Three Essays on Informal and Formal Food Markets

by

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Abstract

Understanding individual and organizational behaviour in reaction to changes in the informal and formal food markets has been an essential topic in economics. This dissertation explores the solutions individuals in a rural economy and retail firms in food markets use to cope with external changes. The first study focuses on the effect of gift-giving and kinship networks on household food security in rural Tanzania. The second and third studies examine how retailers use private labels (PLs) in vertical competition and product line choices in horizontal competition, respectively.

The main objective of the first study is to examine the effect of food gifting and kinship on household food security and incentive to exert self-protection effort. Using data collected in rural Tanzania, the results show that food gifting, either within or outside kinship networks, does not have a significant impact on household food security. The Food Security Scores (FCSs), a measurement of household food security status, for households engaging in food gifting within kinship networks do not significantly differ from those engaging in food gifting outside kinship networks. This study also confirms the free-rider effect of kinship sharing norms. Kinship appears to attenuate poor households' incentive to exert self-protection efforts in a high-risk environment.

The second paper examines the strategic roles of PLs in the retailer-manufacturer relationship when the external weather condition changes. By estimating a structural demand-supply model, I find that it is advantageous for the retailer to use PLs in the competition with manufacturers. As temperature increases, market shares of PLs increase faster than NBs. PLs are not only a source of profit for the retailer but also a strategic tool to gain bargaining power over national brand (NB) manufacturers.

The third paper explores retailers' product line strategy in a differentiated food market, with an objective to identify why some retailers (e.g., Whole Foods Market) choose to specialize in a niche market while product proliferation has become a prevailing strategy for other retailers. This study examines the "halo effect", held by consumers for the retailers who sell exclusively high-quality products, on their product line choice. Through a theoretical model where the retailer halo is incorporated, I find that retailers can benefit from product line specialization. The results show that without the halo effect, both retailers choose a full product line. In the presence of the halo effect, a retailer can be better off with product line specialization, i.e., providing a restricted product line that specializes in the high-quality niche market.

Preface

This dissertation is an original work by Shaoyan Sun under the supervision of Dr. Philippe Marcoul and Dr. Henry An. The research project of Chapter 2 received research ethics approval from the University of Alberta Research Ethics Board, Project Name "Integrating dairy goats and root crop production for increasing food, nutrition and income security of smallholder farmers in Tanzania", CIFSRF No.106512. No part of this dissertation has been previously published.

Dedication

This thesis is dedicated to my parents, my husband, and my son. This endeavour would not have been successful without unconditional support, both physically and mentally, throughout my life from my parents Yongwei Sun and Lina Gao. My husband, Peng Shao, is a source of great inspiration, suupport, and confidence for me. My dream will not come true without him. Our son Andrew Shao supports and blesses me in his own way with lovely hugs, smiling face, and sweet kisses.

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Chapter 1

Introduction

1.1 Thesis Overview

Human and firm behaviour is affected by unexpected changes in both informal and formal food markets. For example, a change in weather may result in serious threats to food security for small-holder farmers in rural economies; the ever-changing consumer demand can also lead to strategic adjustments of firms along the supply chain. In this thesis, I explore two issues: (a) how households cope with risks in an economy in the absence of market-based solutions; and (b) how retailers and producers improve their power under changes in consumer demand in food markets.

The two topics above are discussed in three different studies. The first study, in Chapter 2, focusing on rural areas of Tanzania, examines the behaviour of gift-giving by farmers in a rural economy, and its impacts on household food security. Food gifting (gift-giving in the form of food) is a common practice in some rural areas of less developed countries

(LDCs) and is believed to be a mechanism by which many families cope with bouts of food scarcity (Adams, 1993; Coate and Ravallion, 1993; Fafchamps and Lund, 2003; Fafchamps and Gubert, 2007). Food gifting is also thought of by scholars to be an essential form of risk sharing that can mitigate the problems of hunger and food insecurity in these areas (Coate and Ravallion, 1993; Townsend, 1994; Fafchamps, 1999; Fafchamps and Lund, 2003). However, to what extent does food gifting affect household food security status? Do household networks matter in food gifting and food security improvement? Are other risk management strategies effective in mitigating food scarcity? These specific questions remain interesting and are addressed to a lesser degree in the literature. The first study in Chapter 2 aims at providing answers to these questions by exploring the relationship between food gifting and food security at the household level in rural Tanzania.

The remaining two studies explore competition in food markets with a focus on retailers' strategic behaviour in the horizontal competition with other retailers and vertical competition with manufacturers. The second study, in Chapter 3, investigates how changes in temperature influence the vertical competition between a retailer and its upstream manufacturers. Specifically, I conduct brand-level analysis to examine how retailers use private labels (PLs) to improve market power over national brand (NB) manufacturers when there are changes in consumer demand due to temperature variations. Lastly, Study 3, in Chapter 4 examines why some retailers choose to specialize by offering only high-quality products even though product proliferation has become the most common (or dominant) strategy.

1.2 Gift-giving in Tanzania

1.2.1 Background

In recent years, there has been growing interest in the roles of private transfers, non-market institutions, and informal risk sharing in improving poor households' livelihood. Farming households in agrarian economies, such as countries in Sub-Saharan Africa (SSA), live in a high-risk environment of severe poverty and shocks to well-being. They are exposed to shocks such as extreme weather, crop pests and diseases, and health issues (Fafchamps, 1992; Cox and Fafchamps, 2007), and thus are plagued by poverty, hunger, and malnutrition. Due to the lack of market-based institutions (e.g., insurance) and a comprehensive social safety net, people in poor economies cannot rely on formal risk sharing to fight against food and income insecurity. Under these circumstances, smallholder farmers have developed mutual assistance networks to counteract income shocks (Scott, 1977; Posner, 1980; Platteau, 1991; Fafchamps, 1992). These informal networks are usually sustained through interpersonal relationships, such as kinship, friendship, or patronage. Unlike market-based solutions which are enforced by legal institutions, non-market institutions are enforced by mechanisms such as altruism, reciprocity, social norms, warm glow effect, and human emotions such as guilt and shame. However, it is unclear if these mutual-assistance mechanisms result in adequate risk sharing. The lack of legal enforcement makes the effectiveness of informal institutions controversial in protecting households from risks.

Gift-giving usually occurs among kin group members bound through ties such as blood and marriage. Therefore, the study of the role of the kinship network is especially important in regions such as SSA where kin groups are ubiquitous and strong. In parts of rural

Africa where market systems and legal enforcement mechanisms are weak, kinship networks often fulfill the roles of markets without legal regulations and contracts (Cox and Fafchamps, 2007). Kinship-bonded networks can help smallholders in critical conditions to share risks (Fafchamps and Lund, 2003), smooth consumption (Townsend, 1994; Morduch, 1995), and hence resist food scarcity (Adams, 1993); however, like other informal institutions, kinship networks are criticized for the limited effectiveness on risk sharing and the crowding out of public service due to problems such as limited commitment and moral hazard (Cox and Fafchamps, 2007). An important difference between gift-giving within and outside a kinship network is that within-kin gift-giving can be induced by altruism or coerced altruism, whereas gift-giving outside kinship networks is more likely to occur for reasons of reciprocity (Fafchamps and Lund, 2003).

Interhousehold gift-giving represents a major means of informal risk sharing facilitated by kinship networks. Evidence has shown that gift-giving allow households to share risk within confined networks of family and friends (Fafchamps and Lund, 2003). However, most of the informal risk sharing literature is in favour of the conclusion of partial risk sharing rather than full risk sharing. This study explores the extent to which gift-giving can improve household well-being with a focus on food gifting. In less-developed economies such as SSA, the main form of interhousehold gifts is food gifts, thus food gifting is not only a means of risk-sharing but also an important source of food for households in this area. Therefore, this study is aimed at investigating the effect of food gifting on household food security using detailed data from rural Tanzania. In the meanwhile, this study further examines the effect of kinship relation on households' risk coping behaviour by investigating if kinship reduces households' self-protection effort on practicing ex ante risk-reducing strategies.

