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Decision Models in Supply Chain Management: A Social Responsibility Perspective

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DECISION MODELS IN SUPPLY CHAIN MANAGEMENT: A SOCIAL RESPONSIBILITY PERSPECTIVE

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To my parents

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ABSTRACT

Recent events in emerging countries concerning supplier unethical practices and the resulting fatalities have stressed the need for social responsibility in supply chains. Rising consumer awareness regarding such events and their negative impact pose a challenge in supply management decisions for firms. This research integrates the risk of supplier irresponsibility and the impact of such events from the consumer perspective in developing supply management decision models for maximizing economic performance of firms. Two important issues in supply management: supplier selection and supplier development are addressed through stylized modeling approach.

First, a supplier selection decision model is analyzed that will aid a firm to select between an ethical and unethical (risky) supplier considering the supplier learning for long-term contracts. Next, the decision model is modified to study supplier development decision considering penalty costs to select between three development decisions: direct/binding, non-binding, and third-party/intermediaries.

Our results suggest that firms prefer long-term type of strategies in both supplier selection and development under high risk or impact or both. Contingent policies are only optimal for supplier selection decisions, while firms may use intermediate sourcing/development when the penalty costs are high and the cost of sourcing is low. However, it is also economically optimal for firms to choose unethical supplier or to not invest in supplier development when the risk and the impact are extremely low. This research contributes to the literature in operations and supply chain management by addressing social responsibility including the consumer perspective addressing the research gap in the field of operations and supply chain management.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS . . . iv

ABSTRACT . . . v

LIST OF TABLES . . . ix

LIST OF FIGURES . . . x

CHAPTER

I. Introduction . . . 1

II. Literature Review . . . 5

2.1 Sustainability . . . 5

2.2 Supply Risk Management . . . 6

2.3 Supplier Sourcing and Development . . . 8

III. Supplier Selection . . . 11

3.1 Background . . . 11

3.2 The Model . . . 13

3.3 Analysis . . . 17

3.3.1 Base Model . . . 17

3.3.2 Supplier-Specific Learning . . . 25

3.3.3 Time-Dependent Risk Likelihood or Impact . . . 26

3.4 Summary . . . 29

IV. Supplier Development . . . 30

4.1 Background . . . 30

4.2 The Model . . . 33

4.3 Analysis 39
4.4 Alternative Model 51
4.4.1 Analysis 52
4.5 Summary 60
V. Conclusion 63
APPENDIX 65
A. Supplier Selection 66
A.1 Proofs 66
B. Supplier Development 73
B.1 Proofs 73
Works Cited 82

LIST OF TABLES

Table		Page
I	Admissible Supplier Selection Policies	17
II	Types of Supplier Development	31
III	Admissible Supplier Development Policies	38

LIST OF FIGURES

Figure		Page
1	**Sequence of Events for Supplier Selection**	15
2	Comparative Statics on Second Period c_B Cutoffs ($c_A = 0.6$)	19
3	Expected Profits of Different Policies	21
4	Comparative Statics on First Period c_B Cutoffs ($c_A = 0.6$)	23
5	Optimal Policies as a Function of θ, δ and α ($c_B = 0.4, c_A = 0.6$)	24
6	Optimal Policies as a Function of θ and δ with Nonidentical α's ($c_B = 0.4, c_A = 0.6$)	26
7	Optimal Policies as a Function of θ_2 or δ_2 ($\alpha = 0.1, c_A = 0.6$)	27
8	Optimal Policies as a Function of θ_2 or δ_2 ($\alpha = 0, c_A = 0.6$)	28
9	Sequence of Events for Supplier Development	35
10	Decision Tree for Supplier Development	39
11	Comparative Statics w.r.t. Δc	42
12	Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.5, c_D = 0.2$)	43
13	Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.4, c_D = 0.1$)	44
14	Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.3, c_D = 0.1$)	45
15	Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.3, c_D = 0.05$)	46
16	Comparative Statics w.r.t. δ	48
17	Optimal Policies as a Function of θ_T and c_T	50
18	Optimal Policies as a Function of δ and c_T (θ_D=0.3, c_D=0.1)	51
19	Optimal Policies as a Function of δ and c_T (θ_D=0.3, c_D=0.2)	52

20 Decision Tree for Supplier Development-Alternate Model 53
21 Sequence of Events for Supplier Development-Alternative Model 54
22 Optimal Policies as a Function of Δc and c_T for Alternate Model (θ_D=0.5, c_D=0.2) 57
23 Optimal Policies as a Function of Δc and c_T for Alternate Model (θ_D=0.4, c_D=0.1) 58
24 Optimal Policies as a Function of Δc and c_T for Alternate Model (θ_D=0.3, c_D=0.05) 59
25 Optimal Policies as a Function of θ_T and c_T for Alternate Model (θ_D=0.3, c_D=0.15, Δc=0.2) 60
26 Optimal Policies as a Function of θ_T and c_T for Alternate Model (θ_D=0.3, c_D=0.1, Δc=0.3) 61
27 Optimal Policies as a Function of δ and c_T 62

CHAPTER I

Introduction

Supply chain management and sustainability management are progressively becoming more synonymous among various firms, even more with the recent wake of expanding supply chains.

The United Nations recognizes supply chain sustainability as a critical issue, since it is closely connected to global areas such as human rights, labor force, environment and anti-corruption. In fact, organizations that primarily operate to maximize profits for their stakeholders are seeing the value of this issue and are beginning to implement these more recent supply management decisions.

In addition to cost and quality, supplier ethics is becoming another key factor to consider after a series of unethical practices in supply chains became publicized. For instance, in the garment industry, unsafe working conditions have resulted in two recent incidents in the capital of Bangladesh last year, killing at least 1130 people in the last year in the capital of Bangladesh (McLain, 2013). In another incident, a factory in Cambodia that produces sneakers for ASICS collapsed and three people were killed (McDowell et al., 2013). Even after a spate of suicides and accidents in factories located in China over the past five years, Foxconn, the world's biggest contract manufacturer for consumer electronics, again reported incidents resulting in deaths of two workers in late April 2013 (Luk, 2013). In Indonesia, tin, an essential material for producing tablets and smartphones, has led to 44 deaths in 2011 because of unsafe working conditions (Simpson, 2012). These tragedies have drawn great deal of attention from both consumers and government officials, forcing them to examine all unethical issues in the low labor cost regions which serve the world's product demands. Growing concerns of losing reputation, in addition to compliance pressure from government agencies has led firms to start scrutinizing their supplier production practices and using ethical production as qualification for sourcing decisions.

However, many companies focus more on the short-run tradeoff between cost and ethics at the expense of long run performance, when making sourcing decisions. For instance, shortly after the deadly fire and collapse incidents, Disney completely cut Bangladesh out of its supply chain while Wal-Mart, Gap and J.C. Penney contracted with other Bangladeshi factories, but refused to sign a legally binding accord to improve fire and building safety there. Alternatively, some European companies, like H&M, Inditex, and PVH, agreed to sign the accord and form a more effective coalition to improve the safety and working conditions (Berfield, 2013).

In January 2012, under social pressure from the suicides and an explosion at Foxconn facilities, Apple Inc., for the first time, disclosed in the new "Supplier Responsibility" report, a supplier list with detailed auditing and training programs to better monitor and improve conditions at factories (Vascellaro, 2012). The report found that 62% of its suppliers were not compliant with working-hours limits, 32% violated hazardous-substance management practices, and 35% failed to meet Apple Inc.'s standards to prevent worker injuries.

Firms may adopt supplier development strategies in response to violations by supplier either to preserve their brand reputation or to improve cost efficiency. For instance, after a series of incidents in China and Bangladesh, there was sudden rise in wages at Foxconn that are shared by Apple (Ruwitch, 2012). Walmart, GE, Nike, and Adidas are few of the many companies that are also working to improve their sustainability performance (Plambeck, 2012). After the fatal incident in Bangladesh, numerous firms agreed to sign safety pacts that require them to invest in additional supplier development activities for ensuring safe working practices in factories (Butler, 2013). Although, a few firms opted out of entering into safety agreements and instead chose to retain their existing operations, several companies such as American Eagle Outfitters, H&M, and Benetton did join long-term safety programs that require them to commit to provide financial support to supplier safety programs in Bangladesh for a period of atleast five years.

Moreover, the Automotive Industry Action Group has also succumbed to these growing concerns and issued guiding principles to improve sustainability performance in supply chains focusing on working conditions, human rights, and business ethics (AIAG, 2014).

Another alternative that is gaining popularity enables firms to address compliance of social and environmental regulations in supply chains by sourcing through intermediaries such as Li & Fung Ltd. In January 2010, Wal-Mart decided to enter into an open-ended sourcing arrangement with Li & Fung Ltd. (Belavina, 2012). Sourcing through third-parties is quickly rising because firms expect the intermediary to take full responsibility for safe working conditions along with maintaining protection against any violation of human rights.

Undeniably, ethical production or supplier development investments often involve high costs but unethical sourcing may also increase long-run costs significantly. It is overtly apparent that, additional measures such as supplier development investments which ensure ethical production often involve higher initial costs but conversely, longstanding unethical sourcing also significantly increases costs in the long-run. If consumer's willingness-to-pay is influenced by socially responsible behavior, it would ultimately influence the profitability of the firm (Banjo, 2013). As reflected in a statement from the President of Disney's consumer products division, Bob Chapek, firms must balance profit and reputation against the backdrop of a disastrous social irresponsible incident.

> "These are complicated global issues and there is no one size fits all solution..". "Disney is a publicly held company accountable to its shareholders and after much thought and discussion we felt this was the most responsible way to manage the challenges associated with our supply chain" (Palmeri and Rupp, 2013).

Given the increased utilization of contract manufacturing, these recent developments, along with increasing consumer awareness, makes ethical supply management an increasingly integral part of corporate social responsibility. However, many companies focus more on the short-run tradeoff between cost and ethics, but at the expense of longer-run performance, when selecting a supplier or making a decision to invest in supplier development.

The purpose of our study regarding supply management is two-fold. First, we are motivated to study the supplier selection problem and provide optimal strategies for firms who face the risk of supplier violations. Second, we extend to offer solutions for supplier development problem for firms who face the risk of supplier violations. Overall, our aim is to present optimal strategies in supply management from a social responsibility perspective.

CHAPTER II

Literature Review

2.1 Sustainability

The Brundtland Report on sustainable development for the United Nations (Brundtland, 1987; Elkington, 1997) proposes three types of capital defining the triple bottom line for corporate sustainability: (1) economic (profit); (2) environmental (planet); and (3) social (people) capital. Sustainability is being strongly recognized as a critical element in supply chain management (Linton, Klassen, and Jayaraman, 2007; Kleindorfer, et al. 2005, & Van Wassenhove, 2005). Pagell (2009) integrate three pillars of sustainability to describe a "sustainable supply chain" as the one that performs well both on traditional measures of profit and on expanded conceptualization of performance that includes social and environmental dimensions.

A number of papers have been published addressing sustainability in the field of operations and supply chain management. Providing a comprehensive review, Seuring and Muller (2008) surveyed 191 papers published between 1994 and 2007 addressing sustainability issues in supply chain management. They found that while 74% of literature focused on the environmental dimension of sustainability, only 11% address social dimension, and the remaining 15% included both dimensions in the research. Regarding the research methodology used, they found that only about 10% of the papers use mathematical models, while more than 60% of the papers utilize case study or empirical analysis. Tang and Zhou (2012) and Seuring (2013) provide comprehensive reviews on research applying modeling techniques in sustainable supply chain management. However, both reviews observe that the social aspect is widely ignored as the extant quantitative research is mainly focused on the environmental measure. Clearly, there is a lack of literature addressing social aspect of sustainability that utilize quantitative models.

2.2 Supply Risk Management

Sourcing decisions are vital for effective supply management; integrating a number of papers published concerning supplier sourcing, Talluri and Narasimhan (2004) develop a strategic sourcing framework that deals with the effective management of the supply base through sourcing strategies such as strategic partnerships, supplier development activities. For supplier evaluation and selection problems, Ho, Xu, and Dey (2010) present a comprehensive review of popular multi-criteria decision making approaches. They found that the top three popular criteria (>80%) used for evaluating the supplier performance are quality, followed by delivery, and cost. In contrast, the long-run social attributes (relationship, risk, and safety & environment) are the least used criteria (<4%) among the 78 papers reviewed from 2000 to 2008 (Sarkis and Talluri, 2002; Kull and Talluri, 2008; Huang and Keskar, 2007).

Talluri, Narsimhan and Chung (2010) present an analytical model to address the risk for optimal allocation decisions in supplier development program. However, their model does not specifically address the sustainability related risk. Because of the significance of supply risk management for a successful sustainable supply chain, Butner (2010)suggests that sustainability-related risk should be factored into sourcing decisions. From interviews of top executives, Manuj and Mentzer (2008) propose two components of risk: (1) *impact* (potential losses if the risk is realized); and (2) *likelihood* of the impact (the probability of the occurrence of an event that leads to realization of the risk). By synthesizing risk management literature, Foerstl et al., (2010) develop an extended conceptual framework for sustainable risk management identifying: risk identification, assessment, consequences, response and outcomes as stages of the risk management process. The framework asserts that supplier selection plays a proactive role in the risk mitigation process in foreseeing the consequences and associated outcomes that would benefit firms in decision making under uncertainty.

In terms of the social aspect, supplier ethics has emerged as an important part of corporate social responsibility in safeguarding organizations from being accused of unethical behavior and subsequent reputation damage (Carter and Easton, 2011). Carter and Jennings (2004) empirically examine the drivers of purchasing social responsibility with results indicating that consumer pressure is a critical and significant factor along with organizational culture and top management support, but governmental regulations are not significant. Klassen and Vereecke (2012) find that irresponsible events leave the firm with social risk leading to uncertain negative outcomes on performance. The consumer perspective is reiterated in a study by Melnyk et al., (2010), who state that modern supply chains should be designed with sustainability being one of the outcomes based on consumer's needs. Moreover, experimental studies by Creyer and Ross (1997) indicate that, although consumers buy from unethical firms, they punish them by demanding lower prices. On the other hand, De Pelsmacker, Driesen, and Rayp (2005) find from their survey that consumers pay premium prices for ethical products. In a more recent experimental work, Trudel and Cotte (2009) investigate the impact of ethical production with results suggesting that the punishment exacted is far greater than the premium consumers are willing to pay.

To date, much of the academic literature in the operations management field fails to consider the consumer perspective in assessing social responsibility risk (Tang and Zhou 2012), despite the evidence that the consumer will pay less for unethical products (Trudel and Cotte, 2009). For instance, commenting on Zaras business model, the company's senior executive said, "At Zara, the supply chain is the business model". The operations management field has moved from a narrow focus on costs to an appreciation of the customer (i.e. service, willingness to pay) to a closer scrutiny of assets (Kleindorfer, 2005).

2.3 Supplier Sourcing and Development

Within supply management modeling literature, we focused our review within the literature the addresses social responsibility risks in supplier sourcing and (or) development problems. Xu et al., (2013) present a AHP (Analytical Heirarchy Process) model for supplier selection including criteria such as, human rights issues, underage labor, and long working hours. Chen and Lee (2014) also present a model that examine the supplier responsibility risk mitigation focused on emerging economies, since sourcing from these economies often involves greater risk. Though these researchers do not explicitly study the relationship between inspection or monitoring and the risks involved, the study does disclose that higher inspection efforts lead to lower likelihood of supplier irresponsibility. Guo, Lee,and Swinney (2014) study the impact of supply chain structure on a firm's decision in choosing a socially responsible supplier to find that the structure plays an important role in determining the optimal decision.

While supplier selection is very crucial for risk mitigation, supplier development also plays an important role in supply risk management. Locke and Brause (2007) find from the case study of Nike that their supplier compliance has improved over time after implementing various supplier development initiatives. This is after Nike has been held responsible for sweatshop conditions in many of its supplier factories. Nonetheless, the literature addressing supplier development in the context of "sustainability risk management" is steadily growing. Chan and Kumar (2007) examine the supplier development problem by integrating it into the selection decision-making process by considering risk factors such as political turmoil, terrorism, and economy, and supplier profile.

Chiou, Tzeng, and Cheng (2005) further examine supplier development strategies in the aquatic industry with multiple dependent criteria including, business aspects, regulations, and socio-economic effects. Plambeck and Taylor (2014) examine the supplier motivation problem, for instance, ensuring the compliance of labor and environmental standards, with the results of the study indicating that increasing inspection effort is not adequate. Their research goes on to suggest that firms may motivate suppliers by reducing their profit margin in the supplier contract or through raising worker wages. In an alternative approach, Kim (2013) find that the increase in penalties for violation does not reduce the need for inspection, while random inspections are not always preferred.

Belavina and Girotra (2012) find that sourcing through intermediaries which is gaining popularity, can improve supply chain performance regarding sustainability even in unfavorable situations such as, absence of accurate information and even may outperform the direct sourcing. More specifically, their model follows three steps: (1) information gathering; (2) supplier selection; and (3) the actual transaction (selling) of the product in a multiple buyers and sellers in the setting. Similarly, Mendoza and Clemen (2013) study a model in which a firm outsources its supplier improvement programs to a seller by investing in the effort. They find that a firm's sustainability efforts increase with both their stakeholders' interest in sustainability performance and, when the firm's support to the supplier. This conclusion is related to the similar example, which involves Apple Inc's support for Foxconn to undertake workers' welfare by paying costs.

The gap in the literature review which fails to address social responsibility factors in supply management decisions, only enhances our motivatation to further delve into investigating decision models in supply management for firms who face the risk of supplier irresponsibility. By introducing market factors that have not been previously considered (Tang and Zhou 2012), we anticipate that this novel approach in studying supplier selection and development problems will shed insight and increase awareness for this issue.

CHAPTER III

Supplier Selection

3.1 Background

Most extant supplier selection works through linking the consumer requirements with sustainability and purchasing decisions using quantitative approaches such as multi-criteria decision making and analytical hierarchy process, they focus more on the short-run gain trading off between the sourcing costs and ethical production without considering potential switching costs afterward (Chan et al., 2008; Lee et al., 2009; Dai and Blackhurst, 2012).

Supplier *learning*, the long-term advantage from supplier-buyer relationship, is widely ignored in the context of sustainable supplier selection. It has long been observed that unit production costs are decreased with cumulative production, known as learning-by-doing, due to process improvements and/or technology advances (Yelle, 1979; Argote and Epple, 1990). Learning by supplier, can restrict a firm from switching suppliers even in event of social responsibility violations by suppliers. For example, Apple ended up still giving Foxconn the bulk of the production to Foxconn, though trying to shift supply chain away to another contract manufacturer Pegatron, for its iPad Mini due to the low yield rates with the new contractor (Dou, 2013).

> "There's a learning curve for any new products, so our yield rates are increasing," said Mr. Lin [Chief Financial Officer of Pegatron].

Therefore, the objective of our work is to answer this vital question about how social responsibility and supplier learning affect a firm's sourcing strategy. The review provides an interesting lens for research, amidst the recent developments regarding unethical events in the business world involving production practices at supplier factories of major firms. Synthesis of the literature which indicates the lack of supplier selection models that incorporate social factors, motivates us to integrate factors from the wide spectrum of literature to present a model addressing the following questions:

1. If the contract supplier behaves unethically, should a firm continue contracting to benefit from cost reduction through learning or switch to an ethical supplier? On the other hand, should a firm continue with an ethical supplier or switch to a low cost supplier and bear the risk of supplier's unethical behavior?

2. What is the optimal supplier selection strategy for a firm when a supplier offers low cost, but with risk of unethical behavior regarding social responsibility versus a higher cost ethical supplier?

3. How do the three factors, the risk likelihood of an unethical event, the impact of the event and the supplier learning, affect the supplier selection strategies?

3.2 The Model

We consider a *firm* buying goods from two types of *suppliers* (subscript $i = A, B$), different in their level of ethical production, to sell (or process first and then sell) in the consumer market in a two-period horizon (subscript $t = 1, 2$). We assume in each of the two periods, consumer willingness-to-pay for ethical production of the goods is uniformly distributed between 0 and 1 and we normalize the market size of each period to 1. Such construction leads to the linear inverse demand curve, $p(q) = 1 - q$, where q is the quantity sold. The initial costs to source from the two suppliers are linear in quantity, denoted by c_A and c_B respectively. The product lifetime is assumed to be only one period, that is, the firm cannot stock leftover goods from period 1 and sell them in period 2.

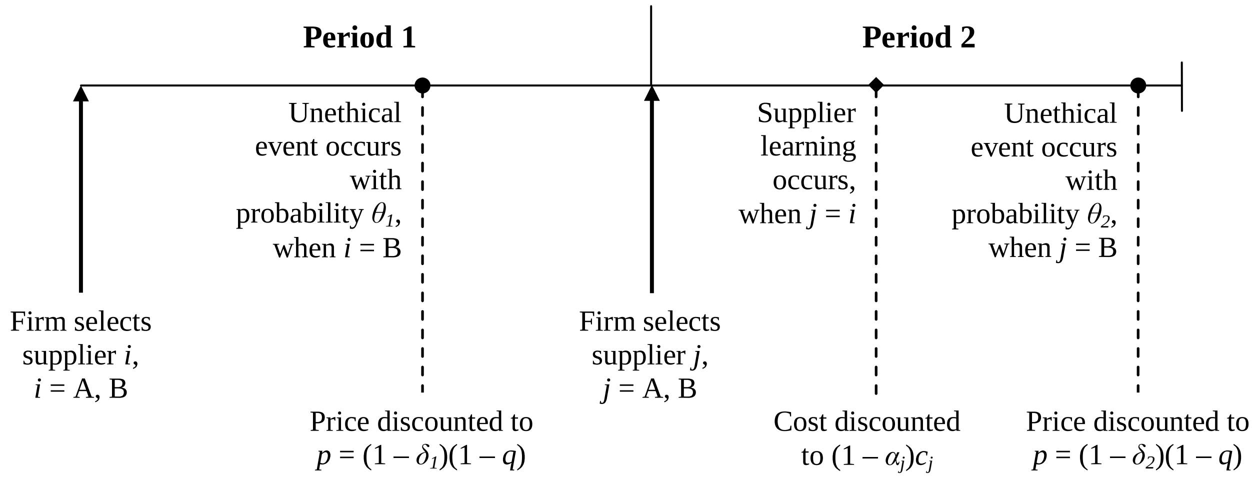
Unethical events: Disclosure or news outbreak of supplier's unethical production practices, such as a fire safety violation or abuse of child labor, may have the buying firms face backlash from consumers. Experimental evidence from (Trudel and Cotte, 2009) suggests that consumers demand a substantial discount from firms that produce goods in an unethical manner. Their study also finds that while consumers reward ethical production, they also punish unethical firms even more in terms of willingness-to-pay. Therefore, we focus on the event of unethical production.

We assume the buying firm knows that, for supplier B, there is some risk likelihood or probability θ_t ($0 \leq \theta_t \leq 1$ and $t = 1, 2$) of its unethical production being disclosed to the consumers. Given the clustering of suppliers and/or their sub-contractors and routine audits of their factories, it is unlikely that the firm does not have some estimate of the chance of an unethical event happening (Lahiri, 2012). The complement $(1 - \theta_t)$ corresponds to the probability of the alternative event, where there are no ethical violations of any kind by the contracted supplier. As a benchmark and to not clutter the expressions for gleaning insights, we assume supplier A is ethical in production and thus has zero probability of any unethical behavior.

Discount willingness-to-pay: When learning corporate's unethical behavior through the disclosure of such event, Trudel and Cotte (2009) find from their experimental studies that consumers punish the firm by discounting their willingness-to-pay and thus, demanding a lower price. For supplier B, we assume a discount factor δ_t $(0 \leq \delta_t \leq 1)$ on the consumer willingness-to-pay and thus the discount price $p = (1 - \delta_t)(1 - q)$ with probability θ_t. Alternatively, with probability $1 - \theta_t$, there is no discount on demand $(\delta_t = 0)$ when the consumers are not aware of unethical production. On the other hand, by choosing the ethical supplier A, the buying firm can secure its demand curve with no exposure to the risk of unethical behavior.

Supplier learning: Should the buying firm continue sourcing from the same supplier across periods, the supplier accumulates knowledge and experience from learning, thus reducing production costs over time (Lewis and Yildirim, 2002; Gray, Tomlin, and Roth, 2009). This cost reduction by supplier is often bargained by the buyer through lower prices as time progresses (Kalwani and Narayandas, 1995). Hence, similar to Kim (2003), we use contract periods as a proxy of cumulative production quantity, which in the learning literature is correlated with the learning effect (Yelle, 1979; Argote and Epple, 1990). We consider a learning factor, α_i, in supplier i's production which would result in a reduced cost of $(1 - \alpha_i)c_i$ if the firm continues with supplier i for another period. On the other hand, we do not incorporate fixed costs associated with switching suppliers as its effect is intuitive and mostly captured by the loss of learning in our model. Similar assumption has been made in some outsourcing studies (Gray et al., 2009; Li and Wang, 2010), where the firm has to select between a low cost offshore production and a high cost domestic production. The events happen in the following sequence as depicted in Figure 1:

Figure 1: Sequence of Events for Supplier Selection



At the beginning of period 1, the firm decides which supplier to source from at a linear unit cost c_i $(i = A, B)$. To avoid a trivial solution, we assume $c_A > c_B$ so the unethical supplier B costs less. If supplier B is chosen, then unethical production is disclosed with probability θ_1, and that discounts the firm's demanding price to $p = (1 - \delta_1)(1 - q)$. We also assume the firm has the flexibility to adjust order quantity after the breakout of the unethical news, which may be due to contract agreement, a rather powerful buying firm, or a reasonably long season remained after the disclosure. Alternatively, with probability $(1 - \theta_1)$, the consumers would not be aware of any unethical sourcing and pay the non-discount price $p = 1 - q$. On the other hand, if supplier A is selected, then the firm bears no risk and always asks for the non-discount price. We can summarize the firm's first period profit function as follows:

$$\pi_{1i}(q|\Theta_1) = \begin{cases} [(1 - \delta_1)(1 - q) - c_B]\, q & \text{if } i = B \text{ and } \Theta_1 = \theta_1 \\ [(1 - q) - c_B]\, q & \text{if } i = B \text{ and } \Theta_1 = 1 - \theta_1 \\ [(1 - q) - c_A]\, q & \text{if } i = A \text{ and } \Theta_1 = \cdot \end{cases} \tag{3.1}$$

where Θ_1 indicates the realization of first period event with "·" representing irrelevance when the ethical supplier A is chosen. The firm realizes profit by producing q in a given period. To ensure $q \geq 0$, we assume that $1 - \delta_1 \geq c_B$ in the presence of an unethical event. In period 2, the firm's profit function would depend on both the first and second period decisions as summarized below:

$$\pi_{2j}(q|\Theta_1, \Theta_2)$$
$$= \begin{cases} [(1-\delta_2)(1-q) - (1-\alpha_B)c_B]\, q & \text{if } j = B \text{ given } i = B, \Theta_1 = \theta_1, \quad \Theta_2 = \theta_2 = 1 \\ [(1-\delta_2)(1-q) - (1-\alpha_B)c_B]\, q & \text{if } j = B \text{ given } i = B, \Theta_1 = 1-\theta_1, \quad \Theta_2 = \theta_2 \\ [(1-q) - (1-\alpha_B)c_B]\, q & \text{if } j = B \text{ given } i = B, \Theta_1 = 1-\theta_1, \quad \Theta_2 = 1-\theta_2 \\ [(1-q) - c_A]\, q & \text{if } j = A \text{ given } i = B, \Theta_1 \in \{\theta_1, 1-\theta_1\}, \quad \Theta_2 = \cdot \\ [(1-q) - (1-\alpha_A)c_A]\, q & \text{if } j = A \text{ given } i = A, \Theta_1 = \cdot, \quad \Theta_2 = \cdot \\ [(1-\delta_2)(1-q_{2B}) - c_B]\, q & \text{if } j = B \text{ given } i = A, \Theta_1 = \cdot, \quad \Theta_2 = \theta_2 \\ [(1-q) - c_B]\, q & \text{if } j = B \text{ given } i = A, \Theta_1 = \cdot, \quad \Theta_2 = 1-\theta_2 \end{cases} \tag{3.2}$$

where Θ_2 indicates the realization of second period event and $1 - \delta_2 \geq (1 - \alpha_B)c_B$ to ensure $q \geq 0$. Note that, although the first and second expressions are the same, the sample routes are different. The first scenario corresponds to an unethical event in period 1 ($\Theta_1 = \theta_1$) and continuing negative impact in period 2 ($\Theta_2 = \theta_2 = 1$; with no uncertainty). Here, from the consumer psychology perspective (Brunk and Blmelhuber, 2011), we assume the negative impact continues, as consumer perception towards unethicalness once formed is resistant to change over time. The second scenario corresponds to no unethical event in period 1 ($\Theta_1 = 1 - \theta_1$) and unethical event in period 2 ($\Theta_2 = \theta_2$; with uncertainty).

