2q(2b_1 b_2 - 1)}$

Table 2b

where $\upsilon = a_1 - c + 2b_1 a_2 + b_1 c_1 + 2b_1 b_2 c$

In case of DS, the dual variable is equal to the product of the probability of no disruption and difference of the cost between the two suppliers. It is independent of the cost difference between the foreign supplier and competitor's procurement cost.

Corollary 1: The critical probability q_1^* and its relation to model parameters are as follows:

i. q_1^* is increasing in β_1 & β_2 and b_1 & b_2.

ii. For fixed market size, where, $a_1 + a_2 = M$, q_1^* is increasing in a_2 and decreasing in a_1.

iii. For a given market size of the competitor, q_1^* is decreasing in both a_2 & a_1.

The above corollary implies that when the retailer is at a severe cost disadvantage compared to the competitor, the retailer should go for single sourcing from the foreign supplier as she cannot go for the expensive domestic supplier. The corollary also brings forward an interesting point regarding market potential for each of the players. With increasing market potential for the retailer, the focus is on reliable supplies and hence DS is the chosen option. When the overall market potential is fixed, an increase in the competitor's market potential leads to an increase in the critical probability implying a shift towards SF. This happens because with fixed market size, the retailer needs to supply at a lower

price to gain market share and hence is forced to go with cheaper foreign supplier even though it is unreliable.

However, if the overall market increases with increase in the competitor's market potential, then the critical probability decreases with the competitor's market potential and in turn the retailer opts for DS. With increasing market potential of the competitor which leads to overall increase in the market, the retailer moves towards reliable supplies in order to hold on to her market potential.

5. Simultaneous-Move Game

When $c_1 < c < c_2$, $c = c_1 + \delta_1, c_2 = c_1 + \delta_1 + \delta_2$ where $\delta_1, \delta_2 > 0$

The competitor procures at cost 'c'that lies between the cost incurred by the retailer while procuring from the foreign and domestic supplier respectively. The retailer can create a supply portfolio where the cost of procurement can be less than or greater than 'c'. This results in a scenario wherein no player has a clear-cut cost advantage. This scenario will further result in a simultaneous move game between the retailers. We have compiled the results in Table 3. The proof for all the strategies can be found in Appendix C.

Lemma 2: The expected profit function in case of dual sourcing can be optimized jointly for split of order and prices charged in normal and disruption cases for $q_2^* < q < 1$ where, $q_2^* = \dfrac{(\delta_1 + \delta_2)(2b_1b_2 - 1)}{(a_2 + c_1 + 2a_1b_2 + b_2c - 2b_1b_2c_1)}$, denotes the probability of disruption at which the retailer switches to DS from SF.

Proposition 3: The expected profit functions of the retailers in the simultaneous move game will be optimised for the unique value of prices and split of order as mentioned below in Table 3. The optimal value of dual variable for the constraint in dual sourcing is $\mu_2^* = (1-q)(\delta_1 + \delta_2)$.

Table 3: Optimum values of Prices and split of Order for Case II

Strategy	Competitor	
	$P_{C,N}$	$P_{C,D}$
SF	$P_{C,N}^{SF*} = \frac{\omega}{4b_1b_2 - 1}$	$P_{C,D}^{SF*} = \frac{a_1 - c + a_2b_1 + b_1b_2c}{2(b_1b_2 - 1)}$
DS $For\ q_2^* \le q \le 1$	$P_{C,N}^{DS*} = \frac{\omega}{4b_1b_2 - 1}$	$P_{C,D}^{DS*} = \frac{b_1(\delta_1 + \delta_2) + q\omega}{q(4b_1b_2 - 1)}$

Table 3a

Strategy	Retailer		
	$P_{R,N}$	$P_{R,D}$	α
SF	$P_{R,N}^{SF*} = \frac{\lambda}{(4b_1b_2 - 1)}$	$P_{R,D}^{SF} = \frac{a_1 + P_{C,D}^{SF*}}{b_1}$	1
DS $For\ q_2^* \le q \le 1$	$P_{R,N}^{DS*} = \frac{\lambda}{(4b_1b_2 - 1)}$	$P_{R,D}^{DS*} = \frac{2b_1b_2(\delta_1 + \delta_2) + q\lambda}{q(4b_1b_2 - 1)}$	$\alpha_2^* = \frac{q_2^*}{q}$