1.2.2 Motivation and Objectives

The first study focuses on the impact of food gifting in counteracting food insecurity in rural areas of SSA. There are several reasons this topic interesting and important. First, food gifting provides an essential form of informal risk sharing and consumption smoothing in poor economies where individuals have a restricted access to market-based solutions in coping with food insecurity. Second, food gifts are also a significant nonmarket source of food for households in rural areas of SSA. Third, food gifting that is dependent on kinship, which is argued to have an adverse effect on individual incentives, may have a limited impact on risk sharing amid poor households. Therefore, this study aims to explore these potentially contradictory features of food gifting and kinship networks. The main objectives of this study are:

1. to examine how kinship-sustained food gifting affects household food security. As food gifting is a direct source of food for many poor households in SSA, its impact on household food security should not be neglected;

2. to investigate whether the food security status of households engaging in food gifting within kinship networks significantly differs from those engaging in food gifting outside kinship networks; and

3. to examine the effect of kinship networks on the efforts exerted by households to insulate themselves from risks. Given the nature of kinship networks, members may free-ride in anticipation of food gifts, and thus reduce self-protection effort.

1.2.3 Contributions

This study has two main contributions. First, this study adds to the literature on the effect of food gifting on household food security. Although we have understood that gift-giving in poor economies plays an important role in risk sharing, consumption smoothing, and income pooling, its impact on food security and self-protection effort is less understood. Using data from rural Tanzania, my results show that food gifting, either through or outside kinship networks, does not have significant effects on household food security. The results further show that household food security for those engaging in food gifting within kinship networks is not significantly different from those engaging in food gifting outside kinship networks. Second, this study provides useful insights into the free-rider behaviour of the rural poor in a network bound by close ties. Specifically, this paper confirms theoretically and empirically that kinship attenuates poor households' incentive to exert self-protection efforts in a high-risk environment.

1.3 Retailer Competition along the Food Supply Chain

1.3.1 Background

A food supply chain refers to the process that describes how food moves from a farmer to our table. The food supply chain involves agents such as farmers, processors and manufacturers, and distributors (i.e., wholesalers and retailers). A food supply chain connects three main sectors: the agricultural sector, the food manufacturing sector and the marketing sector. The agricultural sector includes farms where raw agricultural products (e.g., crops, livestock, milk) are grown, raised, or produced and distributed to the manufacturing sector.

The manufacturing, or processing sector, comprises activities that transform the raw products, produced by the agricultural sector, to the final products delivered to the consumers. The marketing sector (i.e., wholesalers and retailers) is responsible for distributing the final products to consumers. The interactions of players from the three sectors have been an active topic in the supply chain literature. The degree of market power held by these players along the chain varies by product category and depends on the relevant markets in which these players compete.

During the past few decades, the landscape of the food retail industry has undergone significant changes in multiple aspects. One prominent trend is the application of novel technologies in producing and marketing food products. These technologies include genetic modification technology, new food processing technologies, and data and internet innovations. Technical innovations in the food industry lead to an increasing number of new food and beverage products (Bigliardi and Galati, 2013). Another important change is the emergence of retailers of new formats such as supercenters, mass discounters, wholesale clubs, and specialty grocery stores (Singh et al. 2006; Zentes et al. 2007; Volpe, 2013). Traditional retailers also change store design and layout, product mix, and service in response to the changing consumer lifestyle and demand (Kinsey and Senauer, 1996). This leads to increased competition among retailers (Hausman and Leibtag, 2007). The third change has been the power shift from manufacturers to retailers. Up until the 1980s, manufacturers were considered to hold more power than retailers in the vertical channel, as they had easier access to product design and innovation. As this power dynamic began to shift in the 1990s, the media, business practitioners, and academic researchers have taken a greater interest in this phenomenon. This occurs because of a number of notable changes in the retailing sector.

Retailer concentration (Smith, 2004), the rise of PLs (Mills, 1995), the emergence of retail and wholesale supercenters (Chen, 2003), and Point-of-Sale technologies (Lynch, 1990) are considered the major reasons that have led to this power shift.

1.3.2 Motivation and Objectives

Studies 2 and 3 aim to examine retailers' strategic behaviour in response to the changes in the food retail industry and the ever-changing consumer demand. For example, in a food market where consumer demand demonstrates a seasonal pattern, can a retailer use PLs more strategically and improve power over the upstream manufacturers? Another question of interest is why product line specialization is an optimal strategy for some retailers (e.g., Whole Foods Market), while other retailers choose a strategy of product line proliferation. These questions are addressed in Studies 2 and 3, respectively. In Study 2, I examine how consumer demand changes with external conditions (such as temperature) affects how retailers use PLs to improve their power in the competition with NB manufacturers. Study 3 investigates how retailers choose their product offerings to meet the changing consumer demand. Therefore, the specific objectives are as follows:

1. to examine how a retailer strategically uses PLs in the vertical competition with manufacturers in response to a change in temperature. Study 2 addresses the issue by investigating the pricing strategies of PLs and NBs in a market where demand is driven by weather; and

2. to explore the "halo effect" on a retailer's product line strategy. By examining two retailers' product offerings in a differentiated product market, this study addresses the

question of why a retailer, such as Whole Foods Market, chooses to specialize in a high-quality niche market given that product proliferation and assortment has been a prevailing trend in the food retail industry.

1.3.3 Contributions

The second essay has two contributions to the PL literature. First, the study explores the strategic roles of PLs in the retailer-manufacturer competition as the external environment (temperature) changes. Studies (e.g., Chintagunta, Bonfrer, and Song, 2002, and Meza and Sudhir, 2010) have shown that the introduction of PLs can increase a retailer's bargaining power. However, the focus of the second essay is to find out whether the power relation between retailers and manufacturers changes with changing external conditions. The second contribution of this essay is that it explores the roles of retailers' multi-tier PL strategy in the retailer-manufacturer competition. This study sheds light on how retailers use multi-tier PLs to improve their bargaining power over manufacturers.

The main contribution of the third essay is that it adds to the product line design literature by focusing on the product offerings choice of retailers, while most existing product line studies focus on the behaviour of manufacturers. A hypothesis of "halo effect" is examined to explain why some retailers (e.g., Whole Foods Market) choose a specialization product line to focus on a niche market. In a model with the halo effect incorporated, consumers perceive the retailer who exclusively provides high-quality products to have a higher reputation that gives rise to favourable attributes to the products the retailer provides.

Chapter 2

Food Gifting, Kinship, and Household Food Security

2.1 Introduction

Individuals in many agrarian economies are plagued by bouts of food scarcity and income variations due to shocks such as extreme weather, crop pests and diseases, and health issues (Fafchamps, 1992; Cox and Fafchamps, 2007). To counter the effects of food and income insecurity, smallholder farmers, who have only limited access to formal institutions, share risk through mutual assistance networks based on interpersonal relationships, such as kinship, friendship, or patronage. In agrarian economies such as countries in Sub-Saharan Africa (SSA), gift-giving in the form of food is an essential form of informal risk sharing and mutual insurance among households that practice subsistence farming (Sommerfeld et al, 2002).

Mutual assistance systems and informal risk-sharing networks in preindustrial societies have been documented in detail by scholars such as Scott (1977), Posner (1980), Platteau (1991), Fafchamps (1992), and Dercon and Krishnan (2000). One prominent characteristic of informal risk sharing is that it is sustained by self-enforcement driven by altruism (Coate, 1995), reciprocity (Coate and Ravallion, 1993), social norms (Kandori, 1992), warm glow effect (Andreoni, 1989), and human emotions such as guilt and shame (Cox and Fafchamps, 2007). However, the informal systems have long been criticized due to its failure in sharing risks (Fafchamps, 1999). The lack of legal enforcement of these social relations and strategies have also raised doubts regarding their sustainability and efficiency (Popkin, 1979). For example, early studies by anthropologists have shown that social relations and structures may collapse when there is food insecurity (Laughlin, 1974; Dirks et al., 1980). More recent studies by economists on informal risk sharing also provide evidence that inter-personal gifts and loans can function as a consumption smoothing mechanism (Rosenzweig and Stark, 1989; Rosenzweig and Wolpin, 1993, Townsend, 1994; Morduch ,1995; Grimard, 1997; Attanasio and Rios-Rull, 2003), but fail to fully insure risks confronted by small-scale farming households (Altonji, Hayashi, and Kotlikoff, 1992; Townsend, 1994).

