Essays on the Economics of Food Product Quality

by

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ABSTRACT

ESSAYS ON THE ECONOMICS OF FOOD PRODUCT QUALITY

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This dissertation contains three essays in applied industrial organization and demand analysis. The first and second essays are theoretical papers, while the third essay is empirical paper.

The first essay models a quality assurance system for two agents: a third-party certifier (TPC) and certified firms. A dynamic model is used to investigate the path of the TPC's monitoring effort and firm's quality when collective reputation affects the returns for the TPC and firms. The model links the TPC and firms by applying a differential game with two different decision rules: open-loop and Markovian strategies. Findings show that as the number of certified firms increases, a free-riding problem may lead to reduced industry reputation. When the industry has a good reputation for producing high quality, the TPC should undertake higher monitoring effort to prevent free-riding.

The second essay explores how transaction experience influences the competition between a short and long supply chain. Some consumers gain utility from purchasing a product related to a certain shopping location because the interaction with producers gives a benefit to them. Hotelling's location model with a two-stage game is modified to analyze transaction experience as a proxy for the chain length, and links the interaction between producers and consumers through two-sided network effects. The effect of transaction experience on network effects is investigated in two cases: exogenous and endogenous network effects. One important finding is that firms prefer less differentiation when experience interacting with network effects is introduced.

The third essay examines whether there is heterogeneity of consumer preferences for local/organic food with alternative distribution channels and distance in discrete market segments using the latent class model. Results show that consumers are heterogeneous in their preferences within and among types of products. In general, most consumers are willing to pay more for a product with fewer food miles and the certified organic attribute. An important finding is that organic and convenience are more important than distance. Most consumers prefer shopping at supermarket chains, while a few consumers gain utility from purchasing local/organic products through short chains. These findings suggest a new consumer segment that values the benefit from distribution channels.

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Chapter 1

Introduction

This dissertation contains three papers related to identifying opportunities and strategies that add value to products in the market for high-quality food products. Essay 1 and 2 are theoretical papers addressing third-party certification in markets with collective reputation, and transaction experience in food supply chains, respectively. Essay 3 is an empirical paper exploring consumer preferences for local/organic food.

The agri-food industry is becoming an interconnected system with complex relationship between food chain actors. There are challenges to both old and new food chain actors to establish the value of their products and the supply chain (Grunert, 2005; Fritz and Schiefer, 2008). The supply chain not only includes manufacturers and their suppliers, but also participants who play important roles such as retailers, service organizations, certifying institutions, and especially consumers. Complexity of food supply chains and concerns related to food adulteration means that consumers have an interest in specific quality attributes focusing on the food product and also on how it is produced, processed, and distributed (Caswell and Mojduszka, 1996; Agriculture and Agri-Food Canada, 2010a). In addition, emerging trends point to consumer awareness of social and environmental impacts associated with food production, and with many consumers' willingness-to-pay for, for example, locally produced foods, foods that reflect enhance animal welfare or are from a production system embodying environmentally friendly production practices. These quality attributes on food products can be associated with search, experience, or credence characteristics (Nelson, 1970; Darby and Karni, 1973). Search and experience characteristics serve an important role in influencing consumers' perception of product quality before or after the purchase or consumption decision, respectively, while credence characteristics, given their nature, tend to not influence perceptions of quality. With specific quality attributes, quality signals (i.e. brand, reputation, certification, and price) become a prominent indicator to convey product quality information (Nelson, 1970; Shapiro, 1982; Marette and Crespi, 2003). Hence, consumers tend to rely on quality signals that are credible and reliable to predict the quality of the product and make a purchase decision.

Products with specific quality attributes are no longer sold at specialty stores or local markets; they also have been offered through mainstream retail (Sexton et al., 2003; Agriculture and Agri-Food Canada, 2010a). The complexity of food distribution networks coupled with heterogeneity of consumer preferences poses challenges for firms/producers to convey product quality along the supply chain. Consequently, the ability to offer food products with attributes that consumers value, and the establishment of trust and loyalty among consumers are key success factors. The overall purpose of this dissertation is to develop new economic knowledge that contributes to our understanding of the functioning of these markets and the nature of preferences for goods which embody attributes that some consumers value.

1.1 Third-party certification

Markets for food products with quality attributes are often subject to asymmetric information where informed parties (i.e. producers) know what they are selling and uninformed parties (i.e. consumers) often do not know what they are buying. Examples of food quality attributes are organic, local, fair trade, and animal welfare. Without quality signals, a lemons problem (Akerlof, 1970) occurs when high-quality producers are driven out of the market because low-quality producers produce quality lower than the standard and sell at the same price as high-quality products (and consumers cannot differentiate between quality attributes). To overcome this problem, producers of food products with quality attributes often use (collective) reputation (Shapiro, 1983; Tirole, 1996; Marette and Crespi, 2003; Winfree and McCluskey, 2005), third-party certification (Caswell and Mojduszka, 1996; Tanner, 2000; Hatanaka et al., 2005; Jahn et al., 2005) to signal product quality. The concept of collective reputation is defined as an aggregate of individual reputations where the current decision of a member of the group depends on the member's past behavior (Tirole, 1996). Since collective reputation is considered a common property, the firms in the group have an incentive to free-ride (Shapiro, 1982; Tirole, 1996). Consequently, this situation has created a marketplace for third-party certification in establishing collective reputation as a quality signal and firms' incentives to maintain the quality of the product (Jahn et al., 2005; McCluskey and Loureiro, 2005).

The role of certifying institutions is to ensure that quality claims are consistent with a standard and to reduce the gap between informed and uninformed parties with credible information (Jahn et al., 2005). However, consumers appear to have increasing mistrust of quality assurance system or large corporations due to skepticism about standard farm practices, quality and safety control in the production processes, and regulations (Giannakas, 2002; Hatanaka et al., 2005). To improve market transparency, Tanner (2000) and Hatanaka et al. (2005) suggest that a third-party certifier (TPC) should evolve as an independent governance mechanism and ensure the reliability of its certification process. In addition, Jahn et al. (2005) stated that public control (i.e. government monitoring) may be needed in markets with certification, and cheating firms (i.e. producing quality lower than the standard) must be revealed to the public. Hence, both the TPC and firms can play prominent roles in building collective reputation as a credible quality signal.

The market for food products with quality attributes may require a TPC to establish collective reputation to serve as a quality signal for high-quality firms (Caswell and Mojduszka, 1996; Jahn et al., 2005). In the first essay, the effect of collective reputation on the interaction between monitoring by the TPC and product quality of firms is analyzed in a dynamic framework. This study follows (Winfree and McCluskey, 2005) by assuming that both the TPC and firms contribute to collective reputation. The parameters of public control (i.e. the probability of firms being caught cheating) and the punishment for cheating are captured in the model. This would provide additional insights into comparative dynamics of the collective reputation model. A differential game is applied to examine the strategic interaction between the TPC and certified firms in the dynamic model under two decision rules: open-loop and Markovian strategies. This essay provides an extension of implementing collective reputation as a control mechanism to drive firm's incentive to maintain high-quality products.

1.2 Transaction experience in food supply chains

Food markets have become more complicated because consumers not only demand a product with specific product qualities, but expect a benefit from the product they purchase (Pine and Gilmore, 1998; Lusk et al., 2007; Swinnen et al., 2012). For example, some consumers care more about issues such as the sustainability of local communities, environmental impacts, and animal welfare, and are willing to pay a higher price for goods that embody such benefits (Pine and Gilmore, 1998; Swinnen et al., 2012). This concept is referred to as an experience-based market, which is described as a product or an event that allows consumers to add "feelings" or "emotions" to that product or event (Pine and Gilmore, 1998). Short supply chains[1] have emerged as an opportunity for producers to add value to their products and provide experience through direct interaction with consumers (Hunt, 2007; Swinnen et al., 2012). Some participants in long supply chains[2] (i.e. *Starbucks* and *Whole Foods*) have come to understand that consumers are demanding a product related to experience, rather than just a simple good or service.

[1]Short supply chains involve very few intermediaries and refer to an opportunity for producers and consumers to interact, including farmers' markets, roadside stands, community-supported agriculture (CSA).

[2]Long supply chains involve the number of intermediaries from the production point to the selling point, including retailers and large-scale supermarkets.

According to the concept of the experience economy (Pine and Gilmore, 1998; Swinnen et al., 2012), it can be applied in various ways and different types of markets. This essay focuses on the market where consumers value a product at a particular shopping location that gives "transaction experience" through the interaction between producers and consumers.[3] For example, some consumers visit a farmers' market because they gain utility from interacting with producers and purchasing products from that farmers' market.

The interaction between producers and consumers plays an important role in building the network of food chains, as well as improving consumers' trust in product quality and building consumer loyalty (Jahn et al., 2005; Hunt, 2007). Two-sided network effects arise when an increase in usage by one group of users increases the value of the product to the other group of users (Farrell and Klemperer, 2007; Shy, 2011). In this essay, consumers benefit by having more producers at the same shopping location because of increased product variety (Lancaster, 1990) and opportunities to interact with producers (Hunt, 2007). Further, producers benefit by having more consumers at the same shopping location because of increased profit and chances to interact with consumers. Since there is a difference in the complexity of length of supply chains, consumers may have a higher valuation for a product with transaction experience in short supply chains than long supply chains (Brown and Miller, 2008; Thilmany et al., 2008; Adams and Salois, 2010). This is because producers at short supply chains can more readily develop transaction experience through direct interaction with consumers. Thus, a better understanding of how the effect of transaction experience on competition between different chain lengths will provide a useful contribution to our understanding of contemporary agri-food markets.

The second essay deals with the market for a product related to transaction experience, and links the relationship between transaction experience and chain length. This essay allows for the effect of transaction experience on both sides of the market through two-

[3]The transaction experience is defined as a benefit (that involves feelings or emotions, and yields utility) associated with purchasing a product from a unique shopping location, and from a particular seller.

sided network effects. Hotelling's location duopoly model with a two-stage game is used to analyze the effect of transaction experience on network effects and firms' competition. Combining the concept of transaction experience and two-sided network effects yields new insights into a product differentiation model. First, most studies of network effects assumed that network effects are exogenous variables (Farrell and Klemperer, 2007; Shy, 2011). In this paper, the cases where network effects are exogenous and endogenous are investigated. Second, a standard outcome of Hotelling's location model (D'Aspremont et al., 1979) is that firms have an incentive to differentiate their products in order to avoid aggressive price competition. Findings in this essay show that maximizing an optimal strategy is to offer less differentiation when network effects are introduced into the model.

1.3 Local and Organic food markets

Differences in consumer perception of food quality attributes can lead to a wide range of consumer segments, so targeting the right product attributes to specific consumers becomes more difficult for producers/retailers. To understand consumer's purchase behavior across several product attributes, several studies have focused on consumer decision-making based on prices, brands, certification labels, or nutrition claims (Grunert, 2005; Yiridoe et al., 2005). Because of concerns about health, quality and the environment, there occurs a new market for specific food qualities such as organically or locally grown foods (Agriculture and Agri-Food Canada, 2007; Campbell et al., 2013). Almost half of Canadian consumers buy local and organic foods and are willing to pay more for these products (Canada Organic Trade Association, 2013). However, many consumers have doubts about organic or local production practices and labeling (Yue and Tong, 2009; Campbell et al., 2013). Organic food products can travel from different locations, which can be considered as local or not local depending on the distance from production to consumption. Some consumers switch from certified organic food to local food because of mistrust about organic production (Onozaka and Mcfadden, 2011; Campbell et al., 2013; Denver and Jensen, 2014). Consequently, there is no clear relationship between consumer preferences for local and/or organic foods.

Selling locations for organic and local food products have expanded from specialty stores or direct markets to mainstream retail (Canada Organic Trade Association, 2013). Retailers and large-scale supermarkets have offered local and organic sectors in order to attract new consumer segments. Local/organic farmers or producers have moved toward short supply chains to create an opportunity to interact with consumers and a new channel to sell their products (Martinez et al., 2010; Swinnen et al., 2012). Since short chains provide a positive impact on the local community and environment, which adds value to the product that consumers buy, this may create a new consumer segment who gain more utility from buying products sold at a unique selling location (i.e. farmers' market).

The third essay explores whether the choice of distribution channel matters when selling local/organic products to consumers. Several studies have explored consumer preferences for local/organic food products, but less research has focused on consumer valuation of these products associated with distribution channel (Yiridoe et al., 2005; Yue and Tong, 2009; Campbell et al., 2013). It is difficult to obtain information about the actual purchases of consumers for some particular attributes, especially distribution channels. To assess this issue, this paper is undertaken using stated choice preference methods and a choice experiment that included distribution channels in the design attributes. The choice experiment implies a hypothetical situation that contains a set of alternatives with different attributes. The survey and choice experiment were designed and conducted for fresh produce and processed food products. After state choice data were collected, the latent class model is employed to estimate consumer's willingness to pay for attributes associated with local/organic foods.

Findings show that there is significant heterogeneity in consumer preferences for local/organic/distribution channel attributes. In general, consumers have weaker preferences for the distribution channel attribute than local/organic attributes. Consumers value alternative distribution channels differently; most consumers prefer shopping for their groceries at long supply chains, while a few consumers are willing to pay more for products sold at short supply chains. The empirical results in this essay provide not only additional information about a new consumer segment who values the benefit of length of distribution channels, but also provide evidence to support the theoretical model regarding the concept of transaction experience related to food supply chains in the second essay.

1.4 Organization of the dissertation

This dissertation is organized into five chapters. The background of third-party certification, the experience economy, the local and organic market, and the research objectives are presented in Chapter 1. Chapter 2 is devoted to essay 1, which is entitled "Third party certification: dynamic monitoring when product quality depends on collective reputation". Next, Chapter 3 contains the second essay: "The experience economy in product differentiation model: an application to food supply chain". Chapter 4 contains the third essay: "The role of distance and distribution channel in consumers' choices with local and organic food products". Finally, Chapter 5 presents the main conclusions derived from each of the three essays, and provides suggestions for future research.

1.5 Contributions of the dissertation

Each essay in this dissertation contributes to the broader literature on distinct issues related to food product quality in agricultural economics. In the first essay, a dynamic system of collective reputation is developed to link the interaction between the TPC and firms using differential games. Modelling quality assurance system related to collective reputation can help the TPC, producers, and government (or private downstream firms) to implement collective reputation in maintaining high-quality products. The second essay investigates the effect of transaction experience on network effects and firms' competition using Hotelling's location model with a two-stage game. A better understand of the context of the market for a product associated with transaction experience can help producers to decide on selling locations and apply this new strategy in creating value for their products. In the third essay, the latent class model is used to assess consumer preferences for local/organic products related to distribution channels and distance. Findings from this essay will provide additional information about local/organic consumers to producers in developing a marketing strategy and targeting the right consumer segment in the local/organic markets.

Chapter 2

Third-party Certification: Dynamic Monitoring when Product Quality depends on Collective Reputation

2.1 Introduction

In response to concerns related to food adulteration and fraud, high-quality food producers have been increasingly turning to government regulations and third-party certification as a means to ameliorate diminished consumer confidence (Giannakas, 2002; Hatanaka et al., 2005). The motivation of food producers to commit fraud is mostly for economic gain. The majority of fraud incidents go undetected because they usually do not result in public health risks, the certification process lacks efficiency, and consumers cannot detect a problem with quality attributes (Giannakas, 2002; Jahn et al., 2005). The consumer's inability to differentiate between quality attributes[1] is commonly known as 'the Market for Lemons' problem (Akerlof, 1970). Low-quality producers may produce below standard quality products and sell at the same price as high-quality products; in this case, high-quality producers competing in the same market as low-quality producers are driven out of the market. Organic is one example of food production associated with fraud: producers tend to mislabel conventional products as organic products to increase their profits (Giannakas, 2002). Fraudulence

[1]Most quality attributes of food products are considered as credence characteristics, which consumers cannot determine the quality of the product before the purchase and sometimes not even after the purchase or consumprion (Nelson, 1970; Darby and Karni, 1973).

in food production has created a marketplace for third-party certification as well as an opportunity for producers to add more value to food supply chains and improve consumers' trust in the quality of a product (Hatanaka et al., 2005; Jahn et al., 2005).

To overcome the lemons problem, producers often use reputation (Shapiro, 1983; Marette and Crespi, 2003; Winfree and McCluskey, 2005) or a quality guarantee by a third party to signal the quality of goods with some credence characteristics (Tirole, 1996; Tanner, 2000; McCluskey, 2000; Albano and Lizzeri, 2001; Deaton, 2004; Jahn et al., 2005; Duflo et al., 2013). Tirole (1996) introduced the concept of collective reputation as an aggregate of individual reputations, where the current incentives of a member of the group to make a decision are affected by the member's past behavior, as well as by the past behavior of the group. For example, organic or local producers use reputation of the whole industry to signal their integrity to consumers (i.e. *Organic Meadow, Rowe farms*). Thus, firms can share in the industry value by building collective reputation in order to charge a premium price. However, individual firm behavior is imperfectly observed by consumers and each firm can benefit from the same collective reputation without contributing to the cost; therefore, a member of the group has an incentive to free-ride (Shapiro, 1982; Tirole, 1996). Each firm confers a negative externality on other firms through its quality decision and ignores this externality. To prevent the free-rider problem in the market for high-quality products, a third-party certifier (TPC) plays a prominent role in establishing collective reputation as a quality signal and firms' incentives to maintain the quality of a product (Jahn et al., 2005; McCluskey and Loureiro, 2005).

Certifying institutions have become a fundamental way to reduce uncertainty and improve market efficiency in the face of asymmetric information (Tanner, 2000; Deaton, 2004; Hatanaka et al., 2005; Duflo et al., 2013). Tanner (2000) and Hatanaka et al. (2005) suggest that third-party certification (monitored by the third parties) should evolve as an independent governance mechanism and is more reliable than first (monitored by suppliers) or second-party certification (monitored by retailer's paid experts). These authors suggest that third-party certification provides an advantage in the supply chain; however, retailers may leave all responsibility to the TPC. The role of the TPC is to certify quality claims consistent with a predetermined set of standards and compliance procedures. In addition, the TPC are responsible for reducing the gap between informed and uninformed parties by providing consumers with credible information (Hatanaka et al., 2005; McCluskey and Loureiro, 2005; Duflo et al., 2013). The third-party certification can enhance the collective efforts (e.g. through marketing boards or cooperatives) with respect to food product safety and building consumer confidence in purchasing a product with specific quality attributes developed through group action. Therefore, most firms rely on third-party certification to indicate product differentiation and signal their reputation.

In fact, the market for goods with quality attributes is always subject to asymmetric information and the lemons problem. The existence of the market for such a good requires third-party certification to signal quality claims for certified firms. The actions of the TPC and firms depend on the current collective reputation, which is affected by the past behavior of the TPC and firms. Consumers assess the quality by observing collective reputation as a market signal of product quality (Winfree and McCluskey, 2005). If the product is found to be fraudulent, the whole industry is responsible for the negative impact on collective reputation (McCluskey and Loureiro, 2005). To ensure high-quality in the market, the TPC's monitoring is required as a control system to influence the firm's effort on providing product quality in the high-quality market (McCluskey, 2000; Vetter and Karantininis, 2002).

This paper considers the role of collective reputation in a dynamic model to derive the optimal paths for the TPC's monitoring and for the firm's quality over time. To assess the role of collective reputation in the high-quality market, a literature review is presented in Section 2.2. Next, the theoretical framework of both the TPC and firms is described in Section 2.3. After outlining the basic model, a social optimal solution, and decentralized open-loop and Markovian solutions are examined by using the optimal control approach. In addition, comparative dynamics are analyzed to reveal the effect of an exogenous variable on a steady-state control variable such as how the TPC's monitoring changes for the firms being caught cheating. Finally, Section 2.4 concludes the findings with suggestions for future research.

2.2 Literature Review

Some theoretical studies have developed a model to evaluate the performance of a certification mechanism (Tanner, 2000; Albano and Lizzeri, 2001; Carriquiry et al., 2003; Deaton, 2004). Tanner (2000) suggests that there may be trade-offs between the levels of competition among certifiers and the credibility of the certification process. As the number of firms requiring quality assurance systems grows, the cost of certifications plays an important role in the firm's profitability (Deaton, 2004; Hatanaka et al., 2005). This leads to competition among firms to seek the most cost effective approach of certification. The challenges of implementing a third-party certification scheme include difficulties in governing different types and sizes of producers, and unobservable producer's action (Hatanaka et al., 2005). Small and medium-sized producers may not be able to benefit from adopting a third-party certification. Options to overcome an investment in certifications include the formation of cooperatives (Hatanaka et al., 2005) and vertical integration (Vetter and Karantininis, 2002). Albano and Lizzeri (2001) and Duflo et al. (2013) indicated that the quality of information about product quality reported by a certifying agent induces producers to maintain high-quality products. However, Jahn et al. (2005) stated that information (i.e. fraud activity) may be hidden by the TPC, so public control may be required. In order to provide a sustainable certification system, Tanner (2000) and Deaton (2004) suggest that certification will provide an effective signal, if high-quality producers have a cost of production lower than low-quality producers. Carriquiry et al. (2003) pointed out that the TPC will be successful in establishing reputation when its certification is accepted as a credible signal.

There are two concepts to cope with asymmetric information: incentive schemes to reward the agent's action for moral hazard; and signaling by more informed parties or screening by less informed parties for adverse selection. The implications of asymmetric information regarding credence attributes are discussed under different assumptions. Some previous papers have used a principal-agent model to evaluate economic values of quality assurance systems and the incentive behavior under a contract (King et al., 2007; Resende-Filho and Buhr, 2008). These authors concluded that a contract increases the incentive of providing higher quality and add value to a supply chain. Resende-Filho and Buhr (2008) showed that a processor can offer a contract on traceability that encourages a supplier to provide safer materials. King et al. (2007) investigated the impact of ownership structure on a food safety control system using a dynamic principal-agent model. These authors found that reputation can be an additional incentive mechanism to induce performance of the agent under contract.

A few theoretical papers have studied monitoring in the context of food quality. McCluskey (2000) investigated producers' behavior in the market for three type of goods (search, experience, and credence) using a game theoretic approach of repeat-purchasing. She suggests that credence goods with a certification could theoretically be treated as an experience good and a third-party monitor is required to maintain the high-quality market. This finding is supported by Vetter and Karantininis (2002) who applied vertical integration and monitoring in the market for credence goods, and McCluskey and Loureiro (2005) who considered the impact of monitoring on consumers perceptions of quality in a dynamic model. The latter authors indicated that monitoring allows reputation effects to increase a firm's incentive to maintain a higher quality. If the TPC fails to ensure a firm meets the quality standard, then its reputation is diminished. However, these authors treat the level of monitoring as an exogenous constant variable in the dynamic model.

While, several previous studies have developed models of reputation related to firm behavior (Kreps and Wilson, 1982; Shapiro, 1982, 1983; Allen, 1984; McCluskey and Loureiro, 2005; Carriquiry and Babcock, 2007), only a few have studied collective reputation (Tirole, 1996; Winfree and McCluskey, 2005). Kreps and Wilson (1982) showed that when information is imperfect, reputation effects have important consequences for equilibrium selection in many dynamic games. Reputation is considered as a dynamic process depending on consumer's perceived quality and producer's past action that may give a rise to adverse future consequences (Shapiro, 1982). When product quality is not directly observable, an inverse demand (price) will depend on reputation (Shapiro, 1982; Allen, 1984; Winfree and McCluskey, 2005). When high prices are used to signal high-quality products, firms have no incentive to cut their prices because consumers would not buy the products; however, other signals (i.e. advertising, socially responsible claims) are needed in order to gain more sales (Allen, 1984). Shapiro (1983) suggests a model of reputation with non-price competition and no free-entry by firms in the high-quality market. He indicated that reputation can be used as an incentive mechanism if consumers are able to perceive different qualities and remain loyal to high-quality producers. Furthermore, high-quality producers tend to invest highly in establishing reputation because a good reputation allows them to charge a premium price and earns them rents from repeat purchases.

The reputation of product quality can be used as a collective measurement in the sense of dynamic common property (Tirole, 1996; Marette and Crespi, 2003; Winfree and McCluskey, 2005). Tirole (1996) provided a model for collective reputation, which implies that an individual firm's action in a group contributes to collective reputation. He indicated that in the steady state, when collective reputation is good, firms have less incentive to provide low quality. Thus, collective reputation is a powerful tool as a mechanism for influencing agent behavior that prevents agents from free-riding on quality provisions (Tirole, 1996). Winfree and McCluskey (2005) applied the idea of collective reputation for experience goods and revealed that as the size of the group increases, the members will under invest in quality levels compared to an industry level. Carriquiry and Babcock (2007) also showed that when reputation is a public good, a free-rider problem occurs.

As presented above, asymmetric information problems can be reduced by monitoring through the TPC or by offering incentive compatible contracts. To succeed in the market based on quality attributes, the agents need to establish (collective) reputation to serve as a quality signal (Caswell and Mojduszka, 1996; Marette and Crespi, 2003; Jahn et al., 2005; Winfree and McCluskey, 2005). Clearly, there are some previous studies of third-party certification systems (Tanner, 2000; Deaton, 2004), but there has been little research to show how the TPC's monitoring influences collective reputation, and how collective reputation influences firms' efforts in providing product quality. There are a few theoretical studies about monitoring in the context of food quality with various purposes (McCluskey, 2000; Vetter and Karantininis, 2002; McCluskey and Loureiro, 2005), but none of the models account for the interaction between the TPC's monitoring and the firm's quality nor do they address how collective reputation links these two agents in a dynamic context. Indeed, the TPC induces consumers to gain more trust in the quality of a product, so firms take third-party certification into account in establishing collective reputation as a credible signal of product quality. This paper seeks to examine the role of collective reputation in providing product quality within the certification system. Since collective reputation is considered as a dynamic effect and the interaction between the TPC's monitoring and the firm's quality contributes to collective reputation, a differential game is applied.

2.3 Theoretical Framework

In this section, a differential game of collective reputation in a competitive market for a good with quality attributes is analyzed. The TPC's monitoring plays an important role in providing credible signals of the product quality (Shapiro, 1983; Jahn et al., 2005). Third-party certification allows firms to label their products as certified and use such a claim as a marketing tool. Thus, the TPC can improve consumers' trust in the quality of the products they buy (Tanner, 2000; Hatanaka et al., 2005). In this paper, collective reputation is considered as an aggregate reputation among certified firms plus the third-party certifier.[2] After the product is certified by the TPC, consumers who observe collective reputation are aware that the certified firms comply with the quality standard (Shapiro, 1983; Tirole, 1996; Winfree and McCluskey, 2005). This section lays out the analysis as follows. First, the proposed dynamic models for the TPC and firms are developed. Second, a social planner solution is derived as a benchmark case to compare with a decentralized solution. Next, open-loop and Markovian solutions for the decentralized case are analyzed. The effects of public control on the TPC's monitoring effort and the punishment on firms' revenue are examined. To illustrate the problem of free-riding, the firms' cooperative solution is compared with the firms' non-cooperative solution. Finally, numerical analysis is applied to illustrate the characteristics of the model.

2.3.1 The model

The model is an infinite-horizon dynamic game between a third-party certifier (TPC) and certified firms. The TPC certifies N firms, in which the certification is considered as one unit of output for the TPC. Both the TPC and firms move simultaneously and choose their respective variables to maximize profits. The TPC controls the rate of change in monitoring efforts, while firms control the rate of change in quality levels. Collective reputation, R, is determined by the average quality among certified firms and the TPC's monitoring effort. Following in Shapiro (1982) and Winfree and McCluskey (2005), reputation can reward all members of a group through the past reputation and thus their actions in the past affect their profit in the present. In this model, collective reputation, R, is used as an incentive

[2] Note that the role of TPC involves an independent governance mechanism.

for the TPC to provide the monitoring effort and certified firms to provide product quality. Both the TPC and firms act strategically and know that their current actions will affect the future stock of collective reputation, thereby leading to their future profits. The change in reputation, $\dot{R}$, is equal to the average quality plus the monitoring effort perceived by consumers, $m(t)q_s + \frac{\sum_i^N q_i(t)}{N}$, less depreciation of reputation, $R(t)$, times a discount rate. The collective reputation adjustment is given by

$$\dot{R} = \gamma[m(t)q_s + \frac{\sum_i^N q_i(t)}{N} - \delta R(t)] \tag{2.1}$$

where $m(t)$ is the TPC's monitoring effort, q_s is the quality standard, and $q_i(t)$ is product quality provided by firm i. γ is the speed of consumer learning, which implies the rate of how consumers perceive changes in collective reputation (Shapiro, 1982), and δ is the depreciation rate of collective reputation.