Table 3b

Where, $\lambda = a_2 + 2a_1b_2 + b_2c + 2b_1b_2c_1$

$$\omega = a_1 + 2a_2b_1 + b_1c_1 + 2b_1b_2c$$

$$q_2^* = \frac{(\delta_1 + \delta_2)(2b_1b_2 - 1)}{(a_2 + c_1 + 2a_1b_2 + b_2c - 2b_1b_2c_1)}$$

Corollary 2: The critical probability q_2^* and its relation to model parameters are as follows:

i. q_2^* is increasing in δ_1 & δ_2 and b_1 & b_2.

ii. For fixed market size, where, $a_1 + a_2 = M$, q_2^* is increasing in a_2 and decreasing in a_1.

iii. For a given market potential of the competitor, q_2^* is decreasing in both a_2 & a_1.

The above results are on similar lines to the results obtained in Corollary 1. When there is no significant cost advantage to any of the parties, the retailer goes for single sourcing from the foreign supplier in order to lower her procurement cost as she competes directly on pricing with the competitor. We obtain trends similar to what was observed in the previous case with changing market availability.

6. Retailer as Stackelberg Leader

When $c_1 < c_2 < c$, $c_2 = c_1 + \gamma_1, c = c_1 + \gamma_1 + \gamma_2$ where $\gamma_1, \gamma_2 > 0$

Here, the retailer is more efficient in terms of her procurement cost than the competitor. This cost structure results in the retailer assuming the role of a Stackelberg leader. We have assumed that even in the presence of a reliable domestic supplier that is supplying to the retailer at a price c_2, the competitor is procuring at a price higher than that. At times, the production is handled by the ancillary unit of the parent company. This brings the benefit of reliability and control over the production. The downside may be the higher cost. Disposing of an existing costlier production plant is not easy owing to controls on mass layoffs and opposition from labour. The parent company, in that case, ends up procuring at a higher price even when an alternate cheaper option is available. The results have been presented in Table 4 below. The proof of all the results can be found in Appendix C.

Lemma 3: The expected profit function in case of dual sourcing can be optimized jointly for split of order, prices charged under normal and disruption cases for $q_3^* < q < 1$ where, $q_3^* = \dfrac{\gamma_1(2b_1b_2 - 1)}{(a_2 + c_1 + 2a_1b_2 + b_2c - 2b_1b_2c_1)}$, denotes the probability of disruption at which the retailer switches to DS from SF.

Proposition 4: The expected profit in case of Retailer as SL can be optimised for the unique value of prices and split of order as summarised below in Table 4. Dual variable for the constraint in dual sourcing is $\mu_3^* = (1-q)\gamma_1$.

Table 4: Optimum value of Prices and split of Order for Case III

Strategy	Retailer		
	$P_{R,N}$	$P_{R,D}$	α
SF	$P_{R,N}^{SF*} = \frac{\tau}{2(2b_1b_2-1)}$	$P_{R,D}^{SF*} = \frac{a_1 + P_{C,D}^{SF*}}{b_1}$	1
DS $For\ q_3^* \le q \le 1$	$P_{R,N}^{DS*} = \frac{\tau}{2(2b_1b_2-1)}$	$P_{R,D}^{DS*} = \frac{\gamma_1(2b_1b_2-1)+q\tau}{2q(2b_1b_2-1)}$	$\alpha_3^* = \frac{q_3^*}{q}$

Table 4a

Strategy	Competitor	
	$P_{C,N}$	$P_{C,D}$
SF	$P_{C,N}^{SF} = \frac{(a_2 + b_2c + P_{R,N}^{SF*})}{2b_2}$	$P_{C,D}^{SF*} = \frac{(a_1 - c + b_1a_2 + b_1b_2c)}{2(2b_1b_2-1)}$
DS $For\ q_3^* \le q \le 1$	$P_{C,N}^{DS} = \frac{(a_2 + b_2c + P_{R,N}^{DS*})}{2b_2}$	$P_{C,D}^{DS} = \frac{(a_2 + b_2c + P_{R,D}^{DS*})}{2b_2}$

Table 4b

Where $\tau = a_2 - c_1 + 2a_1b_2 + b_2c + 2b_1b_2c_1$

$$q_3^* = \frac{\gamma_1(2b_1b_2-1)}{(a_2 + c_1 + 2a_1b_2 + b_2c - 2b_1b_2c_1)}$$

Corollary 3: The critical probability q_3^* and its relation to model parameters are as follows:

i. q_3^* is increasing in γ_1, b_1 & b_2 but it is decreasing in γ_2.

ii. For fixed market size, where, $a_1 + a_2 = M$, q_3^* is increasing in a_2 and decreasing in a_1.

iii. For a given market potential of the competitor q_3^* is decreasing in both a_2 & a_1.