Food gifting in the form of agricultural staples represents an important form of informal sharing in SSA, and provides small-scale farmers with an important means to cope with income shocks. In this study, food gifting is defined as a risk-sharing behaviour, through kinship or non-kinship networks, to reduce the idiosyncratic risk for members of the networks. After a shock occurs, the giver is willing to share part of his earnings with the recipient because of the care/empathy about the recipient, the intention of reciprocal exchange in the future, or other reasons such as social norms, or emotions. Gift exchange converts social resources into a system of mutual assistance with not-necessarily immediate reciprocation

(Adams, 1993). Gifts are transferred within social networks sustained by interpersonal relations and social norms, with kinship obligations in particular acting as an essential kind of sharing norm that governs food gifting among relatives. The nearly compulsory sharing within a kinship network makes food gifting an effective means to counteract shocks and smooth consumption. However, similar to other forms of social capital, kinship obligations can be costly due to moral hazard, distortive asset accumulation, and nepotism (Di Falco and Bulte, 2011). The main reason behind the kinship-driven moral hazard problem is its adverse effect on the recipients' incentive for self-protection, since kinship ties can significantly reduce their risk-mitigating efforts. Alger and Weibull (2010) model the incentive problems that arise in kinship-based risk sharing and find two effects: (1) a free-rider effect which discourages kin members to invest efforts in production; and (2) an empathy effect which increases kin members' desire to share with others. Di Falco and Bulte (2013) empirically investigate the effects of kinship on farmers' incentives to adopt risk-mitigating practices against exposure to risk. Their study shows that compulsory sharing norms based on kinship lead to attenuated individual incentive for self-protection in a risky environment.

Food gifting, as a parallel non-market source of food, has also been paid growing attention for its potentials in coping with rural food insecurity in agrarian economies that lack market solutions (Fafchamps, 1992; Adams, 1993). In an agrarian economy (such as SSA) where weak formal institutions restrict individual access to market-based risk sharing, studies find that consumption remains relatively stable and smooth, although household income fluctuates with idiosyncratic shocks (Townsend, 1994; Morduch, 1991; Paxson, 1992; Jacoby and Skoufias, 1997). This implies that food security in these areas may be somewhat insured by informal institutions where food gifting represents an essential form.

This study is primarily interested in exploring the effect of food gifting on household food security in an agrarian economy. Even though food gifting has been shown to have a positive effect on consumption smoothing and risk sharing in rural economies, there are relatively few studies on the role of food gifting in counteracting food insecurity. Given that food gifting is a particular source of food, it may be expected to be able to somewhat improve household food security in rural areas. However, on the other hand, a dominant number of food gifts are transferred between kinship-bound members, while kinship obligations have been shown to be a double-edged sword. Despite being helpful in managing income shocks by sharing, kinship may also cause adverse economic consequences for households, such as lowered production efforts and distortive asset accumulation. Thus the interest of this study is to ask and address two main questions: (a) does kinship-based food gifting attenuate self-protection efforts households exert to protect themselves from risks?; and (b) how does kinship-sustained food gifting affect household food security?

I address the first question by examining local households' practice of agricultural strategies that reduce exposure to risks and improve income. Drawing on Walker and Jodha's (1986) approach in which they classify risk management measures into risk-reducing and risk-coping strategies, I define food gifting as an ex post risk-sharing strategy, in contrast to an ex ante risk-reducing strategy[1]. Households can choose to implement: (1) risk-reducing strategies to protect themselves from risks; and (2) risk-sharing strategies (i.e., food gifting in this study) to cope with loss induced by shocks. I address the second question, how kinship-sustained food gifting affects food security, by investigating household Food Consumption

[1]Risk-reducing strategies are the self-protection efforts exerted by households to protect themselves from the exposure to risks. Examples of ex ante risk-reducing strategies are the adoption of drought resistance varieties, the adoption of intercropping, and crop and income diversification.

Score (FCS)–an indicator of household food security status–for households. My hypothesis is that households engaging in food gifting within kinship networks may have a lower FCS, compared those gifting outside kinship networks. That is, kinship-sustained food gifting has a negative effect on household food security.

Theoretical and empirical strategies are developed to address these two questions. I first construct a simple theoretical risk-sharing model in a village economy where (a) the rich household has empathy to the poor household and is willing to share food with the poor household in crisis; and (b) the poor household can decide whether or not to implement risk-reducing strategies in anticipation of the rich household's willingness to share. My theoretical model is simple, but shows how the rich household's empathy affects the poor household's implementation of ex ante risk-reducing strategies and the total welfare of both households (i.e., the aggregate household food consumption of both households). The results show that an increase in the degree of empathy reduces the level of implementation of ex ante risk-reducing strategies for the poor household. This suggests a free-rider effect of food gifting. The results also show that a high-degree of empathy hurts the aggregate household food consumption. A survey conducted in rural Tanzania in 2011 allows me to investigate empirically (a) the linkage between food gifting, which is differentiated by kinship relations, and the implementation of risk-reducing strategies; and (b) the effect of food gifting on household food security. Root crops–cassava and sweet potatoes–are the representative food gifts in the study area. The empirical study provides evidence that households that engage in family gifting (i.e., family gifters) are less likely to implement risk-reducing strategies, yet the data shows no evidence that they are doing worse-off than non-family gifters and non-gifters.

This study sheds light on the roles of food gifting, as an informal risk-sharing arrangement (IRSA) and a non-market source of food, on food security in rural agrarian economies. It also provides useful insights into the adverse effects of gift-giving on incentives to exert self-protection efforts against shocks. The remainder of the paper is organized as follows. Related literature is discussed in section 2.2. In section 2.3, a simple theoretical model consisting of a two-stage game is used to describe the interactions between a poor and rich household. Testable implications are drawn from the theoretical framework. Section 2.4 empirically examines the relationship between food gifting and household food and income security. Lastly, section 2.5 summarizes the results from the theoretical and the empirical analysis.

2.2 Related Literature

Inter-household food gifting is a crucial form of IRSA. An extensive body of literature has examined the role of IRSAs in dealing with income and expenditure shocks in underdeveloped agrarian economies. A large number of studies have shown that IRSAs contribute to consumption smoothing (Rosenzweig and Stark, 1989; Morduch, 1991, Paxson, 1992; Townsend, 1994) and help households respond to unexpected income shocks (Fafchamps and Lund, 2003; Fafchamps and Gubert, 2007) in rural economies. However, some studies also point out that transfers, mostly between relatives and friends, fail to achieve Pareto efficient risk sharing (Morduch, 1991, Townsend, 1994; Fafchamps and Lund, 2003). However, these studies only show the inefficiency of IRSAs in fully sharing risks without further explaining why IRSAs are not a perfect form of full risk sharing.

To understand why IRSAs is not efficient in sharing risk, another strand of literature explores the underlying economic logic that governs and sustains IRSAs. Kimball (1988), Foster (1988), Coate and Ravallion (1993), and Genicot and Ray (2003) provide theoretical analyses of informal risk sharing among self-interested individuals and claim that IRSAs based on the reciprocal relationship between non-altruists can be sustained in the long run through repeated interactions and self-enforcing. La Ferrara empirically (2003) studies the role of kinship-bonded networks in Ghana's credit market and shows that reciprocal transfers through kinship-bonded networks can sustain among kin group members who condition their behaviour on characteristics of others' predecessors. Some researchers claim that altruism is an essential norm that governs IRSAs. Foster and Rosenzweig (2001) empirically examine the role of family-based altruism under imperfect commitment and find that altruism plays a vital role in ameliorating commitment constraints and thus can increase the gains through risk-pooling. However, on the other hand, the imperfection of the moral elements of kinship-sustained risk sharing is also criticized.