With the above introduced notation, we can express the expected total profit function under each supplier selection alternative as:

$$\Pi_{ij} = \mathbb{E}_{\Theta_1}\left[\pi_{1i}(q|\Theta_1) + \mathbb{E}_{\Theta_2}[\pi_{2j}(q|\Theta_1, \Theta_2)]\right] \tag{3.3}$$

$$\Pi_{Bj(\Theta_1)} = \mathbb{E}_{\Theta_1}\left[\pi_{1B}(q|\Theta_1) + \mathbb{E}_{\Theta_2}[\pi_{2j(\Theta_1)}(q|\Theta_1, \Theta_2)]\right] \tag{3.4}$$

We use Π_{ij} to denote the total profit for the policy ij when supplier i is selected in period 1 and supplier j is selected in period 2; similarly $\Pi_{Bj(\Theta_1)}$ denotes the profit if B is selected in period 1, but in period 2 the choice of supplier $j(\Theta_1)$ is contingent on the realization of the event Θ_1. Note that there exists no such contingent policy $Aj(\Theta_1)$, as A is an ethical supplier with no event realization if chosen in period 1. We summarize all admissible policies in Table I. The term "short-term policy" refers to the case in which the firm contracts with a supplier for exactly one period and then switches, while in the "long-term policy," the firm continues to contract with the same supplier across two periods.

Table I: Admissible Supplier Selection Policies

Label	Policy	Period 1 Choice	Period 2 Choice
BB	Long-term contract with B	Choose unethical supplier B	Continue with B
AA	Long-term contract with A	Choose ethical supplier A	Continue with A
AB	Short-term switching contract with A then B	Choose ethical supplier A	Switch (downgrade) to B
BA	Short-term switching contract with B then A	Choose unethical supplier B	Switch (upgrade) to A
$Bj(\Theta_1)$	Contingent/Dynamic contract	Choose unethical supplier B	$\begin{cases} \text{Switch to } A \text{ if unethical event realized } (\Theta_1 = \theta_1) \\ \text{Continue with } B, \text{ otherwise } (\Theta_1 = 1 - \theta_1) \end{cases}$

3.3 Analysis

3.3.1 Base Model

In this section, we consider the base model in which the two parameters, the probability of an unethical event and the discount willingness-to-pay are constant across time periods, i.e., $\theta_1 = \theta_2 = \theta$ and $\delta_1 = \delta_2 = \delta$. We also let the production learning rate be equal for both suppliers, i.e., $\alpha_A = \alpha_B = \alpha$. The selection process allows the buying firm to switch suppliers between the two periods. We start by characterizing the second period results, and solve the first period problem through backward induction.

Proposition 1. *Given the contract supplier in period 1 is i, the selection decision for the buying firm in period 2 can be characterized as follows:*

(a) For $i = B$ and $\Theta_1 = \theta$ in period 1, choose B in period 2 if $c_B \leq \bar{C}_B$, otherwise choose A.

(b) For $i = B$ and $\Theta_1 = 1 - \theta$ in period 1, choose B in period 2 if $c_B \leq \bar{\bar{C}}_B$, otherwise choose A.

(c) For $i = A$ in period 1, choose B in period 2 if $c_B \leq \bar{\bar{\bar{C}}}_B$, otherwise choose A.

Proof. All proofs and expressions for c_B cutoffs are provided in the Appendix. □

When B is the contract supplier in period 1, Proposition 1 (i) and (ii) show the cutoffs below which the firm stays with B depends on the realization of the event in period 1: in particular, $\bar{C}_B$ is a special case of $\bar{\bar{C}}_B$ with $\theta = 1$ as we assume the impact of an unethical event would linger for another period. For the scenarios (ii) and (iii) in which no unethical behavior is observed, the learning-driven cost reduction rate $(1 - \alpha)$ is applied toward to c_B and c_A respectively. Hence the difference between $\bar{\bar{C}}_B$ and $\bar{\bar{\bar{C}}}_B$ exists if and only if $\alpha > 0$. Proposition 2 and Figure 2 depict the behavior of cost cut-offs with respect to the three factors, θ, δ, and α.

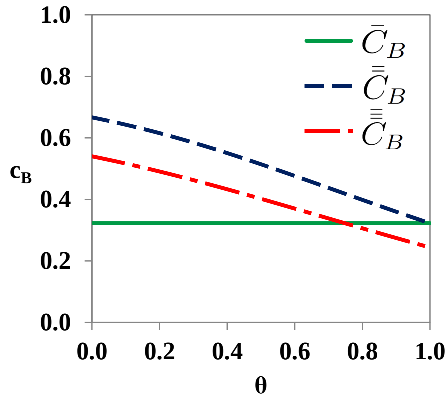
Proposition 2. *(a) $\bar{\bar{C}}_B$ and $\bar{\bar{\bar{C}}}_B$ are decreasing in θ.*

(b) $\bar{C}_B$, $\bar{\bar{C}}_B$ and $\bar{\bar{\bar{C}}}_B$ are decreasing in δ.

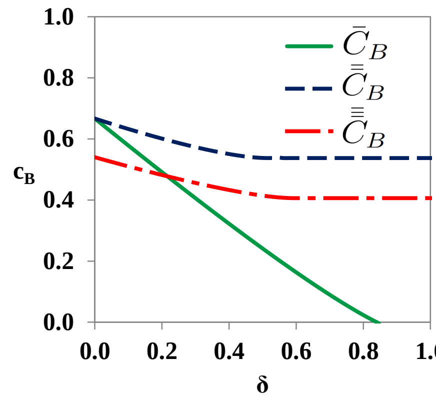
(c) $\bar{C}_B$ and $\bar{\bar{C}}_B$ ($\bar{\bar{\bar{C}}}_B$) are increasing (decreasing) in α.

Figure 3(a) shows that cut-offs $\bar{\bar{C}}_B$ and $\bar{\bar{\bar{C}}}_B$ are decreasing with the increase in the likelihood of an unethical event θ. The firm would require lower costs to offset the decrease

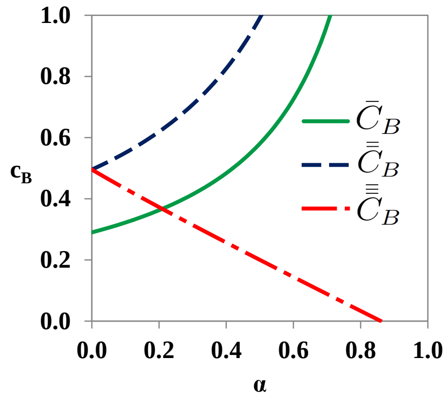
Figure 2: Comparative Statics on Second Period c_B Cutoffs ($c_A = 0.6$)



(a) Cutoffs vs. $\theta(\delta{=}0.4,\alpha{=}0.1)$



(b) Cutoffs vs. $\delta(\theta{=}0.4,\alpha{=}0.1)$



(c) Cutoffs vs. $\alpha(\theta{=}0.4,\delta{=}0.4)$

in their consumer demand in the presence of higher risk likelihood with supplier B. When an unethical event is realized in the first period, the negative impact continues in the next period which means $\theta = 1$ and hence $\bar{C}_B$ does not change with θ. As expected, $\bar{\bar{C}}_B$ degenerates to $\bar{C}_B$ at $\theta = 1$. For small θ, $\bar{\bar{C}}_B$ can be greater than c_A because of the learning factor α, which gives supplier B a competitive advantage in receiving a renewal contract.

In Figure 3(b), the effect of the discount factor δ is greater on $\bar{C}_B$ than on $\bar{\bar{C}}_B$ because $\theta = 1$ in the case of $\bar{C}_B$ and the discount in willingness-to-pay persists if an unethical event was observed in period 1. With a record of unethical behavior as in $\bar{C}_B$, the savings in cost may not justify the tremendous lost due to high impact so the buying firm will favor and switch to supplier A. Lastly, while the learning in continuing with B allows higher pre-adjusted cost cutoffs ($\bar{C}_B$ and $\bar{\bar{C}}_B$), the learning with A discourages the firm from switching to supplier B by imposing a lower cost cutoff ($\bar{\bar{\bar{C}}}_B$) as shown in Figure 3(c).

To summarize the second period outcomes, the firm would prefer the unethical supplier if the lower sourcing cost along with the benefit from learning or long-term relationship could offset the increase in risk. After characterizing the firm's optimal second period choice given Θ_1, we next solve for the optimal policy to adopt in period 1 as in Proposition 3.

Proposition 3. *(a) For $\alpha > \hat{\alpha}$, adopt BB policy if $c_B \leq \hat{C}_B$, otherwise adopt AA.*

(b) For $\alpha \leq \hat{\alpha}$, where $\hat{\alpha}$ satisfies $\bar{C}_B = \tilde{C}_B = \hat{C}_B$,

(i) adopt BB policy if $c_B \leq \bar{C}_B$,

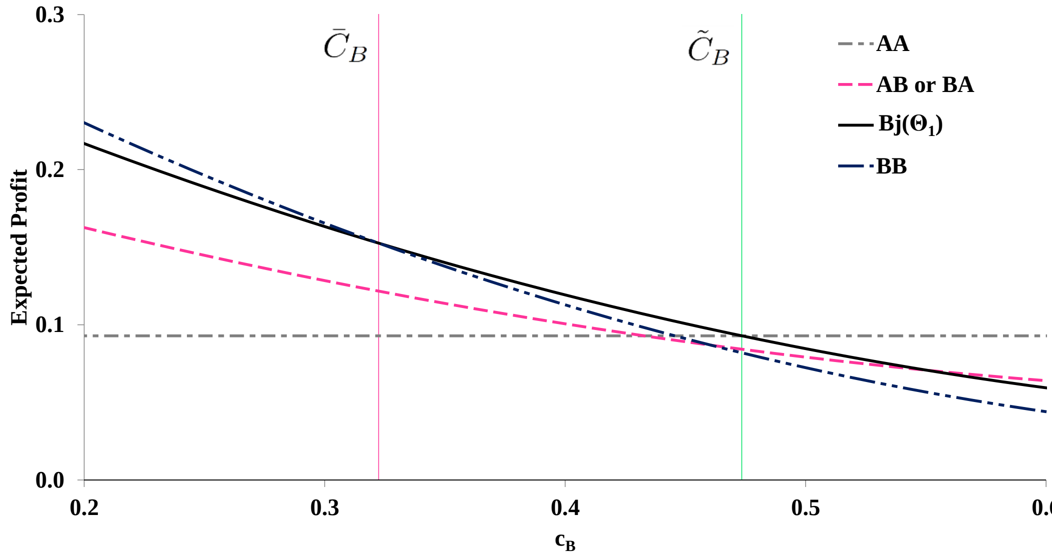
(ii) adopt $Bj(\Theta_1)$ if $\bar{C}_B < c_B \leq \tilde{C}_B$, and

(iii) adopt AA if $c_B > \tilde{C}_B$.

Proposition 3 identifies a learning threshold level $\hat{\alpha}$, above which the optimal policy is to enact a long-term contract, either BB or AA, depending on the sourcing cost c_B relative to the cutoff $\hat{C}_B$, jointly determined by the parameters, θ, δ, α, and c_A. The intuitive reason for only signing up long-term contracts under high learning rate as in part (a) is that switching supplier in period 2 loses the benefit of learning αc_j, which cannot be compensated by bearing no risk (BA or $Bj(\Theta_1)$) or lowered sourcing cost c_B in the case of AB. On the other hand, at low learning rate ($\alpha \leq \hat{\alpha}$), it can now be beneficial for the firm to let go of the small gain in learning but have the option to change the supplier. For subsequent analysis and discussion, since our focal point is to study the impact of unethical behavior, we downplay the role of the learning rate α so that it does not significantly dominate the other two unethical factors θ and δ in the decision-making process as in the case of part (b).

Figure 3 plots the expected profits for each of the five possible strategies at different c_B values for θ=0.4, δ=0.4, α=0.1 ($<\hat{\alpha}$=0.31), and c_A=0.6. The envelope of these curves depicts the optimal selection strategies to adopt, as characterized in Proposition 3(b). The first period results of the base model glean several important managerial insights toward selecting supplier with potential risk of unethical behavior:

Figure 3: Expected Profits of Different Policies



First, the profits of the two short-term switching policies, BA and AB, are the same since no learning occurs when switching to the other supplier and thus the two periods are essentially decoupled. More importantly, these two policies are never optimal suggesting that the switching decision should not be made a priori as it loses the flexibility and potential gain through learning from staying with the original supplier.

Second, the above reasoning naturally leads to the dynamic or contingent policy $Bj(\Theta_1)$ to take advantage of the flexibility in postponing the second period decision until the event Θ_1 is realized. It is only when an unethical event occurs would the firm switch or *upgrade* to supplier A, otherwise the firm should stay with supplier B and take advantage from learning and lower cost. Such apolicy is optimal only for intermediate c_B values between $\bar{C}_B$ and $\tilde{C}_B$ as characterized in Proposition 3(b)(ii). Note that the dynamic policy is only viable for choosing B in the first period which allows two possible outcomes, while selecting A bears no risk of an unethical event and thus requires no contingency plan.

Third and lastly, in the cases when c_B takes the extreme values as in Proposition 3(b) (i) $c_B \leq \bar{C}_B$ and (iii) $c_B \geq \tilde{C}_B$, the long-term contracts, BB or AA, are the best policies. In these two cases, the cost differences between the two suppliers and the advantage of learning warrant a long-term contract.

Proposition 4. *(i)* $\tilde{C}_B$, $\hat{C}_B$ ($\bar{C}_B$) *are decreasing (increasing) in* α.

(ii) $\tilde{C}_B$ *and* $\hat{C}_B$ *are decreasing in* θ.

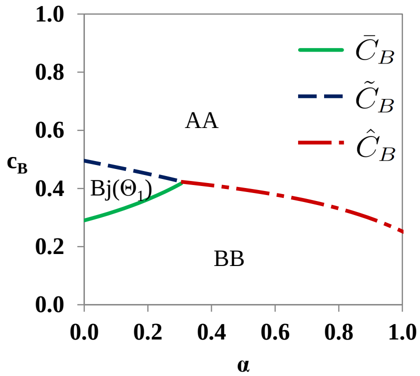
(iii) $\tilde{C}_B$, $\hat{C}_B$ *and* $\bar{C}_B$ *are decreasing in* δ.

Proposition 4 shows how the three policy-setting cutoffs $\bar{C}_B$, $\tilde{C}_B$ and $\hat{C}_B$ are affected by the three key factors θ, δ, and α. Except for the positive effect of α on $\bar{C}_B$ as the firm is able to take higher c_B due to learning when forming a long-term contract with B, all cutoffs are decreasing in the parameters as demonstrated in Figure 4 (with c_A fixed at 0.6).

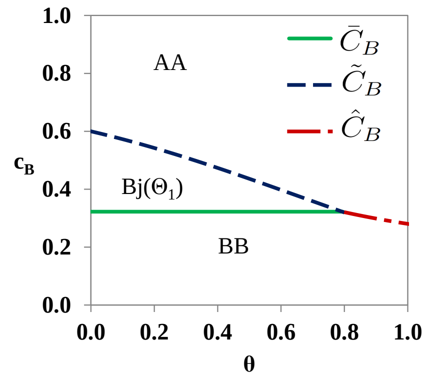
In Figure 5(a), we illustrate the effect of learning factor α on the choice of optimal supplier selection policy for $\theta = 0.4$ and $\delta = 0.4$. As expected from Proposition 3, the c_B range in which the contingent policy $Bj(\Theta_1)$ is optimal is decreasing in α and eventually for high α, the firm is left with no choice but the long-term contract with either B or A. In Figure 5(b) and 5(c), we therefore set $\alpha = 0.1 (< \hat{\alpha}{=}0.31)$ to illustrate how θ δ affect the selection strategy.

As one may expect, when c_B increases, the optimal policy changes from BB, $Bj(\Theta_1)$, to AA; or directly from BB to AA. However, while the c_B range ($\tilde{C}_B - \bar{C}_B$) in

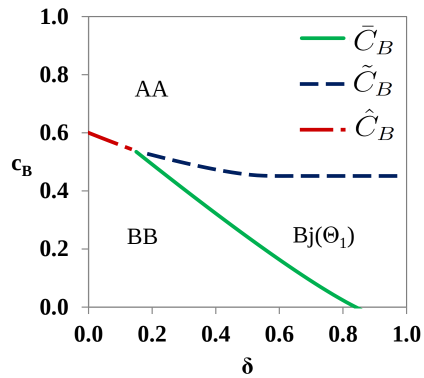
Figure 4: Comparative Statics on First Period c_B Cutoffs $(c_A = 0.6)$



(a) Cutoffs vs. $\alpha(\theta$=0.4, δ=0.4)



(b) Cutoffs vs. $\theta(\delta$=0.4, α=0.1)

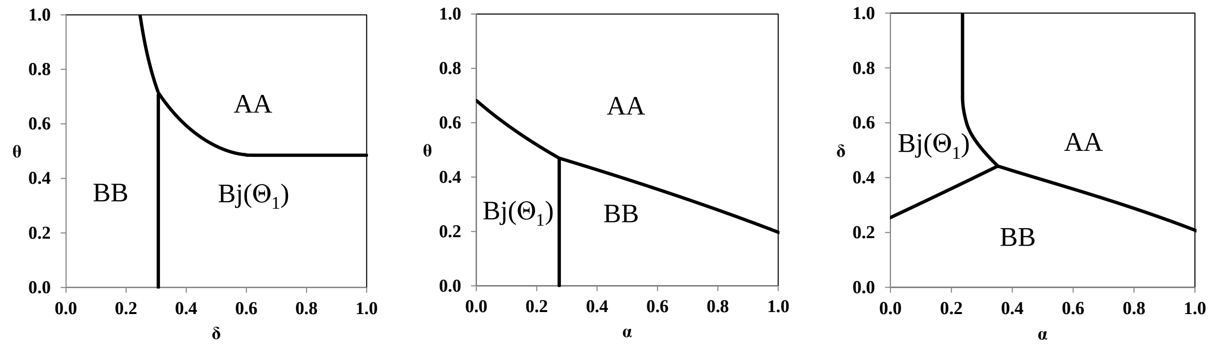


(c) Cutoffs vs. $\delta(\theta$=0.4, α=0.1)

which $Bj(\Theta_1)$ is optimal is diminishing in the risk likelihood θ, it is increasing in the discount factor δ. With high θ, an unethical event is likely to happen in both periods so the demand is discounted in most circumstances if staying with B. So only if c_B is sufficiently low would the firm choose the BB policy to offset the loss in discount; otherwise, it is optimal to simply choose the long-term AA policy. The dynamic policy $Bj(\Theta_1)$ is no longer optimal because it becomes almost like BA as the firm would mostly likely switch from B to A when θ is high (and exactly BA if $\theta = 1$). On the other hand, with low θ, though it is unlikely that an unethical event will take place, but when it does happen in period 1, the effect of an unethical event persists, i.e., $\Theta_2 = \theta_2 = 1$ if $\Theta_1 = \theta_1 = 1$. Therefore, the contingent policy $Bj(\Theta_1)$ does benefit the firm in the rare event of unethical behavior but in most cases, it is like the BB policy because of low θ. In contrast, when δ is low, switching or not does not matter as much as in the case when the discount is high and the firm will lose the benefit of learning if switch from B to A. Hence, it is only with high δ that the firm would utilize $Bj(\Theta_1)$.

Next, we examine the joint effect of any two of the three on the firm's selection strategy. The following figures demonstrate optimal policies the firm should adopt when weighing between flexibility ($Bj(\Theta_1)$) and long-term learning benefit (BB or AA).

Figure 5: Optimal Policies as a Function of θ, δ and α ($c_B = 0.4, c_A = 0.6$)



(a) Effect of θ and δ ($\alpha = 0.1$) (b) Effect of θ and α ($\delta = 0.4$) (c) Effect of δ and α ($\theta = 0.4$)

In Figure 6(a), while the observations for the high-θ-high-δ and low-θ-low-δ regions are not surprising (AA and BB), the interaction between the likelihood and impact is not symmetric when one is low while the other is high. At low discount δ, regardless of the risk likelihood θ, which includes high θ, the firm would favor BB as the impact is small though likely to happen. On the other hand, when θ is low, the firm may use the contingent policy $Bj(\Theta_1)$ for high δ to avoid being tied up with the unethical supplier B and let the negative impact persists. Therefore, to the firm, the two main factors θ and δ are not on a one-to-one tradeoff basis, and the ethical long-term contract AA is never an optimal policy if only one of the two unethical parameters θ or δ is high with c_B being reasonably low.

Figure 6(b) and 6(c) illustrate how the learning rate α moderates the effect of the risk on the choice of optimal policy. In both figures, it is again shown that high α would favor a long-term contract BB if θ or δ is low, and AA otherwise. When significant learning is not presented as in low α, the observations are analogous to those in Figure 5(b) and 5(c) that the contingent policy is desired at low θ or high δ.

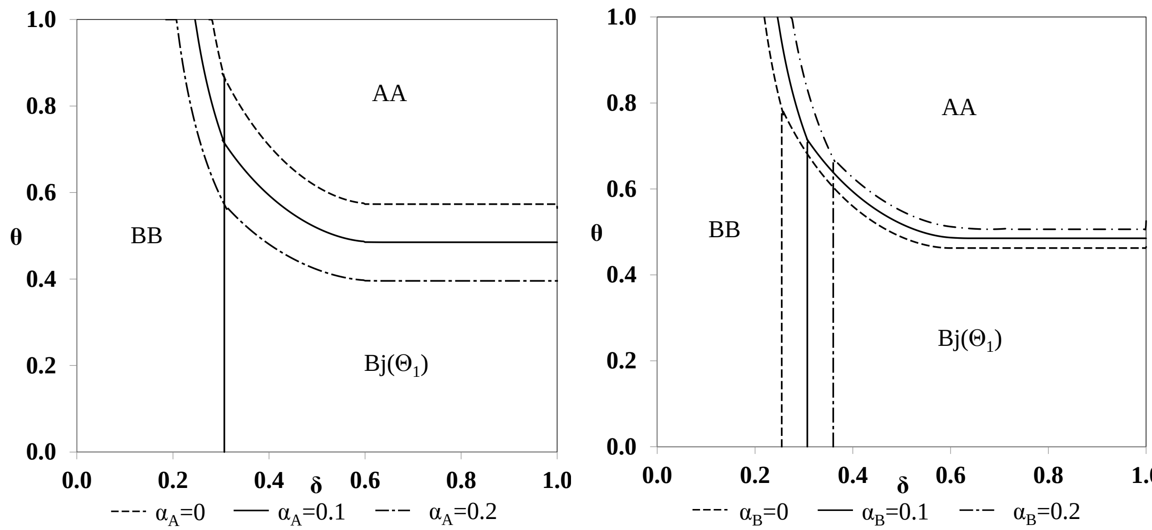
Next we discuss three variants of our base model, each of which represents a relaxation of one key factor: $\alpha_A \neq \alpha_B$, $\theta_1 \neq \theta_2$, and $\delta_1 \neq \delta_2$. In Section 3.3.2, we demonstrate that the insights gleaned from the base model hold true even when the learning rates are not the same between the suppliers. In Section 3.3.3, however, when the risk likelihood or the impact varies in time, the optimal policies may take up to two additional forms.

3.3.2 Supplier-Specific Learning

In this section, we consider the case in which the learning rates are different between the suppliers, i.e., $\alpha_A \neq \alpha_B$. Using Proposition 1 (with α_B replacing α in $\bar{C}_B$ and $\bar{\bar{C}}_B$ and α_A replacing α in $\bar{\bar{\bar{C}}}_B$) and solving for the optimal policy in period 1 backwardly as in Proposition 3, we find similar yet interesting results as illustrated in Figure 6.

Overall, the difference in the learning rates does not require additional form in terms of optimal policy, like BA or AB, but it does alter the preference among the three existing forms: BB, AA, and $Bj(\Theta_1)$. As the learning rate with one supplier increases, so does the preference to the corresponding long-term contract, as depicted by the change of AA region in Figure 7(a) and BB in Figure 7(b). Such preference is more sensitive to α_A than α_B because the base cost is higher with the ethical supplier A ($c_A > c_B$). Furthermore, the preference between BB and $Bj(\Theta_1)$ is only affected by α_B because in neither case would the learning with A occur. While lower learning rates make the long-term contracts less attractive, it does not necessarily imply that the short-term switching contracts like BA or

Figure 6: Optimal Policies as a Function of θ and δ with Nonidentical α's ($c_B = 0.4, c_A = 0.6$)



(a) Effect of α_A ($\alpha_B = 0.1$) (b) Effect of α_B ($\alpha_A = 0.1$)

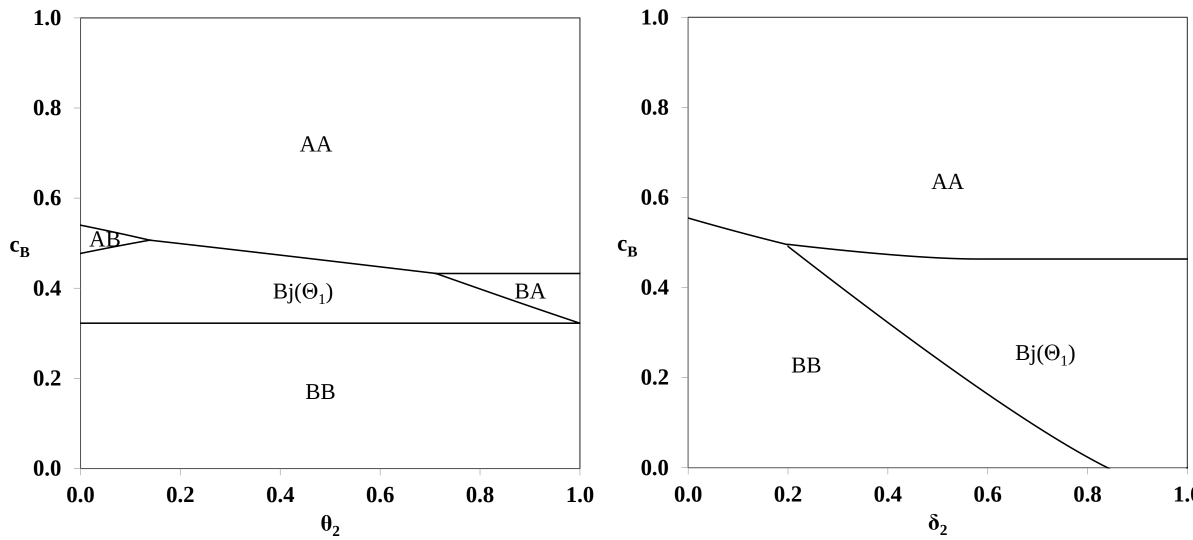
AB would become the best choice but rather just a better alternative. With constant risk likelihood and discount rate across periods, the contingent policy $Bj(\Theta_1)$ would outperform the short-term switching policy BA when B is the better supplier to go with and no unethical event is observed.