Third-party certifier

The TPC's dynamic model incorporates the levels of monitoring effort, $m(t)$, as a control variable to maximize the TPC's profit when collective reputation is a state variable. The TPC's cost function is given by the cost of monitoring effort, $c(m)$, times the level of quality standard, q_s, which is an exogenous variable. Note that third-party certification is assumed to mean that product quality meets (or even exceeds) quality standards-setting organizations, and that such organizations could be a government agency (which is explicitly assumed here) or private firms (or groups of private firms) with their own private standards (i.e. EURPGAP).[3] In this essay, the government sets a quality standard, $q_s \in (0,1]$, which the level of monitoring effort chosen by the TPC must be at least equal to the stringency required to meet the quality standard, $\underline{m}(q_s)$.[4] If firms produce a quality, q_i, which is greater than zero but lower than the quality standard, $0 < q_i < q_s$, they are considered to be cheat-

[3]Note that the TPC may certify beyond government based standards and operate in a manner that the certifying service is consistent with private standards, which can exceed government standards.

[4]For example, the case of organic products, every third-party certifier needs to be accredited by the Canadian Food Inspection Agency (CFIA) under the Organic Products Regulations 2009.

ing or under providing quality. The revenue from certification is divided into two parts: the annual price charged for certifying services, $w(R)$ and a fixed certification fee[5], F. Assume that the greater the (good) collective reputation, the more the TPC is able to charge for the certifying service. Therefore, R determines the (inverse) demand curve for certification, $w(R)$, for the TPC. Assume the standard structural forms, $w'(R) > 0$, $w''(R) < 0$, $c'(m) > 0$, and $c''(m) > 0$. The condition $w''(R) < 0$ is assumed to make sure that the monitoring effort is bounded. Thus, the TPC's profit function is $w(R(t)) + F - c(m(t))q_s$.

The certification process can be monitored by alternative agents (i.e the TPC or government) that differ with respect to their certification systems and liability (Hatanaka et al., 2005; Jahn et al., 2005). The role of public control (i.e. government monitoring) on the TPC's monitoring effort is investigated because it is a better fit with the real market. For example, the government has provided the lists of organic firms/producers being caught cheating. Figure 2.1 illustrates the effect of the public control on the TPC's payoff.

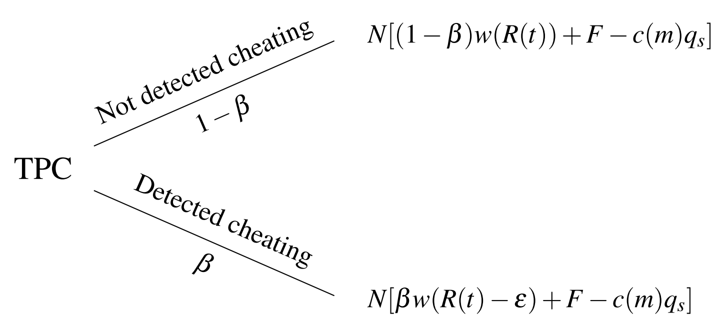

Figure 2.1: The outline of game that models the TPC's monitoring with public control

In this context, two additional assumptions are assumed. First, the government monitoring process for certification is the same for all certified firms and can provide the probability of firms being caught cheating, β, where the cheating firms are the certified firms that provide a quality below the quality standard, q_s. The parameter β captures the government enforcement as public control, which is revealed to the public. Assume that the probability

[5]Note that a third-party certifier charges a fixed certification cost as a annual basic fee to renew a certification contract. Variable costs are product fees, extraordinary fees, and inspector fees.

of firms being caught cheating, β, is fixed and exogenous. Second, the government detection of cheating firms affects the TPC's revenue by decreasing collective reputation by an amount $\varepsilon \in [0,R)$, where ε is a small positive finite value. At time $t=0$, the government announces the probability β and the value ε to the whole industry. When the TPC's payoff for each stage as shown in Figure 2.1 are added and simplified, the TPC's expected profit maximization problem is as follows:

$$\max_{m(\cdot)} \Pi_0 = \int_0^{\infty} e^{-\rho t} N[\beta w(R(t)-\varepsilon)+(1-\beta)w(R(t))+F-c(m(t))q_s]dt \quad (2.2)$$

$$\text{subject to} \quad \dot{R} = \gamma[m(t)q_s + \frac{\sum_i^N q_i}{N} - \delta R(t)] \quad (2.3)$$

$$R(0) = R_0 \quad \text{(given)} \quad (2.4)$$

$$m(t) \geq \underline{m}(q_s) \quad (2.5)$$

where R is a stock of collective reputation in the current period, ρ is a discount rate for future profit, and $\underline{m}(q_s)$ is considered as the fixed minimum level of monitoring effort required to meet the quality standard.

Firms

Each firm chooses quality, $q_i(t)$, as a control variable to maximize its profit. The industry quality is $\sum_i^N q_i(t)$. The firm's revenue, $G(R)$, is a function of price (the inverse demand), which depends on collective reputation. Assume that the greater the (good) collective reputation, the more the firm is able to charge for the product. The firm's cost is the cost of producing the quality of the product, $g(q_i(t))$, plus the cost of certification, $w(R)+F$. Assume that $G'(R) > 0$, $G''(R) < 0$, $g'(q) > 0$, and $g''(q) > 0$. The TPC announces the certification fee, $w(R)+F$, to firms. Assume that the certification fee is the same for all firms and each firm is treated equally.[6] The firm i's profit is given by $G(R(t)) - g(q_i(t)) - w(R(t)) - F$.

With respect to monitoring, firms are audited by the TPC with the probability $\sigma(m;\beta)$ and a fraud activity is revealed to the public, where $\sigma(m;\beta) \in [0,1]$ and $\sigma(0;\beta)$ is zero.

[6]The model in this paper considers the game without outside options (i.e. firms do not use certification), so all firms are certified by the TPC.

Assume that $\sigma(m;\beta)$ has a positive relationship with m. The relationship between the TPC's monitoring and the probability of firms being caught cheating, β, is assumed to be positive and thus it has a positive relationship with $\sigma(m;\beta)$. The intuition is that an increase in the probability of firms being caught cheating by the government causes the TPC's monitoring effort to approach the probability $\sigma(m;\beta)$. When the TPC's monitoring is perfect, the TPC can monitor certified firms and reveals their cheating to public with probability one. This paper focuses on imperfect TPC's monitoring because it is possible that the TPC has an incentive to provide less monitoring effort in order to increase its profit. The probability $\sigma(m;\beta)$ is assumed to be fixed and exogenous. Figure 2.2 illustrates the effect of the TPC's monitoring on the firm's payoff. Let θ be an exogenous probability that firms produce a product with quality lower than the quality standard, q_s. If the cheating firms are caught by the TPC, the firms' revenue is affected by deducting collective reputation by an amount $\varepsilon_f \in [0,R)$ where ε_f is a small positive finite value. With the probability of no monitoring, $1-\sigma(m;\beta)$, cheating or not cheating firms have the same level of collective reputation, R. At time $t=0$, the TPC announces $\sigma(m;\beta)$ and ε_f to certified firms.

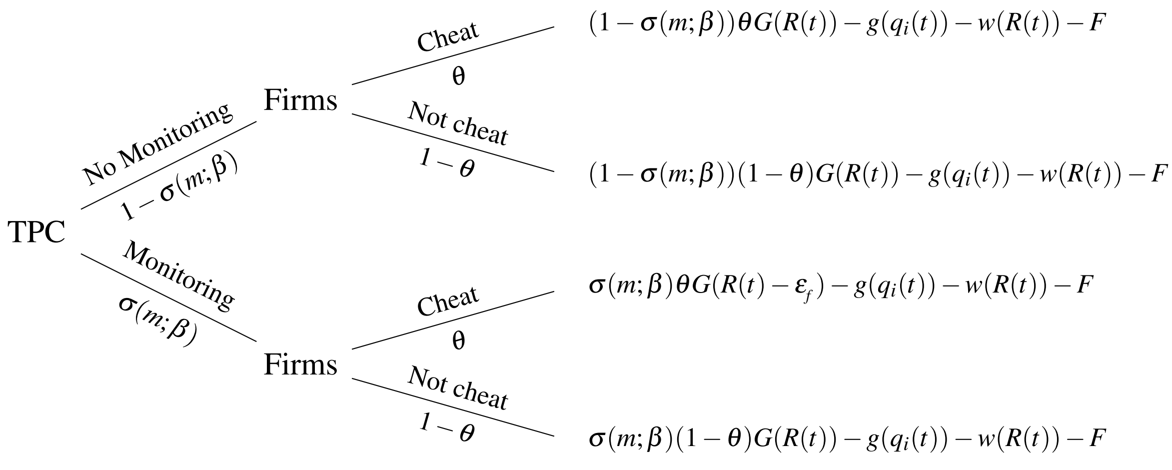

Figure 2.2: The outline of game that models firms with the TPC's monitoring

When the firm's payoff for each stage as shown in Figure 2.2 are added and simplified, the firm's expected profit maximization can then be written as:

$$\max_{q_i(\cdot)} \Pi_0^i = \int_0^{\infty} e^{-\rho t}[\sigma(m)\theta G(R(t)-\varepsilon_f)+(1-\sigma(m)\theta)G(R(t))-g(q_i(t))-w(R(t))-F]dt \tag{2.6}$$

$$\text{subject to} \quad \dot{R} = \gamma[mq_s + \frac{\sum_i^N q_i(t)}{N} - \delta R(t)] \tag{2.7}$$

$$R(0) = R_0 \quad \text{(given)} \tag{2.8}$$

where (2.7) and (2.8) have the same variables as the model setup for the TPC, m is the TPC's monitoring, which the firm treats as an exogenous variable. Note that the probability $\sigma(m;\beta)$ is reduced to $\sigma(m)$ for simplicity.

Structure of the game

The differential game of the TPC and certified firms in the market with collective reputation is analyzed. In this game, at the beginning of the game ($t = 0$), the government announces the probability of firms being caught cheating, β where β is a fixed value over time. Next, both the TPC and firms move simultaneously and choose their control variables to maximize their payoffs. The structure of the differential game in this paper considers two decision rules and game structures. The two different decision rules are open-loop and Markovian strategies. Suppose that both the TPC and firms strategically exploit the same stock of collective reputation. Note that firms are assumed to be identical and to use the same strategy. If the TPC believes that firms use open-loop strategies, firms restrict themselves to a preannounced action, $q(t)$, over time. Alternatively, if the TPC believes that firms use Markovian strategies, firms choose an action as a function of the current stock of collective reputation, denoted $\phi(R(t))$. This strategy allows each firm to update its choice based on the current collective reputation. The game structures define the interaction among certified firms, which is divided into two cases where firms behave cooperatively and non-cooperatively. The game is solved to derive open-loop and Markovian solutions using the optimal control approach.

2.3.2 The benchmark case: no monitoring

The social planning problem presents a useful benchmark case where there is no TPC's monitoring ($m = 0$) to ensure that the firms' quality complies with the quality standard, q_s. Under the benchmark case, information is perfect, so firms have no incentive to under provide quality because consumers can observe the quality of a product. Assume that information is costless and readily available to a social planner. Suppose that the social planner aims to derive the socially optimal level of product quality for the whole industry. Thus, the economic benefit is maximized by choosing a level of quality where firms behave cooperatively. First consider a case where firms use an open-loop strategy. From equation (2.6), the dynamic social welfare function is as follows:

$$\max_{q(\cdot)} W_0 = \int_0^\infty e^{-\rho t} N[G(R(t)) - g(q(t))]dt \tag{2.9}$$

$$\text{subject to} \quad \dot{R} = \gamma[q(t) - \delta R(t)] \tag{2.10}$$

$$R(0) = R_0 \quad \text{(given)} \tag{2.11}$$

The current-value Hamiltonian for the social planner's problem is:

$$\hat{H} = N[G(R(t)) - g(q(t))] + \kappa[\gamma(mq(t) + q(t) - \delta R(t))] \tag{2.12}$$

where κ be the current value co-state variable. The social planner chooses $q(t)$ to maximize social welfare. The first order conditions are:

$$\frac{\partial \hat{H}}{\partial q} = -Ng'(q) + \kappa\gamma = 0 \tag{2.13}$$

$$\frac{\partial \hat{H}}{\partial R} = NG'(R) = (\rho + \gamma\delta)\kappa - \dot{\kappa} \tag{2.14}$$

$$\frac{\partial \hat{H}}{\partial \kappa} = \gamma(q - \delta R) = \dot{R} \tag{2.15}$$

Differentiating (2.13) with respect to t and substituting into (2.14), and solving for a system of differential equations yields:

$$\dot{q} = \frac{\gamma}{g''(q)}\left[\frac{(\rho+\gamma\delta)g'(q)}{\gamma} - G'(R)\right] \quad (2.16)$$

$$\dot{R} = \gamma(q - \delta R) \quad (2.17)$$

Solving for steady-state solutions, setting $\dot{q} = 0$ and $\dot{R} = 0$, gives $R^*_{w_{op}} = \frac{q^*_{w_{op}}}{\delta}$ and

$$G'(R^*_{w_{op}}) = \frac{(\rho+\gamma\delta)}{\gamma} g'(q^*_{w_{op}}) \quad (2.18)$$

where $q^*_{w_{op}}$ and $R^*_{w_{op}}$ is the quality and collective reputation that satisfies the steady-state equations (2.16) and (2.17) in an open-loop strategy. Equation (2.18) equates the marginal benefits to the marginal cost of producing product quality with the discount rate. The parameter δ reflects the discounting effect on collective reputation in which consumers are concerned about the change of product quality. In order to determine the types of stability, the eigenvalues of the system matrix J are derived, indicating that the equilibrium in the benchmark case has a saddle point property (see the proof in Appendix A.1.1).

Next, the solution to the Markovian strategy is analyzed. Using the setup from equation (2.9) to (2.11), the state equation (2.10) changes to $\dot{R} = \gamma[\phi(R(t)) - \delta R(t)]$ where $\phi(R(t))$ is a firms' Markovian strategy. The social planner chooses $q(t)$ to maximize the current-valued Hamiltonian function. Solving for the steady-state condition gives $R^*_{w_{mk}} = \frac{\phi(R^*_{w_{mk}})}{\delta}$ and

$$G'(R^*_{w_{mk}}) = \left[\frac{(\rho+\gamma\delta)}{\gamma} - \phi'(R^*_{w_{mk}})\right] g'(q^*_{w_{mk}}) \quad (2.19)$$

where $q^*_{w_{mk}}$ and $R^*_{w_{mk}}$ present the steady-state solutions of quality and collective reputation in the Markovian strategy. Equation (2.19) illustrates that the marginal benefit of collective reputation is equal to the marginal cost with the discount effect of $\frac{\rho+\gamma\delta}{\gamma}$ deducted by the first derivative of a firm's reaction function. When $\phi'(R)$ is negative (positive), $G'(R^*_{w_{op}})$ is lower (higher) than $G'(R^*_{w_{mk}})$; by assumption of concavity, collective reputation in open-loop strategies is higher (lower) than that in Markovian strategies ($R^*_{w_{op}} > R^*_{w_{mk}}$).

2.3.3 Open-loop and Markovian Solutions

In this subsection, each economic agent makes its decision independently of other agents and thus each agent maximizes its own profit without considering the existence of externalities. There are two externalities in this model. First, externalities may occur between the TPC and firms. Since both agents derive profits from the stock R, they have an incentive not to invest themselves but to benefit from the investment of other agents. Second, externalities may occur among certified firms. For example, an individual firm has an incentive to free-ride other firms' contributions. Two strategies of differential games are explored: open-loop and Markovian.

a) Third-party certifier

Open-loop strategy

From the setup in equation (2.2) to (2.4), the current-valued Hamiltonian function for this problem is as follows:

$$\hat{H} = N[\beta w(R(t)-\varepsilon) + (1-\beta)w(R(t)) + F - c(m)q_s] + \lambda(\gamma[m(t)q_s + q - \delta R(t)]) \quad (2.20)$$

where λ is a co-state variable, which is the marginal value of an additional unit of collective reputation. When the TPC maximizes its profit subject to the constraint on monitoring, which is required to meet the quality standard, q_s, in equation (2.5), the Lagrangian function can be written as:

$$\mathcal{L} = \hat{H} + \tau(m(t) - \underline{m}(q_s)) \quad (2.21)$$

where τ is the Lagrange multiplier, which gives the value of marginal increase in the monitoring level. The first-order conditions for the Lagrangian are:

$$\frac{\partial \mathcal{L}}{\partial m} = -Nc'(m)q_s + \lambda\gamma q_s + \tau = 0 \quad (2.22)$$

$$\frac{\partial \mathcal{L}}{\partial R} = N\big(\beta w(R(t)-\varepsilon) + (1-\beta)w'(R)\big) = (\rho+\gamma\delta)\lambda - \dot{\lambda} \quad (2.23)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = \gamma(mq_s + q - \delta R) = \dot{R} \quad (2.24)$$

$$\frac{\partial \mathcal{L}}{\partial \tau} = m - \underline{m}(q_s) \geq 0; \quad \tau \geq 0 \quad (2.25)$$

The monitoring level in (2.22) is determined by the necessary condition (2.25). The first-order conditions must hold with complementary slackness. Differentiating equation (2.22) with respect to t and substituting into equation (2.23), the system of differential equations becomes

$$\dot{m} = (\rho+\gamma\delta)\frac{c'(m)}{c''(m)} - \Big(\beta w(R-\varepsilon) + (1-\beta)w'(R)\Big)\frac{\gamma}{c''(m)} \quad (2.26)$$

$$\dot{R} = \gamma(mq_s + q - \delta R) \quad (2.27)$$

The solutions to these differential equations yield the two necessary conditions of the Lagrange multiplier (2.25) as follows:

Case 1: If $\tau > 0$, the constraint is binding, which implies $m = \underline{m}(q_s)$ and $\lambda = \frac{Nc'(m)}{\gamma} - \frac{\tau}{\gamma q_s}$. The co-state variable, λ, represents the marginal cost of providing the TPC's monitoring effort to get one more unit of collective reputation. In this case, λ is lower than $\frac{Nc'(m)}{\gamma}$, indicating that the marginal value of collective reputation (MVR) is greater than the marginal cost of monitoring effort (MCM). Thus, the TPC has an incentive to provide more monitoring effort to gain a higher collective reputation; the TPC deviates from $m = \underline{m}(q_s)$ until reaching the steady-state point, where the MVR equals the MCM. Hence, this case is ruled out as a candidate for equilibrium at the steady-state.

Case 2: If $\tau = 0$, the constraint is not binding, which implies $m > \underline{m}(q_s)$ and $\lambda = \frac{Nc'(m)}{\gamma}$. The steady-state occurs when the solution m and R satisfies the steady-state equations (2.26) and (2.27). Setting $\dot{m} = 0$ and $\dot{R} = 0$ gives the condition where the MVR equals the MCM, which the TPC has no incentive to deviate from its choice. Therefore, the solution in the steady-state is derived by setting $\dot{m} = 0$ and $\dot{R} = 0$, which yields $R^*_{op} = \frac{m^*_{op} q_s + q}{\delta}$ and

$$\beta w(R^*_{op} - \varepsilon) + (1-\beta) w'(R^*_{op}) = \frac{(\rho + \gamma\delta)}{\gamma} c'(m^*_{op}) \tag{2.28}$$

where m^*_{op} and R^*_{op} are the monitoring effort and collective reputation at the steady-state in an open-loop strategy. Equation (2.28) equates the marginal benefit of collective reputation to the marginal cost of providing the certifying service. The term $\rho + \gamma\delta$ presents the discount rate plus the depreciation rate of the speed of consumer learning because the additional cost of having a higher reputation is that there must be more monitoring effort to complement depreciated reputation. The equilibrium has a saddle point property, implying that the steady-state value of R^*_{op} provides the optimal boundary condition for m^*_{op} as $t \to \infty$ (see the proof in Appendix A.1.2). If the market does not involve the government detecting cheating firms, then $\beta = 0$ and the steady-state solution (2.28) reduces to $w'(R^*_{op}) = \frac{(\rho+\gamma\delta)}{\gamma} c'(m^*_{op})$.

Given the steady-state solution (2.28), the monitoring effort depends on collective reputation, the quality standard and the parameters. By the implicit function theorem, the changes in monitoring when the average quality changes are defined as:

$$\left.\frac{\partial m}{\partial q}\right|_{m^*_{op}, R^*_{op}} = \frac{\frac{-E(w''(R))}{\delta}}{|H_c|} < 0 \tag{2.29}$$

where $E(w''(R)) = \beta w''(R-\varepsilon) + (1-\beta) w''(R)$ and $|H_c| = \frac{q_s}{\delta}(E(w''(R))) - \frac{\rho+\gamma\delta}{\gamma} c''(m) < 0$. The negative sign of $\frac{\partial m}{\partial q}$ implies that a decrease in the average industry quality would induce the TPC to increase the level of monitoring effort. Markets with collective reputation allow firms to charge a premium, so that firms tend to reduce product quality in order to lower their costs of production (Shapiro, 1983). From the equilibrium condition $R^*_{op} = \frac{m^*_{op} q_s + q}{\delta}$, as q decreases, the industry has an increased chance of losing (good) collective reputation. Therefore, the TPC must provide a level of monitoring effort, which induces firm's incentive to maintain the industry reputation.

Since the quality standard, q_s, set by the government influences collective reputation, the level of q_s affects not only the firm's cost of certification, but also the TPC's monitoring effort. Next, the changes in monitoring when the quality standard changes yields

$$\frac{\partial m}{\partial q_s}\Big|_{m^*_{op},R^*_{op}} = \frac{\frac{-mE(w''(R))}{\delta}}{|H_c|} < 0 \tag{2.30}$$

The term $\frac{\partial m}{\partial q_s}$ has a negative sign, indicating that as the quality standard increases, the TPC has less incentive to provide monitoring effort. This may lead to crowding out effect (Carlson and Spencer, 1975), which the higher quality standard required by the government may crowd out incentives for private sector to provide more effort in the certification process. The economic interpretation is that a higher level of the quality standard leads to a higher cost of certifying services and the agent's effort, which may reduce the TPC's profit or the reliability of certification. The same finding is obtained by Tanner (2000) and Hatanaka et al. (2005), who show that there are trade-offs between the cost of certification and the credibility of the certification process. Jahn et al. (2005) also indicate that the cost of monitoring effort has an impact on a potential loss of reputation.

Next, consider the changes in monitoring when the probability of firms being caught cheating changes is

$$\frac{\partial m}{\partial \beta}\Big|_{m^*_{op},R^*_{op}} = \frac{w'(R) - w'(R-\varepsilon)}{|H_c|} > 0 \tag{2.31}$$

where $w'(R) < w'(R-\varepsilon)$ because of the assumption $w''(R) < 0$. The positive sign of $\frac{\partial m}{\partial \beta}$ shows that if the probability of firms being caught cheating by the government increases, the TPC will increase the level of monitoring effort. Thus, if β is high, the TPC has a higher chance to lose its good reputation because more firms who are under providing quality are caught and revealed to the public. This outcome is supported by Jahn et al. (2005) and Hatanaka et al. (2005) who suggest that public control may be needed and the failed firms, who provide quality under the quality standard, have to be reported to the public.

Markovian strategy

Using the setup from equation (2.2) to (2.4), equation (2.3) changes to $\dot{R} = \gamma[m(t)q_s +$

$\phi(R(t)) - \delta R(t)]$. Firms' strategy, $\phi(R(t))$, allows each firm to condition its quality decision based on the current collective reputation. The TPC maximizes the current-valued Hamiltonian function with respect to monitoring, $m(t)$, and thus solving a system of differential equations $\dot{m}$ and $\dot{R}$. At the steady-state equilibrium, $\dot{m} = \dot{R} = 0$, the equilibrium condition yields $R^*_{mk} = \frac{m^*_{mk} q_s + \phi(R^*_{mk})}{\delta}$ and

$$\beta w(R^*_{mk} - \varepsilon) + (1-\beta) w'(R^*_{mk}) = \left[\frac{(\rho + \gamma\delta)}{\gamma} - \phi'(R^*_{mk}) \right] c'(m^*_{mk}) \tag{2.32}$$

where m^*_{mk} and R^*_{mk} are the monitoring effort and collective reputation at the steady-state in Markovian strategies. The marginal benefit of collective reputation is equal to the marginal cost of monitoring effort as shown in equation (2.32). The term $\frac{\rho+\gamma\delta}{\gamma}$ is a discount effect, which is related to the first derivative of a firm's reaction function. The value of collective reputation depends on the first derivative of the firms' strategy. To find an analytical solution to (2.32), a specific functional form for $\phi(R)$ is needed.

b) Firms

Open-loop strategy

Consider a case where firms play cooperatively and use an open-loop strategy. Suppose that firms can cooperate through the contract so that they make joint strategies. Therefore, the average industry quality becomes $\frac{\sum_i^N q_i(t)}{N} = q_i(t)$. From equation (2.6) to (2.8), the current-value Hamiltonian function for firm i is as follows:

$$\begin{aligned}\hat{H} = {} & \sigma(m)\theta G(R(t) - \varepsilon_f) + (1 - \sigma(m)\theta) G(R(t)) - g(q_i(t)) - w(R(t)) - F \\ & + \mu \left[\gamma (m q_s + q_i(t) - \delta R(t)) \right]\end{aligned} \tag{2.33}$$

where μ is the shadow price associated with the state variable $R(t)$. In each period, the firm chooses quality, $q_i(t)$, based on collective reputation, $R(t)$, to maximize $\hat{H}$. The optimal conditions are:

$$
\begin{aligned}
\frac{\partial \hat{H}}{\partial q_i} &= -g'(q_i) + \mu\gamma = 0 &(2.34)\\
\frac{\partial \hat{H}}{\partial R} &= \sigma(m)\theta G(R(t)-\varepsilon_f) + (1-\sigma(m)\theta)G'(R) - w'(R) = (\rho+\gamma\delta)\mu - \dot{\mu} &(2.35)\\
\frac{\partial \hat{H}}{\partial \mu} &= \gamma(mq_s + q_i - \delta R) = \dot{R} &(2.36)
\end{aligned}
$$

The steady-state solutions are found by setting $\dot{q}_i = \dot{R} = 0$. The open-loop equilibrium yields $R^*_{op} = \frac{mq_s + q^*_{op}}{\delta}$ and

$$
\sigma(m)\theta G(R^*_{op}-\varepsilon_f) + (1-\sigma(m)\theta)G'(R^*_{op}) - w'(R^*_{op}) = \frac{\rho+\gamma\delta}{\gamma} g'(q^*_{op}) \qquad (2.37)
$$

where q^*_{op} and R^*_{op} are the level of quality and collective reputation when firms play cooperatively and use open-loop strategies. Equation (2.37) presents the first-order condition in which the net marginal expected benefit of firms is equal to the marginal cost of producing a high-quality product. This equilibrium has a saddle-point property (see the proof in Appendix A.1.3). Suppose the probability $\theta = 0$, the steady-state solution (2.37) becomes $G'(R^*_{op}) - w'(R^*_{op}) = \frac{\rho+\gamma\delta}{\gamma} g'(q^*_{op})$.

Next, a non-cooperative solution is presented. Each firm must choose a time path of quality, $q_i(t)$, independently where $i = 1, 2, .., N$. From equation (2.6) to (2.8), the current-value Hamiltonian function for firm i is as follows:

$$
\begin{aligned}
\hat{H} = {} & \sigma(m)\theta G(R(t)-\varepsilon_f) + \big(1-\sigma(m)\theta\big)G(R(t)) - g(q_i(t)) - w(R(t)) - F \\
& + \tilde{\mu}\left[\gamma\left(mq_s + \frac{\sum_i^N q_i(t)}{N} - \delta R(t)\right)\right] \qquad (2.38)
\end{aligned}
$$

where $\tilde{\mu}$ is the co-state variable for the non-cooperative case. In each period the firm chooses quality, $q_i(t)$ based on the current collective reputation, $R(t)$, to maximize $\hat{H}$. The first-order conditions are:

$$
\begin{aligned}
\frac{\partial \hat{H}}{\partial q_i} &= -g'(q_i) + \frac{\tilde{\mu}\gamma}{N} = 0 &(2.39)\\
\frac{\partial \hat{H}}{\partial R} &= \sigma(m)\theta G(R-\varepsilon_f) + (1-\sigma(m)\theta)G'(R) - w'(R) = (\rho+\gamma\delta)\tilde{\mu} - \dot{\tilde{\mu}} &(2.40)\\
\frac{\partial \hat{H}}{\partial \tilde{\mu}} &= \gamma\left(mq_s + \frac{\sum_i^N q_i}{N} - \delta R\right) = \dot{R} &(2.41)
\end{aligned}
$$

In equilibrium, firm i's quality, q_i, is equal to firm j's quality. The steady-state solutions in an open-loop strategy occur when $\dot{q}_i = 0$ and $\dot{R} = 0$, which gives $\tilde{R}_{op} = \frac{mq_s + (\frac{\sum \tilde{q}_{op}}{N})}{\delta}$ and

$$\sigma(m)\theta G(\tilde{R}_{op} - \varepsilon_f) + (1 - \sigma(m)\theta)G'(\tilde{R}_{op}) - w'(\tilde{R}_{op}) = \frac{(\rho + \gamma\delta)N}{\gamma} g'(\tilde{q}_{op}) \tag{2.42}$$

where $\tilde{q}_{op}$ and $\tilde{R}_{op}$ are quality and collective reputation when firms use open-loop strategies and behave non-cooperatively. The steady-state solution (2.42) defines the sum of the marginal benefit of collective reputation as equal to the marginal cost of providing quality. This equilibrium point is a saddle-point equilibrium (see the proof in Appendix A.1.4). The steady-state solution (2.42) indicates that the marginal cost of the TPC's monitoring has an influence to the firm's behavior through collective reputation. Hence, the cost of certification plays an important role in firms' behavior (Deaton, 2004; Hatanaka et al., 2005). Jahn et al. (2005) and Hatanaka et al. (2005) suggest that a punishment to cheating firms is required to improve the certifying service and its' effects on reputation. Next, the effect of the punishment ε_f on the relationship between the TPC and firms is examined.