The results are similar to the ones obtained in the previous two cases except for the relationship of q_3^* with γ_2. We find that with increasing difference in the cost of procurement from the domestic supplier and the competitor's procurement cost, dual sourcing becomes the dominant strategy for a larger range of the values of probability of disruption. With increasing γ_2, it is profitable for the retailer to go with dual sourcing and place larger orders with the reliable domestic supplier as the competitor is

stuck with procurement costs that are even higher than the retailer's cost of procuring from the domestic supplier.

SF strategy is driven by cost minimization objectives and is used more often as a sourcing strategy. The retailers opt for the cheaper supplier and it exposes them to supply risk. The other two sourcing strategies namely, Single Domestic (SD) and Dual Sourcing (DS) are driven by risk mitigation objectives. We use the expected profit in case of SF for the retailer as a benchmark and compare the subsequent profit change in case of other sourcing strategies. The next proposition outlines the optimality of sourcing strategies for a given value of probability of disruption.

Proposition 5: The SF is dominant strategy over SD for q less than q*. The dual sourcing is dominant strategy for the value of q above q*. SD is a dominant strategy only at $q = 1.$

i. For $0 \le q \le q_l^*$, $\pi_{l,R}^{SF} \ge \pi_{l,R}^{SD}$

ii. For $q_l^* < q < 1, \pi_{l,R}^{DS} \ge Max(\pi_{l,R}^{SF}, \pi_{l,R}^{SD})$; where $l = 1, 2 \& 3.$

We have defined critical probabilities of disruption of the foreign supplier that determine the sourcing configuration for the retailer when competitor's cost falls in three different categories. In the next section, we compare the profits for the retailer and the competitor under two scenarios: first when there is no price update in case of supply disruption and second when prices are updated. The results provide useful insights that justify the price updating decision.

7. Numerical Analysis

In this section, we report the results obtained from detailed numerical analysis. The analysis provides further insights into the analytical results obtained. We have run our models for various input parameters. However, for expositional brevity, we report the results for the following dataset. We take market potential $a_1 = a_2 = 1.0$ and $b_1 = b_2 = 1.1$. The value of c_1 has been taken to be 0.33 and value of c_2 has been taken as 0.66. The value of q has been taken as 0.25.

7.1 The Profit Function in case of different values of Competitor's Procurement Cost

Here we study the retailer's and the competitor's profit under the three different cost structures that arise due to difference in the procurement cost of the competitor compared with the retailer. The different cost structures have been discussed in detail in sections 4, 5 and 6 (Case I, II and III). In Figure 5a and 5b, the value of c_2 is 0.66 and 0.50 respectively to understand the trend in the results for two values of the competitor's procurement cost. The maximum profit made by the retailer (solid line) and the corresponding aggregate profit of the retailer and competitor (dashed line) across the three strategies, is shown in the graphs below.