3.3.3 Time-Dependent Risk Likelihood or Impact

In this section, we extend our base model to account for the time dependence of the two unethical factors, i.e. $\theta_1 \neq \theta_2$ or $\delta_1 \neq \delta_2$. Using Proposition 1 (with θ_2 replacing θ or δ_2 replacing δ in all three cutoffs $\bar{C}_B$, $\bar{\bar{C}}_B$ and $\bar{\bar{\bar{C}}}_B$) and solving backwardly the first period problem as stated in Proposition 3, we find the optimal policy may take any form of the five admissible policies as described in Table I.

Figure 7 demonstrates the effect of the risk likelihood and discount factors on the optimal policy employed for the same set of parameter values used in earlier numerical

Figure 7: Optimal Policies as a Function of θ_2 or δ_2 ($\alpha = 0.1, c_A = 0.6$)

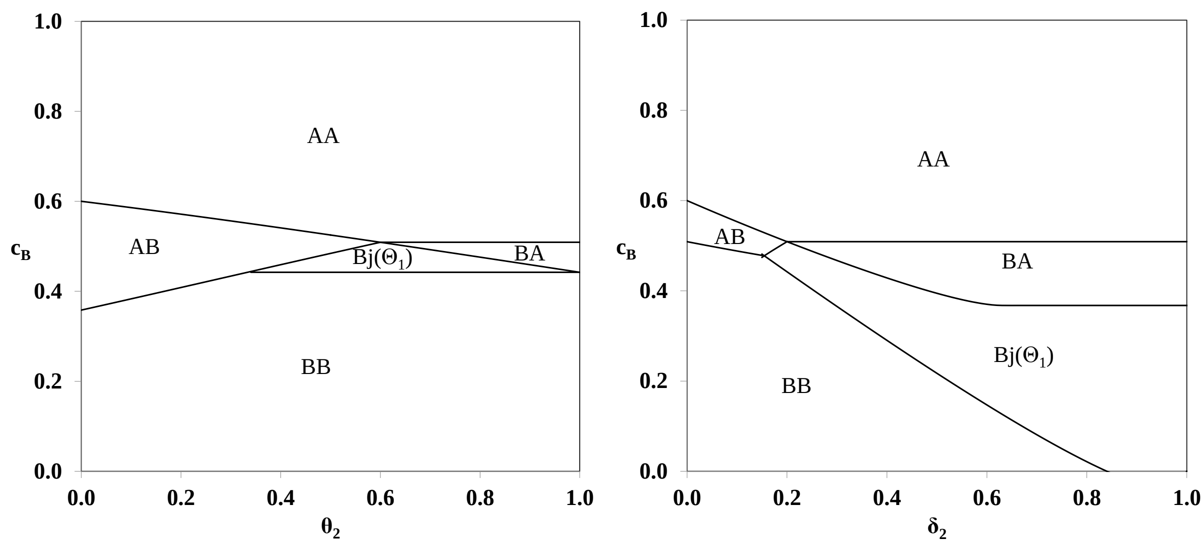


(a) Effect of θ_2 ($\theta_1 = 0.4$, $\delta = 0.4$) (b) Effect of δ_2 ($\theta = 0.4$, $\delta_1 = 0.4$)

examples ($\theta_1 = \delta_1 = 0.4, \alpha = 0.1, c_A = 0.6$). We first examine in Figure 8(a) how the change in the second period risk likelihood θ_2 affects the choice of optimal policy. We observe that for intermediate c_B, the firm would favor the short-term switching policy AB at extremely low θ_2, while BA is preferred at extremely high θ_2. This happens because, as θ_2 approaches the low or high values, the benefit of postponing the second period decision by adopting $Bj(\Theta_1)$ is diminishing. At extreme θ_2 values, supplier B in period 2 becomes almost either ethical or unethical. In the former case of an ethical B in period 2 (low θ_2), the firm would prefer AB to BB or $Bj(\Theta_1)$ as choosing B in the first period, the firm might lose the chance of having an ethical B if an unethical event happens in period 1. In the latter case of an unethical B in period 2 (high θ_2), the firm would be better off just switching to A in period 2 for otherwise the discount would happen almost surely.

We expect similar observations when varying the second period discount δ_2 but because of the choice of the base parameters, it does not show up in Figure 8(b). To illustrate how the differentiated discount factors influence the optimal policies and compare the effects between the risk likelihood and impact factors, we choose the exogenous parameter values so that each possible policy appears.

Figure 8: Optimal Policies as a Function of θ_2 or δ_2 $(\alpha = 0, c_A = 0.6)$



(a) Effect of θ_2 ($\theta_1 = 0.6$, $\delta = 0.2$) (b) Effect of δ_2 ($\theta = 0.6$, $\delta_1 = 0.2$)

By having no learning ($\alpha = 0$), medium-high risk likelihood ($\theta_1 = 0.6$), and low discount ($\delta_1 = 0.2$), in Figure 8, we examine the case where all five admissible policies can take place whether varying θ_2 or δ_2. The main difference between the two figures is the utilization of the contingent policy $Bj(\Theta_1)$. In Figure 9(a), as θ_2 deviates from the base value θ_1 $(= 0.6)$, the short-term policies AB and BA are becoming more prominent that replace the contingent policy because the benefit of $Bj(\Theta_1)$ is diminishing at extremely low or high θ_2 values. On the other hand, in Figure 9(b), though both AB and BA are presented as the discount factor δ_2 varies, it is $Bj(\Theta_1)$ that helps mitigate the impact, in particular at high δ_2.

3.4 Summary

Within the context of social responsibility, our work investigates the effect of three factors on supplier selection decisions: the risk likelihood of an unethical event, the impact of the event, and the supplier learning.

Our study on supplier selection gleans several important insights for the long-run strategy in selecting between ethical and cheap unethical suppliers. Contingent policy, where the firm switches to ethical supplier only if an unethical event happens, can be optimal when either the risk likelihood is low or the impact is high. In the case of Disney, soon after the deadly events happened, it asked licensees producing in Bangladesh to end production to protect the value of the brand. Long-term policies, where the firm stays with the same supplier, are optimal at high learning rates whether or not the rates are different between the suppliers. Even a series of suicidal tragedies did not stop Apple from sourcing its iDevices from Foxconn as other contract manufacturers had difficulties to produce Apple's products due to the growing complexity. For some other firms, like Fairphone, while at higher costs, they contract only with ethical suppliers to avoid the risk of having an impact from social irresponsibilities.

Our results show that for strategic sourcing, a firm should not myopically look at only short-term cost saving but also long-term economical profit and reputation from a social responsibility perspective. Furthermore, only if the risk likelihood or impact may change dramatically over time would the short-term switching policies be optimal, where the firm either always switches from ethical to unethical supplier, or reversely. It is worth noting that as stated on its official website, Disney would consider Bangladesh and other barred countries again only if meaningful improvements on work conditions are demonstrated (The Walt Disney Company, 2014).

CHAPTER IV

Supplier Development

4.1 Background

With a rise in reports pertaining to supplier violations along with stringent regulations from governmental agencies and mounting customer pressure are urging firms to engage in supplier improvement programs. For instance, after the building collapse in Bangladesh, three types of safety development programs were utilized by firms (Butler, 2013) with firms signing up for long-term safety programs. However, some firms stuck to their existing programs by choosing to not enter into safety agreements and stuck to their existing programs citing higher costs. On the other hand, firms may also choose to manage their risk by sourcing through intermediaries such as Li & Fung Ltd. for better collaboration and compliance of social and environmental regulations.

In the instance of social responsibility violations by suppliers, firms generally need to invest in repair activities in the form of payment or penalties to governmental agencies and additional training programs. For example, after a spate of incidents in China and

Bangladesh, rise in wages at Foxconn are shared by Apple Inc. (Ruwitch, 2012), whereas firms using suppliers in Bangladesh also signed pacts to invest in additional supplier development activities as precautionary measures based on these events. In January 2010, Walmart Inc. decided to enter into an open-ended sourcing arrangement with Li & Fung Ltd. (Belavina and Girotra, 2012), but recently it cut ties with the company. Like other firms are discovering, sourcing through third parties is quickly rising because firms expect the intermediary to take responsibility for risks such as, safe working conditions, and no violations of human rights. We summarize key differences in supplier development programs in Table II motivated by the safety agreement plans in Bangladesh, and use of intermediaries for sourcing.

Table II: Types of Supplier Development

	BANGLADESH SAFETY ACCORD	**ALLIANCE FOR BANGLADESH WORKER SAFETY**	**THIRD-PARTY SUPPLIER DEVELOPMENT**
Contract Type	Legally binding	Not legally binding	Agreement with Third-party
Scope	7-tier suppliers	5-tier suppliers	All suppliers
Funding Responsibility	Required	At will	Third-party
Cost	Up to $500,000 a year	Up to $1,000,000 a year	Undisclosed
Contribution	Relative to production volume	Relative to production volume	None
Implementation	Independent and transparent	Not independent	Third-party
Participants	Approximately 150 companies from more than 15 countries	Companies predominantly from the U.S.	JCPenney, Kohl's, Sears, etc.
Governance	Jointly governed by companies and NGO's	Governed only by corporations	Governed by third-party

Lee, O'Marah, and Geraint (2012) from the SCM (Supply Chain Management) World survey of chief supply chain officers and executives that, although supply shortages, shipping disruptions, and supplier financial failures are concerns for supply chain risks, more than half of the respondents were now concerned with supplier responsibility problems. In closely related literature, both Guo, Lee, and Swinney (2014) and Chen and Lee (2014) consider risk management from social responsibility context, but they do not address supplier development which we explicitly study in the model while also including the consumer perspective.

We know from the discussion in Chapter 2 that supplier development is an important decision for a firm, as it directly relates to a firm's supply chain performance, given consumer's interest towards social responsibility is rising. Additionally, recent developments following the incidents in Bangladesh and the subsequent safety programs that are being adopted by firms as stated in II motivate us to study the supplier development problem. Therefore, we develop a model addressing the following questions:

1. What is the optimal supplier development strategy for a firm between a legally binding program and a non-binding program when the costs, the risk likelihood of supplier unethical behavior are different?

2. Whether or not a firm should choose to not participate in any supplier development program, and bear the risk of unethical behavior?

3. How do the three factors, the risk likelihood, the penalty cost realized from unethical event, and finally the discount in the price affect firm's development strategies?

4.2 The Model

Consider a firm buying goods from a supplier who is not completely ethical. Hence, the firm may undertake supplier development activities either to comply with regulations, or to preserve its reputation. We model three types of development programs; the first, a direct and binding type of development program, the second, an indirect type of supplier development in which the firm utilizes intermediaries or third-parties and lastly, a non-binding type of development program.

Once the firm chooses direct or binding type of development, then it commits to investment and participation in the duration of the program. On the contrary, when the firm uses a third-party provider to implement improvement programs at the supplier, the relationship is of not binding in nature. Therefore, we use 'D' for Direct supplier development program and 'T' for Third-party (intermediary) development program. Alternatively, the firm may choose to have Non-binding development program which we represent using 'N'.

Without loss of generality, we assume the cost for the firm in choosing N as $c_N = 0$, while for T and D the firm pays c_T and c_D respectively. We model the firm's selection of the supplier development in a two-period setting (subscript t=1, 2). Once, the decision has been made, the firm then sells a fixed production quantity q to the market at a unit price of p. The product lifetime is assumed to be one period, that is, the firm cannot stock leftover goods from period 1 and sell them in period 2.

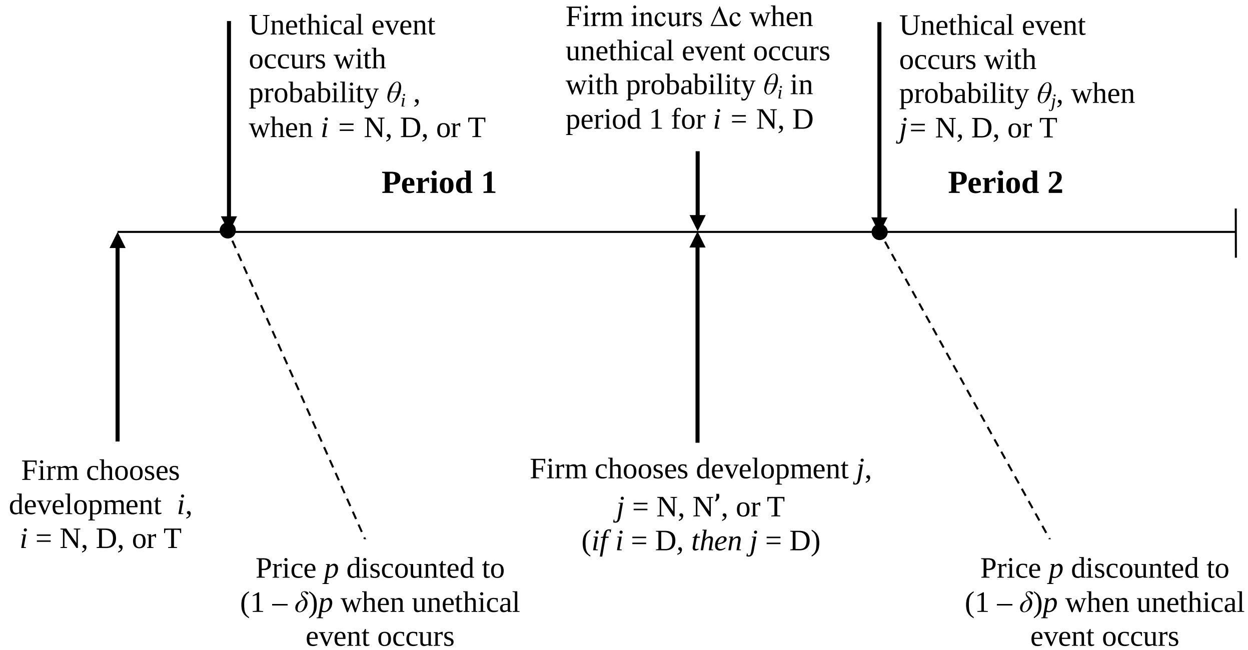
Unethical events: Disclosure or news outbreak of the supplier's unethical production practices, such as a fire safety violation or abuse of child labor, may have the buying firms face backlash from consumers. Experimental evidence from Trudel and Cotte (2009) suggests that consumers demand a substantial discount from firms that produce goods in an unethical manner. Their study also finds that while consumers reward ethical production, they also punish unethical firms even more in terms by demanding a discount in the price p. Therefore, we focus on the event of unethical production.

We assume that, for each supplier development type $i = N, D, T$, there is some risk likelihood or probability θ_i $(0 \leq \theta_i \leq 1)$ of supplier unethical production being disclosed to the consumer. The complement $(1 - \theta_i)$ corresponds to the probability of the alternative event, where there are no ethical violations by the supplier. Given the clustering of suppliers and/or their sub-contractors and routine audits of their factories, it is unlikely that the firm does not have some estimate of the chance of an unethical event happening (Lahiri, 2012). As the firm in our model is sourcing from the supplier who is not perfectly ethical, in the case of non-binding type of supplier development, i.e., for N, the risk probability is always greater in comparison to D and T. Therefore, we assume $\theta_N > \theta_D$ and $\theta_N > \theta_T$.

Discount in price: When learning corporate's unethical behavior through the disclosure of such event, Trudel and Cotte (2009) find from their experimental studies that consumers punish the firm by demanding a lower price.We assume a discount factor $\delta(0 \leq \delta \leq 1)$ on the price and thus the discount price is $(1 - \delta)p$, when an event is realized with probability θ. Empirical evidence suggests that, a firm will always be held accountable for supplier's unethical behavior by its consumers and only the severity of the violation can change accountability (Hartmann and Moeller, 2014). Therefore, when an event occurs in our model, consumers punish the firm by discounting the price by a factor δ since the firm sells one type of product at price p. Alternatively, with probability $1 - \theta$, there is no discount on demand $(\delta = 0)$ when the consumers are not aware of unethical production.

Penalty cost: In the event that the firm experiences supplier violations, it invests in recovery or mitigation efforts such as payment or penalties to governmental agencies,

Figure 9: Sequence of Events for Supplier Development



subsidizing supplier's labor costs, and investing in additional supplier training and safety programs. For example, Bartlett, Dessain, and Sjman (2006) estimated that various supplier noncompliance issues cost the global furniture retailer IKEA millions of dollars in the 1990's. We model this cost as Δc when a violation occurs at the supplier. Apple shared costs with its supplier Foxconn, when they raised employee wages following reports of low wages and underage interns (Ruwitch, 2012). More recently, various firm signed agreements for safety and training programs following fatal accidents at their supplier factories in Bangladesh. We can assume that, in the event the firm does not pay penalty cost Δc, it would experience an increase in the risk of supplier unethical behavior in the next period because the firm would not be able to repair its reputation.

The events happen in the following sequence as depicted in Figure 9:

At the beginning of period 1, the firm selects a supplier development program $(i = N, D, T)$ at a unit cost of c_i. If the firm experiences supplier violations with a risk probability θ_i, the price p will be discounted to $(1-\delta)p$. The firm then sells a fixed quantity in the market, obtaining a profit of $(1-\delta)p - c_i$. Alternatively, when there is no unethical event realization, there will be no discount δ=0.

At the beginning of period 2, the firm makes another selection in supplier development $(j = N, D, T)$ at a cost of c_j per unit. Note that when $i = D$, then $j = D$, since the direct supplier development is binding in nature.

Additionally, the firm incurs the penalty cost Δc if an unethical event happens with the probability θ_i in the first period. The firm pays the penalty cost to restore the reputation and thereby restoring the probability θ_j to θ_i in the second period. Hence, the firm bears the cost Δc at the beginning of period 2. The probability of an unethical event happening is dependent on whether or not the firm pays the penalty cost, and hence the firm may bear the maximum risk probability of θ_N=1 in period 2 if it does not invest in repair activities following an unethical event in a non-binding type of program.

We denote the selection in period as $j = N'$ when $i = N$ and the firm continues to participate in non-binding supplier development program with the risk likelihood of $\theta_j = \theta_N$=1. For a binding or direct type of supplier development program, the firm has to pay penalties in accordance with the agreement, while for a third-party development type the costs are absorbed by the intermediary or the third-party. We can summarize the firm's first period profit function as follows:

$$\pi_{1i}(\Theta_1) = \begin{cases} (1-\delta)p - c_i & \text{if } i = T, D, N \text{ and } \Theta_1 = \theta_i \\ p - c_i & \text{if } i = T, D, N \text{ and } \Theta_1 = 1 - \theta_i \end{cases} \tag{4.1}$$

where Θ_1 indicates the realization of the first period event and Θ_2 indicates the realization of the second period event. The firm's second period profit function of second period based on both the first and second period decisions summarized as follows:

$$\pi_{2j}(\Theta_1, \Theta_2) = \begin{cases} p & \text{if } j = N \text{ given } i = N, & \Theta_1 = 1-\theta_N, & \Theta_2 = 1-\theta_N \\ (1-\delta)p & \text{if } j = N \text{ given } i = N, & \Theta_1 = 1-\theta_N, & \Theta_2 = \theta_N \\ p - c_T & \text{if } j = T \text{ given } i = N, & \Theta_1 = 1-\theta_N, & \Theta_2 = 1-\theta_T \\ (1-\delta)p - c_T & \text{if } j = T \text{ given } i = N, & \Theta_1 = 1-\theta_N, & \Theta_2 = \theta_T \\ (1-\delta)p & \text{if } j = N' \text{ given } i = N, & \Theta_1 = \theta_N, & \Theta_2 = \theta_{N'} = 1 \\ p - \Delta c & \text{if } j = N \text{ given } i = N, & \Theta_1 = \theta_N, & \Theta_2 = 1-\theta_N \\ (1-\delta)p - \Delta c & \text{if } j = N \text{ given } i = N, & \Theta_1 = \theta_N, & \Theta_2 = \theta_N \\ p - (c_T + \Delta c) & \text{if } j = T \text{ given } i = N, & \Theta_1 = \theta_N, & \Theta_2 = 1-\theta_T \\ (1-\delta)p - (c_T + \Delta c) & \text{if } j = T \text{ given } i = N, & \Theta_1 = \theta_N, & \Theta_2 = \theta_T \\ p & \text{if } j = N \text{ given } i = T, & \Theta_1 \in \{1-\theta_T, \theta_T\}, & \Theta_2 = 1-\theta_N \\ (1-\delta)p & \text{if } j = N \text{ given } i = T, & \Theta_1 \in \{1-\theta_T, \theta_T\}, & \Theta_2 = \theta_N \\ p - c_T & \text{if } j = T \text{ given } i = T, & \Theta_1 \in \{1-\theta_T, \theta_T\}, & \Theta_2 = 1-\theta_T \\ (1-\delta)p - c_T & \text{if } j = T \text{ given } i = T, & \Theta_1 \in \{1-\theta_T, \theta_T\}, & \Theta_2 = \theta_T \\ p - c_D & \text{if } j = D \text{ given } i = D, & \Theta_1 = 1-\theta_D, & \Theta_2 = 1-\theta_D \\ (1-\delta)p - c_D & \text{if } j = D \text{ given } i = D, & \Theta_1 = 1-\theta_D, & \Theta_2 = \theta_D \\ p - (c_D + \Delta c) & \text{if } j = D \text{ given } i = D, & \Theta_1 = \theta_D, & \Theta_2 = 1-\theta_D \\ (1-\delta)p - (c_D + \Delta c) & \text{if } j = D \text{ given } i = D, & \Theta_1 = \theta_D, & \Theta_2 = \theta_D \end{cases} \tag{4.2}$$

With the above introduced notation, we can express the expected total profit function under each alternative as follows. Note that these alternatives are for general case in which $j = N, N', D, T$.

$$\Pi_{ij} = \mathbb{E}_{\Theta_1}\left[\pi_{1i}(\Theta_1) + \mathbb{E}_{\Theta_2}[\pi_{2j}(\Theta_1, \Theta_2)]\right] \tag{4.3}$$

$$\Pi_{Tj(\Theta_1)} = \mathbb{E}_{\Theta_1}\left[\pi_{1T}(\Theta_1) + \mathbb{E}_{\Theta_2}[\pi_{2j(\Theta_1)}(\Theta_1, \Theta_2)]\right] \tag{4.4}$$

$$\Pi_{Nj(\Theta_1)} = \mathbb{E}_{\Theta_1}\left[\pi_{1N}(\Theta_1) + \mathbb{E}_{\Theta_2}[\pi_{2j(\Theta_1)}(\Theta_1, \Theta_2)]\right] \tag{4.5}$$

Π_{ij} denotes the total profit for the policy ij, when i is the development choice in period 1 and j in period 2; while $\Pi_{Nj(\Theta_1)}$ denotes the profit if N is the decision in period 1, but in period 2 the choice of development $j(\Theta_1)$ is contingent on the realization of the event Θ_1. Similarly, $\Pi_{Tj(\Theta_1)}$ represents the total profit if T is the choice in period 1, and in period 2 the choice of development $j(\Theta_1)$ is again contingent on the realization of the event Θ_1.

We denote $\Pi_{NN'}$ as a special case of dynamic policy that represents the profit of the firm for $i = N$, while j is based on the realization of θ_i. When θ_i is realized, then $j = N'$, and when no event is realized, then $i = j = N$. $\Pi_{Nj'(\Theta_1)}$ on the other hand represents the profit of the firm for $i = N$, while j is based on the realization of θ_i. When θ_i is realized, then $j = N'$, and when no event is realized, then $j = T$. We summarize all admissible policies in Table III. The term "short-term policy" refers to the case in which the firm adopts a supplier development type for exactly one period and then switches, while the "long-term policy," refers to the policy in which the firm continues with the same selection across both periods.

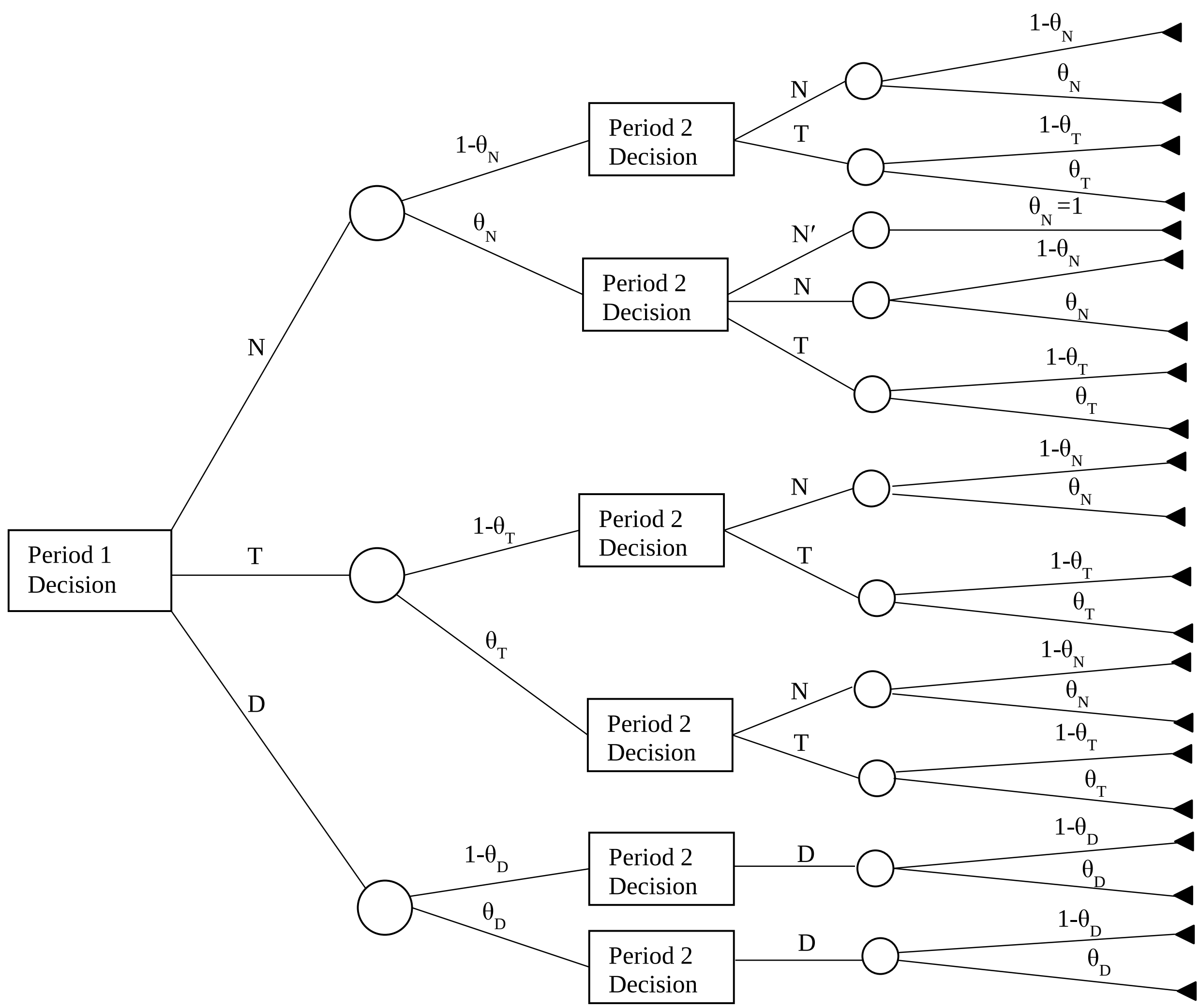
Table III: Admissible Supplier Development Policies

Policy	**Period 1 Choice**	**Period 2 Choice**
TT (Long-term)	T	T
DD (Long-term)	D	D
NT (Switching)	N	Switch to T
TN (Switching)	T	Switch to N
NN (Long-term)	N	N
NN' (Long-term)	N	$\begin{cases} \text{Continue with } N \text{ if no unethical event realized} \\ \text{Continue with } N', \text{ otherwise} \end{cases}$
$Nj'(\Theta_1)$ (Contingent)	N	$\begin{cases} \text{Switch to } T \text{ if no unethical event realized} \\ \text{Continue with } N', \text{ otherwise} \end{cases}$
$Nj(\Theta_1)$ (Contingent)	N	$\begin{cases} \text{Switch to } T \text{ if no unethical event realized} \\ \text{Continue with } N, \text{ otherwise} \end{cases}$
$Tj(\Theta_1)$ (Contingent)	T	$\begin{cases} \text{Switch to } N \text{ if no unethical event realized} \\ \text{Continue with } T, \text{ otherwise} \end{cases}$

4.3 Analysis

The decision tree in Figure 10 for the model depicts all alternatives over the two-period time horizon. We start by characterizing the second period results, and solve the first period problem through backward induction.