Some researchers argue that altruism has an adverse effect on individual incentives to invest costly efforts for self-protection against risks (Coate, 1995). These studies provide important insights into the inefficiency of IRSAs in fully sharing risks and protecting smallholders. Coate (1995) constructs a theoretical framework to examine the efficiency of the public provision of transfers from the rich to the poor considering the free-riding effect of altruism. The results reveal an adverse effect of altruism. If the poor anticipate the rich's charity, they will forego insurance and depend on charitable transfers, which are not sufficient to ensure the poor's possible loss. Alger and Weibull (2010) extends one-sided altruism to bilateral altruism between family members and its effect on production incentives. They show that family-based mutual altruism has not only a free-rider effect but also an empathy effect defined as the desire to be able to help one's family member. Unlike Alger and Weibull (2010), Di Falco and Bulte (2011, 2013) look into the role of kinship obligations in affecting self-protection and asset accumulation decisions. They find that kinship-based risk sharing may attenuate farmers' incentive to adopt risk-mitigating practices and leads to distortive behaviour in home asset accumulation.

My study not only examines if food gifting can improve household food consumption but also explores the possible cause for the failure by looking into the ex ante risk-reducing effort exerted by households. A recent study by Marcoul et al. (2016) also investigates the poor's food gifting behaviour in rural Tanzania. They extend Alger and Weibull's (2010) model of bilateral mutual-assistance by assuming that siblings not only choose to exert effort in production but can also choose to allocate their resources to different types of family assets (e.g., consumptive versus productive assets). They empirically investigate the relationship between family ties and: (a) household crop cultivation, and (b) asset allocation using data collected from the same study area as my study. They find that stronger family ties between food gifters lead to a lower level of effort in cultivation and a higher level of investment in consumptive assets. The major difference between my model and theirs is that I explore a unilateral assistance system where the rich have empathy and willingness to help the poor. This study focuses on the issue of how the poor's risk-reduction behaviour is affected empathy of the rich to the poor.

This study makes several contributes to the gifting literature. First, this study focuses on gifts in the form of food and ties food gifting to household food security. Most of the literature on IRSAs explores the relationship between IRSAs and income and consumption.

A limited number of studies have linked IRSAs to rural food security. To the best of my knowledge, only one study by Adams (1993) has documented the contribution of non-market transfers, including food gifts, to food security in Mali. However, his paper does not explore the correlations between gifting behaviour and food security at the household level using an econometric approach. The effect of food gifts, as a crucial form of IRSA and an essential non-market source of food in rural SSA on rural household food security are worth examining. Second, this study examines the issue of food security by taking both ex ante risk-reducing and ex post risk-sharing strategies into account. Unlike most of the studies that focus only on the IRSAs, the models (both theoretical and empirical) in this study incorporate both types of risk-management strategies. My objective is not only to find out whether food gifting has a negative effect on food security, but also to explain why the effect is adverse. I also provide empirical evidence of a negative correlation between kinship-sustained food gifting and the households' implementation of risk-reducing practices, providing support for the theoretical studies by Coate (1995) and Alger and Weibull (2010).

2.3 A Risk-sharing Model

2.3.1 Model

2.3.1.1 Notations and Assumptions

A gift-giving game between a rich and poor household will be introduced in this section. In this game, the poor are assumed to face uncertainties while the rich do not[2], and can

[2] This assumption is reasonable in a sense that the poor household does not have as many resources (e.g., land, tools and equipment, and technology and information) as the rich household in coping with income shocks.

choose to implement strategies including both ex-ante risk-reducing and ex-post risk-sharing strategies. The goal of this model is to explore the impact of interpersonal empathy on the poor household's self-protection effort and the total welfare of the rich and poor households. I assume that the rich household has empathy for the poor household and an interhousehold transfer may occur from the rich to the poor household. I also assume that the poor household confronted by a high-risk environment can choose to implement risk-reducing strategies to protect themselves against risk. The question is: does kinship-driven empathy encourage or discourage the poor's efforts of implementing risk-reducing strategies, and how does this affect the total consumption of the rich and poor households?

Let's consider a village economy consisting of two households: a poor and a rich. The poor household is vulnerable to shocks and faces two states of future income: good and bad. His income in the bad state is y_l and in the good state is y_h, where $y_h > y_l$. The probability of the bad state (or risk) is $\pi \in [0, 1]$. The poor household is assumed to be risk-averse with the utility function: $u^p(x) = \ln x$. The rich household is assumed to be capable of coping with risks and always earns y_h. The rich household cares about the welfare of the poor household facing uncertainty[3], thus the utility function for the rich is $u^r(x) = \ln x + \alpha u^p(x)$, where $\alpha \in [0, 1]$ is the empathy that the rich household has for the poor household.

To mitigate the production uncertainty caused by shocks such as weather, crop diseases and pests, the poor household can choose a risk-reduction level (or effort) level s to reduce the probability of earning y_l. The rich household may share some of his output when the poor household realizes income y_l, and the poor household can choose to implement a risk-reducing

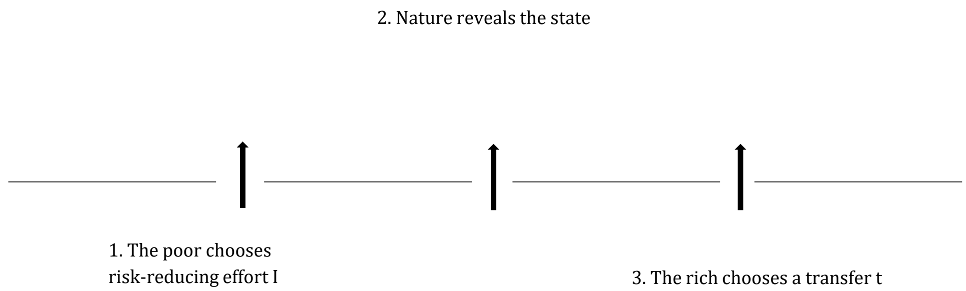
[3]This assumption is different from that in Alger and Weibull (2010). In their paper, mutual altruism is assumed between two siblings, whereas in our study we only consider one-sided altruism from the rich to the poor. The reason is that although the poor household also cares about the rich's welfare, he is not capable of providing any transfers to the rich household.

strategy to reduce the probability of earning y_l. In the utility function, t is a transfer from the rich household to the poor household. In this context, the poor household's expected utility when a transfer occurs is written as: $(\pi - s)\ln(y_l + t) + (1 - \pi + s)\ln(y_h) - I$, where I is the expenditure the poor household spends on the risk-reducing strategy. The rich household's utility function with a transfer t can be written as $\ln(y_h - t) + \alpha[\ln(y_l + t) - I]$.

2.3.1.2 The Game

The timing of the game is shown in Figure 2.1. The poor household first chooses the level of risk reduction by implementing risk-reducing practices such as intercropping and crop diversification. The implementation of the risk-reducing strategies reduces the likelihood of the bad-state income y_l. If the poor household chooses one or several risk-reducing practices, expenditure I is incurred and the probability that bad state occurs is reduced to $\pi - s$, where π is the probability of bad-state, and s denotes risk reduction. I assume $s \in [0, \pi]$ is a function of expenditure I and $s'(I) > 0$, $s"(I) < 0$, so we choose the function from $s = s(I) = \pi(1 - e^{-I})$. Next, nature reveals the state. Without a risk-reducing effort, the probability of earning y_l is π. Once the state of income is revealed[4], the rich household decides whether or not to make a transfer t. Upon observing the poor's income y_l, the rich household decides whether or not to make a transfer t to the poor. In this game, a pure strategy for the two households is $(I_p,\, t_r)$, which leads to the optimal utility for each household.