Figure 5: Competitor's Procurement Cost vs. Retailer's Profit & Total Profit

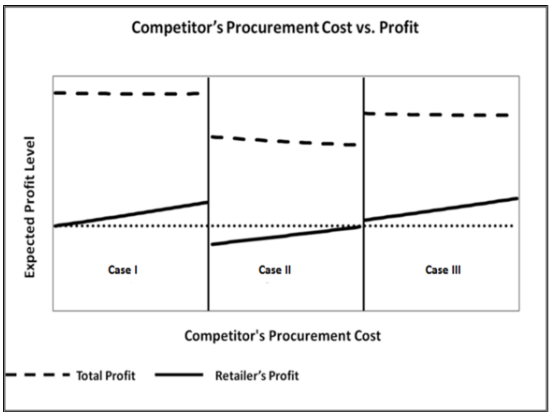


Figure 5a: Competitor's Procurement cost=0.66

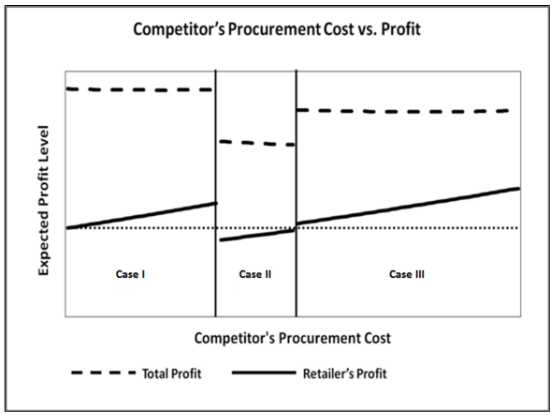


Figure 5b: Competitor's Procurement cost=0.50

The retailer, as well as the competitor, makes the least profit in case of the simultaneous move game. In Bertrand competition, the reaction function is increasing in nature, hence, the retailer (or the competitor) makes the maximum profit when it acts as a Stackelberg leader, followed by the case when the retailer (or the competitor) acts as Stackelberg follower and the least profit is made in a simultaneous move game (Gal-or, 1985; Hamilton & Slutsky, 1990). From the above graphs, we can conclude that the simultaneous move game is clearly not advantageous to either the retailer or the competitor. The retailer makes the maximum profit in Case III where her procurement cost is lower than that of the competitor. Therefore, strategically to minimize the region for Case II, the retailer should try to lower her procurement cost from the domestic supplier. This is highlighted in Figure 5(b) where the region for Case II is decreased by lowering the value of c_2 from 0.66 to 0.50.

7.2 Prices and Demand under No- Disruption and Disruption for different values of Competitor's Procurement Cost

In this section, we report the analysis of the prices charged by the retailer and the competitor under normal as well as disruption and the total supplies in the market under different scenarios given by the cost structures that arise due to the difference in the procurement cost of the competitor compared with the retailer. In Figure 6a, we analyze the prices charged by the retailer and the competitor under no supply disruption. The retailer uses dual sourcing in all the three cases. In Case I, the cost differential between the competitor's and the retailer's procurement cost is not that high. As the cost differential decreases, with increasing procurement cost of the competitor, the retailer starts procuring more from the domestic supplier and reduces her prices to capture the competitor's market share.

Figure 6: Competitor's Procurement Cost vs. Prices (6a and 6b) and Total Supplies (6c)

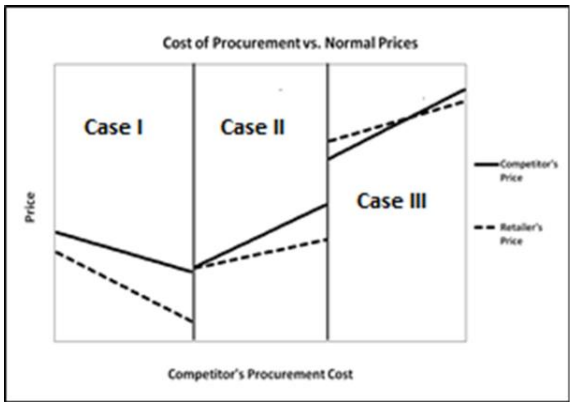


Figure 6a

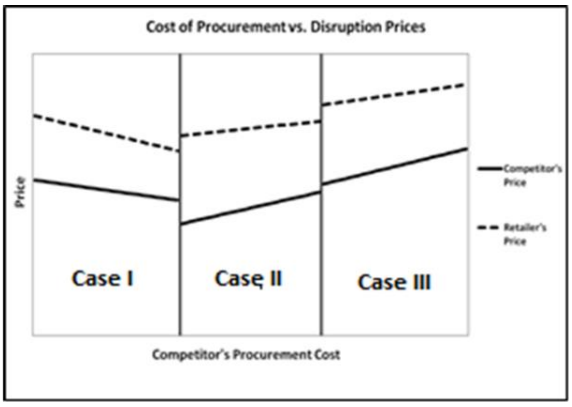


Figure 6b

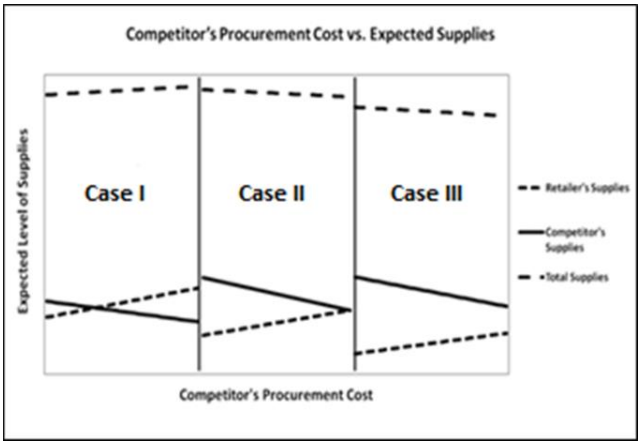


Figure 6c

The competitor, in turn, is also forced to charge a lower price. However, the decrease in prices for the retailer is much steeper than the competitor as the competitor still enjoys a cost advantage in this case.