Figure 10: Decision Tree for Supplier Development



Proposition 5. *Given the development choice in period 1 is 'i', the decision for the buying firm in period 2 can be characterized as follows.*

(a) *For* $i = N$ *and* $\Theta_1 = 1 - \theta_N$ *in period 1, choose* T *in period 2 if* $c_T \leq \bar{C}_T \equiv \delta p(\theta_N - \theta_T)$*, otherwise choose* N*.*

(b) *For* $i = N$ *and* $\Theta_1 = \theta_N$ *in period 1,*

  (i) *When* $\Delta c \leq \delta p(1 - \theta_N)$*, if* $c_T \leq \bar{C}_T$*, choose* T *in period 2, otherwise choose* N*.*

  (ii) *When* $\Delta c > \delta p(1 - \theta_N)$*, if* $c_T \leq \bar{\bar{C}}_T \equiv \delta p(1 - \theta_T) - \Delta c$*, choose* T *in period 2, otherwise choose* N'*.*

(c) *For* $i = T$ *and* $\Theta_1 = 1 - \theta_T$ *in period 1, choose* T *in period 2 if* $c_T \leq \bar{C}_T$*, otherwise choose* N*.*

(d) *For* $i = T$ *and* $\Theta_1 = \theta_T$ *in period 1, choose* T *in period 2 if* $c_T \leq \bar{C}_T$*, otherwise choose* N*.*

Proof. All proofs and expressions for c_T cutoffs are provided in the Appendix. □

When N is the firm's supplier development decision in period 1, Proposition 5 (a) and (b) show the cutoffs below which the firm switches to T depending on the realization of the event in period 1. $\bar{C}_T$ is the cutoff, below which the firm switches to T in Proposition 5 (a) and (b) (i). Below $\bar{\bar{C}}_T$, the firm switches to T as seen in Proposition 5 (b) (ii). Note that the cutoff does not depend on the realization of the event, if $\bar{C}_T < \bar{\bar{C}}_T$. Proposition 5 (b) define a threshold in the penalty cost Δc, that defines the ranking of $\bar{C}_T$ and $\bar{\bar{C}}_T$. At $\bar{\bar{C}}_T$ lower than $\bar{C}_T$, the firm switches to T below $\bar{C}_T$, otherwise it continues with N'. When T is the firm's decision in period 1, the firm will switch to N above the cutoff $\bar{C}_T$ that does not depend on the realization of event in period 1.

To summarize the second period outcomes, for low Δc ($< \delta p(1 - \theta_N)$) values and low c_T values, T is the optimal choice while at higher Δc values, the firm requires lower c_T values to choose T, to offset the $\Delta c = 0$ in choosing N'. After characterizing the firm's optimal second period choice given Θ_1, we next solve for the optimal policy to adopt in period 1 as stated in Proposition 6.

Proposition 6. *(1) For* $\Delta c \leq \delta p(1-\theta_N)$

(i) when $c_T \leq \bar{C}_T$*, adopt* TT*, if* $c_T \leq \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$*, else* DD*.*

(ii) when $c_T > \bar{C}_T$*,*

(a) Given $c_D \leq \tilde{C}_D \equiv \frac{2\delta p(\theta_N - \theta_D) + \Delta c(\theta_N - \theta_D)}{2}$*, adopt* TN *if* $c_T < \tilde{C}_T^{II} \equiv\ 2c_D + 2\delta p \theta_D - \delta p(\theta_T + \theta_N) + \Delta c \theta_D$*, else* DD*.*

(b) Given $c_D > \tilde{C}_D$*, adopt* TN *if* $c_T < \tilde{C}_T^{I} \equiv \delta p(\theta_N - \theta_T) + \Delta c \theta_N$*, else* NN*.*

(2) For $\Delta c > \delta p(1-\theta_N)$

(i) when $c_T \leq \bar{C}_T$*, adopt* TT*, if* $c_T \leq \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$*, else* DD*.*

(ii) when $c_T > \bar{C}_T$*,*

(a) Given $c_D \leq \hat{C}_D \equiv \frac{\delta p \theta_N(3-\theta_N) - \theta_D(2\delta p + \Delta c)}{2}$*, adopt* TN *if* $c_T < \tilde{C}_T^{II}$*, else* DD*.*

(b) Given $c_D > \hat{C}_D$*, adopt* TN *if* $c_T < \hat{C}_T \equiv \delta p(\theta_N - \theta_T) + \delta p \theta_N(1-\theta_N)$*, else* $NN^{'}$*.*

Proof. All proofs and expressions for c_T cutoffs are provided in the Appendix. □

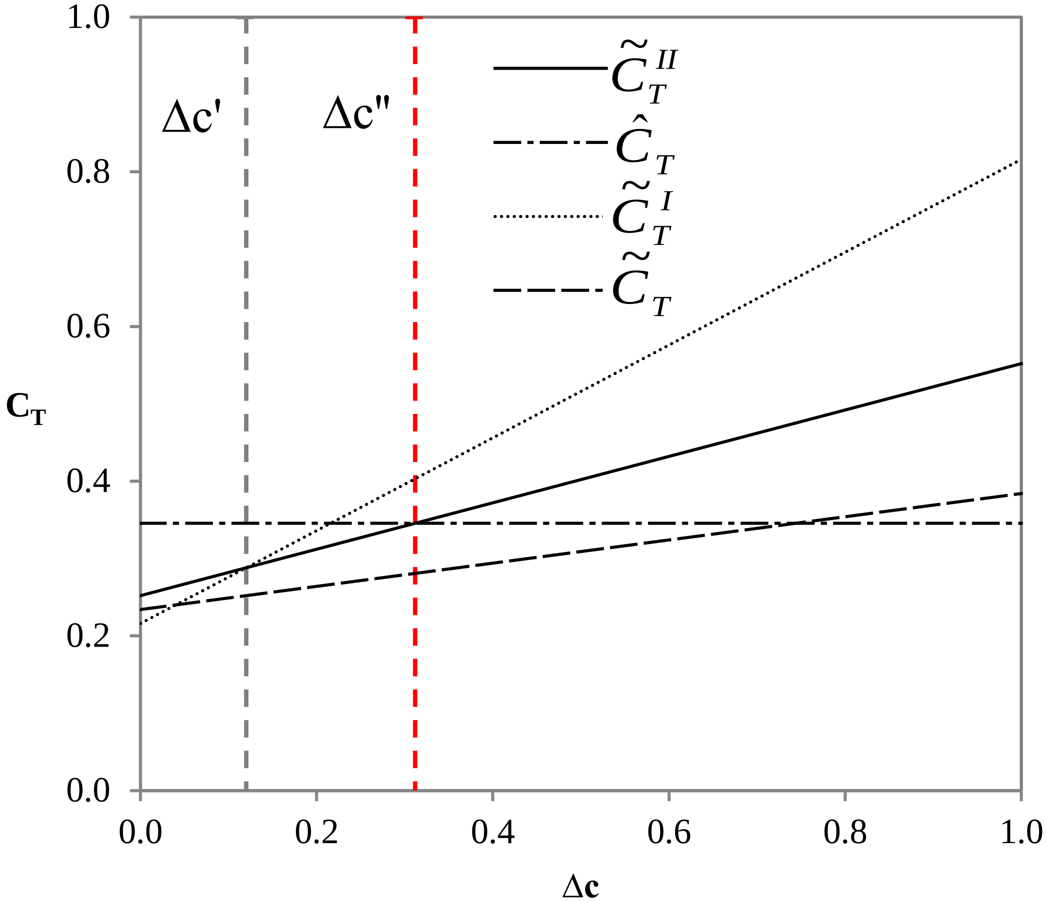
Proposition 7. $\tilde{C}_T^{I}$*,* $\tilde{C}_T^{II}$*, and* $\tilde{C}_T$ *are increasing in* Δc*.*

(i) When $\Delta c < \Delta c^{'} = \frac{2\delta p(\theta_N - \theta_D) - 2c_D}{(\theta_D - \theta_N)}$*, then* $\tilde{C}_T^{I} \leq \tilde{C}_T^{II}$*.*

(ii) When $\Delta c < \Delta c^{''} = \frac{3\delta p \theta_N - \delta p \theta_N^2 - 2c_D - 2\delta p \theta_D}{\theta_D}$*, then* $\tilde{C}_T^{II} \leq \hat{C}_T$*.*

Proposition 6 (1) considers scenarios for all range of c_T values when the penalty cost Δc is lower than the threshold $\delta p(1-\theta_N)$, and Proposition 6 (2) considers scenarios for all range of c_T values above $\delta p(1-\theta_N)$. We begin by examining the joint effect of Δc and c_T

Figure 11: Comparative Statics w.r.t. Δc

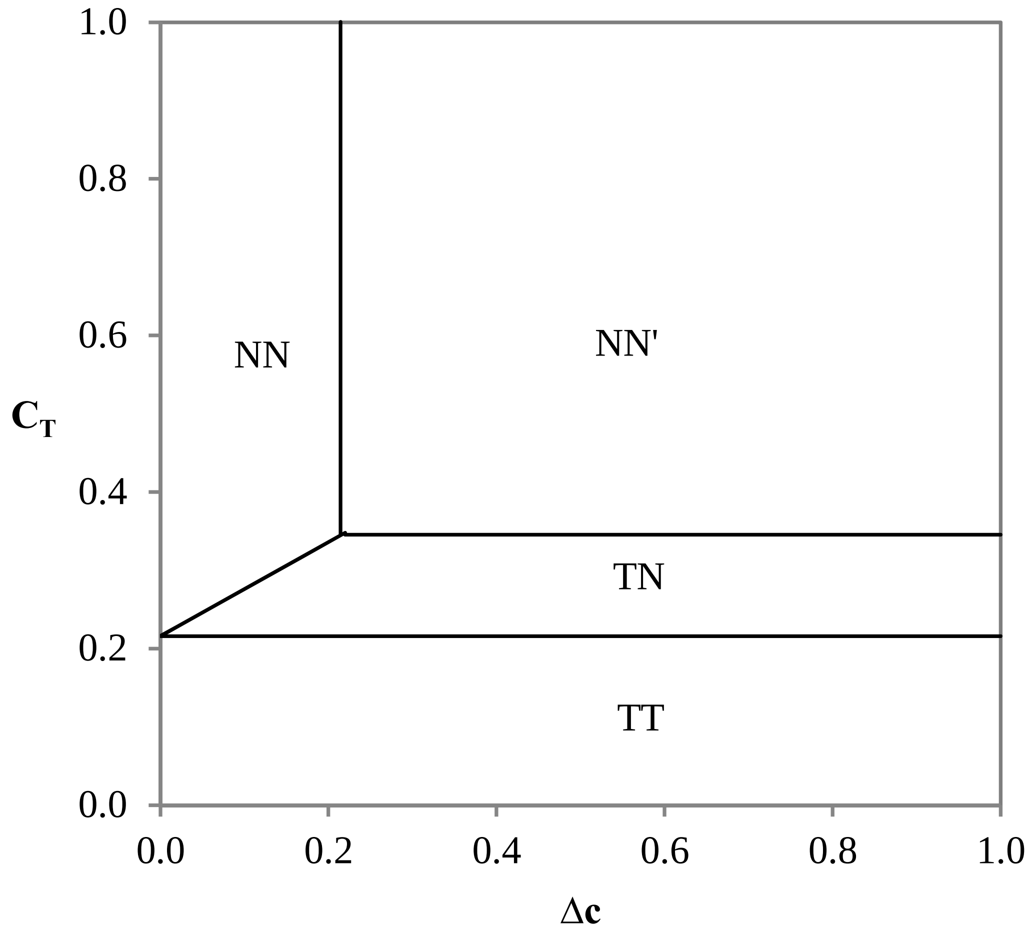


on optimal policies, keeping all other parameters constant. We know that DD is a binding policy, and hence in Proposition 6 (1), $\tilde{C}_D$ is the threshold below which DD is optimal instead of NN, while in Proposition 6 (2), $\hat{C}_D$ is the threshold below which DD is optimal instead of NN'.

For given values of δ=0.6, p=0.9, θ_N=0.6, θ_T=0.2, θ_D=0.5, and c_D=0.2, Figure 12 demonstrates that for low values of c_T, the static policy TT is the optimal choice for all Δc values. At low c_T, the firm has an additional advantage in terms of the penalty cost. Therefore, TT is optimal at all range of Δc values.

For intermediate range of c_T and Δc values, the static switching policy TN is

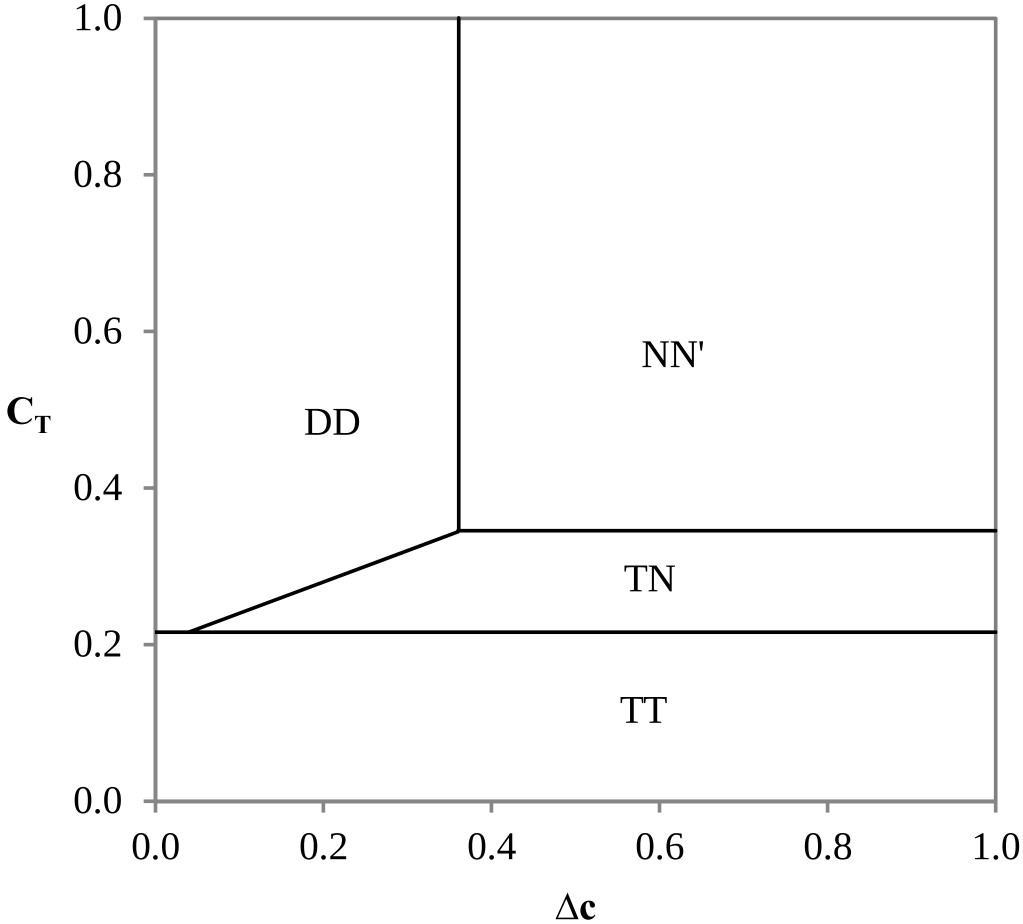
Figure 12: Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.5, c_D = 0.2$)



optimal. If the firm's penalty cost is low, NN is optimal instead of TN, as the firm would pay high cost c_T (c_N=0) in a TN policy. As c_T becomes larger, only one of the static policies NN, NN', or DD is optimal for a firm that depend on the threshold in c_D. When the penalty cost Δc is low along with high cost c_T, then a long-term policy with NN is optimal. At high penalty cost Δc, choosing NN' is optimal, but the firm experiences a maximum risk likelihood of unethical event θ_N=1. On the other hand, the binding policy DD optimal at low θ_D and c_D, as c_T increases further.

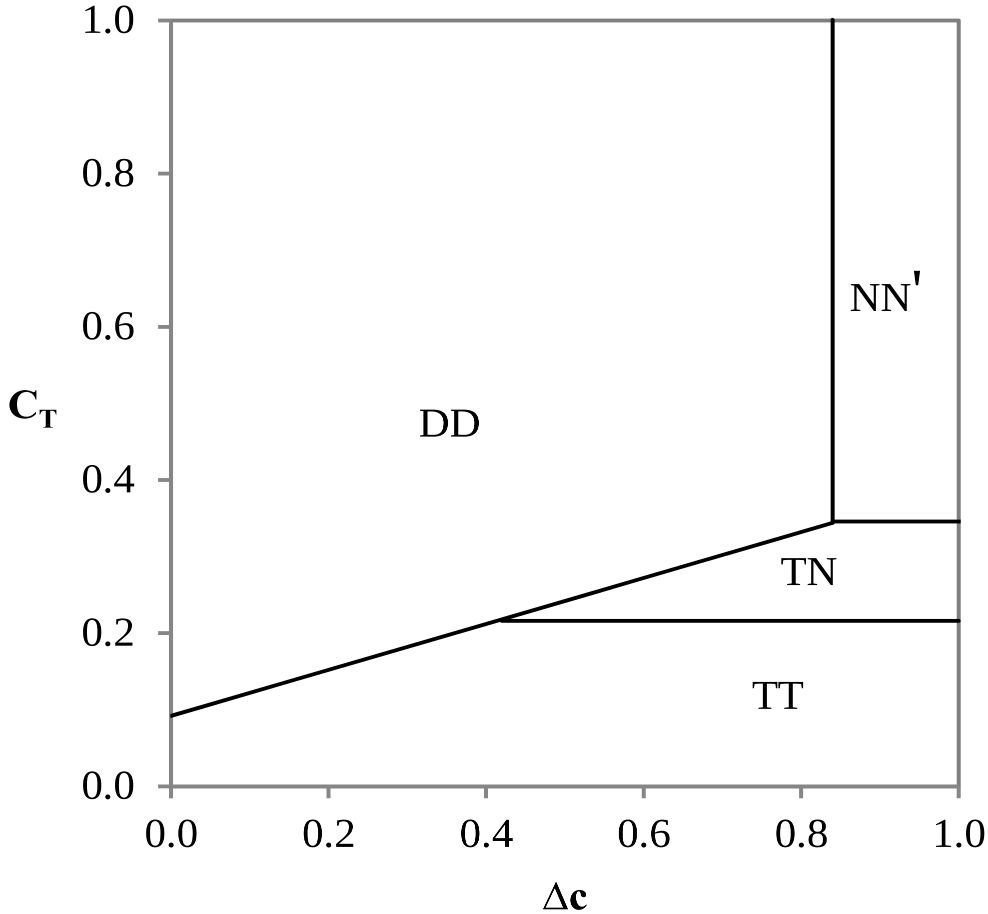
Next, we change the parameters θ_D and c_D in order to see how the optimal policies

Figure 13: Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.4, c_D = 0.1$)



change, especially at large c_T values. In Figure 13, the results are similar to 12 except that at high c_T values, DD is optimal at low range of Δc values, since θ_D and c_D are both lower. Further, when Δc increases, the lower cost and the lower risk of unethical event in choosing DD does not offset the high penalty cost and it is rather optimal to choose NN'. Reducing values of θ_D and c_D further, the firm is more likely to choose DD, as seen in Figure 14. As we further reduce c_D, DD becomes optimal dominating both NN and NN' as seen in Figure 15. Since NN and NN' are not optimal for any Δc, the firm may adopt TN only when the penalty cost is high.

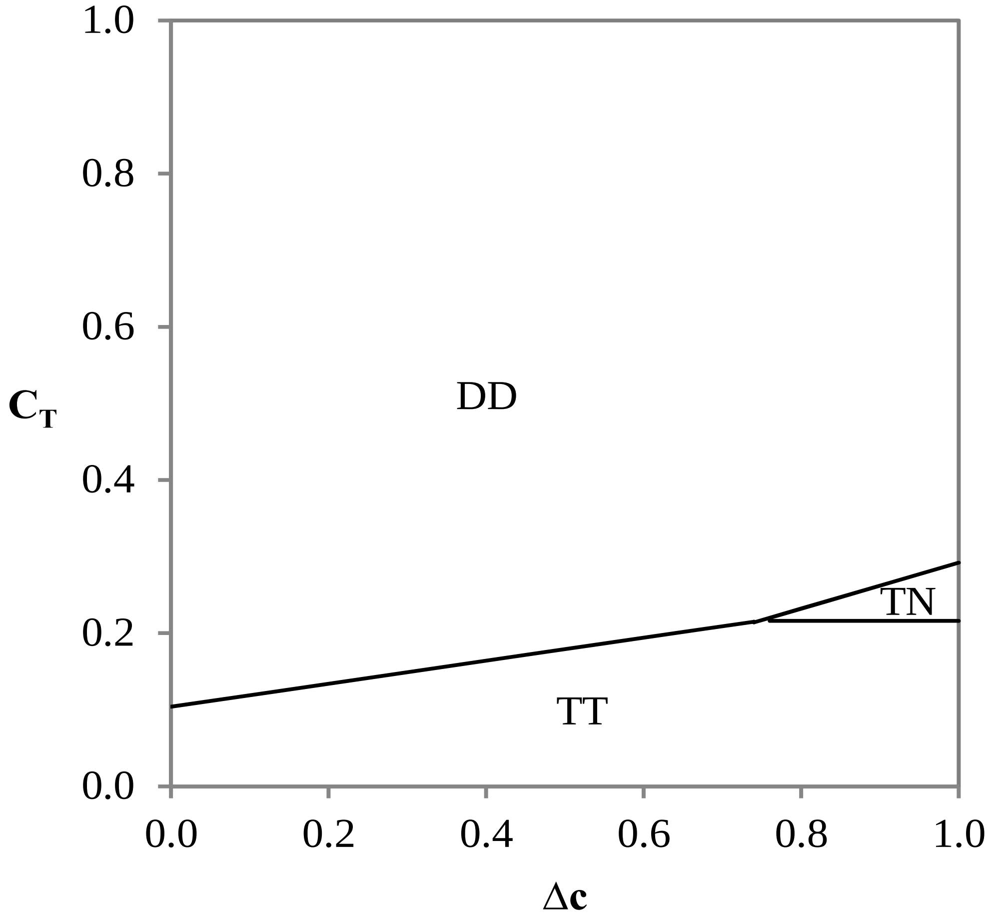
Figure 14: Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.3, c_D = 0.1$)



We observe that the long-term policies are optimal at extreme values of c_T, while the static switching policy TN is optimal for low-to-medium range values of c_T and Δc. Although TN may become optimal for low Δc values, the likelihood of choosing TN is lower when the penalty cost is below the threshold ($\Delta c \leq \delta p(1-\theta_N)$). Note that, for TN to be optimal, the firm requires to have a low cost c_T as well as significant amount of savings from period one in the penalty cost with a high risk probability. If the cost c_T is very low, then the long-term policy TT is optimal for the firm. Hence, the switching policy TN is optimal for small range of parameter values.

The alternate switching policy NT is not optimal for any parameter values, as

Figure 15: Optimal Policies as a Function of Δc and c_T ($\theta_D = 0.3, c_D = 0.05$)



long-term policies are optimal at extreme values of c_T and TN at intermediate range of c_T. In the NT policy, the firm would pay the penalty cost Δc when an unethical event is realized in period 1 and bear Similarly, $Nj^{'}(\Theta_1)$ is never optimal because the firm would bear the risk of unethical event across both periods. Specially, in period 2, the firm bears the maximum risk likelihood of unethical event (θ_N=1) while switching to T when no event is realized in period 1 will only increase the cost for the firm.

Overall, as c_T and Δc vary, the optimal policies change from TT, TN to either one of NN, $NN^{'}$ or DD. Note that, we observe the switching policy TN only when the risk differential between T and N is not large, else the long-term policies are optimal for the firm. At high range of c_T values, the firm chooses between long-term policies NN, $NN^{'}$ and DD. At a combination of large Δc and medium-to-high (θ_D and c_D), long-term non-binding policies NN or $NN^{'}$ are optimal. When the risk likelihood and the cost in choosing direct (binding) development D are relatively low, the long-term policy DD is the optimal decision for the firm.

Corollary 1. *(i) $\tilde{C}_T$, $\tilde{C}_T^I$, $\tilde{C}_T^{II}$, and $\hat{C}_T$ are decreasing in θ_T.*

(ii) $\tilde{C}_T^I$ and $\hat{C}_T$ are increasing in δ.

(iii) $\tilde{C}_T$ is increasing (decreasing) in δ, if $\theta_D > \theta_T(\theta_D < \theta_T)$.

(iv) $\tilde{C}_T^{II}$ is increasing (decreasing) in δ, if $\theta_D - \theta_T > \theta_N - \theta_D$ $(\theta_D - \theta_T < \theta_N - \theta_D)$.