[4]There are two possible states of income for the poor household: y_h and y_l. To be consistent with the gift-giving dataset, in the second state I only consider the case in which transfers has occured, which means the poor household earns lower income y_l and the rich household earns higher income y_h.



Prior to the analysis of the equilibrium of the game, I first examine a baseline case where the poor household anticipates that rich household has low empathy and will not make a transfer. Then I compare the results of the baseline case with a more interesting case in which the poor household knows that the rich household has high empathy and may make a transfer t which depends on his income.

Case 2.1 *Low empathy, no transfer: $\alpha \leq \overline{\alpha}$, where $\overline{\alpha}$ is the threshold of a positive transfer.*

The optimal level of risk-reducing strategies is determined through the poor's household utility maximization problem, which is

$$\underset{s}{Max}\ (\pi - s)\ln(y_l) + (1 - \pi + s)\ln(y_h) - I, \tag{2.1}$$

where $s(I) = \pi(1 - e^{-I})$. Then equation (2.1) can be rewritten as

$$\underset{I}{Max}\ \pi e^{-I}\ln(y_l) + (1 - \pi e^{-I})\ln(y_h) - I, \tag{2.2}$$

From equation (2.2), I^*, denoting the optimal level of risk-reducing expenditure, is determined by solving the first-order condition

$$\pi e^{-I} ln(y_h) - \pi e^{-I} \ln(y_l) = I, \tag{2.3}$$

which yields

$$I^* = -\ln \frac{1}{ln\frac{y_h}{y_l}} + \ln \pi \tag{2.4}$$

and thus, we have the optimal level of risk reduction

$$s^* = \pi - \frac{1}{ln\frac{y_h}{y_l}}, \tag{2.5}$$

where s^* is restricted in the range $[0, \pi]$. We can see that s^* increases with π, which means that in a high-risk environment, the poor household exerts more effort into risk-reducing strategies. The poor household's optimal level of expenditure and risk reduction, with the anticipation of no empathy and transfer from the rich household, is represented respectively by equation (2.4) and (2.5). I use (2.5) to compare with the level of risk reduction in the case where the poor household anticipates the rich household has high empathy and may make a transfer. In the next section, I solve for optimal expenditure and risk reduction when the poor household anticipates a transfer from the rich household.

Case 2.2 *High empathy, a positive transfer: $\alpha > \overline{\alpha}$, where $\overline{\alpha}$ is the threshold of a positive transfer.*

I work backward in this case to determine optimal (I_p, t_r). Let us first look at the rich household's problem at the second stage. A transfer is made from the rich household with y_h to the poor household with y_l. The rich household's problem is

$$\underset{t}{Max}\ \ln(y_h - t) + \alpha[\ln(y_l + t) - I]. \tag{2.6}$$

The first order condition with respect to t is

$$\widehat{t} = \frac{\alpha y_h - y_l}{1 + \alpha} \tag{2.7}$$

Equation (2.7) yields the optimal transfer rule

$$\widehat{t} = \begin{cases} 0 \text{ if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ \frac{\alpha y_h - y_l}{1+\alpha} \text{ if } \alpha > \overline{\alpha} = \frac{y_l}{y_h} \end{cases} \tag{2.8}$$

Equation (2.8) shows that if $\alpha > \overline{\alpha} = \frac{y_l}{y_h}$, an increase in empathy α results in an increase in a transfer t , which means the higher level of empathy the rich household has to the poor household, the more he transfers to the poor household. In the first stage, the poor household decides the level of expenditure I to spend on risk-reducing strategies. The poor household's problem is

$$\underset{I}{Max}\ (\pi - s)\ln(y_l + \widehat{t}) + (1 - \pi + s)\ln(y_h) - I. \tag{2.9}$$

Substituting (2.8) into (2.9), the problem of the poor household at the first stage is

$$\underset{I}{Max}\ \pi e^{-I}\ln(y_l + \frac{\alpha y_h - y_l}{1 + \alpha}) + (1 - \pi e^{-I})\ln(y_h) - I \tag{2.10}$$

The first-order condition[5] with respect to I is

$$\pi e^{-I}\ln y_h - \pi e^{-I}\ln\left(y_l - \frac{1}{\alpha+1}\left(y_l-\alpha y_h\right)\right) - 1 = 0 \tag{2.11}$$

Equation (2.11) yields

$$\widehat{I} = -\ln\left(\frac{1}{\ln y_h - \ln\frac{\alpha}{\alpha+1}\left(y_h+y_l\right)}\right) + \ln\pi. \tag{2.12}$$

Then we have

$$\widehat{s} = \pi + \frac{1}{\ln\left(y_l - \frac{1}{\alpha+1}\left(y_l-\alpha y_h\right)\right) - \ln y_h}. \tag{2.13}$$

Equation (2.13) represents the optimal risk reduction (which is based on the poor household's risk-reducing effort), given a high level of empathy α ($\alpha > \overline{\alpha}$). By comparing the value I^* in the baseline case and $\widehat{I}$ in the second case, I find that the poor household spends less effort on risk-reducing activities.

Then I combine case 1 and case 2 and yield the optimal risk-reduction

$$s = \begin{cases} \pi - \frac{1}{\ln\frac{y_h}{y_l}} & \text{if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ \pi + \frac{1}{\ln\left(y_l - \frac{1}{\alpha+1}\left(y_l-\alpha y_h\right)\right)-\ln y_h} & \text{if } \alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h} \end{cases} \tag{2.14}$$

and we have the optimal expenditure I

$$I = \begin{cases} -\ln\frac{1}{ln\frac{y_h}{y_l}} + \ln\pi & \text{if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ -\ln\left(\frac{1}{\ln y_h - \ln\frac{\alpha}{\alpha+1}\left(y_h+y_l\right)}\right) + \ln\pi & \text{if } \alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h} \end{cases} \tag{2.15}$$

[5] The second order condition is less than 0, ensuring a maximum exists in the poor household's problem.

Equation (2.14) describes the relationship between the risk-reduction s and empathy level α, when $\alpha \geqslant \overline{\alpha}$. According to (2.14), for any $\alpha \geqslant \overline{\alpha}$, $\frac{\partial s}{\partial \alpha} < 0$, thus we conclude that $\widehat{s} < s^*$ if $\alpha \geqslant \overline{\alpha}$. This suggests that the poor household is more likely to earn bad-state income y_l, as risk reduction is lower in anticipation of a transfer from the rich household than in anticipation of no transfer. The following proposition summarizes the poor household's choice of risk reduction level with an increase in empathy α:

Proposition 2.1 *The effort the poor household spends on risk-reducing strategies decreases with empathy α, and the degree of risk-reduction s also decreases with α.*

Equation (2.8) shows that a higher level of empathy leads to a higher transfer to the poor household. This is the empathy effect of kinship in Alger and Weibull (2010). Proposition 2.1 shows that in anticipation of high empathy, the poor household chooses to reduce the level of self-protection efforts. This is the free-rider effect of kinship. The kinship ties between the rich and poor households imply a higher level of empathy, and then more transfers to the poor household. This leads to a further question: does kinship-sustained gift-giving improve or harm the aggregate well-being of both households? For simplicity, I assume all household outputs go to consumption. Although household consumption is not a perfect proxy for household well-being, it provides an important insight into the welfare implications of empathy-based food gifting. Assuming that the household consumption is equal to household output, I then compute the total consumption of both households. The following proposition summarizes the relationship between total consumption and empathy α.