In Case II, the cost differential between the retailer and the competitor is negligible, since the procurement cost of the competitor lies between the foreign and domestic procurement cost of the retailer. Now, as the procurement cost of the competitor increases (in Case II), the competitor is forced to charge a higher price. In this case, the competitor cannot lower the price and increase her profit because the cost advantage that she had over the retailer in Case I is not available here. The retailer, in turn, increases the order quantities placed with the domestic supplier to take advantage of the reliable sourcing option even if the cost is higher as the competitor loses its cost advantage. In this scenario, the cost of procurement for both the competitor as well as the retailer increases. Hence, the retailer must also increase her prices to maintain profit levels.

In Case III, the procurement cost for the competitor is maximum vis-à-vis Case I and II. Therefore, in this scenario, the retailer increases the share of its supplies from the domestic supplier.

This makes the retailer's supplies more reliable but enhances the cost of procurement. Hence, in this case, both the prices charged by the competitor as well as the retailer increases significantly.

Similar price movements are observed in case of prices under supply disruption. Here, the prices charged by the competitor is considerably lower in all the cases than that of the retailer because the competitor enjoys a more reliable supply chain and is not facing any supply disruptions. Any disruption at the retailer's end results in an advantageous outcome for the competitor who in turn charges a much higher price than what it charges under no disruption but is still in a position to charge a price lower than that of the retailer.

In Figure 6c, we analyse the expected supplies in the market. From Figures 6a and 6b, we find that the prices are decreasing in Case I whereas they increase in both Case II and III. This results in increase in expected supplies in Case I with decrease in prices. In Case II and III, as prices increase, the expected supplies in the market decrease. Therefore, from the consumers' point of view, it is most beneficial when the competitor's procurement cost is in the neighbourhood of the retailer's cost of procuring from the foreign supplier. Here, the overall procurement costs are the least, leading to lowest market prices and maximum overall supplies.

7.3 Relative Market Potential vs. Relative Profit

Here, we analyze the expected profit earned by the retailer over that of the competitor under different values of relative market potential (RMP) of the retailer (compared to that of the competitor) and different levels of probability of disruption categorized by high (H), medium (M) and low (L). The results provide important insights into the profits earned by the retailer at different probabilities of disruption and varying levels of market potential. We have used the following values of $c = 0.165,\ 0.495\ \&\ 0.825$ for the three cases.

The increase in relative market potential results in improvement of the profit for the retailer but the advantage available to the retailer decreases with increase in the probability of disruption. Interestingly, the retailer makes a higher profit than the competitor even under high probability of supply disruption when its relative market potential is high and it has no significant cost disadvantage compared to the competitor. When the retailer enjoys higher relative market potential even when there is no cost advantage, she goes for reliable supplies. Although, her sourcing cost increases but the reliability in supplies leads to higher supplies in the market and this combined with the higher market potential results in higher profit than the competitor. Also, the relative profit of the retailer increase across the diagonal as high probability of disruption is countered by growth in market potential.

Table 5: Expected Profit

Case I		RMP			
		L		H	
		π_R	π_c	π_R	π_c
Prob. Of Disruption	L	0.083	0.474	0.172	0.273
	H	0.065	0.458	0.153	0.257

Table 5a

Case II		RMP			
		L		H	
		π_R	π_c	π_R	π_c
Prob. Of Disruption	L	0.086	0.291	0.194	0.145
	H	0.062	0.276	0.170	0.131

Table 5b

Case III		RMP			
		L		H	
		π_R	π_c	π_R	π_c
Prob. Of Disruption	L	0.155	0.214	0.306	0.109
	H	0.130	0.205	0.281	0.100

Table 5c

π_R – Expected profit of Retailer, π_c – Expected Profit of Competitor

7.4 Price Adjustment and Sourcing Strategy

In this section, we study the 'price adjustment' done by the retailer when disruption happens. We define 'price adjustment' as the percentage change in the disruption prices over the normal prices. We also analyze the split of order that the retailer places with the foreign supplier under different relative market potential of the retailer and different values of probability of disruption categorized by high (H) and low (L). We study the above decisions under market scenarios marked by low (L), and high (H) market potential of the retailer compared to that of the competitor and cost advantages available either to the competitor (C, Case I), or the retailer (R, Case III) or nobody in particular (No Adv, Case II). The results are summarized in Table E1 (Appendix E).