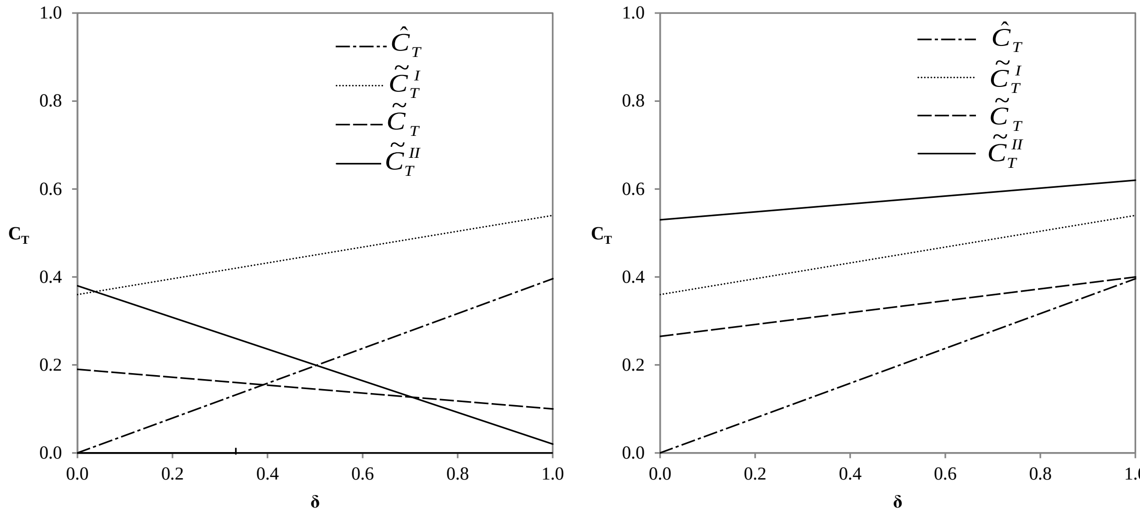
Corollary 1 depicts the variability of period one cutoffs with respect to θ_T and δ. All cutoffs in c_T above are derived according to which the firm chooses between TT, DD, NN, and $NN^{'}$. Hence, as the risk likelihood of unethical event increases in choosing T, the firm would require lower costs in c_T.

$\tilde{C}_T^I$ is increasing with δ from Corollary 1 (ii) suggests that the firm can bear higher costs in c_T, because we know the discount in price δ is the same in TN and NN policies, while the ranking of the risk probabilities is $\theta_N > \theta_T$. Similarly, for the cutoff $\hat{C}_T$ above which $NN^{'}$ becomes optimal over TN for the firm, $\hat{C}_T$ increases with δ due to the assumption that $\theta_N > \theta_T$. Therefore, the firm is likely to choose development policy TN with increase in the δ in order to offset the higher risk of unethical event.

From Corollary 1 (iii), $\tilde{C}_T$ is increasing in δ, when θ_D is greater than θ_T as the firm would prefer long-term policy TT even at higher costs in order to avoid high risk in the binding policy DD. On the contrary, when the risk in choosing T is higher, the threshold $\tilde{C}_T$ below which TT is optimal decreases as the firm would require lower costs to offset the higher risk. Next, in Corollary 1 (iv), the threshold $\tilde{C}_T^{II}$ below which the firm chooses TN over DD increases with δ when the cost differential between D and T (θ_D-θ_T) is greater than the differential between N and T (θ_N-θ_D). With increase in δ, the firm is more likely to choose TN when $\theta_D - \theta_T > \theta_N - \theta_D$. In the alternative case, the firm requires lower costs in c_T to choose TN and hence $\tilde{C}_T^{II}$ decreases with δ.

Figure 17(a) and Figure 17(b) show the opposite effect from the discussion based on Corollary 1.

Figure 16: Comparative Statics w.r.t. δ



(a) θ_D=0.5, c_D=0.2 (b) θ_D=0.4, c_D=0.1

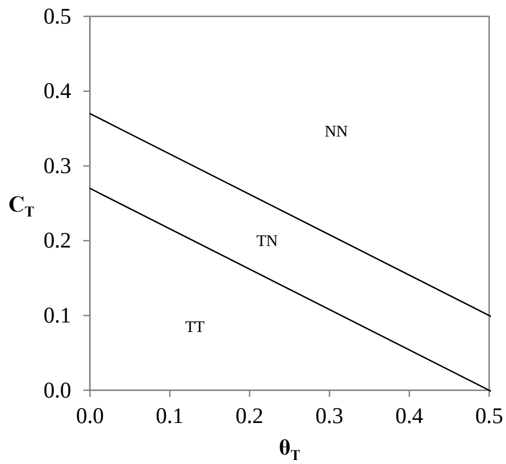
Based on the Corollary 1 (i), we evaluate the joint effect of θ_T and c_T. All cutoffs in c_T are decreasing in θ_T, given other parameters are held constant. We choose parameters δ=0.6, p=0.9, θ_N=0.5, θ_D=0.3, and c_D=0.15 for the purpose of the analysis. In the Figure 18(a), we notice that for low range of c_T and θ_T values the long-term policy TT is optimal for the firm. For intermediate values of c_T and θ_T, the switching policy TN is optimal while for high range of values, NN becomes optimal. Since all cutoffs in c_T are decreasing with θ_T, the shape of the optimal areas show the linear relationship of cut-offs in the

Figure 18(b). The optimal policies are based on the ranking of cutoffs from the Proposition 6 as well as on the range of Δc values.

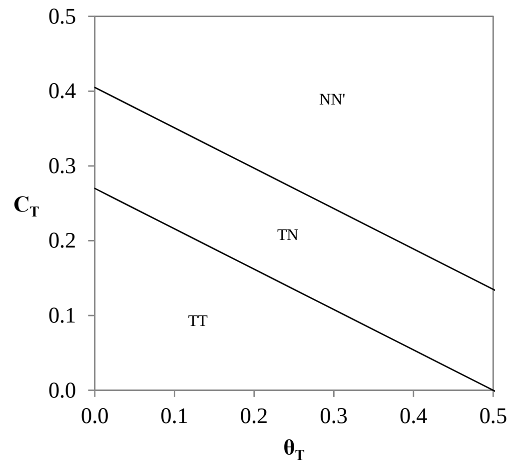
In Fig 17, we observe the effect of θ_T and c_T on the firm's optimal policies. We choose parameters δ=0.6, p=0.9, θ_N=0.5, θ_D=0.3, and c_D=0.15 for the purpose of the analysis. We observe that optimal policies change from TT to TN, and then to NN when we choose $\Delta c = 0.2$ in the Figure 18(a). For an increase in Δc in the Figure 18(b), the long-term policy NN' becomes optimal instead of NN at high c_T and tT as the firm might bear the maximum risk by not investing in repair activities following an unethical event. But, when the cost c_D decreases as seen in the Figure 18(c), the binding policy DD is optimal at high c_T and θ_T values. Altogether, we see the transition of optimal policies from TT at low θ_T, to TN at medium range of θ_T, and to a long-term policy between NN, NN' or DD at high θ_T.

Next, we examine the joint effect of δ and c_T on the optimal supplier development policies. We use parameter values of p=0.9, θ_N=0.5, θ_T=0.2, θ_D=0.3, c_D=0.1, and Δc=0.2 for analysis in Figure 18. For low range of δ and c_T values, we notice that TT is not always optimal. When δ is close to 0, the switching policy TN is optimal for any slight increase in c_T because the discount in the price is so low that the firm may bear a risk in period 2 by switching to N and still benefit from the penalty costs Δc with the third-party from period 1. As c_T increases further at low discount δ values, the long-term policy NN' is optimal, while at high discount δ there is a high risk probability of the discount (θ_N=1) that makes the binding policy DD optimal. The long-term policy NN may also be optimal at high c_D values, when the risk probability in the policy NN offsets the high cost and the risk likelihood in the DD policy as seen in Figure 19.

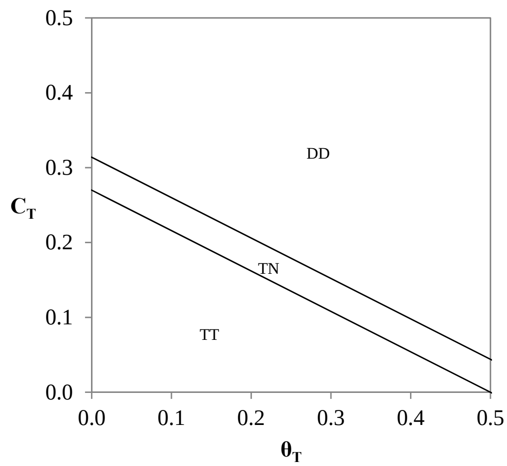
Figure 17: Optimal Policies as a Function of θ_T and c_T



(a) θ_D=0.3, c_D=0.15, Δc=0.2

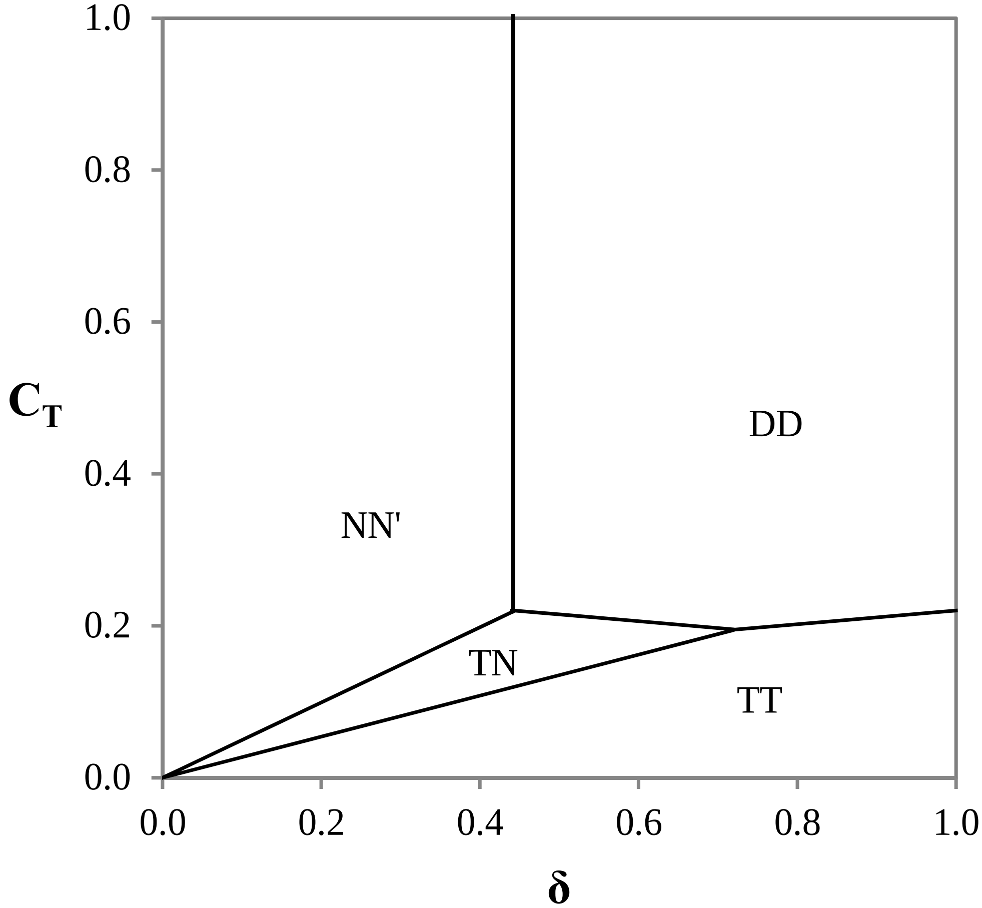


(b) θ_D=0.3, c_D=0.15, Δc=0.3



(c) θ_D=0.3, c_D=0.1, Δc=0.2

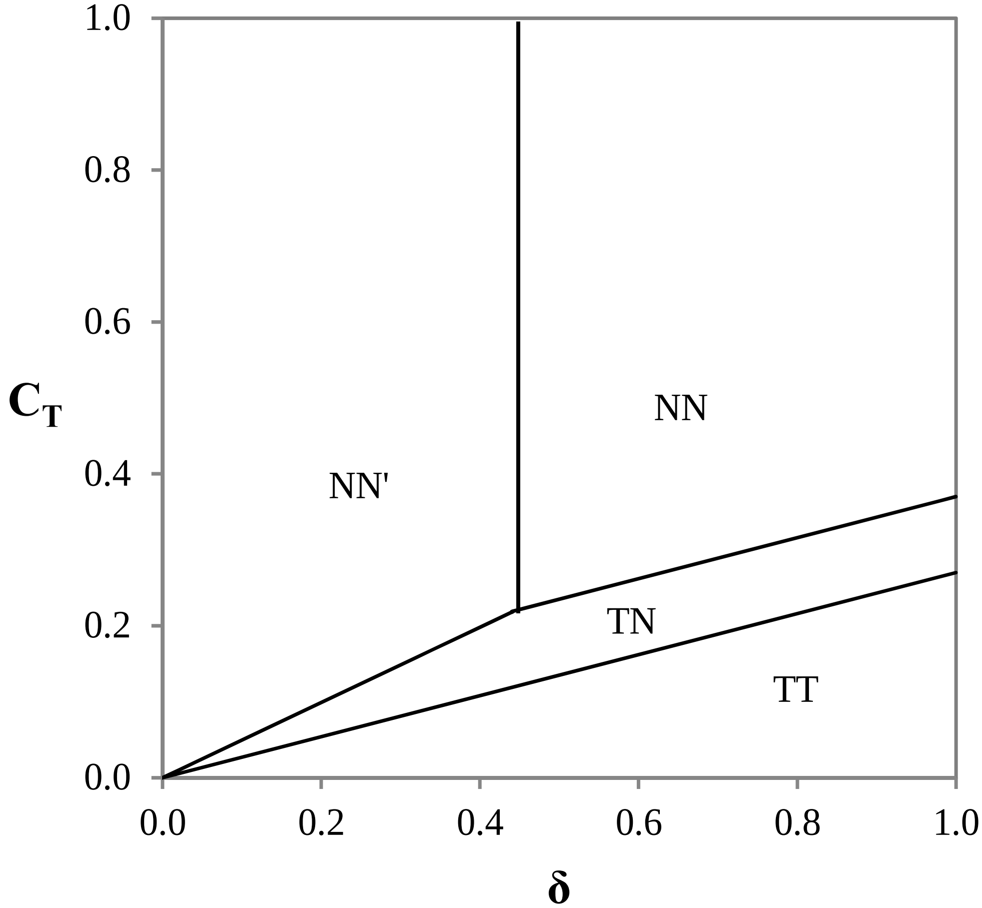
Figure 18: Optimal Policies as a Function of δ and c_T (θ_D=0.3, c_D=0.1)



4.4 Alternative Model

The model discussed in the Section 4.3 considers three alternatives N, N', T, when an unethical event is realized in period one with probability θ_N. A new alternative model is worthwhile to study, when the firm has to pay the cost of Δc in the form of penalties or an investment that is mandatory according to an existing agreement with the supplier or local governmental agencies which rules out the development type N'. The firm may now switch to T or continue with N, in the event of a violation by the supplier by paying the cost Δc. The sequence of events for the alternative model follow as per the Figure 21.

Figure 19: Optimal Policies as a Function of δ and c_T (θ_D=0.3, c_D=0.2)



4.4.1 Analysis

The decision tree for the alternative model shows the supplier development model over the two-period time horizon as seen in Figure 20.

For the alternative model, the events happen in the sequence as depicted in Figure ??:

We start by characterizing the second period results, and then solve the first period problem through backward induction.

Proposition 8. *Given the development choice in period 1 is 'i', the decision for the buying*

Figure 20: Decision Tree for Supplier Development-Alternate Model

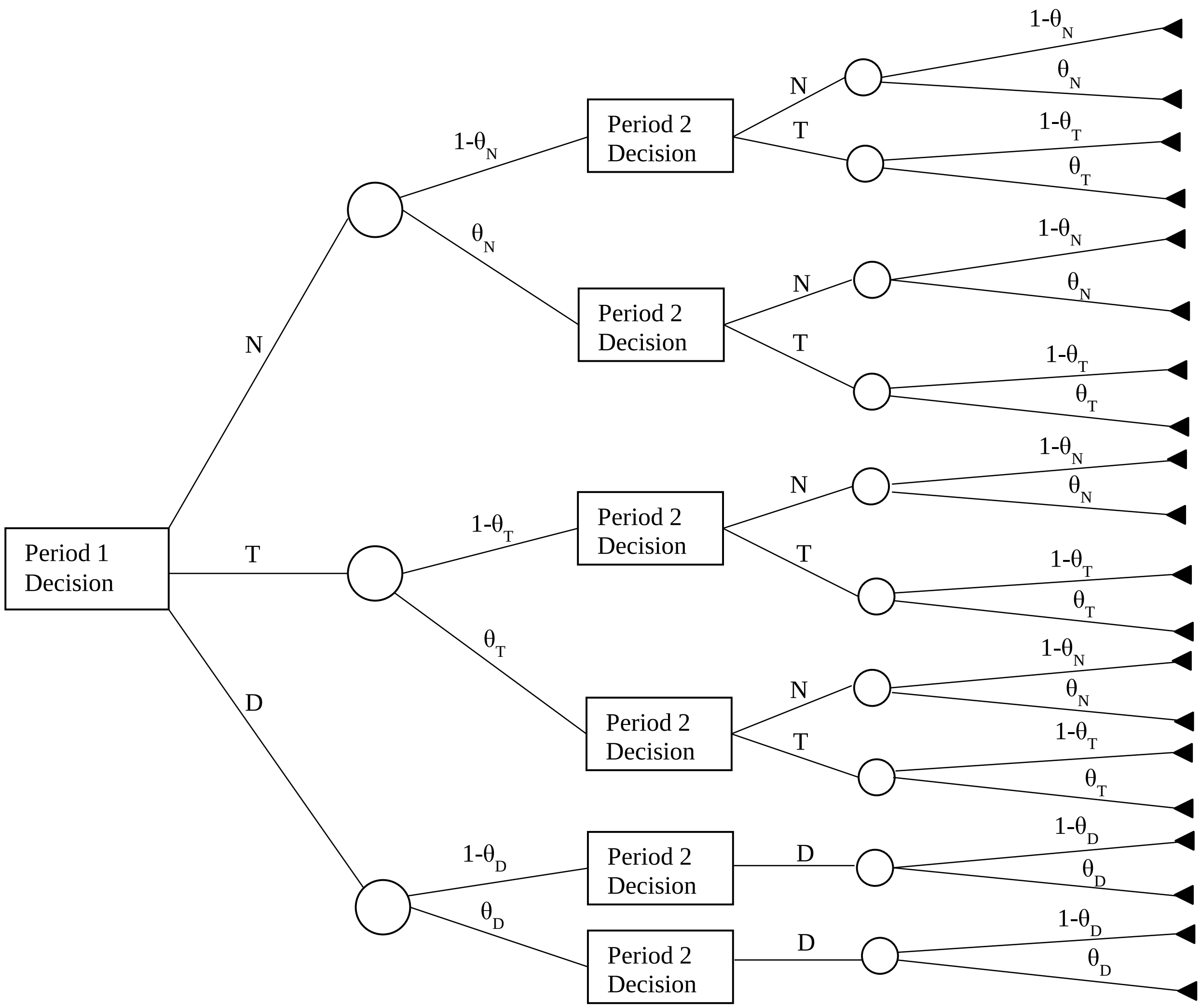
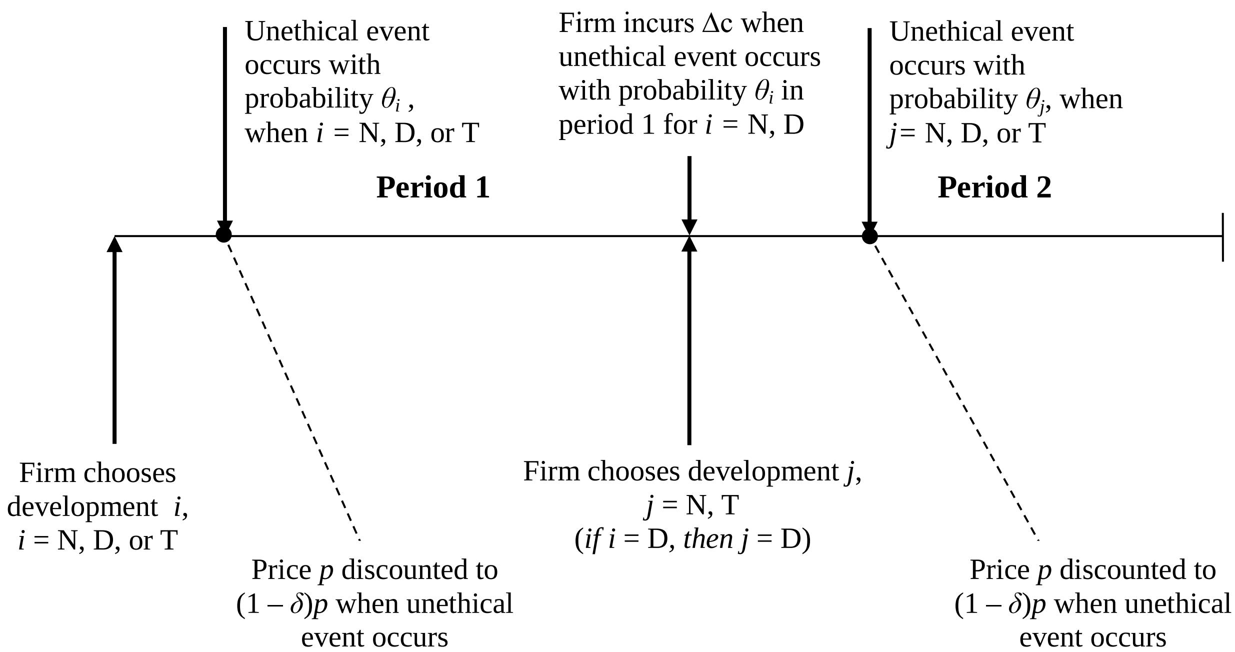


Figure 21: Sequence of Events for Supplier Development-Alternative Model



firm in period 2 can be characterized as follows.

(a) *For $i = N$ and $\Theta_1 = 1 - \theta_N$ in period 1, choose T in period 2 if $c_T \leq \bar{C}_T \equiv \delta p(\theta_N - \theta_T)$, otherwise choose N.*

(b) *For $i = N$ and $\Theta_1 = \theta_N$ in period 1, choose T in period 2 if $c_T \leq \bar{C}_T$, otherwise choose N.*

(c) *For $i = T$ and $\Theta_1 = 1 - \theta_T$ in period 1, choose T in period 2 if $c_T \leq \bar{C}_T$, otherwise choose N.*

(d) *For $i = T$ and $\Theta_1 = \theta_T$ in period 1, choose T in period 2 if $c_T \leq \bar{C}_T$, otherwise choose N.*

Proof. All proofs and expressions for c_T cutoffs are provided in the Appendix. □

When N is the firm's supplier development decision in period 1, Proposition 8 (a) and (b) show the cutoffs below which the firm switches to T depending on the realization of the event in period 1. $\bar{C}_T$ is the cutoff, below which the firm may continue with T, else switch to N as seen in Proposition 8 (c) and (d). In the alternative model, all supplier development decisions in period 2 do not depend on the realization of period 1 event. We also know that if the supplier development decision is D in period 1, the firm would continue with the same development type across both periods because it is binding type.

To summarize the second period outcomes, for low c_T values, T is the optimal decision while at high c_T, the non-binding supplier development type N is optimal. After characterizing the firm's optimal second period, we next solve for the optimal decision to adopt in period 1 as stated in Proposition 9.

Proposition 9. *(i) For* $c_T \leq \bar{C}_T$

(a) when $c_T \leq \bar{C}_T$, *adopt* TT, *if* $c_T \leq \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$, *else* DD.

(ii) For $c_T > \bar{C}_T$

(a) Given $c_D \leq \tilde{C}_D \equiv \frac{2\delta p(\theta_N - \theta_D) + \Delta c(\theta_N - \theta_D)}{2}$, *adopt* TN *if*
$c_T < \tilde{C}_T^{II} \equiv\ 2c_D + 2\delta p \theta_D - \delta p(\theta_T + \theta_N) + \Delta c \theta_D$, *else* DD.

(b) Given $c_D > \tilde{C}_D$, *adopt* TN *if* $c_T < \tilde{C}_T^{I} \equiv \delta p(\theta_N - \theta_T) + \Delta c \theta_N$, *else* NN.

Corollary 2. *When* $\Delta c < \Delta c' = \frac{2\delta p(\theta_N - \theta_D) - 2c_D}{\theta_D - \theta_N}$, *then* $\tilde{C}_T^{I} \leq \tilde{C}_T^{II}$.

Proposition 9 considers all possible scenarios based on the cutoff $\bar{C}_T$. We begin by examining the joint effect of Δc and c_T on optimal policies, keeping all the other parameters constant. We know that DD is a stand alone binding policy, and hence for the purpose of analysis the parameters θ_D and c_D are chosen such that DD does not dominate every feasible policy. We note that NN' is not a feasible policy in the alternative model since the firm would pay the penalty cost Δc in case an unethical event is realized with θ_N in period 1.

Corollary 3. *(i)* $\tilde{C}_T$, $\tilde{C}_T^I$, *and* $\tilde{C}_T^{II}$ *are decreasing in* θ_T.

(ii) $\tilde{C}_T^I$ *is increasing in* δ.

(iii) $\tilde{C}_T$ *is increasing (decreasing) in* δ, *if* $\theta_D > \theta_T(\theta_D < \theta_T)$.

(iv) $\tilde{C}_T^{II}$ *is increasing (decreasing) in* δ, *if* $\theta_D - \theta_T > \theta_N - \theta_D$ $(\theta_D - \theta_T < \theta_N - \theta_D)$.

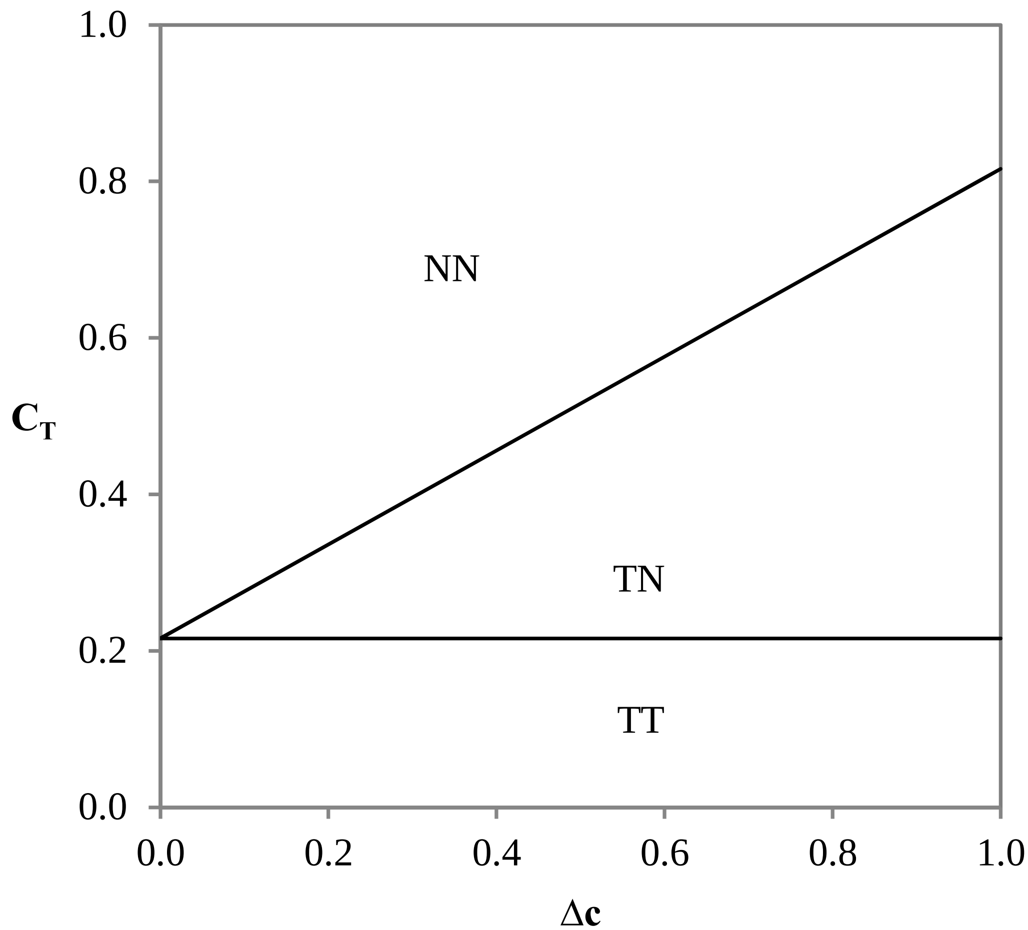
Corollary 3 shows the comparative statics of period 1 cutoffs with the three parameters δ and θ_T. We have the same results, as seen from the Corollary 1.