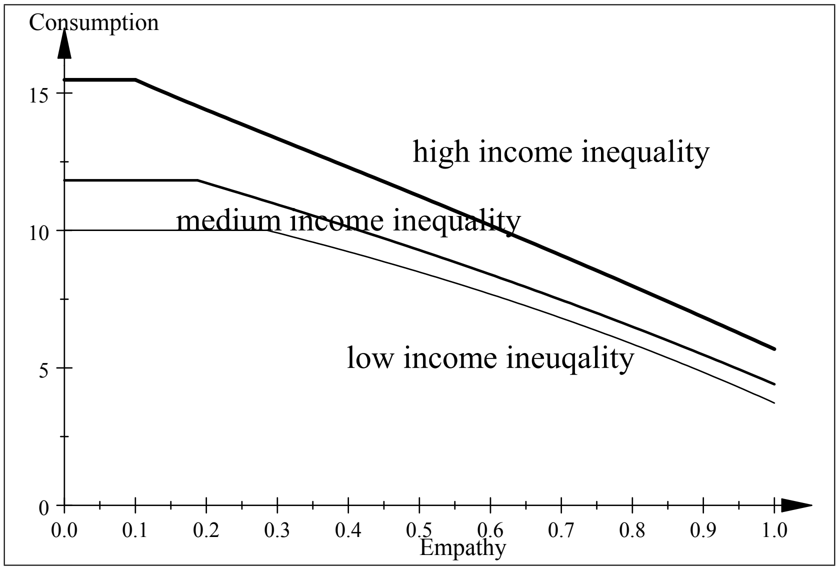
Proposition 2.2 *Total consumption of the poor and rich households decreases with empathy α.*

The proof for this proposition can be found in Appendix 1. Figure 2.2 shows the relationship between aggregate consumption c and the empathy α. Specific numbers are assigned to the parameters to plot the relationships[6]. Three lines (thick, medium, and thin) in Figure 2.2 represent the relationships between aggregate consumption and empathy under three cases: high income inequality, medium income inequality, and low income inequality. The thick solid line illustrates the high income inequality case when $y_h = 10$, $y_l = 1$, and $\pi = 0.8$. If α is lower than 0.1, no transfer is made from the rich household to the poor household. For $\alpha > 0.1$, the rich household makes a positive transfer to the poor household. The higher the empathy the rich household has, the more he transfers to the poor household. The result shows that with the transfer, aggregate consumption decreases with an increase in empathy. The medium and thin solid lines show the relationship between aggregate consumption c and empathy α, given $y_h = 8$, $y_l = 1.5$, or $y_h = 7$, $y_l = 2$, and $\pi = 0.8$. The purpose of the different gaps between y_h and y_l is to compare the poor house's behaviour with various degree of income inequality. Figure 2.2 shows that with lower income inequality, the inflection point indicating a transfer shifts right. This implies that higher empathy ($\alpha = 0.18$, or 0.28, relative to $\alpha = 0.1$) is needed for the rich household to make the transfer. As shown in Figure 2.2, the aggregate consumption of the rich and poor households with lower income inequality appears lower than with higher income equality.

Figure 2.3 illustrates the relationship between risk reduction s of implementing risk-reducing strategies and empathy α. Similarly as in Figure 2.2, the thick solid line in Figure 2.3 represents the case of a higher income inequality. When $0 < \alpha < 0.1$, risk-reduction

[6]The parameters must satisfy the following conditions: (a) $0 < \pi < 1$;(b) $0 < \pi - s < 1$;(c) $0 < s < 1$. From these conditions, we have $\frac{y_h}{y_l} > e^{\frac{1}{\pi}}$.When $\pi = 0.8, \frac{y_h}{y_l} > e^{\frac{1}{0.8}} \simeq 3.49$.

Figure 2.2: Relationship between Consumption and Empathy



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s remains at 0.37. When α exceeds the value of 0.1, the level of risk reduction decreases with α until α reaches 0.35. When $\alpha = 0.35$, the problem has a corner solution, suggesting that no risk-reducing effort is made as $\alpha \geq 0.35$. In the medium and low income equality cases represented by the medium and thin solid lines, the risk-reduction by implementing risk-reducing strategies drops to 0.21 and 0.05. This implies that the poor household exerts less effort in risk-reduction with lower income inequality. α is observed to rise to 0.18 and 0.28 for the rich to make a transfer. The results of the comparative analysis show that the poor household tends to invest less effort in self-protection with low income inequality. This leads to worse-off total welfare for the two households as shown in Figure 2.2.

2.3.2 Results

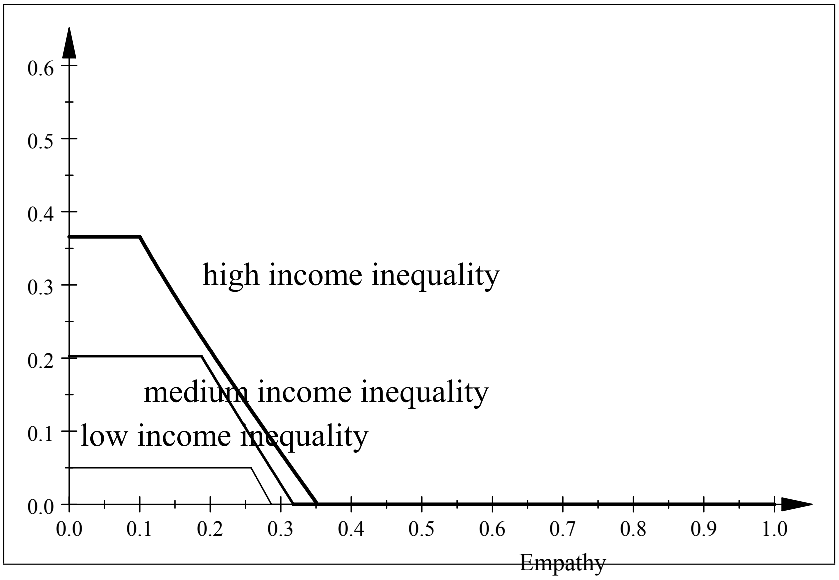
The theoretical model predicts decreasing relationships between aggregate household consumption and empathy, and between risk-reducing effort and empathy. The results can be summarized as follows:

First, when the rich household has a higher level of empathy, the poor household chooses a lower level of risk-reducing effort. This implies a free-rider effect due to kinship-based empathy on the part of the poor household. Anticipating transfers from their rich relatives, the poor household chooses lower risk-reducing effort. An increase in the rich household's empathy therefore results in a higher chance for the poor household to earn a low income.

Second, the empathy the rich household has for the poor has an adverse effect on the aggregate consumption of the rich and poor households. The results of the model show that with a higher level of empathy both households are worse off. This suggests a loss

Risk reduction

Figure 2.3: Relationship between Risk Reduction and Empathy



in social welfare if there is a higher degree of interhousehold empathy. Knowing that the empathic rich household is willing to share his income, the poor household is less motivated to implement risk-reducing strategies. The free-rider behaviour results in a higher chance of earning low income for the poor household, and leads to more transfers that also lowers income for the rich household. Thus the total social welfare of the rich and poor households is reduced in this circumstance.

2.4 Empirical Investigation

The theoretical model in Section 2.3 shows the relationship between the empathy, α, that the rich household has for the poor household and i) the poor household's risk-reduction behaviour, s; and ii) aggregate household food consumption, c. The risk-sharing model predicts that the poor household exerts a lower level of risk-reducing effort in anticipation of a transfer from the rich household, and that aggregate household consumption decreases with empathy. I will test these predictions in this section, using primary survey data collected from an agrarian area in Tanzania, where food gifts and kinship relations are primary means of risk-sharing.

In the study area, small-scale farming households comprise the local population. They are vulnerable to risks due to climate change (e.g., drought), crop pests and diseases. The households have developed several ex ante risk-reducing strategies, such as intercropping and crop diversification, to cope with the disasters. These preventive risk-reducing strategies can help attenuate households' exposure to uncertainties and increase their chance of being in the "good state". However, implementing the risk-reducing strategies is costly and needs an investment in effort (non-monetary and/or monetary form). In addition to the ex ante risk-reducing strategies, ex post risk-sharing networks (based on on kinship, friendship, etc.) are also available for the households to mitigate after-disaster losses.