The retailer adjusts the disruption prices drastically when the cost advantage is with the competitor and the probability of disruption is low. When the competitor has cost advantage, the retailer charges a low price and at low probability of disruption, she sources mainly from the foreign supplier. Hence the retailer's supplies to the market are adversely affected if disruption occurs and she is forced to increase the disruption prices significantly. At high probability of disruption, the retailer sources mainly from the reliable domestic supplier and hence even under disruption her supplies to the end-market remain relatively unaffected. Therefore, the retailer adjusts the disruption prices marginally. The above phenomenon is higher in case of lower market potential for the retailer.

The retailer orders less from the foreign supplier and goes for reliable supplies with improving cost advantage, higher market potential and lower probability of disruption. When there is no cost advantage, the total profit for both the players decrease and competition brings down the market prices. Hence, the retailer goes for cheaper and risky foreign supplier and this explains the increase in the split of order.

From the above analysis, we conclude that the price adjustment and the optimal sourcing strategy are interplay of three factors: market potential, relative cost advantage and probability of disruption. Next, we club the results of the Tables E1a and E1b and focus on the cases where either of the players enjoys cost advantage. Our findings highlight broad strategic implications on how a retailer can use price adjustment and sourcing structure to compete against another player with reliable supply chain under different market potentials and cost structures at varying levels of probability of disruption. The findings are presented in Table 6.

Table 6 summarises the broad pricing and sourcing strategy that can be employed by the retailer for different market conditions, cost structures and various levels of probability of disruption. When the competitor enjoys a significant cost advantage, it is advantageous for retailer to go for cheap and risky supplies and counter supply disruptions with very high price adjustments. With increasing market potential and/or higher probability of disruption retailer should move towards more reliable supplies and rely less on price adjustments. Nevertheless, as the retailer starts enjoying

Table 6: Retailer's Strategies

		Cost Adv w Competitor		Cost Adv w Retailer	
		RPM		RPM	
		L	H	L	H
Prob. Of Disruption	L	"VH" Price Adj & "VH" Cheap and Risky Sourcing	"H" Price Adj & "H" Cheap and Risky Sourcing	"H" Price Adj & "H" Cheap and Risky Sourcing	"H" Price Adj & "H" Cheap and Risky Sourcing
	H	"L" Price Adj & "H" Expensive and Reliable Sourcing	"L" Price Adj & "H" Expensive and Reliable Sourcing	"L" Price Adj & "H" Expensive and Reliable Sourcing	"VL" Price Adj & "VH" Expensive and Reliable Sourcing

VH-Very High, H-High, L-Low and VL-Very Low

procurement cost advantage, the focus should be on gaining market share. When the retailer has less market potential, she does not have pricing power and hence should go for cheaper supplies and relatively high price adjustment in case of disruptions. However, with an increase in market potential, the retailer should go for reliable supplies. With increasing probability of supply disruption, the shift

towards reliable supplies is more pronounced. The above findings provide critical managerial insights for a retailer competing against another player with a reliable supply chain.

8. Discussion and Conclusion

In this paper, we have studied the effect of competition on sourcing strategy of a retailer sourcing from costly but reliable domestic supplier and cheap but unreliable foreign supplier. We included the power dynamics that pans out in the system because of cheaper procurement cost. We prove the concavity of the profit functions in three strategies and then optimize it for different power structures.