Next, we examine the joint effect of Δc and c_T on optimal policies in Figure 22 at given values of δ=0.6, p=0.9, θ_N=0.6, θ_T=0.2, θ_D=0.5, and c_D=0.2. At low c_T, the long-term policy TT is optimal at all Δc values. For medium range of Δc values and c_T values, TN is optimal.

With increase in c_T, TN becomes optimal as the cost c_T becomes high that does not offset the low risk θ_N. The long-term policy NN is optimal, when both c_T and Δc are at high. Interestingly, NN is optimal even at low Δc values, as the firm would benefit from low penalties and take advantage of the low cost in the non-binding type of policy NN. In Figure 23, when θ_D and c_D are both reduced DD becomes optimal instead of NN. Finally, when we further reduce the values of θ_D and c_D in Figure 24, the long-term policy DD becomes optimal even at low range of c_T values.

Based on the Corollary 3 (i), we evaluate the joint effect of θ_T and c_T. Similar to the model in 4.3, all cutoffs in c_T are decreasing in θ_T, given other parameters are held constant. We choose parameters δ=0.6, p=0.9, θ_N=0.5 for the analysis. In the Figure 25, the results observed are similar to ones observed in Figure 18(a) from the analysis of the primary model.

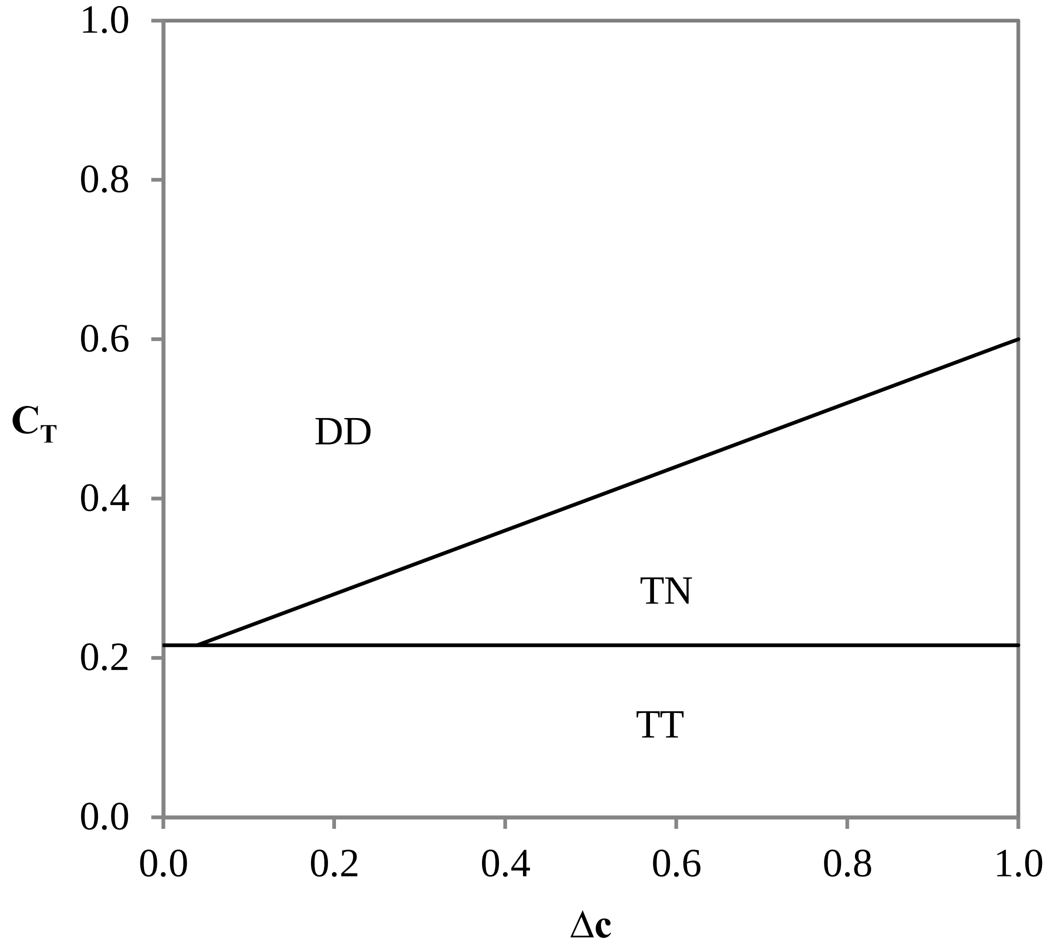
Figure 22: Optimal Policies as a Function of Δc and c_T for Alternate Model (θ_D=0.5, c_D=0.2)



We notice that, for low range of c_T and θ_T values the firm would choose the long-term policy TT. The switching policy TN optimal for intermediate range values of θ_T and c_T, while for high range of values, NN becomes optimal. Since all cutoffs are in c_T and are decreasing with θ_T, the shape of the optimal areas seen in Figure 26 show the linear relationship of cut-offs.

We observe the optimal policies transition from TT to TN, and then to DD policies when we choose c_D=0.2. As we change c_D values, once again TT is optimal at a combination of low c_T and θ_T as seen in the Figure 26, while the TN is optimal for small

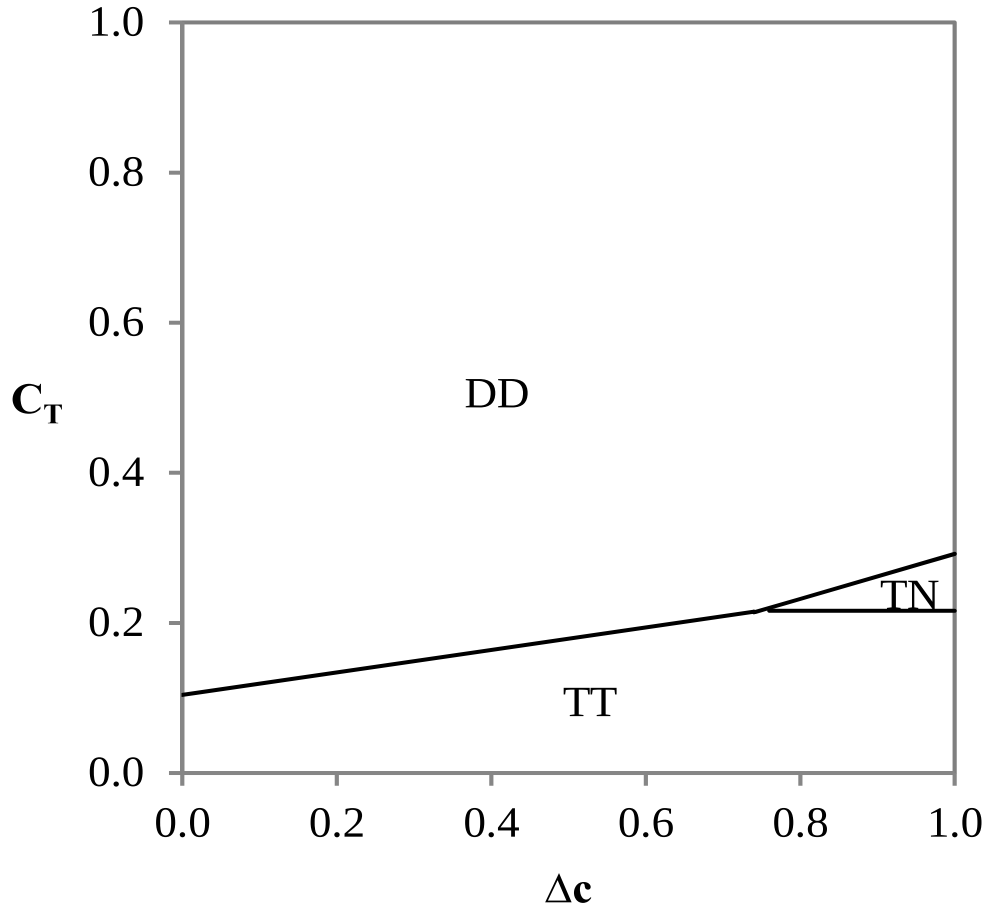
Figure 23: Optimal Policies as a Function of Δc and c_T for Alternate Model (θ_D=0.4, c_D=0.1)



range of the combination of intermediate range of values. For high range of c_T and θ_T, we notice the long-term policy DD becomes optimal when c_D decreases. Altogether, we see the transition of policies from TT to TN, and then to a long-term policy between NN or DD.

Next, we examine the joint effect of δ and c_T on the optimal policies a firm can employ. We use parameter values of p=0.9, θ_N=0.5, θ_T=0.2, and Δc=0.2 for analysis in Figure 28(a) and Figure 28(b). For low range of c_T values, we notice that TT is not always optimal similar to the analysis of the primary model. When δ is close to 0, the firm may switch to TN for any slight increase in c_T, since the δ is so low that the firm can bear the

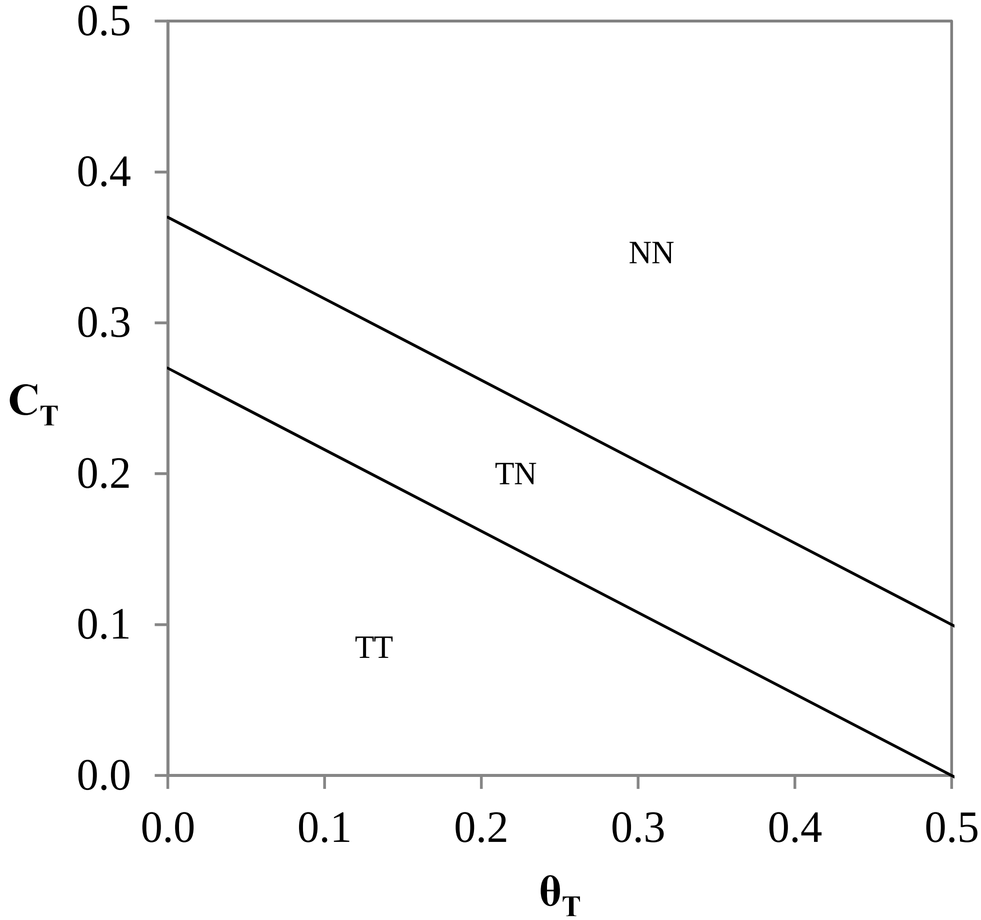
Figure 24: Optimal Policies as a Function of Δc and c_T for Alternate Model (θ_D=0.3, c_D=0.05)



risk in period 2 by switching to N and benefit from low cost. But, if the discount δ becomes large, then the firm would choose TT, since the low cost in choosing N does not offset the high discount δ as seen in Figure 28(a).

As δ increases further at medium range of c_T values, DD is optimal after it reaches a threshold above which the low cost does not offset the high discount for the firm. Up on increasing the c_D as seen in Figure 28(b), we observe that the firm would choose NN instead of DD for medium-to-high range of c_T and δ.

Figure 25: Optimal Policies as a Function of θ_T and c_T for Alternate Model (θ_D=0.3, c_D=0.15, Δc=0.2)

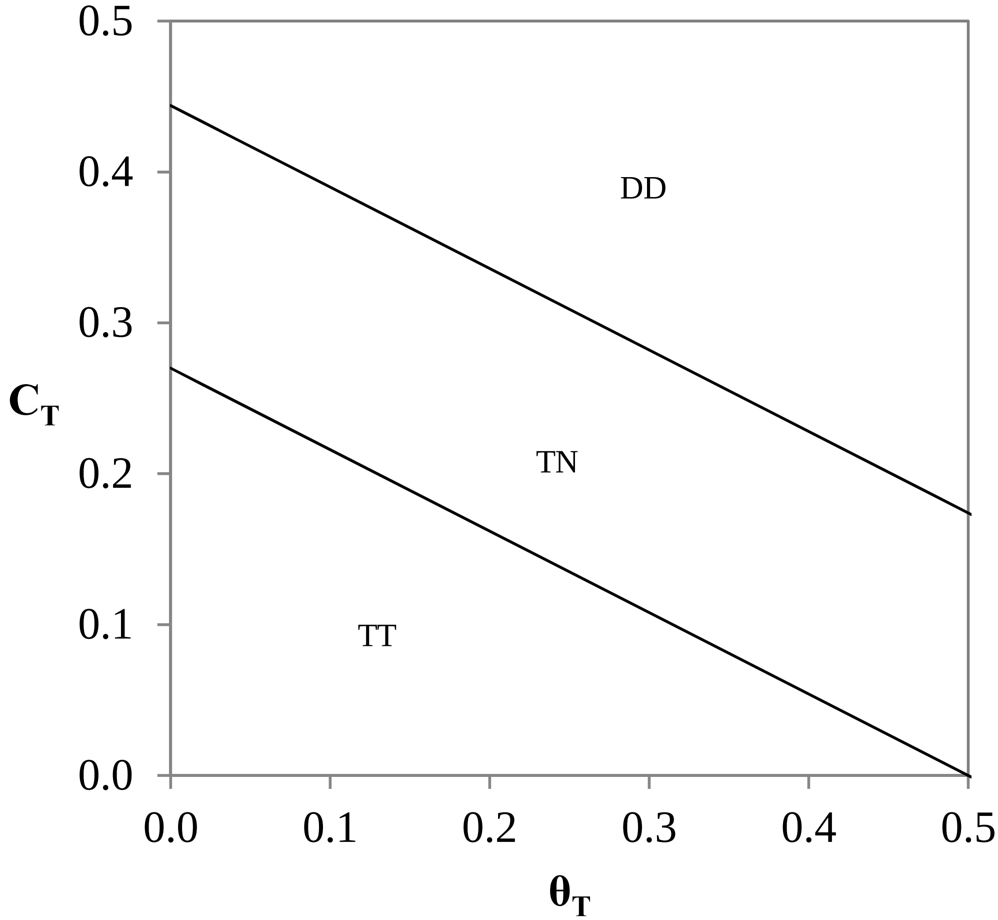


4.5 Summary

In the context of social responsibility, our model investigates the effect of the three factors on a firm's supplier development decision: the risk likelihood of an unethical event, the impact of the event, and the penalty cost.

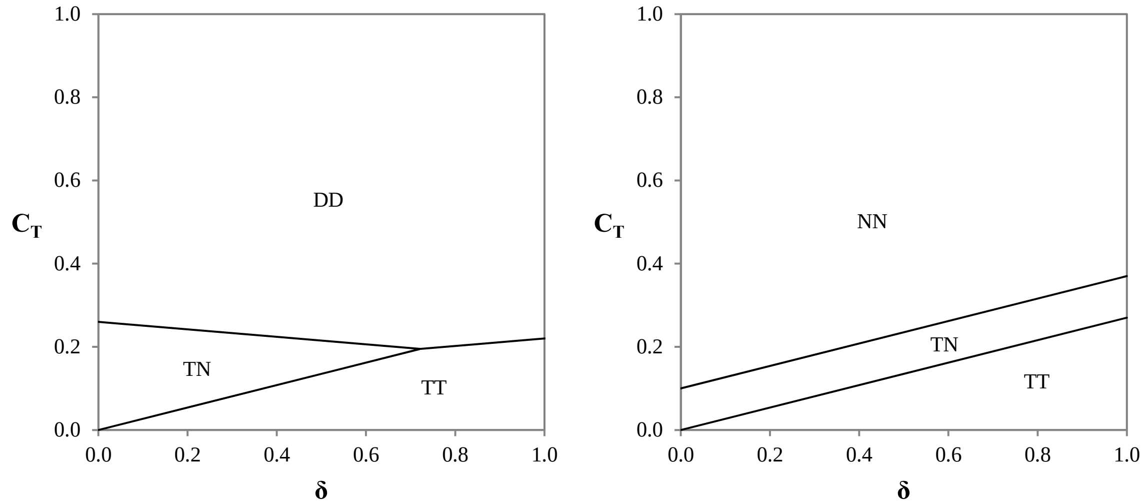
Our model generates insights for a firm to choose between three strategies for developing an unethical supplier; first, the binding type of development program, second, a non-binding type of development program, and lastly, the third-party type of development program.

Figure 26: Optimal Policies as a Function of θ_T and c_T for Alternate Model (θ_D=0.3, c_D=0.1, Δc=0.3)



Summarizing the results from the analysis of Section 4.3 and 4.4.1, we find that it is optimal for the firm to choose a third-party supplier development program, if the cost is low. Interestingly, it is also optimal for the firm to source through intermediaries even at higher risk likelihood since on realization of any event, the penalty costs serve as an insurance for the firm. This may explain the rising popularity of use of third parties for sourcing, in which the firm may benefit from the penalty cost. But, a firm may still switch to a non-binding type of program if cost incurred through intermediary is high and(or) the risk in sourcing through third-party is not significantly lower.

Figure 27: Optimal Policies as a Function of δ and c_T



(a) Optimal Policies as a Function of δ and c_T for Alternate Model (θ_D=0.3, c_D=0.1)

(b) Optimal Policies as a Function of δ and c_T for Alternate Model (θ_D=0.3, c_D=0.2)

On the other hand, firms may choose to participate in a binding type of supplier development program if the costs and risks are lower to offset any penalty cost it may incur upon realization of unethical event. The binding policy is preferred when costs in choosing the third-party program are larger, but the risk in a non-binding type of development is also too high. The cost for a firm in the binding type of supplier improvement program may be higher or lower compared to outsourcing the risk to a third-party or an intermediary. But, in order to make an optimal decision, a firm should consider other factors such as the risk and the discount in the price by the consumer.

CHAPTER V

Conclusion

While many companies are increasingly paying attention to social responsibility issues, most of the extant quantitative research mainly focuses on the environmental measure (Tang and Zhou, 2012). Within the context of social responsibility, our work investigates the effect of two important factors on supplier selection and development decisions: the risk likelihood of an unethical event and the impact of the event from the consumer perspective.

Our results show that for strategic sourcing and supplier development, a firm should not myopically look at only short-term cost saving but also long-term economical profit and reputation from a social responsibility perspective. As Porter (2006) suggests, companies should secure long-term economic performance by avoiding short-term behavior that is socially irresponsible. Our results reiterate that firms should rather foresee the long-run economic and social performance, even though the investment may be high in order to preserve their reputation. According to results from a survey conducted with chief supply chain officers in 2013, companies invest in social and environmental responsibility for a positive image of their brand or company is one of the top three reasons along with the aim of improving cost efficiency and government regulations (Lee et al., 2013). The fact that many companies have joined The Bangladesh Accord or the Alliance for Bangladesh Worker Safety, that requires them to contribute up to $1,00,000 an year indicates that firms are investing for long-run performance (The Accord, May 2013).

In a more holistic view, this study addresses the gap in the literature by studying the supply management problem in social responsibility context by taking market factors into account. The supplier selection model along with supplier development model can provide comprehensive solutions in decision making for firms.

In our work, we did not model the reward for ethical activities but instead focused on the stronger negative impact for unethical events as observed in the experimental study by (Trudel and Cotte, 2009). However, our model can be easily modified to investigate the positive effect of ethical behavior on supplier selection by changing the impact from negative discount to positive premium. It may also yield additional insights by considering a generalized case in which both suppliers are unethical but differ in the attributes, e.g., high risk likelihood and low impact v.s. low likelihood and high impact. The use of intermediaries for sourcing and development are on the rise, and hence we incorporate this into our supplier development model. Future research could include co-operation and competition between firms in supply management decisions, when sourcing from a common supplier.

APPENDIX

APPENDIX A

Supplier Selection

A.1 Proofs

Proof of Proposition 1. For each of the scenarios in the firm's profit function in the second period (B.1), it is straightforward to show the optimal quantity q^* is in the form of $\frac{[1-(\delta_2)]-[1-(\alpha_j)]c_j}{2[1-(\delta_2)]}$ where the discount (δ_2) takes place if an unethical event happens $(\Theta_2 = \theta_2)$ and the learning α occurs if the same supplier is used, $j = i$. Therefore, given j, Θ_1 and

Θ_2, substituting $q = q^*$ in (B.1) leads to the firm's profit for each scenario in period 2:

$$\pi_{2j}(\Theta_1, \Theta_2) = \begin{cases} \frac{[(1-\delta_2)-(1-\alpha_B)c_B]^2}{4(1-\delta_2)} & \text{if } j = B \text{ given } i = B, \Theta_1 = \theta_1, \quad \Theta_2 = \theta_2 = 1 \\ \frac{[(1-\delta_2)-(1-\alpha_B)c_B]^2}{4(1-\delta_2)} & \text{if } j = B \text{ given } i = B, \Theta_1 = 1-\theta_1, \quad \Theta_2 = \theta_2 \\ \frac{[1-(1-\alpha_B)c_B]^2}{4} & \text{if } j = B \text{ given } i = B, \Theta_1 = 1-\theta_1, \quad \Theta_2 = 1-\theta_2 \\ \frac{(1-c_A)^2}{4} & \text{if } j = A \text{ given } i = B, \Theta_1 \in \{\theta_1, 1-\theta_1\}, \quad \Theta_2 = \cdot \\ \frac{[1-(1-\alpha_A)c_A]^2}{4} & \text{if } j = A \text{ given } i = A, \Theta_1 = \cdot, \quad \Theta_2 = \cdot \\ \frac{[(1-\delta_2)-c_B]^2}{4(1-\delta_2)} & \text{if } j = B \text{ given } i = A, \Theta_1 = \cdot, \quad \Theta_2 = \theta_2 \\ \frac{(1-c_B)^2}{4} & \text{if } j = B \text{ given } i = A, \Theta_1 = \cdot, \quad \Theta_2 = 1-\theta_2 \end{cases} \tag{A.1}$$

Using (A.1), we can then express the expected profit for period 2 as follows:

$$\begin{aligned} &\mathbb{E}_{\Theta_2}[\pi_{2j}(\Theta_1, \Theta_2)] \\ &= \begin{cases} \frac{[(1-\delta_2)-(1-\alpha_B)c_B]^2}{4(1-\delta_2)} & \text{if } j = B \text{ given } i = B, \Theta_1 = \theta_1 \\ (1-\theta_2) \cdot \frac{[1-(1-\alpha_B)c_B]^2}{4} + \theta_2 \cdot \frac{[(1-\delta_2)-(1-\alpha_B)c_B]^2}{4(1-\delta_2)} & \text{if } j = B \text{ given } i = B, \Theta_1 = 1-\theta_1 \\ \frac{(1-c_A)^2}{4} & \text{if } j = A \text{ given } i = B, \Theta_1 \in \{\theta_1, 1-\theta_1\} \\ \frac{[1-(1-\alpha_A)c_A]^2}{4} & \text{if } j = A \text{ given } i = A, \Theta_1 = \cdot \\ (1-\theta_2) \cdot \frac{(1-c_B)^2}{4} + \theta_2 \cdot \frac{[(1-\delta_2)-c_B]^2}{4(1-\delta_2)} & \text{if } j = B \text{ given } i = A, \Theta_1 = \cdot \end{cases} \end{aligned} \tag{A.2}$$

The expressions above are for the general case as described in the modeling section. For the base model, however, we would have $\alpha_A = \alpha_B = \alpha$, $\theta_1 = \theta_2 = \theta$, and $\delta_1 = \delta_2 = \delta$.

(i) For $i = B$ and $\Theta_1 = \theta$ in period 1, the firm would stay with B (otherwise, switch to A) iff (if and only if) $\mathbb{E}_{\Theta_2}[\pi_{2B}(\theta, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2A}(\theta, \Theta_2)] \Longleftrightarrow c_B \leq \bar{C}_B \equiv \frac{1-\delta}{1-\alpha}\left(1 - \frac{1-c_A}{\sqrt{1-\delta}}\right)$.

(ii) For $i = B$ and $\Theta_1 = 1-\theta$ in period 1, the firm would stay with B (otherwise, switch to A) iff

$\mathbb{E}_{\Theta_2}[\pi_{2B}(1-\theta, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2A}(1-\theta, \Theta_2)] \Longleftrightarrow c_B \leq \bar{\bar{C}}_B \equiv \frac{1-\delta}{(1-\alpha)(1-\delta+\delta\theta)}(1 - \sqrt{1-\Delta_1})$,

where $\Delta_1 = \frac{(1-\delta+\delta\theta)}{1-\delta}\left[1 - \delta\theta - (1-c_A)^2\right]$.

(iii) For $i = A$ in period 1, the firm would switch to B (otherwise stay with A) iff $\mathbb{E}_{\Theta_2}[\pi_{2B}(\cdot, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2A}(\cdot, \Theta_2)] \iff c_B \leq \bar{\bar{C}}_B \equiv \frac{1-\delta}{(1-\delta+\delta\theta)}\left(1 - \sqrt{1-\Delta_2}\right)$, where $\Delta_2 = \frac{(1-\delta+\delta\theta)}{1-\delta}\left[1 - \delta\theta - (1-(1-\alpha)c_A)^2\right]$.