For simplicity, suppose that the probability that firms are monitored by the TPC is perfect, $\sigma(m) = 1$. By implicit differentiation, the firm's optimal quality is $\tilde{q}_{op}(m, \theta, N)$. From the steady-state equation (2.42), it is interesting to analyze the effect of monitoring on firm's quality:

$$\left.\frac{\partial q}{\partial m}\right|_{\tilde{q}_{op}, \tilde{R}_{op}} = \frac{\frac{q_s}{\delta}(w''(R) - E[G''(R)]) + \theta(G'(R) - G'(R - \varepsilon_f))}{|H_f|} \begin{cases} < 0 & \text{if } \varepsilon_f \text{ is small} \\ > 0 & \text{if } \varepsilon_f \text{ is large} \end{cases} \tag{2.43}$$

where $E[G''(R)] = m\theta G''(R - \varepsilon_f) + (1 - m\theta)G''(R)$ and $|E[G''(R)]| > |w''(R)|$. The denominator, $|H_f| = \frac{E[G''(R)] - w''(R)}{\delta} - (\frac{(\rho + \gamma\delta)}{\gamma})Ng''(q)$, is negative. The sign of the numerator is critical, since the first term is positive, while the second term is negative because of the assumption $G''(R) < 0$. When the rate of marginal benefit is greater than that of the marginal cost, the sign of $\frac{\partial q}{\partial m}$ only depends on the sign of the numerator. The term $G'(R) - G'(R - \varepsilon_f)$

is the difference in the firm's marginal revenue between cheating and not cheating stages. The larger ε_f, the greater $G'(R) - G'(R - \varepsilon_f)$. When ε_f is large enough to make a negative numerator, quality is a strategic complement to monitoring ($\frac{\partial q}{\partial m} > 0$). This means that when the impact of a loss in collective reputation is large, an increase in the TPC's monitoring will raise firm's quality. If the value of ε_f is small, quality and monitoring are strategic substitutes ($\frac{\partial q}{\partial m} < 0$). Thus, the interaction between the TPC and firms depends on the punishment when firms get caught cheating, and the firm's revenue function.

Next, the effect of a number of certified firms on quality is analyzed using the implicit function theorem. Given the steady-state solution (2.42), the solution results in a free-riding problem as follows:

$$\left.\frac{\partial q}{\partial N}\right|_{\tilde{q}_{op},\tilde{R}_{op}} = \frac{\frac{(\rho+\gamma\delta)}{\gamma} g'(q)}{|H_f|} < 0 \tag{2.44}$$

where $|H_f|$ is negative. The negative sign of $\frac{\partial q}{\partial N}$ implies that as the number of certified firms increases, firms have an incentive to free-ride on the investment of other firms, thus exerting a negative externality. The reason is that when the number of firms increases, the share of the marginal benefits decreases so that each firm benefits less from maintaining high-quality products. Thus, firms tend to decrease the cost of producing high quality and earn a premium by taking advantage of other firms' contributions.

Markovian strategy

The solution to the Markovian strategy is investigated under the cooperative and non-cooperative cases. Assume that the TPC is restricted to use the open-loop strategy and other firms use a stationary Markovian strategy, $\phi(R(t))$. For the cooperative case, the Markovian strategy becomes $q(t) = \phi(R(t))$ and the state equation (2.3) changes to $\dot{R} = \gamma[mq_s + \phi(R(t)) - \delta R(t)]$. The firm's profit maximization problem from equation (2.6) to (2.8) is solved by maximizing the current-value Hamiltonian function with respect to quality. Then, a system of differential equations $\{q, R\}$ is obtained. Solving for the steady-state solutions by setting $\dot{q} = 0$ and $\dot{R} = 0$ yields $R^*_{mk} = \frac{mq_s + \phi(R)}{\delta}$ and

$$\sigma(m)\theta G(R^*_{mk} - \varepsilon_f) + (1 - \sigma(m)\theta)G'(R^*_{mk}) - w'(R^*_{mk}) = \left[\frac{(\rho + \gamma\delta)}{\gamma} - \phi'(R^*_{mk})\right] g'(q^*_{mk}) \tag{2.45}$$

where q^*_{mk} and R^*_{mk} are quality and collective reputation when firms use the Markovian strategy and behave cooperatively. Equations (2.45) equate the marginal benefit of collective reputation to the marginal cost of providing quality with $\phi'(R^*_{mk})$ and the discount effect.

For a non-cooperative case, using the setup from equation (2.6) to (2.8), the state equation (2.3) changes to $\dot{R} = \gamma[mq_s + \frac{q_i(t) + (N-1)\phi(R(t))}{N} - \delta R(t)]$. Using the same approach in the cooperative case gives the steady-state solutions $\tilde{R}_{mk} = (mq_s + \frac{\tilde{q}_{mk} + (N-1)\phi(R)}{N})\frac{1}{\delta}$ and

$$\sigma(m)\theta G(\tilde{R}_{mk} - \varepsilon_f) + (1 - \sigma(m)\theta)G'(\tilde{R}_{mk}) - w'(\tilde{R}_{mk}) = \left[\frac{\rho + \gamma\delta}{\gamma} - \frac{N-1}{N}\phi'(\tilde{R}_{mk})\right] Ng'(\tilde{q}_{mk}) \tag{2.46}$$

where $\tilde{q}_{mk}$ and $\tilde{R}_{mk}$ are quality and collective reputation when firms use the Markovian strategy and play non-cooperatively. Expression (2.46) means that the sum of the marginal benefit of collective reputation is equal to the marginal cost of investing in high quality with the discount rate effect. The discount rate effect in the non-cooperative case does not depend only on the firms' strategy, $\phi(R)$, but also on the number of firms. In the decentralized cases, the number of firms plays an important factor in sustaining collective reputation. From the outcome shown in the case of an open-loop strategy, an increase in the number of certified firms leads to diminishing the average industry quality. Therefore, collective reputation depends on both the strategic behavior of firms and the firm's share of benefit from providing high quality. The signs of $\phi'(R^*_{mk})$ and $\phi'(\tilde{R}_{mk})$ are unknown, so a specific functional form of the firm's strategy, $\phi(R)$, is required to evaluate the analytical solution (see discussions in the next subsection).

Comparison between open-loop and Markovian strategies

Table 2.1 summarizes the solutions under different decision rules: open-loop and Markovian strategies. Note that the solutions in Table 2.1 are assuming that there is no public control, $\beta = 0$, and the probability of cheating firms is unknown, $\theta = 0$, for simplicity. This subsection focuses on the presence of externalities that is caused by a stock of col-

Table 2.1: The summary of the solutions with open-loop and Markovian strategies

Model	Open-loop strategy	Makovian strategy
Social planner	$G'(R^*_{w_{op}}) = \frac{(\rho+\gamma\delta)}{\gamma} g'(q^*_{w_{op}})$	$G'(R^*_{w_{mk}}) = \left[\frac{(\rho+\gamma\delta)}{\gamma} - \phi'(R^*_{w_{mk}})\right] g'(q^*_{w_{mk}})$
TPC	$w'(R^*_{op}) = \frac{(\rho+\gamma\delta)}{\gamma} c'(m^*_{op})$	$w'(R^*_{mk}) = \left[\frac{(\rho+\gamma\delta)}{\gamma} - \phi'(R^*_{mk})\right] c'(m^*_{mk})$
Firms behave cooperatively	$G'(R^*_{op}) - w'(R^*_{op}) = \frac{(\rho+\gamma\delta)}{\gamma} g'(q^*_{op})$	$G'(R^*_{mk}) - w'(R^*_{mk}) = \left[\frac{(\rho+\gamma\delta)}{\gamma} - \phi'(R^*_{mk})\right] g'(q^*_{mk})$
Firms behave non-cooperatively	$G'(\tilde{R}_{op}) - w'(\tilde{R}_{op}) = \frac{(\rho+\gamma\delta)N}{\gamma} g'(\tilde{q}_{op})$	$G'(\tilde{R}_{mk}) - w'(\tilde{R}_{mk}) = \left[\frac{(\rho+\gamma\delta)}{\gamma} - \frac{(N-1)}{N}\phi'(\tilde{R}_{mk})\right] N g'(\tilde{q}_{mk})$

lective reputation. Using the social planner solution as a benchmark, the cooperative and non-cooperative open-loop solutions result in externalities. The reason is that, in the social planner's problem, the quality of the product is observable so that firms have no incentive to cheat by under providing product quality. By the concavity assumption of collective reputation of the firm's revenue function, collective reputation in the social planner solution is larger than that in the decentralized solutions:

$$\begin{aligned} G'(R^*_{w_{op}}) &< G'(R^*_{op}) < G'(\tilde{R}_{op}) \\ R^*_{w_{op}} &> R^*_{op} > \tilde{R}_{op} \qquad \text{By concavity assumption} \end{aligned} \tag{2.47}$$

From condition (2.47), the cooperative solution has a larger collective reputation in the steady-state than the non-cooperative solution. The reason is that, in the absence of coordination, each firm ignores the social effects on an additional unit of quality provision, and thus contributes less to collective reputation. The economic interpretation of a free-riding problem in the non-cooperative case is that the marginal cost of providing product quality to get one more unit of collective reputation (co-state variables) in the non-cooperative case is higher than in the cooperative case ($\tilde{\mu} > \mu$). In addition, collective reputation is considered a common property[7], the members of a group try to free-ride on other members.

The solutions in Table 2.1 also imply the comparison of the TPC's monitoring and firm's quality under alternative game structures. By the convexity assumption, the outcome of the TPC's monitoring is $c'(m^*_{op}) > c'(\tilde{m}_{op})$, which indicates $m^*_{op} > \tilde{m}_{op}$. Note that there is no TPC's monitoring in the social planner case. For firm's quality, the result is $g'(q^*_{w_{op}}) > g'(q^*_{op}) > g'(\tilde{q}_{op})$, which points to $q^*_{w_{op}} > q^*_{op} > \tilde{q}_{op}$. To understand these findings, the structure of games where firms play cooperatively and non-cooperatively is discussed. In the decentralized cases, the TPC's monitoring and firms' quality are higher in the cooperative case than in the non-cooperative case. The intuition behind this result is that the cooperative solution applies joint action to collective reputation, while in the non-cooperative solution, each firm derives its own best interest without paying attention to other agents. Hence, the marginal cost in the non-cooperative case are higher than that in the cooperative case. However, the cooperative solution may not imply profitability for all certified firms because each firm may have different costs of producing product quality.

Next, the solutions from the case of the Markovian strategy are discussed. Since the first derivative of the firms' strategy, $\phi(R)$, is unknown, an additional assumption is needed to compare the results between open-loop and Markovian strategies. If the sign of $\phi'(R)$ is assumed to be positive (negative), the marginal benefit of collective reputation in the Markovian strategy is lower (higher) than that in the open-loop strategy. By the concavity assumption, this results in a higher (lower) collective reputation in the Markovian strategy than that in the open-loop strategy. Note that this outcome applies to both the social planner and decentralized cases. The comparison of the solutions from the Markovian strategy among alternative game structures is undetermined because the form of the firms' strategy cannot be expressed in closed form.

[7] The nature of collective reputation in this paper is treated as a club good because it is non-rivalrous within the industry, but accrues only to the members within a group.

2.3.4 Numerical analysis

This paper seeks to understand the properties of the optimal monitoring path and the presence of externalities caused by the effect of collective reputation. To help understand this, numerical analysis with specific functional forms and assumed values are undertaken in this subsection. First, the motions of the TPC's monitoring and collective reputation under open-loop strategies are presented in a phase diagram in Figure 2.3. The isocline is plotted for m and R by setting the m isocline ($\frac{\partial m}{\partial t} = \dot{m} = 0$) and the R isocline ($\frac{\partial R}{\partial t} = \dot{R} = 0$) from the steady-state equations (2.26) and (2.27), respectively. Assume that $w(R) = \sqrt{R}$ and $c(m) = m^2$, and the parameters $\rho = 0.9, \gamma = 0.85$, and $\delta = 0.7$. For simplicity, β is assumed to be zero and firms produce a product with quality that equals the quality standard, $q = q_s$. The level of the TPC's monitoring is at least equal to $\underline{m}(q_s) = aq_s$ where $a \geq 1$. Given $q_s = 0.12$ and $a = 1.5$, the minimum level of monitoring effort, $\underline{m}$, is equal to 0.18. Following this setup, equation (2.26) becomes $m = \frac{\gamma}{4\sqrt{R}(\rho+\gamma\delta)}$ and equation (2.27) becomes $R = \frac{mq_s+q}{\delta}$. Solving for the steady-state solution yields $m^* = 0.30$ and $R^* = 0.22$.

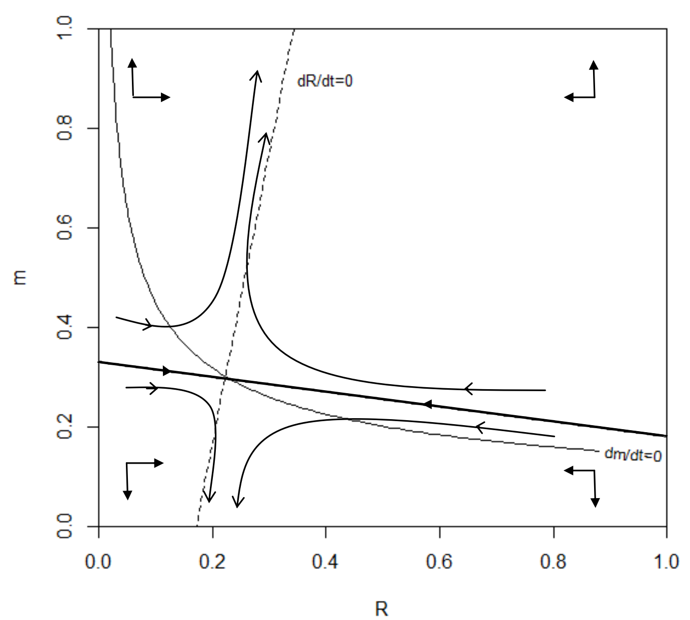

Figure 2.3: The phase diagram for the TPC with $\rho = 0.9, \gamma = 0.85, \delta = 0.7$, and $q_s = 0.12$

To determine the shape of these isoclines, the slope of equation (2.26) is downward sloping ($\frac{\partial m}{\partial R} < 0$). It is straightforward to see that equation (2.27) is upward sloping ($\frac{\partial m}{\partial R} > 0$). The motion of m is found by the sign of the partial derivative of $\dot{m}$ with respect to m, $\frac{\partial \dot{m}}{\partial m} = \rho + \gamma\delta > 0$. This means that the change in $\dot{m}$ is the same as the change in m. Thus, $\dot{m}$ is decreasing below the m isocline and increasing above the m isocline. Next, the motion of R is relatively straightforward where $\frac{\partial \dot{R}}{\partial R} = -\gamma\delta < 0$. As a result, $\dot{R}$ is negative to the right and positive to the left of the R isocline. The point at which the m and R isocline intersect is the steady-state equilibrium point (or the saddle-point). The directions of motion of m and R in Figure 2.3 represent the behavior of trajectories (any pair of $m(t)$ and $R(t)$) in the dynamic system. The directions of motion indicate that there is a saddle-path, the black straight-line, which leads to the saddle-point. Any trajectories on the saddle-path of the dynamic system converge to its steady-state equilibrium point, while all other trajectories diverge. From 2.3, on the saddle-path, when collective reputation is large, the TPC would increase the levels of monitoring to converge to the steady-state equilibrium point.

After investigating the motion of the TPC's monitoring, numerical methods are used to examine the competitive equilibrium for both the TPC and firms in contributing to collective reputation. In the decentralized case, each agent makes its decision independently of other agents. Assume that $w(R) = \sqrt{R}$, $c(m) = m^2$, $G(R) = \ln R$, and $g(q) = q^2$ where $|G''(R)| > |w''(R)|$. For simplicity, the probability θ is assumed to be zero. The decentralized case where firms behave cooperatively and use the open-loop strategy is considered. At the steady-state, equation (2.28) for the TPC becomes $m = \frac{\gamma}{4\sqrt{R}(\rho+\gamma\delta)}$ and equation (2.37) for firms becomes $q = \frac{\gamma}{2\sqrt{R}(\rho+\gamma\delta)}\left(\frac{2}{\sqrt{R}} - 1\right)$. To solve for $\{m^*_{op}, q^*_{op}, R^*_{op}\}$, substituting the functional forms of q and m into the equilibrium condition $R = \frac{mq_s+q}{\delta}$. Assume that $\rho = 0.9, \gamma = 0.85$, $\delta = 0.7$, and $q_s = 0.5$. Thus, at the steady-state, the optimal collective reputation is $R^*_{op} = 0.574$, the optimal monitoring is $m^*_{op} = 0.188$, and the optimal firm's quality is $q^*_{op} = 0.308$. Under this assumption, firms have an incentive to under provide quality, $q = 0.308 < 0.5 = q_s$, because increasing the quality standard causes a higher cost of certification and increases the TPC's monitoring effort to contribute to collective reputation. To define the optimal quality standard, the average firm's quality is assumed to be equal to the quality standard, $q_s = q$. At the steady-state, the optimal collective reputation decreases to 0.552, but the optimal monitoring slightly increases to 0.191 and the optimal firm's quality increases to 0.324. Therefore, with the optimal minimum quality standard, an increase in the TPC's monitoring will increase the average industry quality.

Next, the social planner and decentralized solutions in the open-loop strategy are compared. The functional forms for the TPC and firms have been previously defined above. The steady-state solution for the social planner in equation (2.18) becomes $q = \frac{\gamma}{2R(\rho+\gamma\delta)}$. Solving for the social planner solution, the optimal collective reputation is $R^*_{w_{op}} = 0.637$ and the optimal firm's quality $q^*_{w_{op}} = 0.446$. According to the decentralized solution in the previous paragraph ($R^*_{op} = 0.552$, $m^*_{op} = 0.191$, and $q^*_{op} = 0.324$), this outcome shows $R^*_{w_{op}} > R^*_{op}$ and $q^*_{w_{op}} > q^*_{op}$. This means the average industry quality and collective reputation in the social planner case is greater than that in the decentralized case.

2.4 Conclusion

This paper modifies a dynamic model to assess how a third-party certifier (TPC) accounts for collective reputation that drives certified firms' effort to provide high-quality products. Since collective reputation is considered as a dynamic effect, a differential game is developed to link the interaction between the TPC's monitoring and firms' quality. Both the TPC and certified firms contribute to collective reputation, so the return that they gain or lose from collective reputation depends on their own actions. Consumers also observe the change in collective reputation to predict the quality of the product. The analysis has focused on the effect of collective reputation on the presence of externalities under alternative game structures (the social planner and decentralized cases). The game is constructed with two decision rules: open-loop and Markovian strategies. Optimal control approach is used to solve for the steady-state solutions with both open-loop and Markovian strategies.

Findings show that the social planer solution provides the highest collective reputation compared with the decentralized solutions. In the case of the open-loop strategy, the TPC's monitoring and firms' quality in the cooperative case are higher than that in the non-cooperative case. An increase in the number of certified firms causes the industry to have an increased chance of losing its (good) reputation because firms have incentive to free-ride on other firms. For the Markovian strategy, a free-riding problem in the Markovian strategy is larger or smaller than in the open-loop strategy depending on the firm's strategy associated with collective reputation.

Results show that the better the collective reputation, the more incentive for the TPC to improve its monitoring effort in order to induce certified firms to produce high quality. Public control can be used to drive the TPC's monitoring effort, so that the high-quality market may require public control to maintaining collective reputation. One interesting finding is that the strategic interaction between the TPC's monitoring and firm's quality depends on the punishment for cheating. If the value of loss in collective reputation is large, an increase in the TPC's monitoring will increase firm's quality (a strategic complement). Hence, the quality provision of the market for high-quality products may be improved by promoting the TPC's monitoring, implementing punishment to cheating firms, and encouraging both the TPC and firms to build a (good) collective reputation.

There are some issues that provide interesting points for future research. First, the functional form of the firm's strategy is needed to derive the analytical solution of the first derivative of the firm's Markovian strategy, $\phi'(R)$. Another issue is that the number of certified firms can be treated as an endogenous variable or a function of the probability of being caught cheating. Third, the model in this paper assumes that the TPC charges all firms at the same certification fee. This may bring a challenge to small and medium-sized firms who may not be able to afford the cost of certification. The principal-agent model can be used to offer different contracts (i.e. the different costs of certification) to increase firms' incentive to provide high-quality products. Next, this paper employs a dynamic model in a simultaneous game. Future research should investigate the dynamic model in Stackelberg games where the TPC is the leader and certified firms are the follower. Finally, the measurement of monitoring can be considered in term of quality (i.e. monitoring effort) or quantity (i.e. the frequency of monitoring, or audit report on pesticide contamination or chemical testing). Future research on empirical analysis is needed to investigate the effect of collective reputation in the market for high-quality products.

This paper contributes to the literature on theory of (collective) reputation (Shapiro, 1983; Tirole, 1996; Marette and Crespi, 2003; Winfree and McCluskey, 2005) and the certification system (Tanner, 2000; Deaton, 2004; Hatanaka et al., 2005; Duflo et al., 2013) in a dynamic framework. First, the model developed in this paper provides a broad framework of the collective reputation model by linking the strategic interaction between the TPC and certified firms in the market for high-quality products. Second, the parameters of public control (i.e. the probability of firms being caught cheating by the government) and the punishment for cheating were captured in the dynamic model. The results from comparative dynamics of the model provide interesting insights into a quality assurance system such as the effect of public control on the TPC's monitoring effort and the strategic interaction between the TPC and firms.

Chapter 3

The Experience Economy in A Product Differentiation Model: An Application to Food Supply Chains

3.1 Introduction

Structural changes in food distribution channels pose challenges for farmers to convey product quality information to consumers. Increasing market domination by large agribusinesses has led to an increase in retailer control over aspects of production and price transmission along the supply chain (Sexton et al., 2003). For example, a number of farms have increasingly been under contract or vertically controlled by large retailers or manufacturers, so that the farmer's share of the consumer's retail dollar may be small or product quality may be not fully informed to the public (Martinez et al., 2010; Canadian Co-operative Association, 2008). The emergence of direct sales as a short marketing channel[1] has been the way that helps farmers/producers to cope this problem (Canadian Co-operative Association, 2008; Dimitri, 2012). Through direct marketing, producers are able to establish a closer relationship with consumers, avoid expenses associated with intermediaries, provide opportunities to create value-added products through new marketing strategies (i.e. experience), and increase their market share (Agriculture and Agri-Food Canada, 2007;

[1] Short supply chains include farmers' markets, roadside stands, community-supported agriculture (CSA), and other outlets. The number of direct sales in Canada was about 550 farmers' markets and 300 CSAs in 2008 (Canadian Co-operative Association, 2008; Agriculture and Agri-Food Canada, 2010a).

Hunt, 2007; Brown and Miller, 2008). For example, a community-supported agriculture (CSA) scheme can provide experience to consumers by having, for example, farm tours. However, some producers are not well suited to participating in short marketing channels, while for others, the cost of providing experience through direct marketing is too large. Consequently, farmers who contemplate direct sales need to consider the cost and benefit of selecting the right marketing channel.

Over time, the economy has gone through several structural changes moving from a commodity-based market to a goods-based market and finally to a service-based market (Pine and Gilmore, 1998). More recently, some sectors of the economy are moving into an experience-based marketing strategy. For example, coffee beans are a commodity that is sold at a farm-gate price. The beans are then roasted, packed, and sold for a higher price. A cup of coffee is then sold by retailers and restaurants for $1-$2 or more per cup, or that cup of coffee is marketed as experience for customers by *Starbucks*[2], for example, and sold for $4-$5 or more per cup. Pine and Gilmore (1998) described the experience economy as "memorable" and indicated that consumers are willing to pay more for a product or service if it is part of experience. Some consumers are responsive not only to the way that food is produced, processed and distributed, but also to an event where they can add emotions to the product or service they purchase (Swinnen et al., 2012). Hence, price might not be the first concern for consumers when choosing a food product, but rather an event (or a shopping location) that provides experience.

In this paper, the term "transaction experience" is developed from the concept of the experience economy (Pine and Gilmore, 1998; Swinnen et al., 2012) and is defined as a benefit (that involves feelings or emotions, and yields utility) associated with purchasing a product from a unique shopping location, and from a particular seller (e.g. farmers).[3]

[2]Starbucks has created a unique experience in its store, thereby building consumers' trust in product quality and loyalty.

[3]Note that the concept of transaction experience is different from the concept of experience goods or characteristics in the economic literature on asymmetric information (Darby and Karni, 1973).

For example, gala apples are sold at both short and long supply chains. Some consumers choose to visit short supply chains because transaction experience provided through the direct interaction between producers and consumers gives value added to the purchase of gala apples. In addition, short supply chains involve very few intermediaries, which brings consumers closer to the source of the food product. Hence, some consumers perceive a higher utility from purchasing gala apples at short supply chains than long supply chains. To give a more precise reason, transaction experience may provide a halo effect, which influences consumer belief about the quality of products when they interact with producers.[4] Thus, transaction experience can apply to one of the dimensions of product characteristics.

In addition to defining transaction experience related to a shopping location, the valuation of transaction experience is part of a network which connects producers and consumers. This means that the utility of the network members can be influenced by having more people as part of the same network (Farrell and Klemperer, 2007; Shy, 2011). In particular, participants in each supply chain (or network) can use transaction experience through the network effect to increase the value of the product and build consumer loyalty. Through the interaction between producers and consumers, some consumers may have an attitudinal tendency to favor one seller over other sellers, thereby they repurchase a product from the same seller. The intuition is that the more the transaction experience provided by producers, the larger the network between producers and consumers. Hence, consumers gain more utility from network effects.

New consumer trends toward buying products associated with transaction experience have stimulated changes in the supply side of food markets, as shown by the rise of supermarkets and retailers using transaction experience, which is similar to short supply chains, to attract more customers (Lusk et al., 2007; Adams and Salois, 2010). For example, *Whole Foods* is an upscale supermarket offering food products with specific attributes (i.e. local,

[4]The term halo effect is a cognitive bias that an observer's overall belief about a person may influence feelings about that person (Thorndike, 1920). An example in the marketing field, a consumers' overall attitude toward a (brand) product might influence their assessment of specific attributes of that product.

organic, and natural) and building in-store transaction experience by having an interaction with their consumers. It also supports employee well-being in the workplace and employs social responsibility to attract customers. Therefore, understanding of the role of transaction experience in firms' competition would provide additional information in developing strategies that add value to products.

The objective of this paper is to address how transaction experience creates a value-added product that can enhance consumer's valuation and influence competition between a short and a long supply chain. To address this objective, the next section 3.2 contains a review of the previous literature. Section 3.3 contains a development of a theoretical framework and a horizontal differentiation model for two firms (a farmers' market and a retailer), and consumers. In Section 3.4, the model when one firm chooses transaction experience, given the fixed transaction experience of another firm, is solved for equilibrium prices and experience under exogenous and endogenous network effects. Moreover, the effects of the network size that can lead to positive or negative network effects between firms and consumers are examined. Section 3.5 contains an analysis of a symmetric equilibrium of the model when both firms choose transaction experience simultaneously. Section 3.6 is an extension of discussion on the results and section 3.7 provides conclusion.

3.2 Literature Review

The concept of the experience economy is defined as a new source of value creation for firms and consumers (Pine and Gilmore, 1998; Swinnen et al., 2012). Pine and Gilmore (1998) state that experience is a decisive factor in the development of products, service, and marketing. In addition, the success of companies depends on their ability to build an entire experience around their products and services. The experience is inherently personal and occurs only within the consumer who has an emotional feeling about the product or service with which he/she is involved.[5] The utility from getting a product related to experience can be derived by three components: physical goods, qualities, and experience (Swinnen et al., 2012). When moving from a commodity-based market to an experience-based market, it is important for firms to know how to gain a profit from employing the experience strategy and especially knowing how to differentiate their products from their competitors.

Several studies have explored factors associated with shopping at short supply chains (Hunt, 2007; Thilmany et al., 2008; Adams and Salois, 2010; Martinez et al., 2010; Swinnen et al., 2012). These authors revealed that a high level of consumer demand for products with specific attributes leads to the growth of short supply chains. The development of short supply chains has the potential to reduce risk associated with more complex distribution networks and to improve the local economy and environmental sustainability of the agri-food sector (Thilmany et al., 2008; Dimitri, 2012). For example, consumers visit a farmers' market because of the motivation to support local producers or reduce environmental impacts (Thilmany et al., 2008; Swinnen et al., 2012) and expect to buy higher quality foods (i.e freshness), as well as local and organic products (Adams and Salois, 2010; Dimitri, 2012). Hunt (2007) has conducted a consumer survey at farmers' markets, indicating that some consumers enjoy interacting with farmers/vendors, so social interactions or networks have positive influences on shopping at the local market. Hence, short supply chains can build a network which connects producers and consumers without many of the intermediates, so producers can provide experience directly to consumers. However, the scale of local food markets may not be sufficient enough to compete with long supply chains when retailers start offering a product that provides experience to consumers.