Walker and Jodha (1986) classify risk management strategies into risk-reducing and risk-coping strategies. They define that risk-reducing strategies to include crop diversification, intercropping, and diversification of non-farm sources of income, and so on. Risk coping strategies deal with managing losses have already occurred. Adapting Walker and Jodha's classification, I define risk-sharing strategies to represent ex post loss-managing strategies such as sharing losses through social networks. In rural Tanzania, food gifting, or food gifts exchange, between relatives, neighbors, and friends is an essential form of informal risk-sharing among smallholder households.

In this section, I explore empirically how food gifting and kinship affect household food security in rural Tanzania. To test the predictions from the theoretical model, I classify the households in the dataset into three categories by their social relations: (a) family gifters, (b) non-family gifters, and (c) autarkists. Family gifters are households that give/receive food gifts to/from family or extended family members. Non-family gifters are those who transfer food gifts only with friends or neighbours. Autarkists are households that do not give/receive any food gifts in the past three months. I assume that there is stronger empathy between family gifters than non-family gifters and autarkists. Using this assumption, I can investigate the effects of empathy on risk-reducing effort and household food security, by examining the differences in household food consumption and the implementation of risk-reducing strategies among autarkists, family gifters, and non-family gifters.

According to the results of my theoretical model, the stronger empathy the rich household has for the poor household the less effort the poor household invest in implementing risk-reducing strategies, leading to lower aggregate food consumption. In my empirical analysis, I will first examine the relationship between the food gifting regimes (i.e., no gifting, gifting with family members, or gifting with non-family members) and the implementation of risk-reducing strategies. Then I investigate whether the food security status for family gifters is worse than for non-family gifters and autarkists[7].

2.4.1 Data

The survey data were collected in rural areas of Tanzania in 2011, as part of a food security project titled Crops and Goat Project (CGP), sponsored by the International Development Research Centre (IDRC) and Foreign Affairs, Trade and Development Canada (DFAT-D). The sample comprises 471 households randomly selected from 4 project villages located in Kongwa and Mvomero districts. Both districts have a semi-arid climate and have been characterized as being especially susceptible to impacts of climate change (Safriel and Adeel 2005). To comply with the ultimate objective of the CGP, food gifting in this study is defined as giving/receiving gifts of root crops - cassavas and sweet potatoes. A gifter refers to a household involves in a root crop transfer as either a giver or a recipient in the past three months as of the day of the interview. Cassava and sweet potatoes gifting is used as a proxy for general food gifting for two reasons: first, cassava and sweet potatoes are primary staple crops and are grown by 32% of households interviewed in the study areas; second, cassava and sweet potatoes provide a more reliable source of food during periods of drought and the

[7] The theoretical model predicts the (poor) recipient's free-rider behaviour, due to empathy, in exerting efforts in implementing risk-reducing strategies. However, the empirical part investgates the food gifting behavior of the givers and recipients as a whole (named as food gifters). The main reason is that the data does not allow us to differentiate recipients and givers.

dry season. Households were asked detailed questions on cassava and sweet potatoes gift-giving and receiving, household dietary diversity and food consumption, household income and expenditure, and crop production. Respondents were also asked questions related to their risk-management strategies, such as the use of improved crop varieties[8], the practices of intercropping and crop diversification, as well as income diversification strategies. I define these as ex ante risk-reducing strategies, in contrast with gifting, which is the sole ex post risk-sharing strategy in this study. Table 2.1 summarizes the main variables used in the empirical investigation.

Table 2.2 presents the descriptive statistics of the main variables. The sample is divided into three groups by the different food gifting regimes they belong to. The dependent variables Food Consumption Score (FCS) is used as an indicator of household food security status. The FCS is based on the responses given by an adult member of the household who, in most instances, is the head of the household. The FCS is calculated using a standard method designed by the World Food Programme (World Food Programme, 2008). The FCS reflects both quantity (frequency of consumption) and quality (types of foods) of food consumed by a household in one week. Table 2.2 shows that the mean value of FCS of the sample (50) falls well within the category deemed "acceptable"(35 and above), although about a quarter of the sample are considered to be "struggling". Other variables include food gifting regimes, household assets of different varieties, risk-reducing strategies, household income, and household demographics.

As mentioned in the previous section, this study classifies all the households into three groups (autarkists, family gifters, and non-family gifters) by the food gifting regime (no

[8]Improved variety in the survey are focused mainly on crop varieties that are drought resistant or need less water.

Table 2.1: Definition of Variables

Variables	Definition
Food Consumption Score (FCS)	Index on quantity and quality of food consumed by household members in the last 7 days
Household Size	Total number of household members
Head Age	Age of the household head in years
Head Age Square	Squareded age of the household head
Head Education	Dummy variable=1 if the household head has a primary education
Head Gender	Dummy variable=1 if the household is male-headed
Land Asset	Total land in acres owned by the household
Home Asset	Total household physical asset, index constructed using principle Component Analysis (PCA)
Livestock Asset	Total household livestock units, index constructed using Tropical Livestock Units (TLU)
Cash Income	Annual cash income in million Shillings
Pipe Water	Dummy variable=1 if the household has access to pipe water
Root Crop	Dummy variable=1 if the household grow cassavas or sweep potatoes in the past five years
Improved Variety	Dummy variable=1 if the household used improved crop variety in production
Intercropping	Dummy variable=1 if the household used intercropping in production
Crop Diversification	Number of crops cultivated
Income Diversification	Index on income earned by a household capturing income diversification
District	Dummy variable=1 if it is Mvomero District

gifting, gifting within kinship networks, and gifting outside kinship networks) . Autarkists are households that are not involved in cassava or sweet potato gifting, and are used as a baseline group to compare with the family gifters and non-family gifters. Family gifters are those give or receive cassava or sweet potatoes from their family members, while non-family gifters gift cassavas or sweet potatoes outside their kinship networks, e.g., gift with friends, neighbours, or strangers. The summary statistics show that the mean value of FCS for family gifting households is lower than that for non-family gifting households. For the risk-reducing variables, it is observed that except for the variable improved variety, the percentages of non-family-gifting households that implement risk-reducing strategies are higher than that of family-gifting households. The results of the descriptive statistics suggest that households engaging in family gifting seem less likely to implement risk-reducing strategies and less food secure than those engaging in non-family gifting, even though the difference is not statistically significant. Next, I describe my econometric approach to study these differences between the different groups of households.

2.4.2 A Multinomial Endogenous Switching Model

In this section, an econometric model is specified to investigate how food gifting behaviour affects household food security. The empirical investigation faces several econometric difficulties. First, households' decisions on food gifting are voluntary and based on observable and unobservable characteristics. Households that decide whether or not to gift and with whom to gift are not a random sample of the original population; they may have systematically different characteristics from households that have a different gifting decision. Unobservable characteristics of households may affect both the food gifting decision and household food