□

Proof of Proposition 2. The comparative statics can be derived through employing implicit differentiation on $\mathbb{E}_{\Theta_2}[\pi_{2B}(1-\theta, \Theta_2)] = \mathbb{E}_{\Theta_2}[\pi_{2A}(1-\theta, \Theta_2)]$ (characterizing $\bar{\bar{C}}_B$):

$$\frac{\partial \bar{\bar{C}}_B}{\partial \theta} = \frac{-4(1-\delta)\left(\frac{[1-(1-\alpha)\bar{\bar{C}}_B]^2}{4} - \frac{[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B]^2}{4(1-\delta)}\right)}{2(1-\alpha)\left((1-\theta)(1-\delta)\left[1-(1-\alpha)\bar{\bar{C}}_B\right] + \theta\left[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B\right]\right)} \leq 0$$

The numerator is negative because it is the difference between the discounted and non-discounted profits with B, while the denominator is clearly negative as all three parameters θ, δ, and α vary between 0 and 1.

$$\begin{aligned}\frac{\partial \bar{\bar{C}}_B}{\partial \delta} &= \frac{-\left((1-\theta)\left[1-(1-\alpha)\bar{\bar{C}}_B\right]^2 + 2\theta\left[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B\right] - (1-c_A)^2\right)}{2(1-\alpha)\left((1-\theta)(1-\delta)\left[1-(1-\alpha)\bar{\bar{C}}_B\right] + \theta\left[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B\right]\right)} \\ &\leq \frac{-4\left((1-\theta)\frac{[1-(1-\alpha)\bar{\bar{C}}_B]^2}{4} + \theta\frac{[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B]^2}{4(1-\delta)} - \frac{(1-c_A)^2}{4}\right)}{2(1-\alpha)\left((1-\theta)(1-\delta)\left[1-(1-\alpha)\bar{\bar{C}}_B\right] + \theta\left[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B\right]\right)} = 0\end{aligned}$$

The numerator is negative since the inequality holds as $2 \geq \frac{(1-\delta)-(1-\alpha)\bar{\bar{C}}_B}{1-\delta}$, and by the definition of $\bar{\bar{C}}_B$.

$$\frac{\partial \bar{\bar{C}}_B}{\partial \alpha} = \frac{2\theta\bar{\bar{C}}_B\left[(1-\delta)-(1-\alpha)\bar{\bar{C}}_B\right] + 2(1-\theta)(1-\delta)\bar{\bar{C}}_B\left[1-(1-\alpha)\bar{\bar{C}}_B\right]}{2(1-\alpha)\left[(1-\theta)(1-\delta)(1-(1-\alpha)\bar{\bar{C}}_B) + \theta\bar{\bar{C}}_B((1-\delta)-(1-\alpha)\bar{\bar{C}}_B)\right]} \geq 0$$

The numerator is obviously negative. Since $\bar{C}_B(\delta, \alpha)$ is a special case of $\bar{\bar{C}}_B$ with $\theta = 1$, all comparative statics of $\bar{C}_B$ follow by replacing the above derivations with $\theta = 1$. Similarly, by employing implicit differentiation on $\mathbb{E}_{\Theta_2}[\pi_{2B}(\cdot, \Theta_2)] = \mathbb{E}_{\Theta_2}[\pi_{2A}(\cdot, \Theta_2)]$ (characterizing

$\bar{\bar{\bar{C}}}_B$), we have

$$\frac{\partial \bar{\bar{\bar{C}}}_B}{\partial \theta} = \frac{-4(1-\delta)\left(\frac{(1-\bar{\bar{\bar{C}}}_B)^2}{4}-\frac{\left[(1-\delta)-\bar{\bar{\bar{C}}}_B\right]^2}{4(1-\delta)}\right)}{2\left((1-\theta)(1-\delta)(1-\bar{\bar{\bar{C}}}_B)+\theta\left[(1-\delta)-\bar{\bar{\bar{C}}}_B\right]\right)} \leq 0$$

$$\frac{\partial \bar{\bar{\bar{C}}}_B}{\partial \delta} = \frac{-\left((1-\theta)(1-\bar{\bar{\bar{C}}}_B)^2+2\theta\left[(1-\delta)-\bar{\bar{\bar{C}}}_B\right]-[1-(1-\alpha)c_A]^2\right)}{2\left((1-\theta)(1-\delta)(1-\bar{\bar{\bar{C}}}_B)+\theta\left[(1-\delta)-\bar{\bar{\bar{C}}}_B\right]\right)}$$

$$\leq \frac{-4\left((1-\theta)\frac{(1-\bar{\bar{\bar{C}}}_B)^2}{4}+\theta\frac{\left[(1-\delta)-\bar{\bar{\bar{C}}}_B\right]^2}{4(1-\delta)}-\frac{[1-(1-\alpha)c_A]^2}{4}\right)}{2(1-\theta)(1-\delta)(1-\bar{\bar{\bar{C}}}_B)+2\theta((1-\delta)-\bar{\bar{\bar{C}}}_B)} = 0$$

$$\frac{\partial \bar{\bar{\bar{C}}}_B}{\partial \alpha} = \frac{-2(1-\delta)c_A[1-(1-\alpha)c_A]}{2\left((1-\theta)(1-\delta)(1-\bar{\bar{\bar{C}}}_B)+\theta\left[(1-\delta)-\bar{\bar{\bar{C}}}_B\right]\right)} \leq 0$$

□

Proof of Proposition 3. Following the similar procedure deriving the optimal quantity q^* in the proof of Proposition 1, we can rewrite the first period profit function (3.1) as follows:

$$\pi_{1i}(\Theta_1) = \begin{cases} \frac{[(1-\delta_1)-c_B]^2}{4(1-\delta_1)}q & \text{if } i=B \text{ and } \Theta_1=\theta_1 \\ \frac{(1-c_B)^2}{4} & \text{if } i=B \text{ and } \Theta_1 = 1-\theta_1 \\ \frac{(1-c_A)^2}{4} & \text{if } i=A \text{ and } \Theta_1=\cdot \end{cases} \tag{A.3}$$

Using (A.1) and (B.3) with $\alpha_A = \alpha_B = \alpha$, $\theta_1 = \theta_2 = \theta$, and $\delta_1 = \delta_2 = \delta$, we can then express the total expected profit functions (3.3) and (3.4) in period 1 as follows:

$$\begin{aligned}
\Pi_{BB} &= \theta \cdot \left(\frac{[(1-\delta)-c_B]^2}{4(1-\delta)} + \frac{[(1-\delta)-(1-\alpha)c_B]^2}{4(1-\delta)}\right) \\
&\quad +(1-\theta)\cdot\left(\frac{(1-c_B)^2}{4}+\theta\frac{[(1-\delta)-(1-\alpha)c_B]^2}{4(1-\delta)}+(1-\theta)\frac{[1-(1-\alpha)c_B]^2}{4}\right) \\
\Pi_{AA} &= \frac{(1-c_A)^2}{4}+\frac{[1-(1-\alpha)c_A]^2}{4} \\
\Pi_{AB} &= \Pi_{BA} = \frac{(1-c_A)^2}{4}+\theta\frac{[(1-\delta)-c_B]^2}{4(1-\delta)}+(1-\theta)\frac{(1-c_B)^2}{4} \\
\Pi_{Bj(\Theta_1)} &= \theta\cdot\left(\frac{[(1-\delta)-c_B]^2}{4(1-\delta)}+\frac{(1-c_A)^2}{4}\right) \\
&\quad +(1-\theta)\cdot\left(\frac{(1-c_B)^2}{4}+\theta\frac{[(1-\delta)-(1-\alpha)c_B]^2}{4(1-\delta)}+(1-\theta)\frac{[1-(1-\alpha)c_B]^2}{4}\right)
\end{aligned} \tag{A.4}$$

The supplier choice in first period is either B or A, but the form of the resulting policy (BB, AA, AB, BA, or $Bj(\Theta_1)$) depends on where c_B stands in terms of the three second period cutoffs, $\bar{C}_B$, $\bar{\bar{C}}_B$, and $\bar{\bar{\bar{C}}}_B$. Based on Proposition 2, there could be two possible ranking cases: $\bar{C}_B \le \bar{\bar{\bar{C}}}_B \le \bar{\bar{C}}_B$ and $\bar{\bar{\bar{C}}}_B \le \bar{C}_B \le \bar{\bar{C}}_B$. We consider all possible scenarios and derive the optimal policies accordingly. In the former case of $\bar{C}_B \le \bar{\bar{\bar{C}}}_B \le \bar{\bar{C}}_B$,

- For $c_B \le \bar{C}_B \le \bar{\bar{\bar{C}}}_B \le \bar{\bar{C}}_B$, the firm would always choose B in period 2 regardless of the choice in period 1. Therefore, the firm would adopt BB (otherwise AB) iff $\Pi_{BB} \ge \Pi_{AB} \iff c_B \le \bar{\bar{C}}'_B \equiv \frac{1-\delta}{(1-\alpha)(1-\delta+\delta\theta')}\left(1 - \sqrt{1 - \frac{(1-\delta+\delta\theta')}{1-\delta}[1-\delta\theta' - (1-c_A)^2]}\right)$ where $\theta' = \theta + \theta(1-\theta)$. By Proposition 2(i), $c_B \le \bar{C}_B \le \bar{\bar{C}}'_B \le \bar{\bar{C}}_B$ because $1 \ge \theta' \ge \theta$. So the optimal policy is BB.

- For $\bar{C}_B \le c_B \le \bar{\bar{\bar{C}}}_B \le \bar{\bar{C}}_B$, the firm would adopt $Bj(\Theta_1)$ (otherwise AB) iff $\Pi_{Bj(\Theta_1)} \ge \Pi_{AB} \iff c_B \le \bar{\bar{C}}_B$. So the optimal policy is $Bj(\Theta_1)$.

- For $\bar{C}_B \le \bar{\bar{\bar{C}}}_B \le c_B \le \bar{\bar{C}}_B$, the firm would adopt $Bj(\Theta_1)$ (otherwise AA) iff $\Pi_{Bj(\Theta_1)} \ge \Pi_{AA} \iff c_B \le \tilde{C}_B \equiv \frac{(1-\theta)(1-\delta)^2[1+(1-\theta)(1-\alpha)]}{1+(1-\theta)(1-\alpha)^2(1-\delta+\delta\theta)-\delta}\left(1-\sqrt{1-\Delta_3}\right)$, where $\Delta_3 = 1-\theta+\frac{(1-\alpha)^2\theta}{1-\theta}+\frac{\theta}{1-\delta}\left((2-\delta)-\theta(1-c_A)^2+[1-(1-\alpha)c_A]^2+\frac{(1-\delta\theta)\theta}{1-\theta}\right)$. So conditioned on $\bar{C}_B \le \tilde{C}_B$, the optimal policy is $Bj(\Theta_1)$ if $c_B \le \tilde{C}_B$, otherwise AA.

- For $\bar{C}_B \le \bar{\bar{\bar{C}}}_B \le \bar{\bar{C}}_B \le c_B$, the firm would always choose A in period 2 regardless of the choice in period 1. Therefore, the firm would adopt AA (otherwise BA) iff $\Pi_{AA} \ge \Pi_{BA} \iff c_B \ge \bar{\bar{\bar{C}}}_B$. So the optimal policy is AA.

In the latter case of $\bar{\bar{\bar{C}}}_B \le \bar{C}_B \le \bar{\bar{C}}_B$,

- For $c_B \le \bar{\bar{\bar{C}}}_B \le \bar{C}_B \le \bar{\bar{C}}_B$, the firm would always choose B in period 2 regardless of the choice in period 1. Therefore, the firm would adopt BB (otherwise AB) iff $\Pi_{BB} \ge \Pi_{AB} \iff c_B \le \bar{\bar{C}}'_B$. So the optimal policy is BB for the same reason as in the first case.

- For $\bar{\bar{\bar{C}}}_B \le c_B \le \bar{C}_B \le \bar{\bar{C}}_B$, the firm would adopt BB (otherwise AA) iff $\Pi_{BB} \ge \Pi_{AA} \iff c_B \le \hat{C}_B \equiv \frac{(1-\delta)(2-\alpha)}{\theta+(1-\theta)(1-\delta)+(1-\alpha)^2[1-\delta(1-\theta)^2]}(1-\sqrt{1-\Delta_4})$ where $\Delta_4 = \frac{\big(\theta+(1-\alpha)^2[1-\delta(1-\theta)^2]+(1-\delta)(1-\theta)\big)\big((1-\delta)\theta(3-\theta)+(1-\theta)(2-\theta)-(1-c_A)^2-[1-(1-\alpha)c_A]^2\big)}{(1-\delta)(2-\alpha)^2}$. So conditioned on $\hat{C}_B \le \bar{C}_B$, the optimal policy is BB if $c_B \le \hat{C}_B$, otherwise AA.

- For $\bar{\bar{\bar{C}}}_B \le \bar{C}_B \le c_B \le \bar{\bar{C}}_B$, the firm would adopt $Bj(\Theta_1)$ (otherwise AA) iff $\Pi_{Bj(\Theta_1)} \ge \Pi_{AA} \iff c_B \le \tilde{C}_B$. So conditioned on $\bar{C}_B \le \tilde{C}_B$, the optimal policy is $Bj(\Theta_1)$ if $c_B \le \tilde{C}_B$, otherwise AA.

- For $\bar{\bar{\bar{C}}}_B \le \bar{C}_B \le \bar{\bar{C}}_B \le c_B$, the firm would adopt AA (otherwise BA) iff $\Pi_{AA} \ge \Pi_{BA} \iff c_B \ge \bar{\bar{\bar{C}}}_B$. So the optimal policy is AA.

We note that in all scenarios, the switching policy BA or AB is never chosen so the optimal policy is one of the three base policies BB, $Bj(\Theta_1)$, and AA. Equating any two of the three profit functions Π_{BB}, $\Pi_{Bj(\Theta_1)}$, and Π_{AA} then results in the characterization of the three cost cutoffs $\bar{C}_B$, $\tilde{C}_B$, and $\hat{C}_B$. Together with Proposition 4, it ensures that the three cutoff curves intersect once and only at $\alpha = \hat{\alpha}$, below which $\bar{C}_B \le \tilde{C}_B$, $Bj(\Theta_1)$ is preferred for c_B in between; while above which $\bar{C}_B > \tilde{C}_B$, therefore only BB and AA are considered. □

Proof of Proposition 4. By employing implicit differentiation on $\Pi_{Bj(\Theta_1)} = \Pi_{AA}$ (characterizing $\tilde{C}_B$), we have

$$\frac{\partial \tilde{C}_B}{\partial \theta} = \frac{-(1-\delta)\big[(1-\tilde{C}_B)^2-(1-c_A)^2\big]-(1-\delta)(1-2\theta)\Big(\big[1-(1-\alpha)\tilde{C}_B\big]^2-\big[(1-\delta)-(1-\alpha)\tilde{C}_B\big]^2\Big)}{2\theta\big[(1-\delta)-\tilde{C}_B\big]+2(1-\theta)(1-\delta)(1-\tilde{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\big[1-(1-\alpha)\tilde{C}_B\big]+2(1-\theta)\theta(1-\alpha)\big[(1-\delta)-(1-\alpha)\tilde{C}_B\big]}$$
$$+\frac{-\Big(\frac{1}{1-\delta}[(1-\delta)-(1-\alpha)(1-\delta)\tilde{C}_B]^2-[(1-\delta)-\tilde{C}_B]^2\Big)}{2\theta\big[(1-\delta)-\tilde{C}_B\big]+2(1-\theta)(1-\delta)(1-\tilde{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\big[1-(1-\alpha)\tilde{C}_B\big]+2(1-\theta)\theta(1-\alpha)\big[(1-\delta)-(1-\alpha)\tilde{C}_B\big]} \le 0$$

$$\frac{\partial \tilde{C}_B}{\partial \delta} = \frac{-2(1-\theta)\theta(1-\delta)\big[(1-\delta)-(1-\alpha)\tilde{C}_B\big]+(1-\theta)\theta\big[(1-\delta)-(1-\alpha)\tilde{C}_B\big]^2-2\theta(1-\delta)\big[(1-\delta)-\tilde{C}_B\big]+\theta\big[(1-\delta)-\tilde{C}_B\big]^2}{(1-\delta)\Big(2\theta\big[(1-\delta)-\tilde{C}_B\big]+2(1-\theta)(1-\delta)(1-\tilde{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\big[1-(1-\alpha)\tilde{C}_B\big]+2(1-\theta)\theta(1-\alpha)\big[(1-\delta)-(1-\alpha)\tilde{C}_B\big]\Big)} \le 0$$

$$\frac{\partial \tilde{C}_B}{\partial \alpha} = \frac{-2(1-\delta)c_A[1-(1-\alpha)c_A]+2\tilde{C}_B(1-\theta)\theta\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]+2(1-\delta)\tilde{C}_B(1-\theta)^2\Big[1-(1-\alpha)\tilde{C}_B\Big]}{2\theta\Big[(1-\delta)-\tilde{C}_B\Big]+2(1-\theta)(1-\delta)(1-\tilde{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\tilde{C}_B\Big]+2(1-\theta)\theta(1-\alpha)\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]}$$
$$\leq \frac{-2(1-\delta)\tilde{C}_B\Big[1-(1-\alpha)\tilde{C}_B\Big]+2\tilde{C}_B(1-\theta)\theta\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]+2(1-\delta)\tilde{C}_B(1-\theta)^2\Big[1-(1-\alpha)\tilde{C}_B\Big]}{2\theta\Big[(1-\delta)-\tilde{C}_B\Big]+2(1-\theta)(1-\delta)(1-\tilde{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\tilde{C}_B\Big]+2(1-\theta)\theta(1-\alpha)\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]}$$
$$= \frac{-2(1-\delta)\tilde{C}_B\Big[(2-\theta)\theta\Big(1-(1-\alpha)\tilde{C}_B\Big)-(1-\theta)\theta\Big(1-\frac{1-\alpha}{1-\delta}\tilde{C}_B\Big)\Big]}{2\theta\Big[(1-\delta)-\tilde{C}_B\Big]+2(1-\theta)(1-\delta)(1-\tilde{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\tilde{C}_B\Big]+2(1-\theta)\theta(1-\alpha)\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]} \leq 0$$

The numerators are negative because the assumption $\tilde{C}_B \leq c_A$ and substituting terms using the $\tilde{C}_B$ characterization function $\Pi_{Bj(\Theta_1)} = \Pi_{AA}$, while the denominators are clearly positive since the parameters θ, δ, and α vary between 0 and 1.

Similarly, by employing implicit differentiation on $\Pi_{BB} = \Pi_{AA}$ (characterizing $\hat{C}_B$), we have

$$\frac{\partial \hat{C}_B}{\partial \theta} = \frac{\Big(2(1-\theta)\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]^2-2(1-\theta)(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]^2\Big)-\Big((1-\delta)(1-\hat{C}_B)^2-\Big[(1-\delta)-\hat{C}_B\Big]^2\Big)}{2\theta\Big[(1-\delta)-\hat{C}_B\Big]+2(1-\theta)(1-\delta)(1-\hat{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]+2(2\theta-\theta^2)(1-\alpha)\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]} \leq 0$$

$$\frac{\partial \hat{C}_B}{\partial \delta} = \frac{-2(1-\theta)\theta(1-\delta)\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]+(1-\theta)\theta\Big[(1-\delta)-(1-\alpha)\tilde{C}_B\Big]^2-2\theta(1-\delta)\Big[(1-\delta)-\tilde{C}_B\Big]+\theta\Big[(1-\delta)-\tilde{C}_B\Big]^2}{(1-\delta)\Big(2\theta\Big[(1-\delta)-\hat{C}_B\Big]+2(1-\theta)(1-\delta)(1-\hat{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]+2(2\theta-\theta^2)(1-\alpha)\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]\Big)} \leq 0$$

$$\frac{\partial \hat{C}_B}{\partial \alpha} = \frac{-2(1-\delta)c_A[1-(1-\alpha)c_A]+2\hat{C}_B(2\theta-\theta^2)[(1-\delta)-(1-\alpha)hatC_B]+2\hat{C}_B(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]}{2\theta\Big[(1-\delta)-\hat{C}_B\Big]+2(1-\theta)(1-\delta)(1-\hat{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]+2(2\theta-\theta^2)(1-\alpha)\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]}$$
$$\leq \frac{-2(1-\delta)\hat{C}_B(1-(1-\alpha)\hat{C}_B)+2(2\theta-\theta^2)\hat{C}_B\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]+2(1-\theta)^2(1-\delta)\hat{C}_B\Big[1-(1-\alpha)\hat{C}_B\Big]}{2\theta\Big[(1-\delta)-\hat{C}_B\Big]+2(1-\theta)(1-\delta)(1-\hat{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]+2(2\theta-\theta^2)(1-\alpha)\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]}$$
$$= \frac{-2(1-\delta)(2\theta-\theta^2)\hat{C}_B\Big[(1-(1-\alpha)\hat{C}_B)-(1-\frac{1-\alpha}{1-\delta}\hat{C}_B)\Big]}{2\theta\Big[(1-\delta)-\hat{C}_B\Big]+2(1-\theta)(1-\delta)(1-\hat{C}_B)+2(1-\alpha)(1-\theta)^2(1-\delta)\Big[1-(1-\alpha)\hat{C}_B\Big]+2(2\theta-\theta^2)(1-\alpha)\Big[(1-\delta)-(1-\alpha)\hat{C}_B\Big]} \leq 0$$

The numerators are negative because the assumption $\hat{C}_B \leq c_A$ and substituting terms using the $\hat{C}_B$ characterization function $\Pi_{BB} = \Pi_{AA}$, while the denominators are clearly positive since the parameters θ, δ, and α vary between 0 and 1. $\square$

APPENDIX B

Supplier Development

B.1 Proofs

Proof of Proposition 5 and 8. For each of the following scenarios in the firms's profit function in the second period, it is assumed that the adjusted production quantity $q = 1$, and the profit can be expressed in the most general case, when unethical event is realized $(\Theta_2 = \theta_j)$ as $(1-\delta)p - c_j - \Delta c$. Therefore, for given j, Θ_1, and Θ_2, we expand on profit of period two and write the profit for each scenario in period 2 as:

$$
\pi_{2j}(\Theta_1, \Theta_2) = \begin{cases}
p & \text{if } j = N \text{ given } i = N, \Theta_1 = 1 - \theta_N, & \Theta_2 = 1 - \theta_N \\
(1-\delta)p & \text{if } j = N \text{ given } i = N, \Theta_1 = 1 - \theta_N, & \Theta_2 = \theta_N \\
p & \text{if } j = N \text{ given } i = T, \Theta_1 \in \{1 - \theta_T, \theta_T\}, & \Theta_2 = 1 - \theta_N \\
(1-\delta)p & \text{if } j = N \text{ given } i = T, \Theta_1 \in \{1 - \theta_T, \theta_T\}, & \Theta_2 = \theta_N \\
(p - \Delta c) & \text{if } j = N \text{ given } i = N, \Theta_1 = \theta_N, & \Theta_2 = 1 - \theta_N \\
(1-\delta)p - \Delta c & \text{if } j = N \text{ given } i = N, \Theta_1 = \theta_N, & \Theta_2 = \theta_N \\
(1-\delta)p & \text{if } j = N \text{ given } i = N, \Theta_1 = \theta_N, & \Theta_2 = \theta_N = 1 \\
p - (c_T + \Delta c) & \text{if } j = T \text{ given } i = N, \Theta_1 = \theta_N, & \Theta_2 = 1 - \theta_T \\
(1-\delta)p - (c_T + \Delta c) & \text{if } j = T \text{ given } i = N, \Theta_1 = \theta_N, & \Theta_2 = \theta_T \\
(p - c_T) & \text{if } j = T \text{ given } i = T, \Theta_1 \in \{1 - \theta_T, \theta_T\} & \Theta_2 = 1 - \theta_T \\
(1-\delta)p - c_T & \text{if } j = T \text{ given } i = T, \Theta_1 \in \{1 - \theta_T, \theta_T\} & \Theta_2 = \theta_T \\
p - c_D & \text{if } j = D \text{ given } i = D, \Theta_1 = 1 - \theta_D, & \Theta_2 = 1 - \theta_D \\
(1-\delta)p - c_D & \text{if } j = D \text{ given } i = D, \Theta_1 = 1 - \theta_D, & \Theta_2 = \theta_D \\
p - (c_D + \Delta c) & \text{if } j = D \text{ given } i = D, \Theta_1 = \theta_D, & \Theta_2 = 1 - \theta_D \\
(1-\delta)p - (c_D + \Delta c) & \text{if } j = D \text{ given } i = D, \Theta_1 = \theta_D, & \Theta_2 = \theta_D
\end{cases} \tag{B.1}
$$

Using (B.1), we can write the expected profit function for period 2 as follows

$$\mathbb{E}_{\Theta_2}[\pi_{2j}(\Theta_1, \Theta_2)]$$
$$= \begin{cases} [(1-\theta_N)p + \theta_N(1-\delta)p] & \text{if } j = N \text{ given } i = N, \Theta_1 = 1-\theta_N \\ [(1-\theta_N)(p-\Delta c) + \theta_N((1-\delta)p - \Delta c)] & \text{if } j = N \text{ given } i = N, \Theta_1 = \theta_N \\ [(1-\theta_T)(p-c_T) + \theta_T((1-\delta)p - c_T)] & \text{if } j = T \text{ given } i = N, \Theta_1 = 1-\theta_N \\ [(1-\theta_T)(p-c_T-\Delta c) + \theta_T((1-\delta)p - c_T - \Delta c)] & \text{if } j = T \text{ given } i = N, \Theta_1 = \theta_N \\ [(1-\theta_T)(p-c_T) + \theta_T((1-\delta)p - c_T)] & \text{if } j = T \text{ given } i = T, \Theta_1 \in \{\theta_T, 1-\theta_T\} \\ [(1-\theta_D)(p-c_D) + \theta_D((1-\delta)p - c_D)] & \text{if } j = D \text{ given } i = D, \Theta_1 = 1-\theta_D \\ [(1-\theta_D)(p-c_D-\Delta c) + \theta_D((1-\delta)p - c_D - \Delta c)] & \text{if } j = D \text{ given } i = D, \Theta_1 = \theta_D \end{cases} \tag{B.2}$$

- For $i = N$ and $\Theta_1 = 1 - \theta_N$ in period 1, the firm would switch to T (otherwise, continue with N) iff (if and only if)
  $\mathbb{E}_{\Theta_2}[\pi_{2T}(1-\theta_N, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2N}(1-\theta_N, \Theta_2)] \iff c_T \leq \bar{C}_T \equiv \delta p(\theta_N - \theta_T)$.

- For $i = N$ and $\Theta_1 = \theta_N$, the firm can choose between three alternatives N, N' and T. Since we are determining the optimal decisions based on cutoffs in T, we first determine the cutoffs in c_T between T and N denoted by $\bar{C}_T$. Next, we determine the cutoff between T and N' denoted by $\bar{\bar{C}}_T$.

  - The firm would switch to T (otherwise, continue with N) iff (if and only if)
    $\mathbb{E}_{\Theta_2}[\pi_{2T}(\theta_N, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2N}(\theta_N, \Theta_2)] \iff c_T \leq \bar{C}_T \equiv \delta p(\theta_N - \theta_T)$.