The concept of networks is defined as a connection among social groups (i.e. consumers, firms, communities) as a whole (Shy, 2011). The utility of the network members is affected by an increase or a decrease in the number of members depending on the types of network

[5] Note that the valuation of experience can be considered as a public good where consumers buy a product that provides a positive or negative externality to society (Lusk et al., 2007; Swinnen et al., 2012).

effects: direct or indirect (Farrell and Klemperer, 2007; Shy, 2011). Direct network effects exist when an increase in usage of the product leads to a direct increase the value of the product. Two-sided network effects (or indirect network effects) arise when an increase in usage by one group of users increases the value of the product to the other group of users.

Most theoretical studies on network effects have been on communication technologies (i.e., telephone), hardware-software (Katz and Shapiro, 1985; Chou and Shy, 1996), and payment systems (i.e., ATM-merchants) (Rochet and Tirole, 2003), rather than on the agri-food system. Since the network effect is a broad concept, it has been measured in various ways. Some studies have used a Hotelling model to analyze the number of users (or the network size) and the degree of product differentiation (Farrell and Klemperer, 2007; Shy, 2011). These authors indicate that network effects often give rise to (or reduce) externalities depending on positive or negative network effects.[6] In addition, these network effects lead to the impact on the characteristics of consumer demand and the firm's optimal strategies. Most studies usually make specific assumptions about market competition and consumer preferences (Farrell and Klemperer, 2007; Shy, 2011). In particular, it is typically assumed that consumers are uniformly distributed along the chain length or network effects are exogenous variables, which do not depend on the choice variable in the model. However, the assumption of exogenous network effects may not fully capture the effect of firm' decisions in characterizing the results of product differentiation.

Some theoretical papers have studied two-sided network effects in different types of market competition (Rochet and Tirole, 2003; Armstrong, 2006; Rochet and Tirole, 2006). An example of a two-sided market is one where consumers value a large shopping mall with a greater number of retailers (or the degree of product variety) more than a small shopping mall; the retailer is willing to pay more to locate in a mall with a larger number of consumers visiting the mall (see more examples in Rochet and Tirole (2003) and Arm-

[6] The network effect can be positive or negative. Positive (negative) network effects exist if consumers benefit (are disadvantaged) by having more people as part of the same network.

strong (2006)). Rochet and Tirole (2003) examined the pricing strategy of different competition structures with two-sided network effects and stated that the interaction between two groups gives rise to complementarities because both sides benefit from externalities. One challenge for these networks is to derive a solution that includes the choices of both buyers and sellers. Armstrong (2006) investigated the two-sided market when two sellers are able to interact with two groups of buyers and indicated that cross-group externalities lead to intensified competition and reduced seller profits. The different size of cross-group externalities can result in price discrimination; sellers tend to lower the price for one group to attract more of the other group.

As the number of firms using experience strategies grows, there have been some studies in the economic and marketing literature assessing the market for experience based products (Pine and Gilmore, 1998; Swinnen et al., 2012), but few theoretical studies have investigated firms' competition strategies when a product is associated with experience. A market for experience occurs when an individual cares about a product or service related to an action or a place that involves his/her feeling. In this paper, the experience economy is applied to link the concept of transaction experience to the chain length of food supply chains. Alternative food supply chains (i.e. short and long supply chains) allow consumers to interact with producers and to gain utility from a product differently (Hunt, 2007; Thilmany et al., 2008; Adams and Salois, 2010). Thus, producers/sellers at each food supply chain can use transaction experience to build a network with consumers and add value to their products. In this study, consumer's willingness-to-pay may increase or decrease based on the effect of transaction experience on network effects. There is a trade-off between a firm's interest in moving away from other firms, to differentiate products associated with transaction experience, and in moving closer to the marginal consumers. Consequently, it is interesting to investigate how competition between firms is affected by introducing transaction experience.

3.3 Theoretical Framework

In the market for experience, consumers perceive a higher value for a product related to transaction experience than a product that does not relate to transaction experience (Pine and Gilmore, 1998; Swinnen et al., 2012). Not all consumers have the same reason to value transaction experience based on alternative supply chains: some consumers value the direct interaction with producers and prefer buying a product at the local farmers' market because the product has supported local producers, or was produced in an environmentally friendly way. Other consumers prefer interacting with a retailer and buying a product at that retailer because of in-store environment, price, and convenience. In addition, short supply chains involve very few intermediaries, while long supply chains involve a number of intermediaries.

The theory of horizontal differentiation is applied to analyze a strategic decision between two different firms facing competition in transaction experience (Tirole, 1988). There are two types of firms in the market: a short and long supply chain.[7] Participants in both short and long supply chains use transaction experience in order to attract more consumers, differentiate from their rivals, and obtain higher prices. In this paper, transaction experience is considered as a proxy of the chain length. The difference between short and long supply chains is that consumers may have a higher valuation for a product with transaction experience in a short supply chain, compared with a long supply chain because producers in short supply chains can develop transaction experience through direct interaction with consumers. It is hypothesized that transaction experience benefits short supply chains more than long supply chains and leads to a higher offered price by short supply chains. Therefore, the shorter the chain length, the more the transaction experience provided to consumers. Figure 3.1 presents the linkage between Hotelling's location model (Hotelling, 1929) and the transaction experience (Pine and Gilmore, 1998).

[7] A long supply chain is represented by retailers and supermarkets. A short supply chain is represented by direct sales, farm stores, farmers' markets, and CSAs.

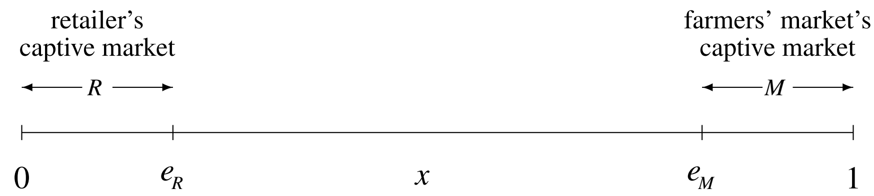

Figure 3.1: The transaction experience and Hotelling's location model

Participants at retailer (R) and farmer's market (M) are differentiated only by where they locate along the chain length [0,1] and choose to provide transaction experience, e_R and e_M respectively. The consumer, x, locates along the chain length and pays distance costs to purchase a product related to transaction experience. Consumers who locate on the left of e_R will prefer buying from R, while consumers who locate on the right of e_M will prefer buying from M.

The concept of two-sided network effects is applied; increasing the number of sellers increases the value of the product to consumers, and increasing the number of consumers increases the benefits to sellers (Rochet and Tirole, 2003; Armstrong, 2006). On the consumer-side, consumer utility is positively impacted by network effects when they interact with more sellers/vendors. One way to interpret this is that the higher the number of sellers/producers, the more the degree of product variety (Lancaster, 1990), thereby leading to increased network effects and consumers' valuation for an additional product with transaction experience. Therefore, consumers perceive a value for product quality and for transaction experience through network effects at each supply chain. On the firm-side, each firm benefits from providing transaction experience to consumers because experience can establish a network between firms and consumers, which leads to the creation of consumer loyalty, increases the consumers' willingness-to-pay, and drives a larger local network.

In this section, Hotelling's location duopoly model with two-sided network effects is presented. The model allows for interaction between two firms and consumers through network effects on both sides of the market. The transaction experience affects consumer utility by increasing (or deceasing) willingness-to-pay through network effects. The effect of transaction experience on network effects is investigated for the cases when network effects are exogenous and endogenous. Both firms play non-cooperatively in a two-stage game where they move simultaneously.[8] In the first stage, participants at retailer (*R*) and farmer's market (*M*) choose to provide transaction experience. In the second stage, given transaction experience, they choose prices simultaneously. The choice of transaction experience in the first stage affects not only the demand function and intensity of price competition, but also consumers' valuation of network effects. The optimal price and transaction experience solutions are derived by using backward induction.

3.3.1 The model

a) Consumers

Consumer utility is derived from perceiving transaction experience from the product he/she purchases (Swinnen et al., 2012). Consumer location is indicated by x. Suppose that n consumers are uniformly distributed along the line of the chain length [0,1]. Participants at R and M provide transaction experience, e_R and e_M respectively, to consumers. Assume that $e_M > e_R$.[9] The transaction experience can affect consumers' valuation of the product through network effects. Let N_R be the number of product choices offered by R and N_M be the number of product choices offered by M, which are treated as exogenous. Note that the number of product choices is defined as the degree of product variety related to transaction experience offered by sellers/producers at a particular selling location. To simplify the analysis, each seller/vendor is assumed to provide a unique product variety.[10] Hence, a greater number of product choices lead to a higher number of sellers/vendors. This means that

[8]The authors consider simultaneous price and location decisions in a two-stage game following the same argument as D'Aspremont et al. (1979) and Anderson et al. (1997), which players choose locations in the first stage and prices in the second stage.

[9]Note that when the firms' experience locates at the same point, $e_R = e_M$, the demand functions are not determined and the profit functions are zero, so that the solution is as in the Bertrand game.

[10]Lancaster (1990) defined the term of product variety as the number of variants within a specific product group or the number of brands.

transaction experience positively influences consumer utility from interacting with more sellers/vendors.

The expression of network effects for consumers who buy a product with transaction experience at R is given by $\alpha_{CR}(e_R, e_M; N_R, N_M)$ and at M is given by $\alpha_{CM}(e_R, e_M; N_R, N_M)$. The network effect can positively or negatively affect consumers' valuation depending on the nature of product attributes. In this paper, assume that consumers enjoy transaction experience from interacting with a producer, so that network effects for consumers interacting with a producer rise in transaction experience that the producer provides ($\frac{\partial \alpha_{CR}(e_R,e_M)}{\partial e_R} > 0$ and $\frac{\partial \alpha_{CM}(e_R,e_M)}{\partial e_M} > 0$), but declines in transaction experience that its rival provides ($\frac{\partial \alpha_{CR}(e_R,e_M)}{\partial e_M}$ < 0 and $\frac{\partial \alpha_{CM}(e_R,e_M)}{\partial e_R} < 0$). Note that for $\alpha_{CR}(e_R, e_M) = \alpha_{CM}(e_R, e_M)$, the model reduces to the standard Hotelling's location model. Following D'Aspremont et al. (1979) and Anderson et al. (1997), quadratic transportation costs are assumed to ensure an existence of equilibrium. To simplify the utility function, the transportation cost (per unit of distance) or searching cost (per unit of time) is normalized to one. Consumers choose to purchase a unit of the product from R or M. The consumer utility function is as follows:

$$U_i(x, e_i, p_i) = V - (x - e_i)^2 + \alpha_{Ci}(e_R, e_M; N_R, N_M) - p_i \quad \text{when } i = \{R, M\} \tag{3.1}$$

where V is gross utility from purchasing the product and is assumed to be large enough for the whole market to be covered. Assume that V is equal for all consumers. p_M and p_R are a price of one unit of M's product and R's product, respectively. The consumer gets disutility, $(x - e_i)^2$, from locating at position, x and from price.

To define the demand function for each firm, the utility from buying from R is equal to the utility from buying from M:

$$V + \alpha_{CR} - (x - e_R)^2 - p_R = V + \alpha_{CM} - (x - e_M)^2 - p_M$$

Solving for the marginal consumer, $\hat{x}$, to get the market share for R's product yields

$$\hat{x}(p, e) = \frac{\alpha_{CR} - \alpha_{CM} + p_M - p_R}{2(e_M - e_R)} + \frac{e_M + e_R}{2} \tag{3.2}$$

where all consumers index by $x \in [0, \hat{x}]$ purchase the product from R and the remainder buys from M. To ensure that the market share for both firms exists, the price difference between R and M is

$$\hat{x}(p,e) = \begin{cases} 1 & \text{if } p_M - p_R \geq L \\ \frac{\alpha_{CR} - \alpha_{CM} + p_M - p_R}{2(e_M - e_R)} + \frac{e_M + e_R}{2} & \text{if } L < p_M - p_R < H \\ 0 & \text{if } p_M - p_R \leq H \end{cases} \tag{3.3}$$

where L is the lower bound of price difference, $\alpha_{CR} - \alpha_{CM} + (e_M^2 - e_R^2)$ and H is the upper bound of price difference, $\alpha_{CM} - \alpha_{CR} - (e_M^2 - e_R^2)$. Expression (3.3) depends on the relative gain or loss in the network effect and the distance of transaction experience between two firms. For example, if R charges p_R lower than $p_M - L$, R obtains the whole market.

b) Retailer and Farmer's market

Two firms, R and M, maximize their profit by choosing price and transaction experience. Following the standard location-price model by D'Aspremont et al. (1979)[11], both firms are restricted to locate inside the chain length [0,1]. Suppose that each firm attempts to convince consumers that its product is different from the product of its competitors. The model allows for the value of network effects to be exogenously or endogenously determined by transaction experience. The network effect for R is $\alpha_R(e_R, e_M)$ and the network effect for M is $\alpha_M(e_R, e_M)$. Assume that $\alpha_R(e_R, e_M)$ and $\alpha_M(e_R, e_M)$ are linear with the number of consumers and depends on transaction experience, where $\frac{\partial \alpha_R(e_R, e_M)}{\partial e_R} > 0$, $\frac{\partial \alpha_M(e_R, e_M)}{\partial e_M} > 0$, $\frac{\partial^2 \alpha_R(e_R, e_M)}{\partial e_R^2} < 0$, and $\frac{\partial^2 \alpha_M(e_R, e_M)}{\partial e_M^2} < 0$. Note that for $\alpha_M(\cdot) = 0$ and $\alpha_R(\cdot) = 0$, the model simplifies to a general setting of profit maximization. Profits for R and M are as follows:

$$\pi_R(p_R, p_M, e_R, e_M) = \hat{x}(p_R - c_R + \alpha_R(e_R, e_M)) \tag{3.4}$$

$$\pi_M(p_R, p_M, e_R, e_M) = [1 - \hat{x}](p_M - c_M + \alpha_M(e_R, e_M)) - f_c \tag{3.5}$$

[11] Some studies did not restrict the locations of firms within the chain length (Tabuchi and Thisse, 1995; Lambertini, 1996). These authors indicated that when firms are allowed to locate outside the chain length, equilibrium prices and transportation costs are higher than the results of D'Aspremont et al. (1979).

where $\hat{x}$ is the market share for R's product at price p_R and $1-\hat{x}$ is the market share for M's product at price p_M. For R, the cost of production and providing transaction experience is c_R. For M, the total cost function is divided into the cost of production and providing transaction experience, c_M, and fixed entry fee, f_c.[12] To simplify the analysis, both firms are assumed to have the same cost of production and providing transaction experience, which are exogenous variables.

3.4 Pricing and Transaction experience equilibrium

To investigate each variable, the solutions for optimal price and transaction experience in each stage are derived using backwards induction. Since M can provide more transaction experience than R through direct interaction with consumers, this section focuses on how network effects influence R's competition with M. To see the result of e_R relative to the fixed transaction experience of M, $\bar{e}_M$, assume that M chooses to experience in the way that provides the most experience to consumers (i.e. at point 1). The timeline of the game is that in the first stage, given $\bar{e}_M = 1$, R chooses to provide experience, e_R. In the second stage, given transaction experience, R chooses price, p_R, and M chooses price, p_M, simultaneously. Solutions when network effects are exogenous and endogenous are analyzed.

3.4.1 Exogenous network effects

In this case, R and M have no control over network effects, so they treat network effects as a constant. In the second-stage game, the profit functions (3.4) and (3.5) are maximized with respect to prices. The equilibrium prices p_R and p_M are:

[12] Note that a fixed entry fee can be applied to both firms (i.e. a fixed fee charged to suppliers or farmers by retailers or supermarkets (R) in order to sell the product in R such as slotting fees, food safety certification, or fixed trade spending). In this paper, a fixed entry fee is applied to only one-side of the chain without loss of generality, in that the fixed entry fee for M could, in fact, reflect the difference between costs of entry into R and M.

$$p_R = \frac{2}{3}(c_R - \alpha_R) + \frac{1}{3}(\alpha_{CR} - \alpha_{CM} + c_M - \alpha_M) + \frac{\Delta e}{3}(e_R + 3)$$
$$p_M = \frac{2}{3}(c_M - \alpha_M) + \frac{1}{3}(\alpha_{CM} - \alpha_{CR} + c_R - \alpha_R) + \frac{\Delta e}{3}(3 - e_R) \tag{3.6}$$

where $\Delta e = 1 - e_R$ and Δe is always positive. The difference in equilibrium prices can be broken down as follows:

$$p_M - p_R = \underbrace{\frac{1}{3}(\alpha_R - \alpha_M)}_{\text{firms' network effect}} - \underbrace{\frac{2}{3}(\alpha_{CR} - \alpha_{CM})}_{\text{consumers' network effect}} - \underbrace{\frac{2e_R}{3}\Delta e}_{\substack{\text{competition in} \\ \text{experience effect}}} \tag{3.7}$$

Note that $c_R - c_M$ is zero by assumption. Equation (3.7) shows the weighted value of network effects between firms and consumers, and competition in transaction experience effect, Δe. Notice that the network effect for consumers and the network effect for firms have opposite effects on price competition. Substituting the price difference (3.7) into (3.2) yields the market share for R:

$$\hat{x} = \frac{\alpha_{CR} - \alpha_{CM} + \alpha_R - \alpha_M}{6\Delta e} + \frac{1}{6}(3 + e_R) \tag{3.8}$$

Let $\Delta NE = \alpha_{CR} - \alpha_{CM} + \alpha_R - \alpha_M$ be the sum of the total network effect between firms and consumers. The market share for M is $1 - \hat{x}$. Equation (3.8) presents two effects on the market share. The first term is the network effect related to the degree of product differentiation. The second term is the product location effect: by increasing the level of transaction experience, R is able to capture a larger market share by shifting the marginal consumer in the direction of the rival firm.

In the first-stage game, substituting the prices (3.6) and the marginal consumer (3.8) into the profit function for R (3.4) yields:

$$\pi_R = \frac{1}{18\Delta e}\left(\Delta NE + \Delta e(3 + e_R)\right)^2 \tag{3.9}$$

Differentiating (3.9) with respect to e_R gives the first-order condition:

$$\frac{\partial \pi_R}{\partial e_R} = \frac{1}{18}\left(\frac{(\Delta NE)^2}{(1 - e_R)^2} + 2\Delta NE - (3e_R^2 + 10e_R + 3)\right) \tag{3.10}$$

In the absence of network effects, the optimal transaction experience for R is $e_R^* = -3$ and $-\frac{1}{3}$. The second-order condition for π_R is negative, so the function has a local maximum point at e_R^*. Substituting $e_R^* = -3$ (and $-\frac{1}{3}$) into the profit associated with R yields 0 (and 0.527), and the profit associated with M yields 0 (and 0.823). Hence, R chooses to locate at $e_R^* = -\frac{1}{3}$ due to a higher profit. This result reveals that R has a strong incentive to differentiate its product from M because when R moves closer to M, the profit for R decreases. When R locates at $e_R^* = 0$, the profit for R is 0.5, so that a best response for R with the restriction of the interval [0,1] is to choose $e_R^* = 0$.

When network effects exist, the first-order condition in (3.10) becomes a fourth degree polynomial, so there are four roots to this condition. The candidates for a transaction experience equilibrium for R are:

$$e_R^* = \frac{1 \pm \sqrt{4 - 3\Delta NE}}{3} \quad \text{or} \quad e_R^* = -1 \pm \sqrt{4 + \Delta NE} \tag{3.11}$$

which give e_R^* as a real number ($\Re$) only for $-4 \leq \Delta NE \leq \frac{4}{3}$. By the implicit function theorem, the solution for transaction experience is written as $e_R^*(\Delta NE)$. Note that a positive (negative) ΔNE means that the network effect for R is higher (lower) than the network effect for M. When $\Delta NE > \frac{4}{3}$ and $\Delta NE < -4$, M will choose to locate at the boundary condition $e_R^* = 0$.[13] Hence, R provides transaction experience given by the first-order condition in (3.10) when $-4 \leq \Delta NE \leq \frac{4}{3}$. When ΔNE is between -4 and 1, the optimal transaction experience, e_R^*, is less than zero, so the best response for R with the restriction of the interval [0,1], is to locate at $e_R^* = 0$. This is because of increasing the profit for R in ΔNE. Therefore, R's incentive to differentiate its product from M depends on the value of ΔNE. If ΔNE is large enough to influence a change in price and market share of R, R has an incentive to move inside the chain length. The economic intuition is that ΔNE compensates the negative

[13]The values of network effects in $\Delta NE < -4$ and $\Delta NE > \frac{4}{3}$ give two real roots and two complex roots. Only the real roots are investigated to compare with the restriction $e_R = 0$. Two real roots result in R locating outside the chain length [0,1]. When $\Delta NE > \frac{4}{3}$, the profit is lower than $\pi_R(e_R = 0)$, so R locates at $e_R^* = 0$. When $\Delta NE < -4$, the profit is higher than $\pi_R(e_R = 0)$, but with the restriction, R locates at $e_R^* = 0$.

marginal profit from the degree of product differentiation in transaction experience. This implies that R's transaction experience equilibrium is

$$e_R^* = \begin{cases} \frac{1-\sqrt{4-3\Delta NE}}{3} & \text{if } 1 < \Delta NE \leq \frac{4}{3} \\ 0 & \text{if otherwise} \end{cases} \tag{3.12}$$

From the result in (3.12), $\frac{\partial e_R}{\partial \Delta NE}$ is positive when $1 < \Delta NE \leq \frac{4}{3}$, but is ambiguous outside of this range. The effect of ΔNE on optimal transaction experience, e_R^*, and profit is shown in Figure 3.2.

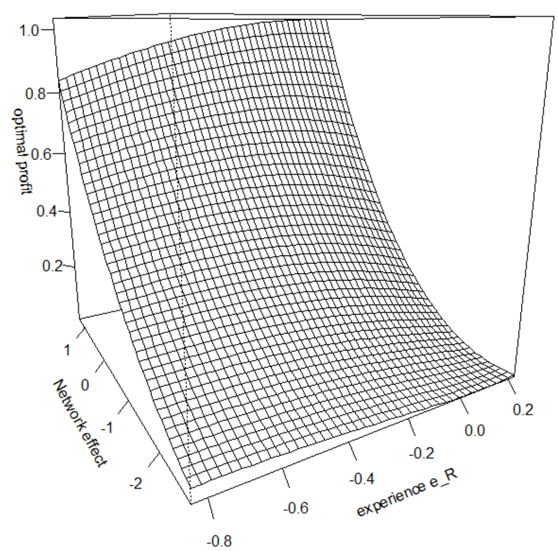

Figure 3.2: The optimal profit for R as a function of e_R and $\Delta NE \in [-2.80, 1.33]$

When the value of ΔNE rises, the profit for R increases, so R prefers to move closer to M. In the case of positive network effects, for example when $\Delta NE = 1.30$, the optimal transaction experience, e_R^*, is 0.22, the optimal profit for R is 1.03, and the market share for R is 0.82. A large market share for R is explained by equation (3.8), where the network effect for R is larger than the network effect for M, so the total network effect is larger than the degree of product differentiation, Δe. This results in the value of network effects compensating consumers who locate on the left side of R and capturing more consumers on the right side of R. Therefore, positive (and large) network effects allow R to move closer to M and obtain a higher market share. To derive the prices for each firm, the values of α_R, α_M, α_{CR}, and α_{CM} are required.

3.4.2 Endogenous network effects

In this subsection, network effects are endogenous variables and depend on transaction experience provided by R. Recall that transaction experience provided by M is fixed and locates at the end of the chain length, denoted by $\bar{e}_M = 1$. Let $\alpha_R(e_R, \bar{e}_M)$, $\alpha_M(e_R, \bar{e}_M)$, $\alpha_{CR}(e_R, \bar{e}_M; N_R, N_M)$, and $\alpha_{CM}(e_R, \bar{e}_M; N_R, N_M)$ be endogenous network effects. The solution for prices in the second-stage game remains the same as in the case of exogenous network effects. In the first-stage game, the profit for R is

$$\pi_R = \frac{1}{18\Delta e}\left(\Delta NE(e_R) + \Delta e(3+e_R)\right)^2 \tag{3.13}$$

where $\Delta NE(e_R) = \alpha_{CR}(e_R, \bar{e}_M; N_R, N_M) - \alpha_{CM}(e_R, \bar{e}_M; N_R, N_M) + \alpha_R(e_R, \bar{e}_M) - \alpha_M(e_R, \bar{e}_M)$ and $\Delta e = \bar{e}_M - e_R = 1 - e_R$. Differentiating (3.13) with respect to e_R gives the first-order condition:

$$\frac{\partial \pi_R}{\partial e_R} = \left(\frac{\Delta NE(e_R) + \Delta e(3+e_R)}{18(\Delta e)^2}\right)\left(\Delta e\left(2\frac{\partial \Delta NE(e_R)}{\partial e_R} - (1+3e_R)\right) + \Delta NE(e_R)\right) \tag{3.14}$$

To derive an analytical result, the functional forms for consumer and firm network effects are specified as follows:

$$\alpha_{CR}(e_R, e_M; N_R, N_M) = \frac{e_R\sqrt{N_R}}{e_R\sqrt{N_R} + e_M\sqrt{N_M}} \quad \text{and} \quad \alpha_{CM}(e_R, e_M; N_R, N_M) = \frac{e_M\sqrt{N_M}}{e_R\sqrt{N_R} + e_M\sqrt{N_M}}$$
$$\alpha_R(e_R, e_M) = \frac{e_R}{e_R + e_M} \quad \text{and} \quad \alpha_M(e_R, e_M) = \frac{e_M}{e_R + e_M} \tag{3.15}$$

The functional forms follow from the assumptions regarding the first derivatives of network effects which are positive and the second derivatives of network effects which are negative. To make sure that the network effect is bounded, these functional forms yield $\frac{\partial \alpha_{CR}}{\partial N_R} > 0$,

$\frac{\partial \alpha_{CM}}{\partial N_M} > 0$, $\frac{\partial^2 \alpha_{CR}}{\partial N_R^2} < 0$, and $\frac{\partial^2 \alpha_{CM}}{\partial N_M^2} < 0$. The advantage using the functional forms in (3.15) is that they allow for investigating the effect of the difference in the number of product choices offered by sellers between R and M in terms of relative value. For simplicity, $\alpha_{CR}(e_R, \bar{e}_M; N_R, N_M)$ and $\alpha_{CM}(e_R, \bar{e}_M; N_R, N_M)$ are reduced to $\alpha_{CR}(e_R; \theta)$ and $\alpha_{CM}(e_R; \theta)$ where $\theta = \sqrt{\frac{N_R}{N_M}}$ is the square root of the ratio of the number of product choices offered by R relative to the number of product choices offered by M. The lower the value of θ, the more the number of product choices offered by M compared to the number of product choices offered by R. Hence, the total network effect for both firms and consumers becomes $\Delta NE(e_R; \theta) = \frac{\theta e_R - \bar{e}_M}{\theta e_R + \bar{e}_M} + \frac{e_R - \bar{e}_M}{e_R + \bar{e}_M}$. Substituting the functional forms (3.15) into (3.14) yields

$$\frac{\partial \pi_R}{\partial e_R} = \left(\frac{1 + (3\theta + 1)e_R + 3(\theta - 1)e_R^2 - (3\theta + 1)e_R^3 - \theta e_R^4}{(e_R\theta + 1)(e_R + 1)} \right) \left(\frac{(4\theta - 1) - 4\theta e_R + \theta^2 e_R^2}{(\theta e_R + 1)^2} + \frac{(2 - 6e_R - 7e_R^2 - 3e_R^3)(1 - e_R)}{(1 + e_R)^2} \right) = 0 \tag{3.16}$$

The solutions for transaction experience, e_R^*, depend on the value of θ. By the implicit function theorem, the optimal transaction experience for R is written as $e_R^*(\theta)$. From the first-order condition in (3.16), there is no convenient closed form solution, so numerical methods are used to solve for the solution of optimal transaction experience and analyze the effect of θ on e_R^* and the profit for R, as illustrated in Figure 3.3. Only values of $\theta \in [0, 2.69]$ gives solutions in $\Re$ because a value of $\theta \geq 2.7$ yields all complex roots. Hence, the solutions for transaction experience with the specific functional forms (3.15) is bounded. When $0 < \theta < 2.7$, R chooses to provide e_R^* given by the first-order condition in (3.16). Figure 3.3 shows that, given e_R^*, increasing θ increases the optimal profit for R. By the assumption $\frac{\partial \Delta NE(e_R)}{\partial e_R} > 0$, the total network effect increases in e_R, which implies that $\Delta NE(e_R)$ increases in θ. This means that consumer's valuation of a product offered by R increases by increasing θ, so R has an incentive to provide more transaction experience, leading to more competition in the market. The reason is that a higher number of product choices offered by R compensates the consumer who locates to the left of e_R and attract

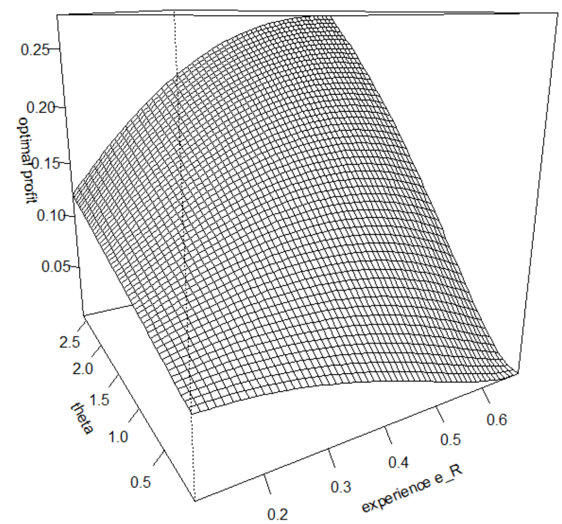

Figure 3.3: The optimal profit for R as a function of e_R and $\theta \in [0, 2.65]$

rival consumers. Thus, decreasing N_M allows R to move closer to M (Δe decreases). From the specific functional forms (3.15), the results illustrate that with the presences of endogenous network effects, R locates inside the chain length [0,1], which leads to the existence of a transaction experience equilibrium (see more detail in Appendix A.2.1).