We define supply chain disruption as a low frequency-high impact event that results in severance of one or more nodes of the supply chain leading to unavailability of services or goods. Events such as socio-political instability, civil unrest, natural hazards, terrorist attack, and epidemics can be classified under catastrophic risk (Kleindorfer & Saad, 2005). In our model, the foreign supplier has a 'q' probability of meeting such catastrophic events and will not supply anything in case of such events. Tang & Nurmaya Musa (2011), Wagner & Bode (2008), Jüttner (2005) and references therein provide a comprehensive list of supply disruption risks that affect firms. Natural disasters result in transportation delays, closure of ports, and closure of production facilities and so on. Many times, news agencies and weather channels assign probabilities or report the chance of occurrence of natural calamities; the news agencies assign a probability in case of any looming disaster that may affect a particular region. In terms of socio-economic and political disruptions, multiple groups and organisations such as Euromoney.com that publishes report on country-specific risk, The Economist publishes risk associated with countries, The PRS Group publishes monthly report on country-specific risk, and the World Bank publishes the ease of doing business that can be used as a proxy for reflection of uncertainty[3]. The retailers need to draw a list of risk that affects their business with a foreign supplier and can calculate the probability of supply disruption (q) based on these reports and by compounding the impact of events that affect them and their suppliers.

[3] *Euromoney.com* publishes a report on ranking of countries for political risk, economic performance/projections, structural assessment, debt indicators, credit Ratings, access to bank finance and access to capital markets

The Economist publishes a list assigning risk to each country

The Political Risk Services Group publishes a monthly report on country specific political, financial and economic risk

The World Bank under the domain name doingbussiness.org/rankings provides the list of ease of doing business for each country on multiple parameters

We were able to calculate the critical probabilities of disruption that determines the sourcing structure that will be used by the retailer when competing with a competitor with more reliable supplies. We further jointly optimise the prices and split of order for the retailer in case of dual sourcing.

As own-cross price elasticity of the retailer or the competitor increases, the retailer moves to cheaper supplies even at the cost of higher risk since she cannot charge higher prices to offset the increased cost of sourcing from the reliable but expensive domestic supplier. In case of fixed market, as the share of market potential increases for the retailer, she moves for stable supplies and the order placed with the reliable domestic supplier increases. On the contrary, when the market potential of the competitor increases, the retailer prioritises cheaper and riskier supplies. In case of expanding market, the retailer moves for consistent supplies and larger orders are placed with reliable supplier. Based on the above findings we recommend that in growing markets, larger emphasis should be placed on increasing market share by relying on stable supplies.

The profit of the retailer is decreasing in probability of disruption. Also, the profit of the competitor increases and then it starts decreasing. Total profit of both the retailers combined follows a similar trend and increases till the critical probability and then it starts decreasing. The important insight is that unreliable supplies of even one retailer decrease the overall profit of system.

The joint profit of both the players is maximum when competitor with reliable supplies has lesser procurement cost. The total profit is least when both the players are involved in a simultaneous move game. One crucial insight is that it is not only beneficial for the retailer to have lesser procurement cost but also the difference between the costs of supply from both the suppliers should be less.

The prices are decreasing in procurement cost of the competitor till the competitor's cost of procurement reaches the cost of procurement of the retailer from foreign supplier and then it starts increasing. On the other hand, the supplies are increasing in procurement cost of the competitor till the cost of procurement of the competitor reaches that of the retailer's cost of procurement from the foreign supplier and then it starts decreasing. Hence, the consumers are benefited the most when the competitor's procurement cost is in the neighbourhood of the cost of procurement of the retailer from the foreign supplier which in turn means overall the procurement cost should be less.

The retailer's profit is decreasing in the probability of disruption. In the case of competitor, it is decreasing till the point when the retailer moves from SF to DS. This implies that higher probability of disruption of the retailer's foreign supplier has an inverse effect on the competitor's profit.

Finally, we conclude that the competitive dynamics in our models is shaped by the interplay of three important factors; market potential, relative cost advantage and probability of disruption and the retailer can use combination of price adjustments and sourcing strategies as critical decision levers to maximize her profits. The procurement cost advantage and higher market potential is with the retailer then she should aim at gaining market share by opting for reliable supplies and relying less on price

adjustments to counter supply disruptions. On the other hand, as the procurement cost advantage and market potential shifts to the competitor, the retailer should opt for cheaper but risky supplies and rely on high price adjustments. The above result has important strategic implications for retailers competing in a duopoly under supply disruption risks.

Most of the papers in dual-sourcing literature look at the sourcing decision from a price-taking retailer's perspective. We have included competition and how it affects sourcing and pricing decisions when a competitor has more reliable supplies and can have variable cost of procurement. We have assumed deterministic demand structure which can be extended to a stochastic setting and yield uncertainty at the supplier's end can be included in a future research endeavor. We have not assumed capacity constraints on the supplier. This can be included to build a richer model. Uncertainty in the competitor's supply chain can be studied in another interesting future extension.

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