  - The firm would switch to T (otherwise, switch to N') iff (if and only if)
    $\mathbb{E}_{\Theta_2}[\pi_{2T}(\theta_N, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2N}(\theta_N, \Theta_2 = \theta_N = 1)] \iff c_T \leq \bar{\bar{C}}_T \equiv \delta p(1-\theta_T) - \Delta c$.
    Based on the above expressions for $\bar{C}_T$ and $\bar{\bar{C}}_T$, we derive a condition to rank the cutoffs that would facilitate in choosing between three alternatives. For $\bar{C}_T - \bar{\bar{C}}_T < 0$, the condition $\Delta c < \delta p(1-\theta_N)$ is true. And hence, when

$c_T \leq \bar{C}_T \leq \bar{\bar{C}}_T$, the firm always chooses T. Alternatively, when $\Delta c > \delta p(1-\theta_N)$, the firm chooses T, when $c_T \leq \bar{\bar{C}}_T \leq \bar{C}_T$.

- For $i = T$ and $\Theta_1 \in \{1-\theta_T, \theta_T\}$ in period 1, the firm would continue with T (otherwise, switch to N) iff (if and only if) $\mathbb{E}_{\Theta_2}[\pi_{2T}(\Theta_1, \Theta_2)] \geq \mathbb{E}_{\Theta_2}[\pi_{2N}(\Theta_1, \Theta_2)] \iff c_T \leq \bar{C}_T \equiv \delta p(\theta_N - \theta_T)$.

□

Proof of Proposition 6 and 9. Following the similar procedure from the proof of Proposition 5, we can rewrite the first period profit function as follows:

$$\pi_{1i}(\Theta_1) = \begin{cases} p & \text{if } i = N \text{ and } \Theta_1 = 1-\theta_N \\ (1-\delta)p & \text{if } i = N \text{ and } \Theta_1 = \theta_N \\ (p - c_D) & \text{if } i = D \text{ and } \Theta_1 = 1-\theta_D \\ (1-\delta)p - c_D & \text{if } i = D \text{ and } \Theta_1 = \theta_D \\ (p - c_T) & \text{if } i = T \text{ and } \Theta_1 = 1-\theta_T \\ (1-\delta)p - c_T & \text{if } i = T \text{ and } \Theta_1 = \theta_T \end{cases} \tag{B.3}$$

Using (B.3), we can express the total expected profit functions as follows

$$
\begin{aligned}
\Pi_{NN} &= \theta_N \left[(1-\delta)p + (1-\theta_N)(p-\Delta c) + \theta_N(1-\delta)p - \Delta c)\right] \\
&\quad +(1-\theta_N)\left[p + (1-\theta_N)p + \theta_N(1-\delta)p\right] \\
\Pi_{NN'} &= \theta_N \left[(1-\delta)p + (1-\delta)p)\right] \\
&\quad +(1-\theta_N)\left[p + (1-\theta_N)p + \theta_N(1-\delta)p\right] \\
\Pi_{Nj'(\Theta_1)} &= (1-\theta_N)\left[p + (1-\theta_T)(p-c_T) + \theta_T((1-\delta)p - c_T)\right] \\
&\quad +\theta_N\left[(1-\delta)p + (1-\delta)p\right] \\
\Pi_{Nj(\Theta_1)} &= (1-\theta_N)\left[p + (1-\theta_N)p + \theta_N(1-\delta)p\right] \\
&\quad +\theta_N\left[(1-\delta)p + \theta_T((1-\delta)p - c_T - \Delta c) + (1-\theta_T)(p - c_T - \Delta c)\right] \\
\Pi_{NT} &= \theta_N\left[(1-\delta)p + (1-\theta_T)(p - c_T - \Delta c) + \theta_T((1-\delta)(p - c_T - \Delta c)\right] \\
&\quad +(1-\theta_N)\left[p + (1-\theta_T)(p-c_T) + \theta_T((1-\delta)p - c_T)\right] \\
\Pi_{TT} &= \theta_T\left[(1-\delta)p - c_T + (1-\theta_T)(p-c_T) + \theta_T((1-\delta)p - c_T)\right] \\
&\quad +(1-\theta_T)\left[(p-c_T) + (1-\theta_T)(p-c_T) + \theta_T((1-\delta)p - c_T)\right] \\
\Pi_{DD} &= \theta_D\left[(1-\delta)p - c_D + (1-\theta_T)(p - c_D - \Delta c) + \theta_T((1-\delta)p - c_D - \Delta c)\right] \\
&\quad +(1-\theta_D)\left[(p-c_D) + (1-\theta_D)(p-c_D) + \theta_D((1-\delta)p - c_D)\right] \\
\Pi_{TN} &= \theta_T\left[(1-\delta)p - c_T + (1-\theta_N)p + \theta_N(1-\delta)p\right] \\
&\quad +(1-\theta_T)\left[(p-c_T) + (1-\theta_N)p + \theta_N(1-\delta)p\right]
\end{aligned}
\tag{B.4}
$$

The development choice in the first period is either N, D or T, but the form of the resulting policy depends on where c_T stands in terms of the two second period cutoffs, $\bar{C}_T$ and $\bar{\bar{C}}_T$. When $\Delta c < \delta p(1-\theta_N)$, then $\bar{C}_T \leq \bar{\bar{C}}_T$, otherwise $\bar{C}_T > \bar{\bar{C}}_T$. We note that DD is a stand alone feasible policy in all scenarios. Therefore, we compare DD with all feasible policies in each of the following cases and determine the optimal policies accordingly.

For $c_T \leq \bar{C}_T \leq \bar{\bar{C}}_T$, the firm would choose T (between T and N) in period 2 regardless of the choice in period 1. Then, the three possible policies are TT, NT, and DD.

- The firm would adopt TT (otherwise DD) iff $\Pi_{TT} \geq \Pi_{DD} \iff$

$c_T < \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$.

- The firm would adopt TT (otherwise NT) iff $\Pi_{TT} \geq \Pi_{NT} \iff$ $c_T \leq \delta p(\theta_N - \theta_T) + \Delta c\theta_N \equiv \bar{C}_T + \Delta c\theta_N$. Therefore, $\Pi_{TT} \geq \Pi_{NT}$ and NT is never the optimal policy.

For $\bar{C}_T \leq c_T \leq \bar{\bar{C}}_T$, the firm would choose N in period 2 if $\Theta_1 = 1 - \theta_N$, else switches to T. Then the three possible policies are TN, NN and DD.

- The firm would adopt TN (otherwise NN) iff $\Pi_{TN} \geq \Pi_{NN} \iff$ $c_T < \tilde{C}_T^I \equiv \delta p(\theta_N - \theta_T) + \Delta c\theta_N$.

- The firm would adopt TN (otherwise DD) iff $\Pi_{TN} \geq \Pi_{DD} \iff$ $c_T < \tilde{C}_T^{II} \equiv\ 2c_D - \delta p(\theta_N - \theta_T) - \delta p(\theta_N - \theta_D) + \Delta c\theta_D$.

- The firm would adopt DD (otherwise NN) iff $\Pi_{DD} \geq \Pi_{NN} \iff$ $c_D < \tilde{C}_D \equiv \frac{2\delta p(\theta_N - \theta_D) + \Delta c(\theta_N - \theta_D)}{2}$.

For $\bar{C}_T \leq \bar{\bar{C}}_T \leq c_T$, the firm would choose the type N in period 2 regardless of the choice in period 1. Then, the three possible policies are TN, NN and DD.

- The firm would adopt TN (otherwise NN) iff $\Pi_{TN} \geq \Pi_{NN} \iff$ $c_T < \tilde{C}_T^I \equiv \delta p(\theta_N - \theta_T) + \Delta c\theta_N$.

- The firm would adopt TN (otherwise DD) iff $\Pi_{TN} \geq \Pi_{DD} \iff$ $c_T < \tilde{C}_T^{II} \equiv\ 2c_D + 2\delta p\theta_D - \delta p(\theta_T + \theta_N) + \Delta c\theta_D$.

- The firm would adopt DD (otherwise NN) iff $\Pi_{DD} \geq \Pi_{NN} \iff$ $c_D < \tilde{C}_D \equiv \frac{2\delta p(\theta_N - \theta_D) + \Delta c(\theta_N - \theta_D)}{2}$.

When $\Delta c > \delta p(1 - \theta_N)$, then $\bar{C}_T \geq \bar{\bar{C}}_T$, there will be new admissible policies $NN\prime$, and a dynamic $Nj^{'}(\Theta_1)$ along with TT and DD.

For $c_T \leq \bar{\bar{C}}_T \leq \bar{C}_T$, the three feasible policies are TT, DD, and NT.

- The firm would adopt TT (otherwise DD) iff $\Pi_{TT} \geq \Pi_{DD} \iff$ $c_T < \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$.

- The firm would adopt TT (otherwise NT) iff $\Pi_{TT} \geq \Pi_{NT} \iff$ $c_T <\equiv \delta p(\theta_N - \theta_T) + \Delta c \theta_N \equiv \bar{C}_T + \Delta c \theta_N$. Therefore, $\Pi_{TT} \geq \Pi_{NT}$ and NT is never the optimal policy.

For $\bar{\bar{C}}_T \leq c_T \leq \bar{C}_T$, the three feasible policies are TT, DD, and $Nj^{'}(\Theta_1)$.

- The firm would adopt TT (otherwise DD) iff $\Pi_{TT} \geq \Pi_{DD} \iff$ $c_T < \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$.

- The firm would adopt TT (otherwise $Nj^{'}(\Theta_1)$) iff $\Pi_{TT} \geq \Pi_{Nj^{'}(\Theta_1)} \iff$ $c_T <\equiv \frac{\delta p(\theta_N - \theta_T) + \delta p \theta_N (1-\theta_T)}{1+\theta_N}$. We know that $\delta p(\theta_N - \theta_T) < \frac{\delta p(\theta_N - \theta_T) + \delta p \theta_N (1-\theta_T)}{(1+\theta_N)} \equiv \delta p(\theta_N - \theta_T) + \delta p \theta_N(\theta_N - \theta_T) < \delta p(\theta_N - \theta_T) + \delta p \theta_N (1-\theta_T) \equiv \delta p \theta_N(\theta_N - \theta_T) < \delta p \theta_N (1-\theta_T) \implies \bar{C}_T = \delta p(\theta_N - \theta_T) < \frac{\delta p(\theta_N - \theta_T) + \delta p \theta_N (1-\theta_T)}{1+\theta_N}$. Since $c_T \leq \bar{C}_T$, $\Pi_{TT} > \Pi_{Nj^{'}(\Theta_1)}$.

For $\bar{\bar{C}}_T \leq \bar{C}_T \leq c_T$, the three feasible policies are TN, DD, and $NN^{'}$.

- The firm would adopt TN (otherwise $NN^{'}$) iff $\Pi_{TN} \geq \Pi_{NN^{'}} \iff$ $c_T < \hat{C}_T \equiv \delta p(\theta_N - \theta_T) + \delta p \theta_N (1-\theta_N)$.

- The firm would adopt TN (otherwise DD) iff $\Pi_{TN} \geq \Pi_{DD} \iff$ $c_T \leq 2c_D + 2\delta p \theta_D - \delta p(\theta_T + \theta_N) + \Delta c \theta_D \equiv \tilde{C}_T^{II}$.

- The firm would adopt DD (otherwise $NN^{'}$) iff $\Pi_{NN^{'}} \geq \Pi_{DD} \iff$ $c_D < \hat{C}_D^{I} \equiv \frac{\delta p \theta_N (3-\theta_N) - \theta_D(2\delta p + \Delta c)}{2}$.

□

Proof. Proof of Corollary 7 and Corollary 2

- We know that when $c_T < \tilde{C}_T^I \equiv \delta p(\theta_N - \theta_T) + \Delta c \theta_N$, the firm would adopt TN, else NN. While at $c_T < \tilde{C}_T^{II} \equiv\ 2c_D + 2\delta p\theta_D - \delta p(\theta_T + \theta_N) + \Delta c\theta_D$, the firm chooses TN over DD. Hence, we define a condition in Δc that would facilitate in ranking the cutoffs $\tilde{C}_T^I$ and $\tilde{C}_T^{II}$. Solving $\tilde{C}_T^I - \tilde{C}_T^{II} = 0$, we define that when
  $\Delta c < \Delta c^{'} = \frac{2\delta p(\theta_N - \theta_D) - 2c_D}{(\theta_D - \theta_N)}$, then $\tilde{C}_T^I \leq \tilde{C}_T^{II}$.

  At this same condition, we also know $\Pi_{NN} > \Pi_{DD}$.

- Similarly, we also know that when $c_T < \hat{C}_T \equiv \delta p(\theta_N - \theta_T) + \delta p\theta_N(1 - \theta_N)$, the firm would adopt TN, else $NN^{'}$. While at $c_T < \tilde{C}_T^{II}$, the firm chooses TN over DD. Hence, we define a condition in Δc that would facilitate in ranking the cutoffs $\hat{C}_T$ and $\tilde{C}_T^{II}$. Solving $\hat{C}_T - \tilde{C}_T^{II} = 0$, we define that when
  $\Delta c < \Delta c^{''} = \frac{3\delta p\theta_N - \delta p\theta_N^2 - 2c_D - 2\delta p\theta_D}{\theta_D}$, then $\tilde{C}_T^{II} \leq \hat{C}_T$.

  At this same condition, we also know that $\Pi_{DD} > \Pi_{NN^{'}}$.

□

Proof. Proof of Corollary 1 and Corollary 3

- We know that $\tilde{C}_T^I \equiv \delta p(\theta_N - \theta_T) + \Delta c\theta_N$ is decreasing in θ_T, since $\theta_N > \theta_T$. On the other hand, it increases with δ as $\theta_N - \theta_T > 0$.

- We know that $\tilde{C}_T^{II} \equiv\ 2c_D + 2\delta p\theta_D - \delta p(\theta_T + \theta_N) + \Delta c\theta_D$ is decreasing in θ_T, since it has a negative coefficient. On the other hand, by rearranging $\tilde{C}_T^{II}$, we have
  $2c_D + \delta p(\theta_D - \theta_T) - \delta p(\theta_N - \theta_D) + \Delta c\theta_D$ is decreasing with δ if
  $(\theta_D - \theta_T) - (\theta_N - \theta_D) < 0$, else it increases with δ.

- We know that $c_T \leq \tilde{C}_T \equiv c_D + \delta p(\theta_D - \theta_T) + \frac{\Delta c \theta_D}{2}$ is decreasing with θ_T. On the other hand, it increases with δ if $\theta_D - \theta_T > 0$, else it decreases with δ.

- We know that $\hat{C}_T \equiv \delta p(\theta_N - \theta_T) + \delta p \theta_N (1 - \theta_N)$ is decreasing with θ_T, since $\theta_N - \theta_T > 0$. On the other hand, it increases with δ, since $\theta_N - \theta_T > 0$.

$\square$

Works Cited

"Accord on Fire and Building Safety in Bangladesh." 2013. 13 May 2013: Web.

"Automotive Industry Guiding Principles to Enhance Sustainability Performance in the Supply Chain." 2014 : Web. 2 June 2014.

Argote, Linda, Epple, Dennis " *Learning curves in manufacturing* ". Science Magazine 247 (1990): 4945. Print.

Banjo, Shelly. "Bangladesh Compensation Fund Sought."
The Wall Street Journal 13 May 2013: Web.

Bartlett, Christopher A., Dessain, Vincent and Sjman, Anders. "IKEA's Global Sourcing Challenge: Indian Rugs and Child Labor (A)." *Harvard Business School Case*, 2006. No. 9-906-414. Print.

Belavina, Elena and Girotra, Karan. "The Relational Advantages of Intermediation." *Management Science* 58.9 (2013): 1614-1631. Print.

Berfield, Susan. H&M Pledges to Make Bangladeshi Factories Safer. *The Wall Street Journal* 13 May 2013: Web.

Brundtland, Gro Harlem " *Our Common Future: Report by the World Commission on Environment and Development* ". Brussels. United Nations, 1987: Print.

Brunk, Katja H., and Blmelhuber, Christian. "One Strike and you're Out: Qualitative Insights into the Formation of Consumers' Ethical Company or Brand Perceptions." *Journal of Business Research* 64.2 (2013): 134-141. Print

Butler, Sarah. "Three Factory Safety Deals in Bangladesh Aim to Improve Conditions." *The Guardian* 23 October 2013: Web.

Butner, Karen. "The smarter supply chain of the future." *Strategy & Leadership* 38.1 (2010): 22-31. Print.

Carter, Craig R. and Easton, P. Liane. "Sustainable Supply Chain Management: Evolution and Future Directions." *International Journal of Physical Distribution & Logistics Management* 41.1 (2011): 46-62. Print.

Carter, Craig R. and Jennings, Marianne M. "The Role of Purchasing in Corporate Social Responsibility: A Structural Equation Analysis." *Journal of Business Logistics* 25.1 (2004): 145-186. Print.

Chan, Felix T.S. and Kumar, Niraj. "Global Supplier Development Considering Risk Factors using Fuzzy Extended AHP-Based Approach." *Omega* 35.4 (2007): 417-431. Print.

Chan, Felix T. S., Kumar, N., Tiwari, M. K., Lau, H. C. W. and Choy, K. L. "Global Supplier Selection: A Fuzzy-AHP Approach." *International Journal of Production Research* 46.14 (2008): 3825-3857. Print.

Chen, Li and Lee, Hau L. "Mitigate Supplier Responsibility Risk in Emerging Economies : An Ethical Sourcing Framework" *Working Paper*. 2014. Web.

Chiou, H., Tzeng, G., and Cheng, D. "Evaluating Sustainable Fishing Development Strategies Using Fuzzy MCDM Approach." *Omega* 33.3 (2005): 223-234. Print.

Chu, Kathy and Banjo, Shelly. "Li & Fung to Launch Factory-Safety Business". *The Wall Street Journal* 12 January 2014: Web.

Creyer, Elizabeth H. and Ross, William T. "The Influence of Firm Behavior on Purchase Intention : Do Consumers Really Care About Business Ethics ?" *Journal of Consumer Marketing* 14.6 (1997): 421-432. Print.

Dai, Jing and Blackhurst, Jennifer. "A Four Phase AHP-QFD Approach for Supplier Assessment: A Sustainability Perspective." *International Journal of Production Research* 50.19 (2012): 5474-5490. Print.

De Pelsmacker, Patrick, Driesen, Liesbeth and Rayp, Glenn. "Do Consumers Care about Ethics? Willingness to Pay for Fair-Trade Coffee." *Journal of Consumer Affairs* 39.2 (2005): 363-385. Print.

Dou, Eva. "Apple Shifts Supply Chain Away From Foxconn to Pegatron." *The Wall Street Journal* 29 May 2013: Web.

Elkington, John. "*Cannibals with forks: The triple bottom line of 21 st century business*". Oxford: Capstone Publishing, 1997. Print.

Foerstl, Kai, Reuter, Carsten, Hartmann, Evi and Blome, Constantin. "Managing Supplier Sustainability Risks in a Dynamically Changing EnvironmentSustainable Supplier Management in the Chemical Industry." *Journal of Purchasing and Supply Management* 16.2 (2010): 118-130. Print.

Gray, John V., Tomlin, Brian, and Roth, Aleda V. "Outsourcing to a Powerful Contract Manufacturer: The Effect of Learning-By-Doing." *Production and Operations Management* 18.5 (2009): 487-505. Print.

Guo, Ruixue, Lee, Hau, and Swinney, Robert."The Impact of Supply Chain Structure on Responsible Sourcing" *Working Paper*. 2014. Web.

Ho, William, Xu, Xiaowei and Dey, Prasanta K. "Multi-Criteria Decision Making Approaches for Supplier Evaluation and Selection: A Literature Review." *Production and Operations Management* 202.1 (2010): 16-24. Print.

Hartmann, Julia and Moeller, Sabine. "Chain Liability in Multitier Supply Chains? Responsibility Attributions for Unsustainable Supplier Behavior." *Journal of Operations Management* (2014). Web.

Huang, Samuel H. and Keskar, Harshal. "Comprehensive and Configurable Metrics of Supplier Selection." *International Journal of Production Economics* 105.2 (2007): 510-523. Print.

Kalwani, Manohar U. and Narayandas, Narakesari. "Long-Term Manufacturer-Supplier Relationships : Do they Pay off for Supplier Firms?" *Journal of Marketing* 59.1 (1995): 1-16. Print.

Kim, Bowon. "Dynamic Outsourcing to Contract Manufacturers with Different Capabilities of Reducing the Supply Cost" *International Journal of Production Economics* 86.1 (2003): 63-80. Print.

Kim, Sang-hyun."Time to Come Clean? Disclosure and Inspection Policies for Green Production" *Working Paper*. Yale University (2014). Web.

Klassen, Robert D. and Vereecke, Ann. "Social Issues in Supply Chains: Capabilities Link Responsibility, Risk (Opportunity), and Performance" *International Journal of Production Economics* 140.1 (2012): 103-115. Print.

Kleindorfer, Paul R., Singhal, Kalyan and Van Wassenhove, Luk N. "Sustainable operations management" *Production and Operations Management* 14.4 (2005): 482-492. Print.

Kull, Thomas J. and Talluri, Srinivas. “A Supply Risk Reduction Model using Integrated Multicriteria Decision Making” *IEEE Transactions on Engineering Management* 55.3 (2008): 409-419. Print.

Lahiri, Tripti. “U.S. Retailers Grapple with Bangladesh Fire Safety.” *The Wall Street Journal* 11 November 2012: Web.

Lee, Hau L. “Don’t Tweak your Supply Chain Rethink it End to End” *Harvard Business Review* 88 (2010): 6269. Print.

Lee, Amy H.I., Kang, He-Yau, Hsu, Chang-Fu and Hung, Hsiao-Chu.“A Green Supplier Selection Model for High-Tech Industry” *Expert Systems with Applications* 36.4 (2009): 7917-7927. Print

Lee, Hau, O’Marah, Kevin and John, Geraint. “The Chief Supply Chain Officer Report 2012.” Web.

Lee, Hau, O’Marah, Kevin, John, Geraint and Blake, Barry. “The Chief Supply Chain Officer Report 2013.” Web.

Lewis, Tracy R. and Yildirim, Huseyin. “Managing Dynamic Competition” *The American Economic Review* 92.4 (2002): 779-796. Print.

Li, Shanling and Wang, Letian. “Outsourcing and Capacity Planning in an Uncertain Global Environment” *European Journal of Operational Research* 207.1 (2010): 131-141. Print.

Linton, Jonathon D., Klassen, Robert and Jayaraman, Vaidyanathan. “Outsourcing and Capacity Planning in an Uncertain Global Environment” *Journal of Operations Management* 25.6 (2007): 1075-1082. Print.

Locke, Richard M. and Brause, Alberto. "Does Monitoring Improve Labor Standards ? Lessons from Nike." *Industrial and Labor Relations Review* 61.1 (2007): 1-31. Print.

Luk, Lorraine. "Hon Hai confirms employee deaths." *The Wall Street Journal* 05 May 2013: Web.

Manuj, Ila and Mentzer, John T. "Global Supply Chain Risk Management Strategies" *International Journal of Physical Distribution & Logistics Management* 38.3 (2008): 192-223. Print.

McDowell, Patrick, Negishi, Mayumi and Barta, Patrick. "3 die in Cambodia Factory Collapse." *The Wall Street Journal* 05 May 2013: Web.

McLain, Sean. "After Bangladesh Collapse, Reckoning Looms; Police Mull Formal Charges, A Rarity in Previous Disasters." *The Wall Street Journal* 25 July 2013: Web.

Melnyk, Steven A., Davis, Edward W., Spekman, Robert E., and Sandor, Joseph. "Outcome-Driven Supply Chains." *MIT Sloan Management Review* 51.2 (2010): 33-38. Print.

Mendoza, Alvaro J. and Clemen, Robert T. "Outsourcing Sustainability: A Game-Theoretic Modeling Approach." *Industrial and Labor Relations Review* 33.2 (2013): 224-236. Print.

Pagell, Mark and Wu, Zhaohui. "Building a More Complete Theory of Sustainable Supply Chain Management using Case Studies of 10 Exemplars." *Journal of Supply Chain Management* 45.2 (2009): 37-56. Print.

Palmeri, Christopher and Rupp, Lindsey. “Disney Bangladesh Exit Puts Pressure on Those Who May Stay.” *The Bloomberg News* 03 May 2013: Web.

Plambeck, Erica, Lee, Hau L. and Yatsko, Pamela. “Improving Environmental Performance in your Chinese Supply Chain.” *MIT Sloan Management Review* 53.2 (2012): 42-51. Print.

Plambeck, Erica L. and Taylor, Terry A. “Supplier Evasion of a Buyer’s Audit : Implications for Motivating Compliance with Labor and Environmental Standards.” *Working Paper*. Web.

Porter, Michael E. and Kramer, Mark R. “Supplier Evasion of a Buyer’s Audit : Implications for Motivating Compliance with Labor and Environmental Standards.” *Strategy and society*. 85.12 (2006): Print.

Ruwitch, John. “Apple, Supplier Foxconn to Share Costs on Improving Factories.”*Reuters* 10 April 2012: Web.

Sarkis, Joseph and Talluri, Srinivas. “A Model for Strategic Supplier Selection.” *Journal of Supply Chain Management* 38.1 (2002): 18-28. Print.

Schectman, Joel. “Conflict Minerals rules Stretch Supply Chain Software Capabilities.” *The Wall Street Journal* 08 July 2013: Web.

Seuring, Stefan. “A Review of Modeling Approaches for Sustainable Supply Chain Management.” *Decision Support Systems* 54.4 (2013): 1513-1520. Print.

Seuring, Stefan and Muller, Martin. “From a Literature Review to a Conceptual Framework for Sustainable Supply Chain Management.” *Decision Support Systems* 16.15 (2008): 1699-1710. Print.

Simpson, Cam. “The Deadly Tin Inside Your Smartphone.” *Bloomberg Businessweek* 23 August 2013: Web.

Talluri, Srinivas and Narsimhan, Ram. “A Methodology for Strategic Sourcing.” *Europena Journal of Operational Research* 154.1 (2004): 236-250. Print.

Talluri, Srinivas, Narasimhan, Ram and Chung, Wenming. “Manufacturer Cooperation in Supplier Development under Risk” *European Journal of Operational Research* 207.1 (2010): 165-173. Print.

Tang, Christopher S. and Zhou, Sean. “Research Advances in Environmentally and Socially Sustainable Operations.” *European Journal of Operational Research* 223.3 (2012): 585-594. Print.

Tomlin, Brian. “On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks.” *Management Science* 52.5 (2006): 639-657. Print.

Tozzi, John. “Selling Ethical Fashion to the Whole Foods Set.” *Bloomberg Businessweek* 17 April 2014: Web.

Trudel, Remi and Cotte, June. “Does it pay to be good ?” *MIT Sloan Management Review* 50.2 (2009): 61-68. Print.

Vascellaro, Jessica E. and Fletcher, Owen. “Apple Navigates China Maze.” *The Wall Street Journal* 1 January 2012: Web.

. “ Update regarding bangladesh”. 2014: Web. 2 June 2014.

“Automotive Industry Guiding Principles to Enhance Sustainability Performance in the Supply Chain.” 2014 : Web. 2 June 2014.

Winter, Caroline. “Why it’s Hard to Make an Ethically Sourced Smartphone.” *Bloomberg Businessweek* 09 September 2013: Web.

Xu Lei, Thresh Kumar D., Madan Shankar K., Devika Kannan and Gang Chen. “Analyzing Criteria and Sub-criteria for the Corporate Social Responsibility-based Supplier Selection Process using AHP” *International Journal of Advanced Manufacturing Technology* 10(2013): 907-916. Print.

Yelle, Louis E. “The Learning Curve: Historical Review and Comprehensive Survey” *Decision Sciences* 10.2 (1979): 302-328. Print.