The impact of θ on firms' competition in the market for experience

To investigate the effect of θ on firm competition, equation (3.7), which presents the weighted value of network effects between firms and consumers, and competition in transaction experience, provides some intuition for understanding these results. Figure 3.4 illustrates the relationship between network effects, ΔNE, and θ. The values of θ affecting firms' competition are divided into three regions when a particular effect dominates. The first region is characterized as having no price or market share effects when $\theta < 0.88$; the negative network effect is strong and $\alpha_{CR}(e_R;\theta)$ is less effective on price competition than $\alpha_R(e_R)$. R has an incentive to differentiate its product from M and charges a lower price because transaction experience provided by R is not effective enough to attract more con-

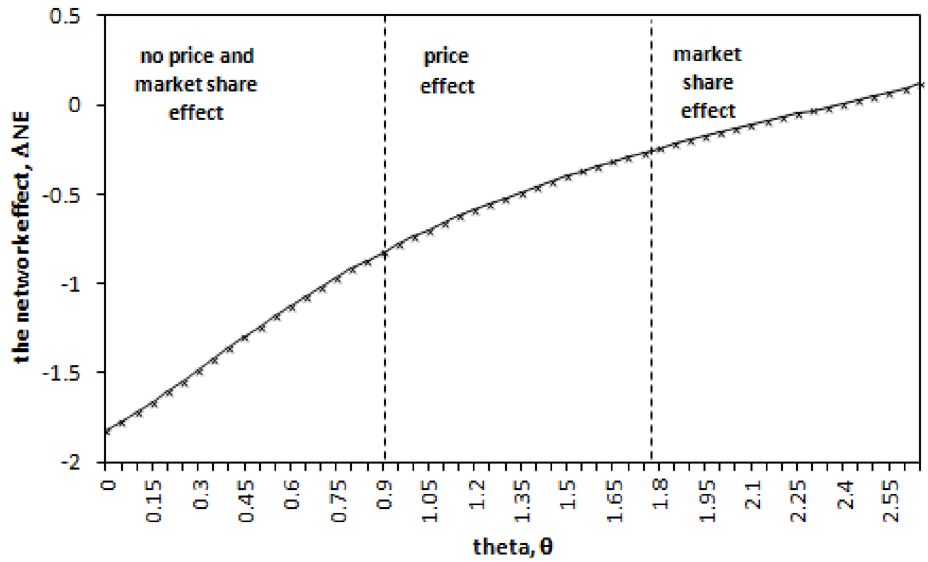

Figure 3.4: The relationship between network effects and $\theta \in [0, 2.65]$

sumers. The price difference, $p_M^* - p_R^*$, decreases in θ.[14] In the first region, as θ is small, the value of $\alpha_{CR}(e_R;\theta)$ is less than $\alpha_R(e_R)$, so p_R is lower than p_M. This means that the network between M and consumers is large, so it is better for R to offer a lower price.

Next, the second region affects when the price effect dominates, and occurs when $0.88 \leq \theta < 1.80$. In this region, the negative network effect is weak and $\alpha_{CR}(e_R;\theta)$ is more effective on price competition than $\alpha_R(e_R)$. The weak negative network effect reduces the degree of product differentiation between R and M because transaction experience provided by R is large enough to increase network effects, as well as for R to compete with M and offer a higher price. However, transaction experience provided by R is not large enough for R to get a dominant market share. Therefore, under weak negative network effects, R benefits from offering a product with transaction experience and can charge a higher price when compared to the first region.

The third region is characterized as having a dominant market share effect, when $\theta \geq 1.80$. In this region, network effects range from very weak negative to a positive value and

[14] Using the envelope theorem to investigate the effect of θ on the difference in price equilibrium, substituting $e_R^*(\theta)$ into (3.7) and then differentiating $(p_M^* - p_R^*)$ with respect to θ yields $\frac{\partial(p_M^* - p_R^*)}{\partial\theta} = -\frac{4}{3}\frac{e_R^*(\theta)}{(\theta e_R^*(\theta)+1)^2} < 0$.

$\alpha_{CR}(e_R;\theta)$ is more effective on price competition than $\alpha_R(e_R)$. Note that the sign of the total network effect (ΔNE) changes from negative to positive when $\theta \geq 2.38$.[15] In this region, R gains a dominant market share and can charge a higher price. The reason is that the network between R and consumers is large enough to compensate R's captive consumers and rival consumers. Hence, competition between R and M becomes more intensive.

Fixed entry fee

Under the first region, the farmers' market becomes attractive to entrant vendors/farmers. With free entry, an increase in the size of vendors may reduce the profit of incumbent vendors. This brings about the fixed entry fee, f_c, playing an important role in restricting the number of vendors. Note that a higher number of product choices leads to a greater number of vendors. Given the solutions from the subsection 3.4.2, the difference between profits for M and R is:

$$\begin{aligned}\Delta\pi(e_R^*) = \pi_M(e_R^*) - \pi_R(e_R^*) &= \frac{2}{3}\Big((e_R^*)^2 - e_R - \Delta NE(e_R^*)\Big) - f_c \\ &= \frac{2}{3}\Big((e_R^*)^2 - e_R^* - \frac{\theta e_R^* - 1}{\theta e_R^* + 1} - \frac{e_R^* - 1}{e_R^* + 1}\Big) - f_c \end{aligned} \tag{3.17}$$

Using the envelope theorem to evaluate a small change in θ changes the difference between optimal profits for M and R, differentiating $\Delta\pi(e_R^*(\theta))$ with respect to θ gives

$$\frac{\partial \Delta\pi(e_R^*(\theta))}{\partial\theta} = -\frac{4}{3}\frac{e_R^*(\theta)}{(\theta e_R^*(\theta)+1)^2} < 0 \tag{3.18}$$

Expression (3.18) implies that as θ decreases, the difference between profits for M and R increases. This indicates that when the number of vendors at M is significantly higher than the number of sellers at R, selling a product at M may attract new vendors to enter the farmers' market. Hence, the manager of M should increase the fixed entry fee, but by less than $\Delta\pi(e_R^*)$ in order to restrict the number of vendors and maintain the same level of profit. The decision for setting the fixed entry fee depends on whether doing so increases

[15]When $\theta = 2.38$, the total network effect yields $\Delta NE = 0$, which means that the network effect between R and R's captive consumers is equal to the network effect between M and M's captive consumers.

or decreases the average profit of an individual vendor. It is possible that the manager of M charges a lower fixed entry fee faced by entrant vendors if the manager wants to encourage more vendors entering the market. This shows the trade-off between the network size (or the number of vendors/farmers) and the value of the fixed entry fee.

3.4.3 Comparison between exogenous and endogenous network effects

Table 3.1 summarizes the effect of network effects on the solutions for transaction experience (e_R), market share ($\hat{x} - 0.5$), profit difference ($\pi_R - \pi_M$), and price difference ($p_R - p_M$).[16] Both cases show that R has an incentive to move closer to M when ΔNE increases. The range of network effects that gives e_R in the interval [0,1] under exogenous network effects is smaller than that under endogenous network effects. This is shown in equation (3.14); the gain in the profit for R from choosing a higher transaction experience is proportional to its network effect, so as e_R increases, the profit for R and ΔNE increase. Under exogenous network effects, in general, R prefers to maximize product differentiation and locates outside the chain length [0,1]. Only when the positive network effect is high ($1 \leq \Delta NE < 1.33$), R prefers to move closer to M and locates inside the chain length. Under endogenous network effects, R has control over the value of network effects, which makes R's decision about transaction experience become more intensive. The choice of transaction experience affects not only price competition and consumer's valuation, but also a network with consumers. Given the range of network effects ($\Delta NE(e)$) from -1.82 to 0.12, e_R falls inside the chain length.

When the number of product choices offered by M increases, R has more incentive to differentiate its product and prefers to be less aggressive in price competition. In the market for a product with transaction experience, the network size plays an important role in market competition. The valuation of network effects can be influenced by firms' choices and

[16] Note that the result of endogenous network effects is derived by the specific functional forms (3.15).

Table 3.1: The summary of the effect of increasing network effects on the solutions

	market share effect			price effect
Exogenous network effects	e_R	$\hat{x}-0.5$	$\pi_R-\pi_M$	p_R-p_M
$\Delta NE<0$	-	-	-	
$0\leq\Delta NE<0.31$	-	+	-	
$0.31\leq\Delta NE<1$	-	+	+	
$1\leq\Delta NE<1.33$	+	+	+	
Endogenous network effects with specific functional forms				
$-1.82<\Delta NE(e)<-0.84$	+	-	-	-
$-0.84\leq\Delta NE(e)<-0.24$	+	-	-	+
$-0.24\leq\Delta NE(e)<0.12$	+	+	+	+

consumer preferences. Following the model in this section, an increase in network effects will increase economic profit for R, but reduce economic profit for M. Thus, both short and long supply chains can use transaction experience to create marketing opportunities by enhancing interaction with consumers. Overall, the use of experience interacting with network effects result in decreasing the degree of product differentiation.

3.5 Endogenous experience

This section presents a symmetric solution for equilibrium prices and transaction experience when the assumption of the fixed transaction experience of M, $\bar{e}_M$, is relaxed. The cases of exogenous and endogenous network effects are analyzed. Assume that the fixed entry fee, f_c, is zero, for simplicity. Under endogenous experience, in the first period, R and M choose to provide e_R and e_M, respectively. In the second period, given transaction experience, R and M choose prices p_R and p_M simultaneously. The game is solved backward by starting from the second-stage game, the profit functions (3.4) and (3.5) are maximized with respect to prices. The equilibrium prices $\{p_R, p_M\}$ are:

$$
\begin{aligned}
p_R &= \frac{2}{3}(c_R-\alpha_R)+\frac{1}{3}(\alpha_{CR}-\alpha_{CM}+c_M-\alpha_M)+\frac{\Delta e}{3}(2+e_R+e_M)\\
p_M &= \frac{2}{3}(c_M-\alpha_M)+\frac{1}{3}(\alpha_{CM}-\alpha_{CR}+c_R-\alpha_R)+\frac{\Delta e}{3}(4-e_R-e_M) \qquad (3.19)
\end{aligned}
$$

where $\Delta e = e_M - e_R$. Substituting (3.19) into (3.2) gives the market share for R is

$$\hat{x} = \frac{\Delta NE}{6\Delta e} + \frac{1}{6}(2 + e_R + e_M) \tag{3.20}$$

where $\Delta NE = \alpha_{CR} - \alpha_{CM} + \alpha_R - \alpha_M$. The market share for M is $1 - \hat{x}$.

3.5.1 Exogenous network effects

In the first-stage game, substituting the equilibrium prices (3.19) and the marginal consumer (3.20) into the profit functions (3.4) and (3.5) yields

$$\pi_R = \frac{1}{18\Delta e}\left(\Delta NE + \Delta e(2 + e_R + e_M)\right)^2$$
$$\pi_M = \frac{1}{18\Delta e}\left(\Delta e(4 - e_R - e_M) - \Delta NE\right)^2 \tag{3.21}$$

Differentiating (3.21) with respect to transaction experience, the first-order conditions are

$$\frac{\partial \pi_R}{\partial e_R} = \frac{1}{18}\left(\frac{\Delta NE}{\Delta e} + 2 + e_R + e_M\right)\left(\frac{\Delta NE}{\Delta e} - 2 - 3e_R + e_M\right) \tag{3.22}$$
$$\frac{\partial \pi_M}{\partial e_M} = \frac{1}{18}\left(\frac{\Delta NE}{\Delta e} + 4 + e_R - 3e_M\right)\left(4 - e_R - e_M - \frac{\Delta NE}{\Delta e}\right) \tag{3.23}$$

To solve for the candidates of a transaction experience equilibrium, the values of ΔNE are required. In the absence of network effects, to solve for a symmetric solution, substituting $e_R + e_M = 1$ into the first-order conditions (3.22) and (3.23) gives a symmetric equilibrium $e_R^* = -0.25, e_M^* = 1.25$.[17] Given a transaction experience equilibrium, R and M equally share the market ($\hat{x} = 0.5$) and the profit ($\pi_R = \pi_M = 0.75$). Comparing this result with $e_R = 0$ and $e_M = 1$, both firms share an equal market share, but earn a lower profit ($\pi_R = \pi_M = 0.5$). Results show that firms have a strong incentive to differentiate their products and prefer to locate outside the chain length [0,1]. The reason is that the marginal profit is negative when firms moving closer to the marginal consumer, indicating that decreasing the distance between transaction experience, Δe, reduces profits for both firms. As a result,

[17] To ensure the existence of a symmetric equilibrium, given $e_M^* = 1.25$, R does not want to deviate from its optimal choice, $e_R^* = -0.25$ because $\pi_R(-0.25, 1.25) > \pi_R(0, 1)$. The same argument applies to M. This outcome is supported by the results of Tabuchi and Thisse (1995) and Lambertini (1996).

under a uniform distribution and the absence of network effects, there is no symmetric equilibrium when firms are restricted to locate inside the chain length [0,1]. From the first-order conditions (3.22) and (3.23), if ΔNE is large enough to influence competition in transaction experience, firms may have less incentive to differentiate their products.

When network effects exist, the first-order conditions (3.22) and (3.23) give two conditions: $e_R = \frac{-5}{2} - \frac{\Delta NE}{\Delta e}$ and $e_R = \frac{\Delta NE}{2\Delta e} - \frac{1}{4}$. To solve for a symmetric solution, substituting $e_M = 1 - e_R$ into these conditions yields the candidates of a transaction experience equilibrium:

$$e_R^* = \frac{-2 \pm \sqrt{9 + 2\Delta NE}}{2} \quad \text{or} \quad e_R^* = \frac{1 \pm \sqrt{9 - 2\Delta NE}}{8} \tag{3.24}$$

and $e_M^* = 1 - e_R^*$, which give the solutions $\{e_R^*,\ e_M^*\}$ in $\Re$ when $-\frac{9}{2} \leq \Delta NE \leq \frac{9}{2}$. From (3.24), the sign of changes in transaction experience when ΔNE changes is ambiguous. When $\Delta NE < -\frac{9}{2}$ and $\Delta NE > \frac{9}{2}$, both R and M prefer to deviate from their optimal choice. When ΔNE is between $-\frac{9}{2}$ and $\frac{9}{2}$, a symmetric equilibrium is given by $e_R^* < 0$ and $e_M^* > 1$. As $|\Delta NE|$ increases, both firms move closer to the marginal consumer, but they still locate outside the chain length [0,1]. The profit and market share for R increase in ΔNE, while the profit and market share for M decrease in ΔNE. By the restriction of the interval [0,1], the best response for R is restricted at $e_R^* = 0$ and for M is restricted at $e_M^* = 1$. Hence, there is no symmetric equilibrium in the case of exogenous network effects and both firms choosing transaction experience simultaneously.

3.5.2 Endogenous network effects

Recall specific functional forms of network effects in (3.15) from the section 3.4.2. Let $\alpha_R(e_R, e_M)$, $\alpha_M(e_R, e_M)$, $\alpha_{CR}(e_R, e_M; \theta)$, and $\alpha_{CM}(e_R, e_M; \theta)$ be endogenous network effects. The solution for prices in the second-stage game remains the same as in the case of exogenous network effects. In the first-stage game, substituting the equilibrium prices (3.19) and the marginal consumer (3.20) into the profit functions (3.4) and (3.5) yields

$$\pi_R = \frac{1}{18\Delta e}\left(\Delta NE(e) + \Delta e(2 + e_R + e_M)\right)^2$$
$$\pi_M = \frac{1}{18\Delta e}\left(\Delta e(4 - e_R - e_M) - \Delta NE(e)\right)^2 \tag{3.25}$$

where $\Delta e = e_M - e_R$ and $\Delta NE(e) = \alpha_{CR}(e_R, e_M; \theta) - \alpha_{CM}(e_R, e_M; \theta) + \alpha_R(e_R, e_M) - \alpha_M(e_R, e_M)$. Differentiating (3.25) with respect to transaction experience, the first-order conditions are

$$\frac{\partial \pi_R}{\partial e_R} = \frac{1}{18}\Big(\frac{\Delta NE(e)}{\Delta e} + 2 + e_R + e_M\Big)\Big(\frac{\Delta NE(e)}{\Delta e} - 2 - 3e_R + e_M + 2\frac{\partial \Delta NE(e)}{\partial e_R}\Big) \tag{3.26}$$
$$\frac{\partial \pi_M}{\partial e_M} = \frac{1}{18}\Big(4 - e_R - e_M - \frac{\Delta NE(e)}{\Delta e}\Big)\Big(\frac{\Delta NE(e)}{\Delta e} + 4 + e_R - 3e_M - 2\frac{\partial \Delta NE(e)}{\partial e_M}\Big) \tag{3.27}$$

The solution for transaction experience can be determined by solving (3.26) and (3.27), which give three conditions, $e_R = \frac{1}{2}\big(\frac{\partial \Delta NE(e)}{\partial e_M} - \frac{2\Delta NE(e)}{\partial \Delta e} - 5\big)$, $e_R = \frac{1}{2}\big(1 + \frac{\partial \Delta NE(e)}{\partial e_R}\big)$, and $e_R = \frac{1}{4}\big(\frac{3\partial \Delta NE(e)}{\partial e_R} - \frac{\partial \Delta NE(e)}{\partial e_M} + \frac{2\Delta NE}{\Delta e} - 1\big)$.[18] The strategic interaction between two firms depends on the own and cross effects of transaction experience on network effect functions. In general, if $\frac{\partial \Delta NE(e)}{\partial e_R} > 0$, $\frac{\partial \Delta NE(e)}{\partial e_M} > 0$, and ΔNE is positive, the solutions are located outside the chain length with condition $e_R = \frac{1}{2}\big(\frac{\partial \Delta NE(e)}{\partial e_M} - \frac{2\Delta NE(e)}{\partial \Delta e} - 5\big)$, or give a negative profit with condition $e_R = \frac{1}{2}\big(1 + \frac{\partial \Delta NE(e)}{\partial e_R}\big)$, then the solutions are derived with the rest of these conditions. In this paper, network effect functions increase in transaction experience that one firm provides, but decrease in transaction experience that its rival firm provides. However, the first derivatives of the total network effect, $\frac{\partial \Delta NE(e)}{\partial e_R}$ and $\frac{\partial \Delta NE(e)}{\partial e_M}$, are derived from the sum of the difference between the first derivatives of the network effect for firms and consumers, which the sign of these derivatives are undefined without the functional specification. Hence, the functional forms of network effects are needed to derive the first derivatives of $\Delta NE(e)$ and analytical solutions.

To solve for a symmetric solution, substituting $e_M = 1 - e_R$ and network effect functions (3.15) into the first-order conditions (3.26) and (3.27) gives three equilibrium conditions as shown in the above paragraph. Using numerical methods, given the restriction of the chain

[18] To verify a transaction experience equilibrium in general, these solutions must satisfy the second-order conditions where $\frac{\partial^2 \pi_R}{\partial e_R^2} \leq 0$ and $\frac{\partial^2 \pi_M}{\partial e_M^2} \leq 0$. However, the test results for second-order conditions are undetermined because there is generally no closed from of the second-order condition without tactical solutions.

length [0,1], these three equilibrium conditions yield two ranges of solutions for experience $\{e_R^*, e_M^*\}$ depending on the value of θ. Note that the solutions where $e_R > 0.5$ and $e_M < 0.5$ are ruled out from the candidates of an equilibrium because these solutions yield negative profits. First, when $0 < \theta < 1.17$, both firms choose to locate outside the chain length [0,1] because of a higher profit when compared to $\pi_R^*(0,1)$ and $\pi_M^*(0,1)$. This range reveals that firms prefer to move away from each other, or to maximize product differentiation. The reason is that a low relative value of the number of product choices offered by R to M leads to large network effects between M and consumers.

Second, when $\theta \geq 1.17$, R chooses to locate at its optimal level because the profit for R increases in θ and is greater than $\pi_R^*(0,1)$, so that R has an incentive to move closer to the marginal consumer. While, with the constraint of the interval [0,1], M prefers to deviate from its optimal choice and locates at $e_M = 1$, because of decreasing the profit for M in θ. Hence, in this range, the optimal solutions for transaction experience $\{e_R^*, e_M^*\}$ occur when R chooses to locate at its optimal choice and M chooses to locate at $e_M^* = 1$. When $\theta = 1.17$, the solution for transaction experience equilibrium exists at $e_R^* = 0$ and $e_M^* = 1$, which gives $\Delta NE(e) = -2$ and $\hat{x} = 0.17$. With specific functional forms (3.15), the results show that firm's incentive to differentiate its product depends on the value of θ or the network size. This implies that when network effects exist, both R and M prefer to move toward to the marginal consumer compared with the case of no network effect.

3.6 Discussion

This section provides a more elaborate discussion of the results from specific functional forms of network effects (3.15). The main results are presented in Figure 3.5 where case I and II stand for the solution ($\circ$) when R chooses transaction experience (e_R) given the fixed transaction experience of M ($\bar{e}_M$) under the cases of exogenous and endogenous network effects, respectively. Case III and IV stand for the solution ($\bullet$) when R and M simultaneously choose transaction experience under the cases of exogenous and endogenous network effects, respectively. The solutions for these four cases are compared at $\Delta NE = -1.5$ when the restriction of locating inside the chain length [0,1] is relaxed. Note that the solution for transaction experience in case II and IV is derived and given when $\Delta NE(e_R, e_M) = -1.5$. Price and experience competition under quadratic transportation costs is very intense, leading firms to move further apart. When the chain length is restricted to the interval [0,1], in case I and III, R and M choose the maximum differentiation and the best response for R is to locate at $e_R^* = 0$ and for M is to locate at $e_M^* = 1$. Profits for R and M in case I and III are $\pi_R^*(0,1) = 0.125$, $\pi_M^*(0,1) = 1.125$, which is lower than the profits when the restriction of the chain length is relaxed. Without this restriction, profits for R and M in case I are $\pi_R^*(-0.64,1) = 0.190$, $\pi_M^*(-0.64,1) = 1.888$, and profits for R and M in case III are $\pi_R^*(-0.31,1.31) = 0.385$, $\pi_M^*(-0.31,1.31) = 1.385$.

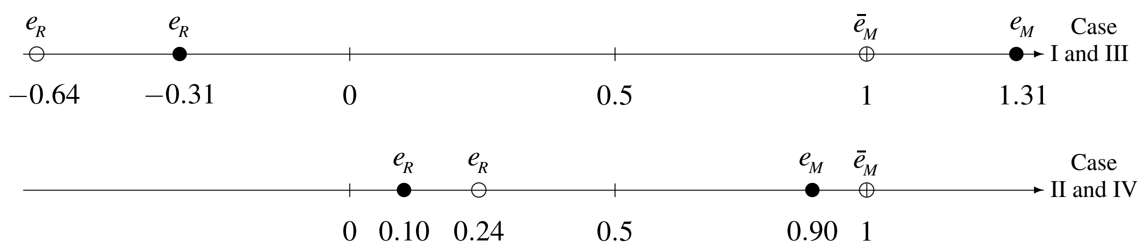

Figure 3.5: Firms' location with different cases

The solutions for case II and IV are to locate inside the chain length because endogenous network effects reduce the distance between firms and intensify price competition. Case IV presents a higher degree of product differentiation than case II because R has an additional incentive to compete for the market share in case II with the fixed M's experience. The profit for R in case II ($\pi_R^*(0.24,1) = 0.071$) is higher than that in case IV ($\pi_R(0.1,0.9) = 0.054$). While, the profit for M in case II ($\pi_M^*(0.24,1) = 0.939$) is lower than that in case IV ($\pi_M(0.1,0.9) = 1.058$).[19] The reason is that both firms correspond to

[19]Note that with the restriction of the chain length [0,1], the optimal solution for case IV when

their optimal choices in case IV, leading to a decrease in the profit for R and increase in the profit for M when compared to case II.

The results that are shown in Figure 3.5 are not clear which model performs best in term of its ability to capture the effect of transaction experience. In terms of the implications of marketing strategy, the case of endogenous network effects provides a more effective analysis of the results than the case of exogenous network effects. Both firms tend to compete more aggressively under endogenous network effects than under exogenous network effects. One reason is that a firms' decision about transaction experience affects the value of network effects for consumers and firms. Different consequences of the models depend on the strategies of R and M, as well as consumers' valuation of a product related to transaction experience. In this paper, the strategic interaction between firms is determined through specific functional forms of network effects. When transaction experience is a strategic substitute, price competition will be intense. The main feature of the model is that an increase in network effects reduces experience competition between firms and increases the intensity of price competition. Hence, product differentiation is determined by experience competition, which depends on the network between producers and consumers.

3.7 Conclusion

This paper presents a comparison of the market with a short supply chain versus a long supply chain when transaction experience plays a prominent role in creating value added to products. A two-sided network effect is applied to the relationship between producers and consumers, which is influenced by transaction experience. Producers benefit from interacting with their own customers, and consumers enjoy interacting with producers. The total network effect is defined in terms of the sum of the difference between network effects for firms and consumers. Using Hotelling's location model with a two-stage game,

$\Delta NE(e_R, e_M) = -1.5$ is $e_R^* = 0.10$ and $e_M^* = 1$. The profit for R becomes $\pi_R^*(0.1,1) = 0.069$ and the profit for M becomes $\pi_M^*(0.1,1) = 1.158$, which are greater than $\pi_R(0.1,0.9)$ and $\pi_M(0.1,0.9)$, respectively.

transaction experience is considered as a proxy for the chain length. There are two different scenarios: *R* chooses transaction experience given the fixed transaction experience provided by *M*, or both *R* and *M* choose transaction experience simultaneously. The solutions for these two scenarios are analyzed under the cases of exogenous and endogenous network effects. Specific functional forms of network effects are specified to derive analytical results of endogenous network effects and to investigate the relative competition in transaction experience between both firms.

Findings show that the case of endogenous network effects provides a more effective analytical solution for experience than the case of exogenous network effects when the chain length is restricted. The number of product choices offered by sellers/vendors increases consumers' valuation of a product associated with transaction experience, as well as firm competition. Under a uniform distribution with quadratic transportation cost (D'Aspremont et al., 1979), firms have an incentive to differentiate their products in order to avoid aggressive price competition. Findings in this paper show that this outcome can be changed to be less differentiated when network effects are introduced into the model. With the presence of network effects, the higher the network effect between *R* and consumers, the less the *R*'s incentive to differentiate its product, thereby leading to more aggressive price competition in the market. Consequently, market competition in the presence of network effects is more intense than in the absence of network effects.

Some remarks regarding assumptions and future research should be pointed out. In the analysis, specific functional forms are applied to network effects. An interesting direction for future research would be to examine how the results in this paper are expected to change with other functional forms. The paper has taken the market structure of duopoly firms, it would be interesting to examine the case of retail mergers or oligopoly in the same geographical area by using Salop's model. This paper presents a symmetric equilibrium under the case of endogenous network effects in a simultaneous game. Future research should look at the case of asymmetric equilibrium, or a sequential game. In the real market, the first entrant that uses transaction experience will have to make a decision about the choice of the subsequent entrants. In addition, future research could also investigate the issue of repeat-purchasing in a two-period model where transaction experience that consumers perceive in the first period can influence their choices in the second period. Finally, the relation between transaction experience effects and the length of supply chain can be interpreted in different ways depending on how transaction experience (i.e. interaction between producers and consumers or convenience) changes along the supply chain. The marketing mix model that includes transaction experience strategies should be considered for future research.

This paper provides an important contribution to the broader literature in that it modifies Hotelling's location model with a two-stage game by linking the concept of transaction experience to the structure of supply chain. The linkage between transaction experience and two-sided network effects gives the optimal result locating inside the chain length, which differs from the standard Hotelling's location model result (D'Aspremont et al., 1979). The theoretical results in this paper also provide a better understanding of why some consumers prefer visiting farmers' markets or short supply chains and are willing to pay more for product sold at those venues. Furthermore, this paper contributes to the economic and marketing literature on the experience economy (Pine and Gilmore, 1998; Swinnen et al., 2012) and network effects in agri-food sector (Farrell and Klemperer, 2007; Shy, 2011). In this paper, the concept of transaction experience is defined as consumers' willingness to pay for a product associated with a particular shopping location can be influenced by the interaction between producers and consumers. This means that the longer the chain length, the lower the transactional experience provided to consumers. The results in this paper give insights into the firms' decision in term of product differentiation, how to generate value for consumers, and how short supply chains compete with a longer supply chain using transaction experience.

Chapter 4

The Role of Distance and Distribution Channel on Consumers' Choices with Local and Organic Food Products

4.1 Introduction

Consumer interest in production practices and their benefits have stimulated changes in the supply side of food markets (Adams and Salois, 2010; Campbell et al., 2013). Agricultural food production systems have responded to consumer demand by developing markets for foods that embody specific quality attributes such as local, organic, and fair trade. Some consumers are willing to pay more for these attributes because they feel good about supporting locally based producers or environmental impacts (Brown and Miller, 2008; Adams and Salois, 2010; Swinnen et al., 2012), while others are willing to pay more for these attributes because they are concerned about their own personal health and safety (Padel and Foster, 2005; Cranfield et al., 2009; Lusk and Briggeman, 2009). Some studies suggest that consumers of local and organic foods share some similar purchasing motives; however, the links between two attributes on influencing consumer's purchasing decisions are unclear (Yue and Tong, 2009; Campbell et al., 2013). In addition, consumer attitudes toward social and environmental concerns have been found to be important factors in the consumer's motivation to buy local/organic products. Thus, consumer preferences over these product quality attributes may be more complex than just one dimension of product characteristics.

When consumers become more heterogeneous and differ in their demand for product quality attributes, an opportunity occurs for a new market segment (Grunert, 2005). Recently, consumers are not only interested in a product attribute itself, but also how the product provides a benefit to them (Lusk et al., 2007; Yue and Tong, 2009; Swinnen et al., 2012). In particular, the choice of alternative food supply chains (i.e. short chains, independent stores, and supermarkets) may affect consumers' attitudes towards local and organic products. For example, buying a product at a farmers' market provides a belief that supporting local farmers or producing in environmentally friendly ways is embedded in that product (Swinnen et al., 2012). As a result, the different characteristics of food supply chains allow consumers to derive additional benefits from products, leading to a higher willingness-to-pay (WTP) for the product (Thilmany et al., 2008; Yue and Tong, 2009).

Growing segments of consumer demand for food products with specific quality attributes has resulted in long supply chains (i.e. supermarkets) offering local and/or organic food sections (Agriculture and Agri-Food Canada, 2010b; Campbell et al., 2013; Canada Organic Trade Association, 2013). Some producers have moved toward short supply chains (i.e. farmers' markets), which allow producers to create value-added products and establishing a direct relationship with consumers, to sell local and organic products (Brown and Miller, 2008; Adams and Salois, 2010; Dimitri, 2012). As local and organic products are available in both short and long supply chains, a producers' decision about which distribution channel to use to reach the right consumer segment becomes more complicated. Understanding consumer preferences for local and organic foods with other product attributes would help producers to identifying the differences among consumer choices.

The market for organic food in Canada was valued at $3.5 billion in 2012, which was estimated at 75% growth over 2008 ($2 billion) (Agriculture and Agri-Food Canada, 2010b; Canada Organic Trade Association, 2013). Almost half of total organic sales were in the mainstream retail (46%) followed by natural health stores and online retail (25%), direct market (11%), and others (18%), and about 58% of all Canadian consumers bought organic food occasionally (Canada Organic Trade Association, 2013). For the local food market, the sales at farmers' markets were valued at $3.1 billion in 2008, and 48% of Canadian consumers were found to shop at farmers' markets weekly (Farmers' market Canada, 2009). One-third of vendors' income was received from selling their products through farmers' markets and 71% of vendors travelled less than 50 km to the selling location. Even though the Canadian markets for local and organic products have grown over past ten years (Agriculture and Agri-Food Canada, 2010b), these markets gain a small market share of the total food market. Some purchasing barriers for local and organic markets are a lack of trust and awareness about the benefit and quality of local/organic products, as well as a price premium charged differently from a conventional product (Yiridoe et al., 2005; Farmers' market Canada, 2009; Canada Organic Trade Association, 2013).

The objective of this study is to investigate whether there is heterogeneity of preferences across food products embodying local, organic, and distribution channel attributes. In particular, the question of whether distance and distribution channesl result in emerging segments of consumer preferences for local and organic products is explored. To assess this issue, the state choice data from a choice experiment were analyzed by using the latent class model (LCM). The rest of the paper is organized as follows. Section 4.2 contains a review of the previous literature. Section 4.3 presents the method and data used in this research. Section 4.4 presents the empirical results and discussion, and section 4.5 concludes the paper and provides suggestions for future research.

4.2 Literature Review

Previous literature on short supply chains has mainly focused on qualitative research to evaluate the impact of farmers' markets or community supported agriculture (CSAs) on consumer perceptions (Padel and Foster, 2005; Brown and Miller, 2008). A few empirical studies have estimated willingness-to-pay for food products sold at farmers' markets or retailers (Darby et al., 2008; Thilmany et al., 2008; Dimitri, 2012). Those that do explore this issue indicated that some consumers prefer locally and/or organically grown food products, and are willing to pay a premium for a product from direct markets. Consumers visit local farmers' markets because they expect a higher quality of products (i.e. freshness) and support for the local community, as well as environmental sustainability. Other consumers, who might lack trust in supermarkets, prefer purchasing local or organic products from short chains; however, some of these consumers still prefer shopping at supermarkets because of convenience and price (Agriculture and Agri-Food Canada, 2007; Canadian Co-operative Association, 2008). Selling products via short chains, which are highly associated with personal relationships, knowledge, and trust in product quality, give potential opportunities to local farmers or producers to add value to their products and increase their profits (Thilmany et al., 2008; Yue and Tong, 2009; Martinez et al., 2010; Dimitri, 2012). These authors also suggest that short chains play a prominent role in local/organic markets. However, findings of consumer preferences for local and organic food related to distribution channel are ambiguous, leading to the need for more research.

Studies of consumer preferences for locally grown food have increasingly received attention on the benefits of local production as a part of a sustainable food system (Martinez et al., 2010; Campbell et al., 2013). According to previous research, the term local[1] has been used in different ways; most papers define local as an attribute of the product or the label (Onozaka and Mcfadden, 2011; Cranfield et al., 2012; Hu et al., 2012; Denver and Jensen, 2014), while very few papers use local as a distance travelled by food products (Grebitus et al., 2013). In addition, most studies used local fresh produce in their analysis and concluded that locally grown products positively influence willingness-to-pay in a wide range of premiums. Hu et al. (2012) investigated the valuation of local/organic blackberry

[1]According to the Canadian Food Inspection Agency (CFIA), local food is defined as a product that is produced and sold in the same province or a product that sold across provincial borders within 50 kilometers from the originating province.

jam in various regions and indicated that consumers are willing to pay for local production labeling. Grebitus et al. (2013) studied consumer preferences for food miles (or the distance) in red apple and wine by using the second price auction approach and found that consumers have a higher willingness to pay for food with fewer food miles.

There are some studies that focused on consumer preferences for both local and organic products (Onozaka and Mcfadden, 2011; Campbell et al., 2013; Denver and Jensen, 2014). These authors indicated that organically and locally grown food share some similar product buying motives such as supporting local communities, reducing environmental impacts, and improving safety with respect to food supply chains. Furthermore, organic consumers are more likely to be interested in buying local products. However, Yue and Tong (2009), Lusk (2011) and Hu et al. (2012) suggest that little is known about whether consumers prefer organically and/or locally grown products and how consumers value additional factors (i.e. psychographic factors) associated with local and/or organic food products. Campbell et al. (2013) also stated that consumers who tend to have a correct meaning of local and organic are more likely to have a similar pattern of consumer profiles, while others seem to have various consumer profiles. Since the results of several studies seem to vary among consumer characteristics, consumer preferences may appear to be heterogeneous in the market for organic and local foods.

Previous studies in the context of organic products mainly deal with analyzing the factors influencing purchase motives and identifying consumer perception of organic standards and certification programs (see more detail in Yiridoe et al. (2005) and Campbell et al. (2013)). Consumer preferences for organically produced foods are influenced by product attributes (i.e. freshness, price, taste, nutrition, safety) (Lusk and Briggeman, 2009; Lusk, 2011; Onozaka and Mcfadden, 2011), as well as attitudinal factors (i.e. environmental impact and local support) (Cranfield et al., 2009; Yue and Tong, 2009; Swinnen et al., 2012). Apart from these factors, Yue and Tong (2009) suggest that distribution channels also affects consumer's WTP for fresh produce. In general, consumers are willing to pay a positive price premium for organically produced foods (Campbell et al., 2013) and some are likely to be less price sensitive than non-organic buyers (Yue and Tong, 2009; Stolz et al., 2011). However, Padel and Foster (2005), Lusk and Briggeman (2009), and Denver and Jensen (2014) found that a price premium is a major factor in buying organic products.

Empirical studies of consumer preferences for food products have used discrete choice models with the assumption of homogenous preferences and independence from irrelevant alternative (IIA) property (i.e. multinomial logit model, conditional logit model) (Louviere et al., 2000; Lusk and Hudson, 2004; Hensher et al., 2005). Although these models can examine consumer choices of a particular product, they are limited because consumers are widely regarded to have heterogeneous preferences that are difficult to capture in these models. A number of alternative models have been developed to overcome these limitations including the mixed logit model and latent class model (LCM) (Greene and Hensher, 2003; Shen, 2009). Both models account for heterogeneity by allowing coefficients in the model to vary across observations, thereby enhancing the accuracy and reliability of consumer preferences. Since estimation in this paper focuses on heterogeneity at the segment level, the LCM is appropriate for classifying the impact of product attributes on consumer preferences and allows for comparison of segments across different products.

Several empirical studies have analyzed consumer preferences for different food attributes by using the LCM for various food products: benefits of health and environmental attributes in genetically modified bread (Hu et al., 2004), quality verification in bread (Innes and Hobbs, 2011), certification programs with different brands in pork (Nilsson et al., 2006), and organic and conventional attributes in yogurt, milk, and apples (Stolz et al., 2011). Overall, the results of these studies show preference heterogeneity for food attributes or types of products, some of which demonstrate that consumer preferences may be linked to attitudinal factors (Ortega et al., 2011; Stolz et al., 2011) or socio-demographic characteristics (Hu et al., 2004).

While previous research has investigated consumer preferences for local and/or organic food products, less attention has been given to distribution channel, especially in evaluating whether it matters which distribution channels sell local/organic products to consumers or whether it matters how far distance travelled by a product (Yiridoe et al., 2005; Yue and Tong, 2009; Campbell et al., 2013; Grebitus et al., 2013). Some consumers prefer visiting farmers' markets because they believe that a product has supported local producers or been produced in an environmentally friendly way (Yue and Tong, 2009; Dimitri, 2012; Swinnen et al., 2012). Other consumers may prefer shopping at supermarket chains because of price and convenience. These previous studies have shown some potential for consumers who value visiting a particular distribution channel as additional benefits to the product they purchase. This means that consumers may not only value a dimension of quality, but also the dimensions of the benefit from the product (a horizontal dimension). However, the success of selling local and organic products at each distribution channel is unclear. Thus, this paper addresses this gap in the literature by evaluating whether consumers prefer local/organic food with certain distribution channels using the LCM approach. In addition to this issue, empirical evidence in this paper can be used to test a theoretical model in chapter 3, which assesses only a horizontal dimension.

4.3 Methods and Data

The choice modeling framework of this research is based on theory of choice by Lancaster (1966), which states that utility is obtained from the attributes of a good. This theory is incorporated into a random utility maximization model, which assumes that an individual makes choices among alternatives that maximize his/her utility (Louviere et al., 2000; Lusk and Hudson, 2004; Hensher et al., 2005). The random utility model is widely used to analyze consumer preferences based on a bundle of attributes of the good taken into account, as well as assuming some degree of heterogeneity among individuals. In choice set c, individual n faces a choice among a finite set of $j = 1...J$ alternatives, then the derived utility function of alternative i is:

$$U_{nic} = V_{nic} + \varepsilon_{nic} \tag{4.1}$$

where V_{nic} is a deterministic component representing the attributes of an alternative and ε_{nic} is a stochastic component. An alternative i will be chosen over alternative j by individual n if and only if the utility associated with alternative i is greater than the utility associated with other alternatives within the choice set, $U_{nic} > U_{njc}, \forall j \neq i$. The probability that individual n chooses alternative i in choice set c is given by:

$$P_{nic} = Prob(V_{nic} + \varepsilon_{nic} > V_{njc} + \varepsilon_{njc};\ \forall j \in c,\ \forall j \neq i) \tag{4.2}$$

This study uses the LCM approach, which assumes the functional form of the random utility model. The LCM approach relaxes the assumption of homogeneity to account for a discrete parameter variation among individuals, which are unobserved by the analyst. Suppose that individual n belongs to segment s, where $s \in S$, then individual n's utility for the preferred alternative i in choice set c is given by:

$$U_{nic|s} = x'_{nic}\beta_s + \varepsilon_{nic|s} \tag{4.3}$$

where x'_{nic} is the vector of attributes in the i alternative and β_s is the specific parameter vector for class s. $\varepsilon_{nic|s}$ is an unobserved random term that is assumed to be independently and identically distributed according to an extreme value distribution within each segment. In a standard logit specification, the coefficient β_s is fixed across the choices made by an individual, while, in the LCM approach, the coefficient β_s varies between consumer segments. Thus, the latent classes can probabilistically be determined by estimating preferences for each individual's choices. Following Boxall and Adamowicz (2002) and Greene and Hensher (2003), the probability that individual n selects alternative i from choice set c, which is conditional on a given segment s is as follows:

$$P_{nic|s} = \text{Prob}(\text{choice } i \text{ by individual } n \text{ in choice set } c|\text{class } s)$$
$$= \frac{\exp(x'_{nic}\beta_s)}{\Sigma_{j=1}^{J}\exp(x'_{njc}\beta_s)} \tag{4.4}$$

Given the assumption of independence of latent classes, the joint probability of alternative i by individual n in choice set c is $P_{n|s} = \prod_{c=1}^{C} P_{nic|s}$. Following Greene and Hensher (2003), the probability that individual n chooses alternative i in a given segment s is the expectation of the class-specific contributions, $P_n = \sum_{s=1}^{S} H_{ns}P_{n|s}$. The log-likelihood for the LCM with s latent segments is:

$$\ln L = \sum_{n=1}^{N} \ln P_n = \sum_{n=1}^{N} \ln\Big[\sum_{s=1}^{S} H_{ns}\big(\prod_{c=1}^{C} P_{nc|s}\big)\Big] \tag{4.5}$$

where H_{ns} is the probability that individual n belongs to segment s. The expression for H_{ns} can be specified as:

$$H_{ns} = \frac{\exp(z'_n\lambda_s)}{\Sigma_{s=1}^{S}\exp(z'_n\lambda_s)} \tag{4.6}$$

where z'_n is a set of observable individual characteristics[2] (i.e. socio-demographic variables or attitudinal factors) that affect the class membership for individual n, and λ_s is the class-specific parameter vector for individuals in segment s.

To apply the LCM approach, a survey design needs to be developed to elicit stated preferences for local and organic food products. The state preferences of consumers are derived from the design attributes, so a choice experiment is needed to generate the state choice data.

4.3.1 Survey design

The survey was conducted by the marketing company *Ipsos* in March/April 2013 in Canada using an online website and was available in both English and French. The survey instru-

[2] In this analysis, the main objective is to identify segments within the sampled consumers that differ from other consumers with respect to local, organic and distribution channel attributes. Thus, each class share is the same for all individuals.

ment includes as follows: section 1 screening questions[3], section 2 consumer's knowledge and perception of organic food, section 3 consumer's knowledge and perception of local food, section 4 the choice experiment questions, and section 5 socio-demographic characteristics of respondents (Tsang, 2014). In section 4, participants were given a set of hypothetical questions and asked to make a choice about a product that is produced in different ways and sold at different distribution channels they would prefer to purchase. To make sure that responses to hypothetical scenarios were consistent with the consumers' willingness to pay, respondents were asked to keep in mind what they would normally pay for the product and what specific product attributes they are interested in buying the product.

The choice experiment was designed to assess consumer preferences and the WTP for different distribution channels and production practices for two types of products: fresh produce (gala apple and red tomato) and processed food products (pork tenderloin, whole wheat grain, and cheddar cheese). These products were selected because they are commonly purchased by Canadian consumers. The description of product attributes and their levels are summarized in Table 4.1.

Four product attributes were included in the experimental design. First, three levels were considered for production systems: not certified organic, certified organic, and conventionally produced. The production systems indicate which agricultural methods were used during production. If the product is certified organic, the product carries a certification issued by a third-party agent assuring that the product was inspected for quality. For the second attribute, distribution channel indicates alternative selling locations where respondents normally buy local and/or organic products; four levels were considered for distribution channel (farm direct/independent stores/provincial or national supermarkets). Next, the total distance travelled by food products contains four levels: 10, 50, 100, and 1000 km. The total distance travelled by food products indicates the distance in kilometers

[3]For the screening questions, respondents who are from Nunavut or Yukon; or work in agricultural production/food industry; or do not share grocery responsibility were screened out.

(km) that the product travels from the production stage to the selling point, and from that point to the consumption stage. For the fourth attribute, prices contain four levels: base price, 50%, 100%, 200%. Each product shares the same level of each attribute, except the price levels as shown in Table 4.2.

Table 4.1: Description of specific attributes in the choice experiment

Attribute	Levels	Code	Data coding
Price	Base 50% 100% 200%	*PRICE*	Continuous variables
Production system	Not certified organic	*NONC*	Dummy = 1 if a product was grown organically, but not certified organic
	Certified organic	*CERT*	Dummy = 1 if a product was grown organically and certified organic
	Conventionally produced	*CONV*	Base level, which a product was conventionally produced
Distribution channel	Farm direct	*SHORT*	Dummy = 1 if the selling location of a product is farmers' market or CSA
	Independent stores	*INDP*	Dummy = 1 if the selling location of a product is independent stores that cater to a specific region
	Province-wide supermarket chains	*PROV*	Dummy = 1 if the selling location of a product is chain stores that are specific to one province
	Nation-wide supermarket chains	*NANT*	Base level, which the selling location of a product is supermarket chains that serve multiple provinces
Total distance travelled by food products	10 km 50 km 100 km 1000 km	*DIST*	Continuous variables

Table 4.2: Levels of prices of five products in the choice experiment

Red Tomato $/kg	Gala Apple $/kg	Pork Tenderloin $/kg	Whole grain bread $/loaf	Cheddar cheese $/kg
0.80	0.75	8.80	2.50	12.41
1.20	1.13	13.20	3.75	18.62
1.61	1.15	17.60	5.00	24.83
2.41	2.26	26.39	7.50	37.24

A full factorial experimental design of three four-level attributes and one three-level attribute would require $4^3 * 3 = 192$ possible product profiles. Since it is not practically feasible to assign all product profiles to each respondent, a D-optimal design was used. The *%MktBlock macro* procedure in SAS was used to minimize the length of the survey by blocking the choice design to a small number of possible product profiles to each participant. In total there were 96 choice sets with two alternatives per choice set; all were randomly assigned to 12 blocks of eight choice sets. The D-efficiency of this design was 65.34.[4] Each choice set includes two unlabeled alternatives and a no-choice option as illustrated in Figure 4.1. Each respondent was randomly assigned to one product of five different products and one block of 12 blocks in that product.

Figure 4.1: Example of a choice set for gala apple in the experimental design

Attribute	**Alternative**		
	Product 1	**Product 2**	
Production system	Certified organic	Conventionally produced	I would not choose either product 1 or product 2
Price ($/kg)	1.50	0.75	
Distribution channel	Farm direct	National supermarket chains	
Distance (km)	10	50	
I would choose: *(Please check one box)*	☐	☐	☐

The data set includes 2,006 completed surveys, with about 400 observations for each product. Descriptive statistics for the sample, and each product sample is presented in Appendix A.3.1. The majority of participants are female (81.9%), between 35-54 years old (46.4%), and graduated from college or hold a university degree (69.1%). Half of the survey sample reported an annual household income less than $CND 60,000 and have 2-3 members in a family. More than 70% of the survey sample live in the provinces of Ontario, Quebec, and British Columbia, which are consistent with the 2011 Canadian census (Statistics Canada, 2011). Comparing the socio-demographic characteristics of the sample

[4]A D-efficiency score values from 1-100, which means that the design is orthogonally balanced and the variance of the estimated coefficients is minimized. D-efficiency is 65.34, but the blocking of a full factorial design and a large sample size would compensate the low D-efficiency score.

with the 2011 Canadian census reveals some differences in gender and income. One of the reasons is that the survey asked for the primary grocery shopper and women are more likely to be responsible for grocery shopping in the family (Louviere et al., 2000; Campbell et al., 2013). The majority of participants purchase conventional products at large chain grocery stores (86.6%), organic labeled food products at large chain grocery stores (29.5%), and local labeled food products at farmers' markets (43.8%). This indicates that, in general, the survey sample is more likely to shop for their groceries at long supply chains rather than short supply chains. In addition, the choice of distribution channels depends on what products consumers are interested in purchasing.

4.3.2 Estimation

The empirical model for this study includes prices and three attributes (distance, organic, and distribution channel). According to Hensher et al. (2005), the alternative specific constant (*ASC*) refers to a parameter for a particular alternative representing the role of unobserved source of utility. In the context of the unlabelled choice experiment, including the *ASC* variable in the model captures the utility related to a no-choice option. There are two options for coding explanatory variables: effect and dummy coding (Hensher et al., 2005). Some studies use effect coding because it avoids correlation with the intercepts and minimizes collinearity in estimation matrices used to estimate interaction effects (Ortega et al., 2011; Innes and Hobbs, 2011). Other studies that estimate only main effects usually use dummy coding (Lusk and Hudson, 2004; Nilsson et al., 2006). Since the empirical model in this analysis focuses only on main effects, the data were dummy coded.[5] The parameters and the optimal number of classes were estimated by using the Stata 12.0 software (Pacifico and Yoo, 2013).

[5]The effect coding was used to estimate preliminary results of the LCM. The outcomes, signs and significant levels of effect coding are similar to those of dummy coding. Moreover, dummy coding is more convenient and relevant to interpret the results (Hensher et al., 2005).

Willingness-to-pay

The willingness-to-pay (WTP) is calculated as the ratio of the attribute and the price attribute, referring to the marginal rate of substitution between the attribute and the price attribute. In the case of the LCM, the conditional WTP estimate is calculated in the same method as other discrete choice models, but it is based on a given number of latent classes (Greene and Hensher, 2003). The WTP estimate for attribute k that belongs to segment s is given by:

$$WTP_{k,s} = -\frac{\beta_{k,s}}{\beta_{p,s}} \tag{4.7}$$

where $\beta_{k,s}$ is the estimated parameter of k attribute in segment s and $\beta_{p,s}$ is the estimated price attribute in segment s.

4.4 Result and Discussion

This section presents the results of the LCM for five products, and the graphical comparisons of the WTP estimates for distance and organic certification attributes among latent classes. Before presenting the results, the standard procedure for determining the optimal number of classes, S, is discussed. The number of class selection criteria includes four information criteria: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Consistent Akaike Information Criterion (CAIC), and the maximum Akaike Likelihood Ratio Index ($\bar{\rho}^2$). (Louviere et al., 2000; Boxall and Adamowicz, 2002; Greene and Hensher, 2003; Hu et al., 2004; Shen, 2009).[6] The results of these information criterion for the different number of classes for five products are presented in Appendix A.3.2.[7] The class model that minimizes the value of the AIC, CAIC, and BIC criteria is considered to

[6]The AIC equals $-2\ln L + 2m$, where $\ln L$ is the maximized sample log likelihood and m is total number of estimated model parameters. The BIC and CAIC penalize models with extra parameters more heavily by using penalty functions increasing in N, the number of choice makers. The BIC equals $-2\ln L + m\ln N$ and CAIC equals $-2\ln L + m(1+\ln N)$. The $\bar{\rho}^2$ is calculated using $1 - \frac{AIC}{2L(0)}$ where $L(0)$ is log likelihood evaluated at zero. See more information in Boxall and Adamowicz (2002) and Pacifico and Yoo (2013).

[7]Note that the results of these information criterion in Appendix A.3.2 is from the restricted LCM (as a final model). The same argument of the number of class selection is applied to the full LCM.

be the optimal number of classes. The increase of the $\bar{\rho}^2$ value reflects the improvement in model fit. However, a larger number of classes will decrease the significance of parameter estimates in each class, especially the class with few members.[8] To avoid the problem with a zero probability of class assignment, the authors take into account the statistical significance, interpretation of the parameter, and value of class probability in selecting the optimal number of classes.

The results for five products from Appendix A.3.2 show that as the number of classes increases, the value of log likelihood decreases and $\bar{\rho}^2$ increases from the two-class to the seven-class model, indicating the improvement in model fit. For red tomato, the AIC, CAIC, and BIC values decrease up to the five-class model and slightly increase from the five-class model to the seven-class model, except the AIC value that deceases up to the seven-class model. By the results from these information criterion, the five-class model was selected as the optimal number of latent classes for red tomato. For gala apple, the results from information criterion show that the five-class model was specified, but the estimation in the five-class model fails to converge. Thus, the five-class model has gone down to the three-class model for gala apple. For pork tenderloin (and cheddar cheese), when estimating the six-class to the four-class model (and the five-class to the four-class model), the estimation in these class models fail to converge, so class models for both products were reduced to the three-class model. When the three-class model was estimated, one segment has few significant coefficients, so the two-class model was selected for both pork tenderloin and cheddar cheese. For whole grain bread, the values of different information criteria for the six-class model are slightly better than that of the three-class model; however, the coefficients between segments in the six-class model have a similar significance level and sign. Thus, the three-class model was selected for whole grain bread.

[8]Note that a high number of class assignments may be probabilistic since every respondent must have a positive probability of being a member of each of all classes. However, in the process of selecting the optimal number of latent classes, a few respondents were fail to be assigned to one of classes (a zero probability), thus the result does not converge to the local maximum. This leads to lower the selected number of classes from the optimal number of classes.

After estimation of the full model, including only main effects, nine *PROV* parameters across five products were insignificant.[9] Therefore, the restricted model is proposed by dropping *PROV* variable from the full model. A likelihood ratio (LR) test is used to test for a statistically significant difference between full and restricted models. The result of LR test statistic shows that adding *PROV* as an explanatory variable results in a statistically insignificant improvement in model fit (see the result of LR test statistic in Appendix A.3.3). In addition, the signs and magnitudes of the analysis are robust across two models. Consequently, this section presents only the results from the restricted LCM as a final model[10] for five products as given in Tables 4.3 and 4.4. All classes for each product were named to illustrate relevant preference heterogeneity between different latent segments based on the relative significance and magnitude of the coefficients.

The pseudo R^2 for the latent class model for red tomato, gala apple, pork tenderloin, whole grain bread and cheddar cheese is 0.300, 0.226, 0.247, 0.275, and 0.232, respectively, indicating that the models fit the data well (Hensher et al., 2005). Coefficients on price variables for all five products are significant at the 1% level and negatively affect utility, as expected. The distance and organic certification attributes have a significant impact on the probability of choice. Distribution channel attributes have a fewer number of significant coefficients than other attributes, suggesting that consumers have a weaker preference for distribution channel than for local and/or organic attributes. Overall, the longer the distance travelled by a product reduces the likelihood that the product will be purchased. This result is similar to that reported in Grebitus et al. (2013). Consumer preferences for a product grown organically with and without certification vary among classes and types of products. Some respondents have a preference for organic certification, while others do not.

[9] Note that the results of the parameter and WTP estimates of full model for five products are presented in Table A.3.10 and A.3.11 in Appendix A.3.3.

[10] It is worth noting that socio-demographic variables (age, gender, income, education, and family size) were included as individual-specific variables in the LCM, but the results do not significantly improve the goodness of fit. In addition, the class probability does not change significantly. Hence, the individual-specific variables were not included in the final result to facilitate the understanding and interpretation of the model.

Table 4.3: Estimates for the latent class model for two fresh food products

Attribute	Red tomato					Gala apple		
	Class1 Organic focus	Class2 Certification focus	Class3 Short chain focus	Class4 Convenience shoppers	Class5 Price sensitive	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers
PRICE	-1.951***	-0.554***	-1.189***	-1.897***	-5.122***	-1.034***	-4.887***	-2.429***
	(0.315)	(0.105)	(0.343)	(0.675)	(0.497)	(0.103)	(0.842)	(0.364)
DIST	-0.0016***	-0.0014***	-0.0005	-0.0005	-0.0011***	-0.0011***	-0.0010***	-0.0004*
	(0.0003)	(0.0001)	(0.0005)	(0.0009)	(0.0002)	(0.0001)	(0.0003)	(0.0003)
NONC	0.912***	0.299**	-0.630	-5.971***	-0.198	0.118	-0.087	-0.737**
	(0.328)	(0.118)	(0.435)	(1.305)	(0.236)	(0.113)	(0.231)	(0.29)
CERT	0.613**	0.721***	-0.135	-6.140***	-0.378	0.400***	-0.451	-0.545*
	(0.307)	(0.117)	(0.412)	(1.571)	(0.236)	(0.119)	(0.282)	(0.299)
SHORT	-0.063	0.199*	1.198***	-1.314	-0.289	0.096	-0.062	0.204
	(0.312)	(0.121)	(0.431)	(1.072)	(0.258)	(0.101)	(0.252)	(0.246)
INDP	-0.375	-0.175	0.313	1.998*	-1.121***	0.030	-0.548**	-0.286
	(0.257)	(0.118)	(0.463)	(1.074)	(0.245)	(0.104)	(0.225)	(0.263)
ASC	2.751***	3.516***	-0.994	6.059***	12.440***	2.990***	12.388***	1.662***
	(0.505)	(0.352)	(0.61)	(1.587)	(0.998)	(0.261)	(1.611)	(0.362)
Class Probability	0.129	0.33	0.102	0.025	0.413	0.459	0.351	0.189
Observations	9576					9600		
PseudoR^2	0.300					0.226		
Log-likelihood	-1932.56					-2166.77		

*,**,***indicate that the parameter is significant at 10%,5%,1% level

Table 4.4: Estimates for the latent class model for three processed food products

Attribute	Pork tenderloin		Whole grain bread			Cheddar Cheese	
	Class1 Conventional shoppers	Class2 Certification focus	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers	Class1 Certification focus	Class2 Conventional shoppers
PRICE	-0.299***	-0.178***	-0.575***	-1.156***	-0.525***	-0.127***	-0.191***
	(0.024)	(0.008)	(0.032)	(0.101)	(0.133)	(0.005)	(0.02)
DIST	-0.0007***	-0.0007***	-0.0006***	-0.0011***	-0.0006	-0.0005***	-0.0009***
	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)	(0.0002)
NONC	-0.351*	0.054	0.424***	-0.057	-1.095***	-0.132	-0.712***
	(0.181)	(0.088)	(0.103)	(0.186)	(0.363)	(0.083)	(0.199)
CERT	0.184	0.382***	0.530***	0.242	-1.745***	0.303***	-0.488**
	(0.17)	(0.087)	(0.101)	(0.175)	(0.484)	(0.084)	(0.201)
SHORT	-0.340*	-0.023	0.072	0.086	-0.126	0.032	-0.364*
	(0.178)	(0.088)	(0.104)	(0.164)	(0.333)	(0.083)	(0.207)
INDP	-0.286*	-0.276***	-0.235**	-0.168	-0.419	-0.112	-0.417*
	(0.173)	(0.094)	(0.109)	(0.181)	(0.401)	(0.088)	(0.214)
ASC	2.396***	4.846***	5.693***	4.878***	0.455	4.513***	2.242***
	(0.302)	(0.18)	(0.329)	(0.462)	(0.546)	(0.158)	(0.361)
Class Probability	0.386	0.614	0.471	0.330	0.200	0.677	0.323
Observation	9672		9696			9600	
PseudoR^2	0.247		0.275			0.232	
Log-likelihood	-2185.11		-2143.14			-2233.59	

*,**,***indicate that the parameter is significant at 10%,5%,1% level

A significant negative sign on farm direct (or short chain) and independent store coefficients of some classes across five products indicates that most consumers prefer to shop at long supply chains or national/provincial supermarket chains. Only tomatoes have a positive and significant sign on short chain and independent store attributes, showing that almost half of consumers (45.7%) prefer short supply chains as a shopping location for purchasing red tomatoes, rather than long supply chains. One reason is that tomatoes are a perishable food, so consumers may have a higher perception of freshness and taste for red tomato compared to other products (Yue and Tong, 2009; Grebitus et al., 2013). Evidently, consumers have differing valuation of products sold at different distribution channels.

There are five latent classes in the model for red tomatoes. The *organic focus* class (13% of respondents fall into this class) has the highest positive magnitude on organic attribute and negative magnitude on distance attribute, indicating that respondents in this class have a strong preference for organic tomatoes and are highly sensitive to food miles, but the certified organic label does not matter to them. The *certification focus* class (33%) has a similar sign to the *organic focus* class, but respondents in this class focus more on organic certification and seek short chains to buy local and/or organic tomato produce. The *short chain focus* class (10%) gains utility from buying red tomatoes at farmers' markets or CSAs because of the largest positive value on short chains relative to other attributes. This shows that some consumers do derive utility from interaction with farmers or producers at short chains. This additional benefit can provide a positive impact on consumers' attitudes toward a product (Pine and Gilmore, 1998; Swinnen et al., 2012). The *convenience shoppers* class (2.5%) has the highest positive magnitude of the independent store coefficient and is not interested in purchasing local/organic tomatoes. This small segment reveals consumer preferences for convenience to purchase products at a store related to a specific geographic area. The largest class of the sample (41%) was named *price sensitive*, which has a large negative magnitude of the price and independent store coefficients. They prefer either consuming a conventional red tomato or shopping at long supply chains. In addition, the price coefficient is approximately nine times as large as the lowest magnitude on the price coefficient in the *certification focus* class, which shows that participants in the *price sensitive* class are highly price sensitive.

For gala apples, three latent classes differ substantially in consumer preferences with respect to product attributes. In general, respondents for gala apples were less interested in the distribution channel attribute compared to other products as shown by several insignificant parameters of distribution channel coefficients. The *certification focus* class (46%) is the largest segment among three classes. A significant magnitude of certification and distance coefficients shows that the members of this class are highly focused on certified organic labels and are highly sensitive to local apples. For the second class, the price coefficient is four times larger than the lowest magnitude of the price coefficients among classes, leading to naming this class the *price sensitive* class (41%). A negative sign on the independent store coefficient confirms the same pattern of consumer preferences in the *price sensitive* class as in red tomatoes, which indicates that consumers in this class prefer to shop for apples at long supply chains. The *conventional shoppers* class (19%) has negative and significant signs on organic and distance attributes, indicating that this class prefers consuming conventional apples and may not derive as much utility from consuming certified organic apples. They are more likely to gain utility from consuming local apples than other classes and are willing to purchase apples with longer food miles. The authors suggest that participants in this class prefer shopping primarily at national supermarket chains.

There are two latent classes for pork tenderloin: *conventional shoppers* (39%) and *certification focus* (61%). Participants in both classes have a strong preference for not purchasing pork tenderloin at an independent store. The reasons are that most consumers may be concerned about the quality of pork tenderloin (Nilsson et al., 2006) and a high price offered by independent stores. With the similar (and significant) magnitude of distance coefficients for both classes, food miles for pork tenderloin do matter to consumers in general. For the first class, coefficients in the *conventional shoppers* class have the highest magnitude on all attributes, except the certification attribute. Participants in this class are concerned about the presence of a certifying label when pork tenderloin is claimed as organic. They are more likely to gain utility from consuming conventional pork tenderloin and shop at provincial or national grocery chains. The *certification focus* class heavily relies on organic certification labels, indicating that respondents in this class prefer consuming certified organic pork tenderloin. The large probability of the *certification focus* class may result from consumer interest in meat products/process based attributes such as the use of animal antibiotics/hormones in animal feed. Thus, some consumers tend to rely on certification as a signal of quality attributes.

Three latent classes were selected for the whole grain bread model. Insignificant parameters on the distribution channel coefficient for whole grain bread indicate that participants pay more attention to local or organic attributes rather than the distribution channel attribute. This finding is similar to the results of gala apples. Since certified and non-certified organic coefficients are significant and have the largest magnitude among classes, the first class is referred to as the *certification focus* class (47%). Participants in this class obtain utility from either non-certified or certified organic whole grain bread and prefer not to buy whole grain bread at independent stores. The *price sensitive* class (33%) has the largest magnitude on price and distance attributes, revealing that this class has a relatively high price sensitivity and are more conscious of food miles for whole grain bread. The *conventional shoppers* class (20%) has a negative significant sign for the coefficient on the organic certification attribute, indicating that the members in this class are likely to prefer consuming conventional whole grain bread. The authors suggest that the *price sensitive* and *conventional shoppers* classes represent a traditional shopper that gains utility from purchasing whole grain bread in long supply chains.

For cheddar cheese, the two latent classes are *certification focus* (68%) and *conventional shoppers* (32%). The *certification focus* class has the largest magnitude on the coefficient for the organic certification attribute, indicating that respondents in this class gain utility from consuming certified organic cheddar cheese. Moreover, they are less sensitive to the change in the distance travelled by cheddar cheese than any other class. For the *conventional shoppers* class, all attributes are negative and significant, indicating that respondents perceive utility from either consuming conventional cheddar cheese or shopping at long chain channels. Significance in distribution channel coefficients suggests that some consumers are influenced by alternative distribution channels. It is worth noting that the number of classes and almost all signs of attributes for cheddar cheese are similar to pork tenderloin. Since both products are animal-based processed food products, the authors suggest that animal-based processed food is generally less heterogeneous than in fresh produce and grain products.

Tables 4.5 and 4.6 illustrate the WTP estimates for each attribute of the two fresh food products and the three processed food products, respectively. The WTP estimates represent the change in price premium that consumers are willing to pay for a change in each attribute. The results demonstrate the variation in the ranking of attributes among latent classes and types of products, indicating the importance of investigating heterogeneity of consumer preferences. From the negative signs on distance coefficients across all classes and five products, consumers have a lower willingness to pay for products with longer food miles. However, WTP estimates for distance (per km) is very small compared to other attributes, indicating that organic and supermarket (i.e. convenience) attributes are more important to consumers than the distance attribute. Participants in the *certification focus* class for all five products are willing to pay the most for organic certification. In addition, participants in the *certification focus* class are willing to pay the least premium for products with longer food miles, except for cheddar cheese. Findings for gala apple and pork

Table 4.5: WTP estimates from latent class model for two fresh food products

Attribute	Red tomato ($/kg)					Gala apple ($/kg)		
	Class1 Organic focus	Class2 Certification focus	Class3 Short chain focus	Class4 Convenience shoppers	Class5 Price sensitive	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers
DIST (per km)	-0.0008***	-0.0026***	-0.0005	-0.0003	-0.0002***	-0.0011***	-0.0002***	-0.0002*
NONC	0.467***	0.540**	-0.530	-3.148***	-0.039	0.114	-0.018	-0.303**
CERT	0.314**	1.303***	-0.113	-3.237***	-0.074	0.387***	-0.092	-0.224*
SHORT	-0.032	0.360*	1.007***	-0.693	-0.056	0.093	-0.013	0.084
INDP	-0.192	-0.316	0.263	1.053*	-0.219***	0.029	-0.112**	-0.118

*,**,***indicate that the parameter is significant at 10%,5%,1% level

Table 4.6: WTP estimates from latent class model for three processed food products

Attribute	Pork tenderloin ($/kg)		Whole grain bread ($/loaf)			Cheddar Cheese ($/kg)	
	Class1 Conventional shoppers	Class2 Certification focus	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers	Class1 Certification focus	Class2 Conventional shoppers
DIST (per km)	-0.0025***	-0.0039***	-0.0011***	-0.0009***	-0.0011	-0.0036***	-0.0046***
NONC	-1.172*	0.301	0.738***	-0.049	-2.085***	-1.039	-3.718***
CERT	0.616	2.146***	0.921***	0.209	-3.324***	2.387***	-2.547*
SHORT	-1.137*	-0.128	0.125	0.075	-0.240	0.252	-1.899*
INDP	-0.956*	-1.547***	-0.409**	-0.145	-0.799	-0.882	-2.177*

*,**,***indicate that the parameter is significant at 10%,5%,1% level

tenderloin reveal that the *conventional shoppers* class, who prefers not to consume organically grown products, has a higher willingness to pay for the product with fewer food miles than the *certification focus* class. Overall, these results suggest that organic consumers may be less likely to purchase local food products; however, it depends on which types of products and other product attributes.

Most participants in the *conventional shoppers* and *price sensitive* classes are willing to pay more to shop for their groceries at provincial and national supermarket chains. The highest WTP estimates on distribution channel attributes in the *short chain focus* and *convenience shoppers* classes for red tomato indicate that consumers perceive a higher value for purchasing fresh produce than processed food products at short supply chains. These niche consumer segments for red tomato suggest a new market segment, who value a benefit of a certain distribution channel, and opportunities for farmers or producers in the market for local/organic food.

To compare the marginal values of food miles among types of products, the WTP estimates are weighed by their class probability to obtain a weighted average WTP for each product. Evaluated at the same distance travelled by the product from the production point to the consumption point, the weighted average WTP estimates for local fresh foods (red tomato (-0.00022) and gala apple (-0.00021)) are higher than local processed foods (pork tenderloin (-0.00168), whole wheat bread (-0.00078), and cheddar cheese (-0.00197)). This indicates that disutility for the distance travelled by the food product is smaller for fresh produce than processed food products, so consumers are willing to pay more for local fresh produce than for local processed products.

To get more insight on the distribution of the WTP estimates for food miles (per kilometer) among five products, the WTP estimates for food miles on the percentage based average price for each product is calculated and shown in Figure 4.2. Red tomato has the highest deviation in the WTP estimates for the distance attribute followed by gala apple, pork tenderloin, whole grain bread, and cheddar cheese. This finding means that food miles do not hold the same value to all consumers. This result is supported by Grebitus et al. (2013), who studied consumers' valuation of extending food miles in conventional food products. In addition, other factors play an important role in the valuation of food miles such as: attitudes toward supporting local producers, improving environmental impacts, perception of food safety or health concerns, and socio-demographic characteristics (Yue and Tong, 2009; Cranfield et al., 2012; Swinnen et al., 2012; Campbell et al., 2013).

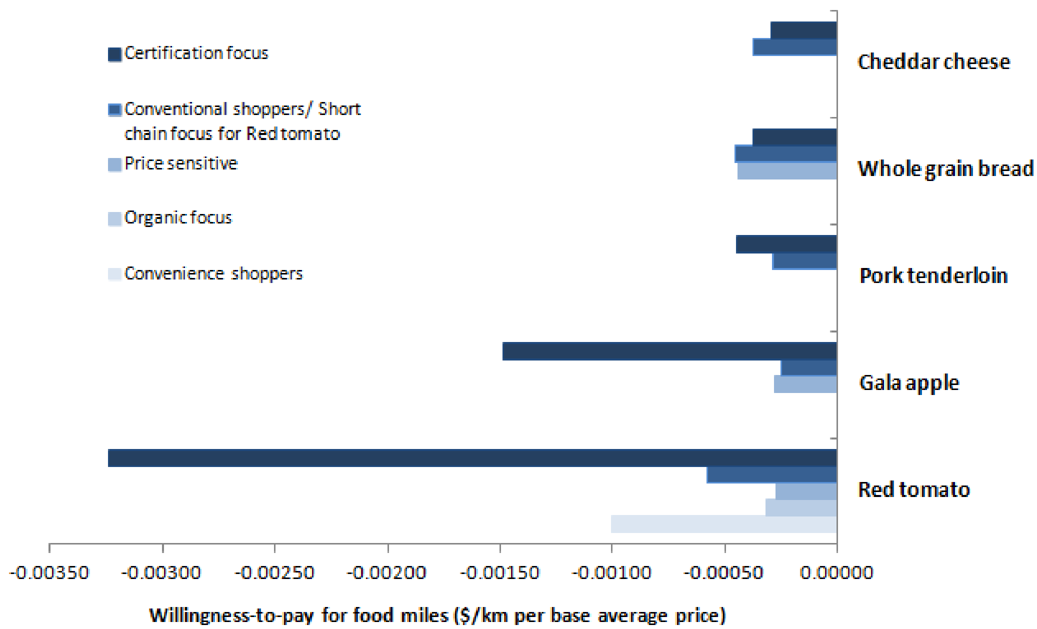

Figure 4.2: The willingness-to-pay estimates for distance travelled by the product (km) on the percentage based average price with five products

Overall, the results show that, on average, consumers gain (53.6%), lose (14.7%), or are indifferent (31.6%) to the presence of certification labels. To investigate how much retailers or producers can charge for a premium for organic certification, the difference between the WTP for non-certified and certified organic is calculated to obtain the percentage relative premium for certification as presented in Figure 4.3. Note that the percentage relative premium for certification is $\frac{WTP_{CERT} - WTP_{NONC}}{|WTP_{NONC}|} * 100$. Gala apple has the highest deviation of the relative premium for organic certification followed by whole grain bread, pork tenderloin, cheddar cheese, and red tomato. Participants are willing to pay a premium for organic certified pork tenderloin and cheddar cheese, while not all participants are willing to pay a premium for organic certified red tomato, gala apple, and whole grain bread. This indicates that some participants may lack trust in certification labels or perceive disutility from the presence of certification labels (Padel and Foster, 2005; Nilsson et al., 2006; Campbell et al., 2013). Furthermore, the presence of certification labels may not matter to consumers who focus on other product attributes such as distribution channels, food miles, or prices. In general, the authors suggest that the organic certification label carries a high relative premium to animal-based food products than to fresh and grain products.

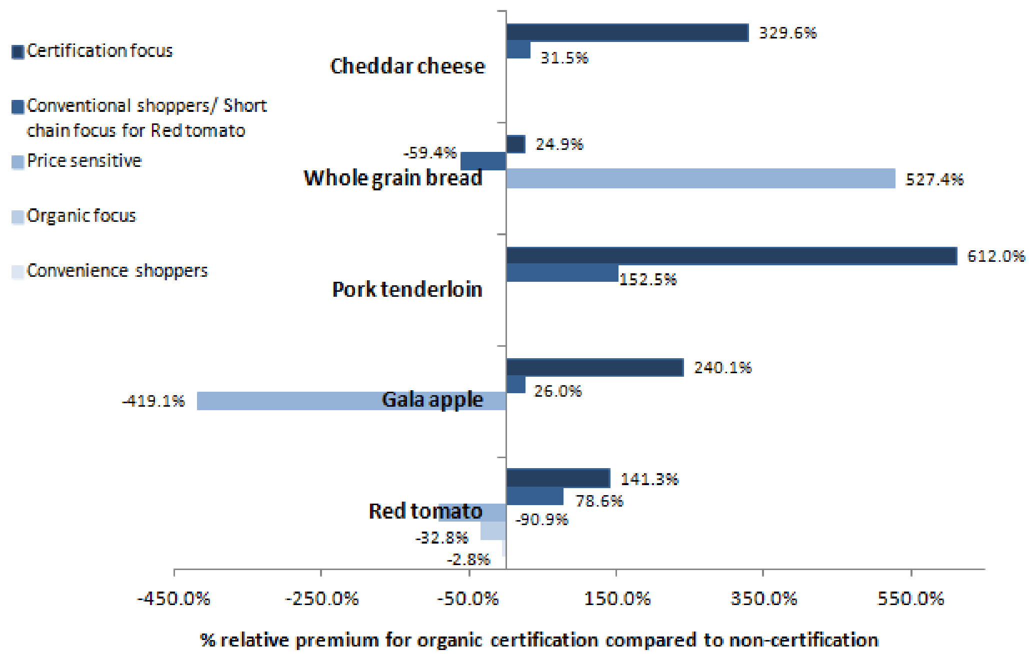

Figure 4.3: The percentage relative premium for organic certification with five products

In summary, the results from the latent class model present an interesting insight into preferences for local, organic and distribution channel as they differ among consumers. Consumers are diverse in how they value attributes within and among products. Adding more distance travelled by food products is unlikely to be preferred by all consumers. It is worth noting that the distance does not matter to consumers as much as other attributes;

however, it does matter with longer distance. Two relevant segments across five products are the *certification focus* and *conventional shoppers* classes.[11] In general, the *certification focus* class is much less price sensitive compared to the *conventional shoppers* or *price sensitive* classes. Moreover, some consumers do not see the organic certification label as an important quality signal in buying organic products.

Overall, consumer preferences are heterogeneous over local and organic attributes, but not heavily over the distribution channel attribute. The majority of consumers prefer to shop for their groceries at long chain channels or national/provincial supermarket chains. A few consumers perceive a higher utility from visiting short chains or independent stores, which may be associated with purchasing a product from a particular seller or vendor. The interaction between producers and consumers may influence consumers' attitude toward a product related to supporting environmental impacts and the local community, thereby leading to a higher willingness-to-pay for the product (Pine and Gilmore, 1998; Hunt, 2007; Swinnen et al., 2012). This leads to a new consumer segment who values the benefit of a certain distribution channel. These empirical findings provide weak support for the theoretical proposition in chapter 3, which states that consumers perceive a higher value for a product at short supply chains than at long supply chains. One reason is that the theoretical model (in chapter 3) captures only a horizontal dimension, while the analysis in this paper captures more dimensions of product attributes. As a result, consumer preferences for local and organic products are more complex than a horizontal dimension.

Different types of products affect consumer's WTP for each attribute differently. Local fresh produce carries a higher value for food miles than locally processed food products, but WTP estimates for distance is small when compared to other attributes. Similarly, distribution channel attributes appear to become more important to consumer preferences for fresh produce than processed food products. This is possibly related to the perishable

[11] Note that the *conventional shoppers* class does not contain in Red tomato since participants prefer shopping at short chains rather than long chains.

state of fresh produce compared to processed food products. In contrast, animal-based food products, carry a higher value for the organic certification label than fresh produce and bread products. Throughout this study, there is a market opportunity for local/organic products related to alternative distribution channels, which have increasingly become a new path for marketing strategies within the agri-food sector.

4.5 Conclusion

This study investigates the motivations behind consumer preferences for local and/or organic food products related to distribution channel attributes (short and long chains) using the latent class model. Red tomato and gala apple were chosen to represent fresh produce, and pork tenderloin, whole grain bread, and cheddar cheese were chosen to represent processed food products. Findings show that all five products contain at least two latent classes, revealing the heterogeneity of consumer preferences for local and/or organic products. In general, consumers are more likely to focus on local and/or organic attributes than distribution channel attributes. Consumers have a higher willingness to pay for food with fewer food miles. Fresh produce carries a higher value for food miles than processed food products. Almost half of respondents pay attention to organic certification labels, while others disregard organic certification labels or perceive disutility from the presence of certification. The latter group is an interesting outcome, indicating that not all consumers want to be informed about certification attributes. In addition, the *certification focus* class who prefers consuming non-certified or certified organic food products are less price sensitive than the *conventional shoppers* class.

One of the main findings for this paper is that consumers value a product associated with alternative distribution channels differently; some consumers prefer visiting short chains because they value the interaction with a particular seller or vendor and thus believe that a product supports the local community or improves the environmental impact. Others prefer shopping at long chains for different reasons (i.e. price or convenience). Thus, it is worth noting that Canadian consumers may be aware of other attitudinal factors related to distribution channel attributes that can drive up the willingness-to-pay for local and/or organic products, suggesting the emergence of a new market segment for the market of local and/or organic products.

From a marketing perspective, producers or retailers can position themselves by offering local and/or organic products, as well as choosing the right distribution channels to sell appropriate types of products. In addition, it is necessary to determine if premiums are substantial enough to cover the additional cost associated with the certification fee and travel distance from farms to selling locations. A manager at local farmers' markets needs to make sure that farmers or vendors sell local and/or organic products that reach the definition of local and the organic standard, as well as promotes local farmers' markets throughout the immediate community.

One limitation of this research is that comparisons between fresh produce and processed food products may be more efficient if both products come from the same product base. For example, if gala apple is used for fresh produce, apple sauce or apple cider can be used for processed food. Another limitation of this study is the issue of product choice design. It is challenging to examine product choice from a set of all possible attributes using choice experiments. There is a trade-off between the number of unlabelled alternatives and choice sets versus minimizing choice complexity. For future research, in a choice set, labeled alternatives by distribution channels (i.e. short chains or supermarkets) may be a more appropriate approach than unlabelled alternative (i.e. product 1 or 2). The use of labeled alternatives may help the respondents make more informed decisions and realistic choices. The last limitation is the dimensions of factors affecting consumer preferences for local/organic products. Findings show that attitudinal factors may influence consumer purchasing decisions about local/organic food products. Future research should investigate whether attitudes toward environmental impacts and local community support affect consumer preferences for local/organic food products related to food supply chains.

This paper provides two important contributions to the broader literature on consumer choice of food products (Yiridoe et al., 2005; Yue and Tong, 2009; Campbell et al., 2013), especially local and organic foods. First, results contribute to the theoretical proposition (in chapter 3) regarding the concept of experience economy related to food supply chains (which states that consumers are willing to pay more for the product, if they involve into a place or an event that provides some benefits to them). To address this contribution, the LCM is applied to analyze consumer preferences for local and organic products, which are sold at alternative distribution channels including both short and long supply chains. The empirical findings show a consumer segment that values the benefit of distribution channels, which provide support to the theoretical proposition (in chapter 3). Second, the paper contributes to the literature on consumer preferences for various food products with specific quality attributes (i.e. organic, local, animal welfare, environmental impacts) using the LCM approach (Hu et al., 2004; Nilsson et al., 2006; Innes and Hobbs, 2011; Ortega et al., 2011; Stolz et al., 2011) by focusing on the influence of distance travelled by the product and the choice of distribution channels in selling local/organic products to consumers. The empirical results show how length of distribution channel and the presence of organic certification versus non-certification are important to consumers' valuation of local/organic products. Overall, the market segments for five products have been explored to identifying the presence of preference heterogeneity and the pattern of consumer preferences within each segment. These interesting insights can help producers/retailers to understand Canadian consumers' choices in the market for local/organic products.

Chapter 5

Conclusions

Increasing consumer interest in specific quality attributes regarding agricultural production practices has led to a potential demand for understanding these markets and consumer needs. To address these issues, three essays were explored in different economic areas related to food product quality: third-party certification, the experience economy, and demand analysis. The results of this dissertation help to develop strategies related to the market for specific product quality and diversification of consumer preferences for particular attributes.

5.1 Main Conclusion of Essay 1

This essay provides a dynamic framework examining the interaction between a TPC and certified firms through collective reputation in the market for high-quality products. A differential game is applied to link the TPC and firms under two different decision rules: open-loop and Markovian strategies. These strategies differ in the manner that players update their decisions based on collective reputation. Previous studies have focused on reputation related to product quality or monitoring (McCluskey, 2000; Jahn et al., 2005; McCluskey and Loureiro, 2005), but a few papers have explored collective reputation in a market with quality attributes (Tirole, 1996; Marette and Crespi, 2003; Winfree and McCluskey, 2005). This study views collective reputation as an aggregation that is contributed from the interaction between the TPC's monitoring and firm's quality. The model also develops the concept of public control (i.e. the government enforcement) and the punishment for cheating when firms provide product quality lower than a quality standard.

The model explores the impact of externalities on the market with collective reputation under alternative game strategies, by showing that collective reputation in a benchmark social planner case is higher than in a decentralized case. In the non-cooperative case, as the number of certified firms increases, free-riding may lead to reduced industry reputation, implying that each firm confers a negative externality on other firms through its quality decision and ignores this externality. As well, outcomes show that the strategic interaction between the TPC and firms depends on the punishment for cheating. In addition, the results from comparative dynamic analysis reveal that public control may be required in the market for high-quality products to maintain collective reputation as a reliable quality signal. Finally, a market for food products with quality attributes mainly depends on consumers' trust in a quality signal (i.e. reputation and certification), so it is important to improve the efficiency of the certification system and prevent fraud activities.

The theoretical findings in this paper contribute to a model of (collective) reputation (Shapiro, 1983; Tirole, 1996; Marette and Crespi, 2003; Winfree and McCluskey, 2005) and the certification system (Tanner, 2000; Deaton, 2004; Hatanaka et al., 2005; Duflo et al., 2013), especially the TPCs' monitoring, in a dynamic framework. This essay analyzes outcomes of a collective reputation model under various market structures that differ according to decision rules and agent's behavior. The theoretical findings will help food chain actors (i.e. the TPC, firms, and the government) to ensure that collective reputation can be used as a control mechanism and serve as a credible quality signal in the high-quality market.

There are issues that are not addressed in this paper. Future research could continue to investigate a specific functional form of the firm's strategy in the Markovian strategy case. This paper has addressed only the dynamic model in a simultaneous game, so it would be interesting to examine how the results of externalities differ from the case of a sequential game. Furthermore, in the model, the cost of certification is assumed to be the same for all firms. For future research, the construction of a model that allows for different costs of certification could be considered.

5.2 Main Conclusion of Essay 2

In the second essay, Hotelling's location model with a two-stage game is used to analyze competition between a short and a long supply chain using transaction experience. According to the concept of the experience economy (Pine and Gilmore, 1998; Swinnen et al., 2012), the authors define transaction experience as a benefit (that involves feelings or emotions, and yields utility) associated with purchasing a product from a unique shopping location, and from a particular seller. Some consumers buy a product at short supply chains (i.e. farmers' markets) because consumers value the interaction between producers and consumers. Others buy a product at long supply chains (i.e. supermarkets) because of in-store environment, price, or convenience. Therefore, alternative shopping locations allow sellers/vendors to interact with consumers and create networks through transaction experience (Hunt, 2007; Thilmany et al., 2008; Yue and Tong, 2009; Adams and Salois, 2010). The model links transaction experience and the interaction between producers and consumers through two-sided network effects (Farrell and Klemperer, 2007).

Since network effects can be influenced by transaction experience, network effects are analyzed into two cases: exogenous and endogenous network effects. Results suggest that the endogenous network effect model performs better than the exogenous network effect model. Price competition depends on the value of network effects between firms and consumers, as well as competition in experience. In addition, the results show that the larger the difference in the number of product choices between short and long supply chains, the more competitive the market. This means that when network effects exist, firms may prefer less product differentiation, which differs from the standard outcome of Hotelling's location model (D'Aspremont et al., 1979) where maximum product differentiation is preferred.

This paper contributes to economic and marketing literature on the concept of experience (Pine and Gilmore, 1998; Swinnen et al., 2012) by linking transaction experience and the structure of food supply chains. In addition, there are a number of bodies of literature on network effects applied to communication technology, payment methods, and hardware-software, but not to agri-food sector (Farrell and Klemperer, 2007; Shy, 2011). The theoretical findings in this paper give additional insight into the broader literature on network effects in the context of food product quality by providing a better understanding of some consumers who value purchasing a product from a unique shopping location and a particular seller. Results also help government and producers in their attempt to promote a product with specific benefits (i.e. supporting local producers or environmental impacts). In particular, producers can develop their marketing strategies using transaction experience and make decisions on where they should sell the product.

There are some issues with the assumptions and recommendations for future research to this study. In the case of endogenous network effects, an analytical result of specific functional forms for network effects is derived, thus the results may not be generalized to the model. Despite this limitation, the theoretical results present new insights into firms' competitive strategies in the market for a product associated with experience. Other functional forms of network effects should be examined to compare with the results presented in this paper. In addition, future research could consider the case of an asymmetric game. To support this theoretical model, an empirical model that allows for capturing consumers' attitude toward a product related to experience could be the subject of future research.

5.3 Main Conclusion of Essay 3

This essay examines whether there is heterogeneity of consumer preference for local and/or organic food related to distance and distribution channels, using the latent class model. Since the effect of shopping locations on consumers' attitudes toward local/organic products are not clear (Yiridoe et al., 2005; Yue and Tong, 2009; Campbell et al., 2013), this essay contributes new knowledge about whether different distribution channels or distance (travelled by the product in km) affect the consumers' motivation to buy local/organic products. An online survey and a choice experiment are designed to collect the state choice data. Two fresh food products (red tomato and gala apple) and three processed food products (pork tenderloin, whole grain bread, and cheddar cheese) were included in the analysis. The survey shows that most participants prefer to shop for their groceries at long supply chains (i.e. provincial/national supermarket chains) rather than short supply chains (i.e. farmers' markets).

Overall, findings reveal that consumer preferences for local/organic/distribution channel attributes vary across consumers, indicating the heterogeneity of consumer preferences for these attributes. In general, consumers have a higher willingness to pay for a product with fewer food miles. One interesting result shows that distance does not matter as much as organic certification or shopping at supermarket chains. The authors suggest that even though a discount on consumers' willingness-to-pay for distance is very small compared to other attributes, it is possible that long distance travelling by the product may offset willingness-to-pay for other attributes (i.e. organic). Some consumers, who gain utility from purchasing certified organic food products, are likely to be less price sensitive, while others, who are less likely to buy certified organic products, are likely to be more price sensitive.

In general, consumers have stronger preferences for local and organic attributes than for the distribution channel attribute. The empirical results also show that there may be preference heterogeneity in consumers' attitude toward a product related to experience (i.e. a positive impact of supporting local community on consumers' valuation when consumers visiting farmers' markets); this is evidently shown by a few consumers who prefer to shop at short chains rather than long chains. Hence, findings suggest that price may be not the most important factor for some consumers' choices; more important is how consumers perceive the value of local/organic products related to distance or shopping locations, and is perhaps based on consumers' attitude toward a benefit from purchasing the product.

This paper contributes to the literature on consumer preferences for local/organic products (Yiridoe et al., 2005; Yue and Tong, 2009; Stolz et al., 2011; Campbell et al., 2013) by identifying consumer segments related to distribution channels and distance. Empirical results in this essay would help producers and marketing developers to target the right consumer segment, promote specific quality attributes that consumers' value, and decide on the selling location, so that they can create opportunity and become more competitive in the market for local/organic foods. Defining the term local as distance travelled by the product (in km) is useful for estimating the cost and benefit of transportation and choices of selling locations. Furthermore, findings help the government to promote local food and evaluate the definition of local (i.e. a local food Act, which is implemented by OMAF).

Future research can draw from the empirical results and limitations in several ways. First, the survey data were analyzed at the national level, so the results may not fully explain the term local food as it relates to specific geographical area. A breakdown of the survey analysis into provincial levels can be considered for future research. Second, it would be interesting to estimate consumer preferences for local/organic food related to distribution channel using different types of food products from this analysis. Next, findings show that some consumers have a positive willingness-to-pay for food products sold at short chains, so attitudinal factors (i.e. supporting local producers or environmental impacts) may play an important role in consumer purchasing decisions. Future research could investigate whether these factors matter with respect to consumers' attitude toward local/organic products.

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Appendix

A.1 Appendix of Essay 1

A.1.1 Proof of stability properties in the benchmark case

To determine the stability properties of the steady state point $\{q^*(t)R^*(t)\}$, the determinant of the coefficient matrix J is calculated as follows:

$$J = \begin{bmatrix} \frac{\partial \dot{q}}{\partial q} & \frac{\partial \dot{q}}{\partial R} \\ \frac{\partial \dot{R}}{\partial q} & \frac{\partial \dot{R}}{\partial R} \end{bmatrix} = \begin{bmatrix} \rho + \gamma\delta & -\frac{G''(R)\gamma}{g''(q)} \\ \gamma & -\delta\gamma \end{bmatrix}$$

The determinant of matrix J is

$$|J| = -\delta\gamma(\rho + \gamma\delta) + \gamma^2 \frac{G''(R)}{g''(q)} < 0 \tag{A-1}$$

The characteristic equation $r_J^2 - tr(J)r_J + |J| = 0$ where $(tr(J))^2 - 4|J| > 0$ where r_J is the characteristic roots and $tr(J)$ is the trace of matrix J. The solutions of the system of differential equations are real and distinct. The equilibrium is saddle point equilibrium because $|J| < 0$ and the roots have opposite sign.

A.1.2 Proof of stability properties in the third-party certifier case

To determine the stability properties of the steady state point $\{m^*(t), R^*(t)\}$, the determinant of the coefficient matrix A and the characteristic roots are calculated as follows:

$$A = \begin{bmatrix} \frac{\partial \dot{m}}{\partial m} & \frac{\partial \dot{m}}{\partial R} \\ \frac{\partial \dot{R}}{\partial m} & \frac{\partial \dot{R}}{\partial R} \end{bmatrix} = \begin{bmatrix} \rho + \gamma\delta & -\frac{\gamma E(w''(R))}{c''(m)} \\ \gamma & -\delta\gamma \end{bmatrix}$$

where $E(w''(R)) = \beta w''(R - \varepsilon) + (1 - \beta)w''(R)$ The determinant of A is

$$|A| = -\delta\gamma(\rho + \gamma\delta) + \gamma^2 \frac{E(w''(R))}{c''(m)} < 0 \tag{A-2}$$

The characteristic equation $r_A^2 - tr(A)r_A + |A| = 0$ where $(tr(A))^2 - 4|A| > 0$ where r_A is the characteristic roots and $tr(A)$ is the trace of matrix A. The solutions of the system of differential equations are real and distinct. The equilibrium is saddle point equilibrium because $|A| < 0$ and the roots have opposite sign.

A.1.3 Proof of stability properties in the cooperative case

To determine the stability properties of the steady state point $\{q^*(t), R^*(t)\}$, the determinant of the coefficient matrix B and the characteristic roots are calculated as follows:

$$B = \begin{bmatrix} \frac{\partial \dot{q}}{\partial m} & \frac{\partial \dot{q}}{\partial R} \\ \frac{\partial \dot{R}}{\partial m} & \frac{\partial \dot{R}}{\partial R} \end{bmatrix} = \begin{bmatrix} \rho + \gamma\delta & -\frac{\gamma(w''(R) - E[G''(R)])}{g''(q)} \\ \gamma q & -\delta\gamma \end{bmatrix}$$

The determinant of B is

$$|B| = -\delta\gamma(\rho + \gamma\delta) - \frac{\gamma^2 q(w''(R) - E[G''(R)])}{g''(q)} < 0 \tag{A-3}$$

where $E[G''(R)] = m\theta G''(R - \varepsilon) + (1 - m\theta)G''(R)$ and $|E[G''(R)]| > |w''(R)|$ by differentiating the equation (2.35) at the equilibrium. The characteristic equation $r_B^2 - tr(B)r_B + |B| = 0$ where $(tr(B))^2 - 4|B| > 0$ where r_B is the characteristic roots and $tr(B)$ is the trace of matrix B. The solutions of the system of differential equations are real and distinct. The equilibrium is saddle point equilibrium because $|B| < 0$ and the roots have opposite sign.

A.1.4 Proof of stability properties in the non-cooperative case

To determine the stability properties of the steady state point $\{\tilde{q}(t), \tilde{R}(t)\}$, the determinant of the coefficient matrix C and the characteristic roots are calculated as follows:

$$C = \begin{bmatrix} \frac{\partial \dot{q}}{\partial m} & \frac{\partial \dot{q}}{\partial R} \\ \frac{\partial \dot{R}}{\partial m} & \frac{\partial \dot{R}}{\partial R} \end{bmatrix} = \begin{bmatrix} \rho + \gamma\delta & -\frac{\gamma(w''(R) - E[G''(R)])}{g''(q)N} \\ \frac{\gamma q}{N} & -\delta\gamma \end{bmatrix}$$

The determinant of C is

$$|C| = -\delta\gamma(\rho+\gamma\delta) - \frac{\gamma^2 q(w''(R) - E[G''(R)])}{N^2 g''(q)} < 0 \tag{A-4}$$

where $E[G''(R)] = m\theta G''(R-\varepsilon) + (1-m\theta)G''(R)$ and $|E[G''(R)]| > |w''(R)|$. The characteristic equation $r_C^2 - tr(C)r_C + |C| = 0$ where $(tr(C))^2 - 4|C| > 0$ where r_C is the characteristic roots and $tr(C)$ is the trace of matrix C. The solutions of the system of differential equations are real and distinct. The equilibrium is saddle point equilibrium because $|C| < 0$ and the roots have opposite sign.

A.2 Appendix of Essay 2

A.2.1 Deriving the condition for endogenous network effects

From the solution for prices, $p_R^*(e_R)$ and $p_M^*(e_R)$, in the second-stage game, the profit function for R is written as $\pi_R(e_R)$:

$$\pi_R(e_R) = \hat{x}(p_R^*, p_M^*, e_R)\left[p_R^* - c_R + \alpha_R(e_R)\right] \tag{A-5}$$

Note that $\bar{e}_M$ is fixed at 1. Using the envelope theorem, differentiating (A-5) with respect with e_R yields the effect of a change in e_R on $\pi_R(e_R)$:

$$\frac{\partial \pi_R(e_R)}{\partial e_R} = \hat{x}(p_R^*, p_M^*, e_R)\left(\frac{\partial p_R^*}{\partial e_R} + \frac{\partial \alpha_R(e_R)}{\partial e_R}\right) + \left[p_R^* - c_R + \alpha_R(e_R)\right]\left(\frac{\partial \hat{x}}{\partial p_R}\frac{\partial p_R^*}{\partial e_R} + \frac{\partial \hat{x}}{\partial p_M}\frac{\partial p_M^*}{\partial e_R} + \frac{\partial \hat{x}}{\partial e_R}\right) \tag{A-6}$$

where $\frac{\partial p_R^*}{\partial e_R}$ is zero due to the envelope theorem. The first term is always positive because of $\frac{\partial \alpha_R(e_R)}{\partial e_R} > 0$. Hence, the sign of $\frac{\partial \pi_R(e_R)}{\partial e_R}$ depends on two terms: the effect of e_R on the rival's price ($\frac{\partial \hat{x}}{\partial p_M}\frac{\partial p_M^*}{\partial e_R}$) and the effect of e_R on the market share ($\frac{\partial \hat{x}}{\partial e_R}$). Then, the first derivative of

(A-5) with respect to e_R is given by

$$\frac{\partial \pi_R(e_R)}{\partial e_R} = \hat{x}(p_R^*, p_M^*, e_R)\frac{\partial \alpha_R(e_R)}{\partial e_R} + \frac{p_R^* - c_R + \alpha_R(e_R)}{6\Delta e}\left(2\left[\frac{\partial \alpha_{CR}(e_R)}{\partial e_R} - \frac{\partial \alpha_{CM}(e_R)}{\partial e_R}\right] - \frac{\partial \alpha_R(e_R)}{\partial e_R} - 2\frac{\partial \alpha_M(e_R)}{\partial e_R} + \frac{\Delta NE}{\Delta e} - 1 - 3e_R\right) \quad \text{(A-7)}$$

In the case of no network effect, the sign of second term is negative, so $\frac{\partial \pi_R(e_R)}{\partial e_R} < 0$, then R prefers to locate at $e_R = 0$. This turns to the general result of maximum differentiation (D'Aspremont et al., 1979). When network effects exist, the sign of $\frac{\partial \pi_R(e_R)}{\partial e_R}$ is ambiguous, thus more assumptions of network effects as a function of transaction experience are needed. Following specific functional forms of network effects (3.15), the first derivative of (A-5) with respect with e_R becomes

$$\frac{\partial \pi_R(e_R)}{\partial e_R} = \frac{\hat{x}}{(e_R+1)^2} + \frac{p_R^* - c_R + \alpha_R(e_R)}{6\Delta e}\left(\frac{4\theta}{(\theta e_R+1)^2} + \frac{1}{(e_R+1)^2} + \frac{\Delta NE(e_R)}{\Delta e} - 1 - 3e_R\right) \quad \text{(A-8)}$$

where $\Delta e = 1 - e_R$ and $\Delta NE(e_R) = \frac{\theta e_R - 1}{\theta e_R + 1} + \frac{e_R - 1}{e_R + 1}$. From the condition (A-8), if e_R is in the interval [0,1] and θ is large enough to dominate the negative term of R's competition in experience, the term $\frac{\partial \pi_R(e_R)}{\partial e_R}$ is positive. To derive the condition of θ, substituting $e_R = 0$ into (A-8) and then $\frac{\partial \pi_R(e_R)}{\partial e_R} > 0$ if the condition of θ satisfies $\theta > \frac{1}{2}(1 - 9\hat{x})$. When $e_R = 0$, the term $\frac{1}{2}(1-9\hat{x})$ is negative, so the condition of θ satisfies. From the solutions for transaction experience $e_R^*(\theta)$ from equation (3.16), the value of $e_R^*(\theta)$ satisfies the condition of θ since $\frac{\partial \hat{x}}{\partial e_R} > 0$. Thus, $\frac{\partial \pi_R(e_R)}{\partial e_R} > 0$ and R has an incentive to locate inside the chain length [0,1].

A.3 Appendix of Essay 3

A.3.1 Descriptive statistics of the survey

Table A.3.1: Descriptive statistics of the survey for five food products

	Total sample	Red tomato	Gala apple	Pork tenderloin	Whole grain bread	Cheddar cheese	Canadian census
Sample size	2,006	399	400	403	404	400	33,476,688
Age (%)							
18-24	2.6	2.5	2.0	2.2	3.2	3.0	11.6
25-34	13.7	14.8	13.0	15.9	11.4	13.3	16.3
35-44	19.8	18.8	17.8	22.1	20.1	20.3	16.9
45-54	26.6	26.6	27.8	25.8	26.2	26.8	20.1
55-64	16.3	18.6	15.0	12.7	17.1	18.0	16.5
>65	21.1	18.8	24.5	21.3	22.0	18.8	18.6
Gender (%)							
Male	18.1	18.8	19.3	18.4	13.4	20.8	49.0
Female	81.9	81.2	80.8	81.6	86.6	79.3	51.0
Education (%)							
Less than high school	4.9	5.3	5.3	3.5	6.4	4.0	12.7
Graduated high school	18.5	18.3	19.5	19.4	18.1	17.5	23.2
College/CEGEP/Trade School	37.4	40.9	35.0	35.0	39.1	37.3	38.2
University undergraduate degree	31.7	29.3	32.8	32.8	30.9	32.8	19.9
University graduate degree	6.9	5.0	7.3	9.4	5.0	8.0	6.0
No Answer	0.5	1.3	0.3	0.0	0.5	0.5	
Household income (%)							
Less than $20,000	8.3	7.5	7.8	7.7	10.7	7.8	5.1
$20,000-$39,999	19.9	19.6	21.8	20.6	18.3	19.3	14.0
$40,000-$59,999	21.8	19.8	21.0	25.6	20.1	22.5	16.0
$60,000-$79,999	12.9	14.5	11.5	11.9	14.4	12.0	15.2
$80,000-$99,999	9.1	8.3	9.3	9.7	9.2	9.3	13.1
$100,000 or more	10.0	10.5	11.5	8.2	9.4	10.5	36.6
Prefer not to answer	18.1	19.8	17.8	16.4	18.3	18.8	
Family size (%)							
Less than 2	33.9	34.3	36.5	35.5	32.7	30.3	27.6
2 to 3	54.1	55.4	51.5	51.9	54.5	57.5	49.7
more than 3	12.0	10.3	12.0	12.7	12.9	12.3	22.7
Province (%)							
Alberta	8.6	7.5	7.3	8.7	9.2	10.5	11.1
British Columbia	14.9	16.8	16.8	12.4	15.1	13.5	13.5
Manitoba	4.9	3.8	5.8	5.0	5.0	5.0	3.6
New Brunswick	2.5	1.8	2.0	3.0	3.5	2.3	2.2
Newfoundland	0.7	0.5	1.0	0.7	0.7	0.5	1.5
Nova Scotia	2.8	2.8	2.8	2.0	3.2	3.3	2.8
Ontario	42.8	43.1	40.3	45.7	41.6	43.3	38.7
Prince Edward Island	0.5	0.5	0.5	0.5	0.5	0.3	0.4
Quebec	20.4	21.6	21.5	20.1	19.6	19.5	23.4
Saskatchewan	1.9	1.8	2.3	2.0	1.7	2.0	3.1

Source: Statistics Canada, 2011 Census of Population.

A.3.2 Information criteria for determining the optimal number of classes for five prducts

Table A.3.2: Information criteria for red tomato

Classes	Log likelihood (L)	Number of parameters (m)	AIC	CAIC	BIC	$\bar{\rho}^2$
2	-2187.90	15	4405.79	4480.63	4465.63	0.202
3	-2012.87	23	4071.73	4186.48	4163.48	0.262
4	-1975.39	31	4012.77	4167.43	4136.43	0.273
5	-1932.56	39	3943.12	4137.69	4098.69	0.286
6	-1917.76	47	3929.53	4164.01	4117.01	0.288
7	-1897.27	55	3904.54	4178.93	4123.93	0.293

Table A.3.3: Information criteria for gala apple

Classes	Log likelihood (L)	Number of parameters (m)	AIC	CAIC	BIC	$\bar{\rho}^2$
2	-2280.00	15	4590.00	4664.87	4649.87	0.180
3	-2166.77	23	4379.54	4494.34	4471.34	0.218
4	-2092.82	31	4247.64	4402.37	4371.37	0.241
5	-2053.88	39	4185.75	4380.42	4341.42	0.253
6	-2040.38	47	4174.77	4409.37	4362.37	0.254
7	-2010.74	55	4131.47	4406.00	4351.00	0.262

Table A.3.4: Information criteria for pork tenderloin

Classes	Log likelihood (L)	Number of parameters (m)	AIC	CAIC	BIC	$\bar{\rho}^2$
2	-2185.11	15	4400.22	4475.20	4460.20	0.242
3	-2079.35	23	4204.69	4319.67	4296.67	0.276
4	-1995.53	31	4053.05	4208.02	4177.02	0.302
5	-1945.91	39	3969.81	4164.77	4125.77	0.316
6	-1912.47	47	3918.94	4153.89	4106.89	0.325
7	-1900.44	55	3910.88	4185.82	4130.82	0.326

Table A.3.5: Information criteria for whole grain bread

Classes	Log likelihood (L)	Number of parameters (m)	AIC	CAIC	BIC	$\bar{\rho}^2$
2	-2282.98	15	4595.97	4670.99	4655.99	0.223
3	-2143.14	23	4332.28	4447.32	4424.32	0.267
4	-2051.44	31	4164.87	4319.92	4288.92	0.296
5	-2015.31	39	4108.63	4303.68	4264.68	0.305
6	-1986.16	47	4066.32	4301.38	4254.38	0.312
7	-1967.58	55	4045.16	4320.24	4265.24	0.316

Table A.3.6: Information criteria for cheddar cheese

Classes	Log likelihood (L)	Number of parameters (m)	AIC	CAIC	BIC	$\bar{\rho}^2$
2	-2233.60	15	4497.19	4572.06	4557.06	0.227
3	-2111.49	23	4268.98	4383.79	4360.79	0.266
4	-1986.33	31	4034.66	4189.39	4158.39	0.307
5	-1938.24	39	3954.48	4149.15	4110.15	0.320
6	-1919.00	47	3931.99	4166.59	4119.59	0.324
7	-1885.24	55	3880.47	4155.00	4100.00	0.333

A.3.3 Likelihood ratio test and the results of the parameter and WTP estimates of full model for five products

Table A.3.7: Likelihood ratio test for adding *PROV*

	Classes	Full model	Restricted model	Likelihood ratio (LR)	df	p-value
Red tomato	5	-1925.06	-1932.56	15.00	1	0.0001
Gala apple	3	-2163.50	-2166.77	6.537	1	0.0106
Pork tenderloin	2	-2183.89	-2185.11	2.44	1	0.1184
Whole grain bread	3	-2138.68	-2143.14	8.91	1	0.0028
Cheddar cheese	2	-2233.45	-2233.60	0.29	1	0.5892

Table A.3.8: Estimates for the LCM for two fresh food products (full model)

Attribute	Red tomato					Gala apple		
	Class1 Organic focus	Class2 Certification focus	Class3 Short chain focus	Class4 Convenience shoppers	Class5 Price sensitive	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers
PRICE	-1.995***	-0.580***	-1.245***	-2.036***	-5.210***	-1.027***	-4.753***	-2.336***
	(0.338)	(0.104)	(0.339)	(0.736)	(0.523)	0.099	0.707	0.285
DIST	-0.0015***	-0.0015***	-0.0007	-0.0004	-0.0011***	-0.0012***	-0.0009***	-0.0004*
	(0.0003)	(0.0001)	(0.0005)	(0.0010)	(0.0002)	(0.0001)	(0.0003)	(0.0003)
NONC	0.971***	0.309***	-0.669	-6.201***	-0.154	0.130	-0.026	-0.782***
	(0.341)	(0.117)	(0.420)	(1.401)	(0.249)	(0.109)	(0.238)	(0.251)
CERT	0.668**	0.728***	-0.141	-6.326***	-0.261	0.412***	-0.340	-0.598**
	(0.306)	(0.115)	(0.397)	(1.724)	(0.233)	(0.114)	(0.252)	(0.260)
FARM	-0.020	0.356***	1.637***	-0.769	0.060	0.058	0.199	0.271
	(0.361)	(0.139)	(0.567)	(1.131)	(0.302)	(0.115)	(0.266)	(0.259)
INDP	-0.266	-0.034	0.685	2.685*	-0.891***	-0.034	-0.206	-0.150
	(0.280)	(0.132)	(0.570)	(1.440)	(0.269)	(0.116)	(0.258)	(0.284)
PROV	0.148	0.276***	0.840	1.128	0.629**	-0.137	0.587**	0.287
	(0.299)	(0.136)	(0.632)	(1.204)	(0.263)	(0.120)	(0.268)	(0.289)
ASC	2.701***	3.389***	-1.288**	5.740***	12.126***	3.066***	11.567***	1.535***
	(0.526)	(0.357)	(0.655)	(1.612)	(1.021)	(0.239)	(1.326)	(0.368)
Class Probability	0.127	0.335	0.104	0.025	0.409	0.448	0.357	0.195
Observations	9576					9600		
PseudoR^2	0.303					0.227		
Log-likelihood	-1925.06					-2163.50		

*,**,***indicate that the parameter is significant at 10%,5%,1% level.

Table A.3.9: Estimates for the LCM for three processed food products

Attribute	Pork tenderloin		Whole grain bread			Cheddar Cheese	
	Class1 Conventional shoppers	Class2 Certification focus	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers	Class1 Certification focus	Class2 Conventional shoppers
PRICE	-0.301***	-0.178***	-0.571***	-1.187***	-0.503***	-0.127***	-0.191***
	(0.024)	(0.008)	(0.032)	(0.088)	(0.112)	(0.005)	(0.02)
DIST	-0.0008***	-0.0007***	-0.0006***	-0.0011***	-0.0006	-0.0005***	-0.0009***
	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)	(0.0002)
NONC	-0.351*	0.049	0.416***	-0.055	-1.054***	-0.132	-0.713***
	(0.181)	(0.088)	(0.104)	(0.187)	(0.310)	(0.083)	(0.199)
CERT	0.185	0.393***	0.538***	0.285	-1.670***	0.303***	-0.481**
	(0.17)	(0.087)	(0.101)	(0.174)	(0.439)	(0.084)	(0.202)
SHORT	-0.291	0.087	0.220*	0.264	-0.156	0.049	-0.321
	(0.195)	(0.104)	(0.122)	(0.191)	(0.365)	(0.096)	(0.234)
INDP	-0.240	-0.167	-0.094	0.001	-0.409	-0.093	-0.374
	(0.194)	(0.108)	(0.125)	(0.208)	(0.410)	(0.102)	(0.241)
PROV	0.103	0.210**	0.275**	0.314*	0.012	0.035	0.086
	(0.192)	(0.104)	(0.118)	(0.185)	(0.343)	(0.098)	(0.217)
ASC	2.370***	4.723***	5.534***	4.849***	0.409	4.493***	2.196***
	(0.31)	(0.188)	(0.338)	(0.394)	(0.513)	(0.169)	(0.379)
Class Probability	0.386	0.614	0.467	0.330	0.202	0.677	0.323
Observations	9672		9696			9600	
PseudoR^2	0.248		0.277			0.232	
Log-likelihood	-2182.89		-2138.68			-2233.45	

*,**,***indicate that the parameter is significant at 10%,5%,1% level.

Table A.3.10: WTP estimates from the LCM for two fresh food products

Attribute	Red tomato ($/kg)					Gala apple ($/kg)		
	Class1 Organic focus	Class2 Certification focus	Class3 Short chain focus	Class4 Convenience shoppers	Class5 Price sensitive	Class1 Certification focus	Class2 Price focus	Class3 Conventional shoppers
DIST (per km)	-0.0008***	-0.0025***	-0.0006	-0.0002	-0.0002***	-0.0011***	-0.0002***	-0.0002***
NONC	0.487***	0.532***	-0.538	-3.045***	-0.030	0.126	-0.006	-0.335***
CERT	0.335**	1.255***	-0.113	-3.107***	-0.050	0.401***	-0.072	-0.256**
SHORT	-0.010	0.613***	1.315***	-0.378	0.011	0.056	0.042	0.116
INDP	-0.133	-0.059	0.551	1.319*	-0.171**	-0.033	-0.043	-0.064
PROV	0.074	0.476**	0.675	0.554	0.121***	-0.134	0.124**	0.123

*,**,***indicate that the parameter is significant at 10%,5%,1% level

Table A.3.11: WTP estimates from the LCM for three processed food products

Attribute	Pork tenderloin ($/kg)		Whole grain bread ($/loaf)			Cheddar Cheese ($/kg)	
	Class1 Conventional shoppers	Class2 Certification focus	Class1 Certification focus	Class2 Price sensitive	Class3 Conventional shoppers	Class1 Certification focus	Class2 Conventional shoppers
DIST (per km)	-0.0025***	-0.0039***	-0.0011***	-0.0009***	-0.0012	-0.0036 ***	-0.0046***
NONC	-1.167*	0.276	0.729***	-0.046	-2.094***	-1.045	-3.727***
CERT	0.616	2.206***	0.942***	0.240	-3.318***	2.394***	-2.514**
SHORT	-0.967	0.487	0.385*	0.208	-0.310	0.389	-1.679
INDP	-0.799	-0.938	-0.165	0.001	-0.814	-0.735	-1.952
PROV	0.341	1.179**	0.482**	0.264*	0.024	0.276	0.448

*,**,***indicate that the parameter is significant at 10%,5%,1% level