Table 2.2: Descriptive Statistics of Variables

	(1) Autarkists		(2) Family-gifters		(3) Non-family gifters	
	mean	sd	mean	sd	mean	sd
Dependent Variable						
FCS	51.352	19.821	49.021	22.036	50.487	18.021
Demographics						
Household Size	5.811	2.674	5.383	2.454	5.333	2.474
Head Age Square	2314.850	1813.707	2348.872	1510.969	1620.897	778.624
Head Education	0.500	0.501	0.426	0.500	0.667	0.478
Head Gender	0.794	0.405	0.787	0.414	0.846	0.366
Assets						
Land Asset	8.330	16.445	7.606	8.019	7.288	7.001
Home Asset	-0.032	0.974	0.281	1.098	0.393	1.184
Livestock Asset	4.392	16.512	6.153	25.668	1.181	3.159
Intruments						
Pipe Water	0.314	0.465	0.490	0.505	0.575	0.501
Root Crop	0.338	0.474	0.510	0.505	0.650	0.483
Risk-reducing Strategies						
Improved Variety	0.275	0.773	0.208	0.410	0.154	0.366
Intercropping	0.283	0.451	0.250	0.438	0.256	0.442
Crop Diversification	1.765	0.847	1.896	0.994	2.000	1.170
Income Diversification	1.994	2.192	1.741	0.592	2.005	0.931
District	0.442	0.497	0.653	0.481	0.675	0.474

security status, resulting in invalid estimates of the effect of food gifting on household food security. Second, household food security status may also have an effect on the household choice of food gifting regimes, resulting in an endogeneity problem. To address these issues, I estimate a multinomial endogenous switching model (Maddala and Nelson, 1975) using a two-stage procedure. In the setting of the two-stage model, household food security equations are estimated in the second stage. In the first stage, the equations of the food gifting decisions, as a criterion function to determine which household food security equation is applicable, are estimated. In this study, I extend the binary selection procedure at the first stage to allow for polychotomous choices. The model is specified as follows:

$$y_{ij}^* = z_{ij}\gamma_{ij} + u_{ij}, j = 1, 2, 3, \tag{2.16}$$

$$y_{i1} = x_i\beta_1 + \varepsilon_{i1}, \text{if } D_i = 1, \tag{2.17}$$

$$y_{i2} = x_i\beta_2 + \varepsilon_{i2}, \text{if } D_i = 2, \tag{2.18}$$

$$y_{i3} = x_i\beta_3 + \varepsilon_{i3}, \text{if } D_i = 3. \tag{2.19}$$

In equations (2.16) to (2.19), i denotes a household, and j represents a food gifting regime; y_{ij}^* is a latent variable representing the gifting regime selection decision; z_{ij} is a vector of explanatory variables affecting the selection decision; u_{ij}, ε_{i1}, ε_{i2}, and ε_{i3} are assumed to have a multivariate normal distribution. The dependent variable y_{ij} is observed if category

j is chosen, where category j is chosen if $y^*_{ij} > max_{k \neq j}(y^*_{ik})$. D denotes a polychotomous variable with values 1, 2 and 3, and $D_{ij} = j$,if $y^*_{ij} > max_{k \neq j}(y^*_{ik})$

In the first stage represented by equation (2.16), households choose from the following set of gifting regimes: (a) non-gifting, (b) gifting with family members only, and (c) gifting with non-family members only (e.g., friends or neighbours). The variables included in z_{ij} are household demographic variables, household asset variables (physical asset, land, livestock, etc.), variables representing the implementation of risk-reducing strategies, variables representing exclusion restrictions and other control variables. In the second stage which includes equations (2.17) to (2.19), FCS is regressed against a vector of explanatory variables, X_i, including household demographic variables, household asset variables, variables representing the implementation of risk-reducing strategies, and other control variables.

The primary focus of the food gifting equation is to identify the correlations between the risk-reducing strategies and the food gifting regimes. For the model to be identified, it is necessary to find selection instruments to act as exclusion restrictions. The selected instrumental variables must have a direct effect on the selection process but not on the outcome variables. In this study, I use two variables as exclusion restrictions: the use of pipe water at the village level and whether and the decision to grow cassava/sweet potatoes in the past five years. There are two reasons to believe the two variables can serve as valid instruments. First, the use of pipe water at the public site in a village provides villagers an opportunity to socialize with others and to cultivate other types of networks that can facilitate risk sharing. Although having a reliable source of water is also likely to be associated with better household consumption, pipe water is merely one of the water sources in the study area. The villagers have other sources of water (e.g., borehole water) for day-to-day production and consumption needs. Second, having grown cassava/sweet potatoes in the past may directly determine whether a household decides to engage in cassava/sweet potatoes, but its effect on current family consumption might be very minimal. However, given that there is still a potential effect of the second instrument on family consumption, I have to point out cautiously that the selected exclusion restrictions may not be perfect in this study. To further probe the validity of the instruments, I perform a falsification test (Di Falco, Veronesi, and Yesuf, 2011): if a variable is a valid selection instrument, it will affect the decision of choosing a gifting regime, but it will not affect household FCS for those that did not exchange food gifts (i.e., autarkists/non-gifters). The results in table 2.3 show that the two instrumental variables (Pipe Water and Root Crop) have no statistically significant effect on household FCS for the non-gifters.

A two-step procedure is conducted to estimate the switching model. To correct for the potential selectivity bias, I employ the technique developed by Lee (1983) and Maddala (1983), which takes into account the correlation between the error terms u_{ij} from the multinomial logit model estimated in the first stage and the error terms from each food security equation ε_{ij}. The error-correction terms, $-\sigma_j * (\phi(\gamma\prime z_i))/(\Phi(\gamma\prime z_i))$ are incorporated into the outcome equations, where ϕ is standard normal probability density function, and Φ is standard normal cumulative distribution function.

2.4.3 Counterfactual Analysis

The last question I answer in the empirical study is: what are the effects of food gifting on household food security? This can be addressed using a counterfactual approach which Di Falco and Veronesi (2013) employed to evaluate the effects of farmers' adaptation strategies

Table 2.3: Test for the Validity of the Exclusion Restrictions

	FCS
Household Size	-0.009
	(0.013)
Head Age	0.005
	(0.008)
Head Age Square	-0.000
	(0.000)
Head Education	0.136
	(0.066)
Head Gender	0.078
	(0.035)
Land Asset	-0.002
	(0.002)
Home Asset	0.113*
	(0.038)
Livestock Asset	0.003
	(0.001)
Cash Income	0.005
	(0.011)
Improved Variety	-0.071
	(0.033)
Intercropping	-0.079**
	(0.024)
Crop Diversification	0.013
	(0.051)
Income Diversification	0.009**
	(0.003)
District	0.129**
	(0.033)
Pipe Water	-0.093
	(0.067)
Root Crop	-0.076
	(0.083)
Constant	3.681***
	(0.240)
Observations	305

Note: Clustered Standard Errors in Parenthesis to climate change in Ethiopia. In the absence of self-selection, it would be appropriate to treat gifters' counterfactual outcome, which is the outcome if gifters did not engage in any kind of gifting, as being equal to the outcome of non-gifters with the same observable characteristics. However, unobserved heterogeneity in the propensity to choose a gifting regime creates selection bias in the outcome equation. The endogenous switching approach allows us to correct the selection bias and to produce reliable predictions of the counterfactual outcome.

First, the expected outcome of gifters, which in my study means $j = 2$ or $j = 3$, is written as

$$E(y_{i2}|D = 2) = \beta_{i2}\prime x_i - \sigma_2 * \frac{\phi(\gamma' z_i)}{\Phi(\gamma' z_i)}, \tag{2.20}$$

$$E(y_{i3}|D = 3) = \beta_{i3}\prime x_i - \sigma_3 * \frac{\phi(\gamma' z_i)}{\Phi(\gamma' z_i)}. \tag{2.21}$$

Then, the expected outcome of gifters in the counterfactual hypothetical case that they do not gift, which means $j = 1$, is written as

$$E(y_{i1}|D = 2) = \beta_{i1}\prime x_i - \sigma_1 * \frac{\phi(\gamma' z_i)}{\Phi(\gamma' z_i)}, \tag{2.22}$$

$$E(y_{i1}|D = 3) = \beta_{i1}\prime x_i - \sigma_1 * \frac{\phi(\gamma' z_i)}{\Phi(\gamma' z_i)}. \tag{2.23}$$

The effects of gifting regimes are calculated as the difference between equations (2.20) and (2.22), and between equations (2.21) and (2.23), which are represented as

$$E(y_{i2}|D=2) - E(y_{i1}|D=2) = (\beta_{i2} - \beta_{i1})'x_i + (\sigma_1 - \sigma_2) * \frac{\phi(\gamma' z_i)}{\Phi(\gamma' z_i)}, \tag{2.24}$$

$$E(y_{i3}|D=3) - E(y_{i1}|D=3) = (\beta_{i3} - \beta_{i1})'x_i + (\sigma_1 - \sigma_3) * \frac{\phi(\gamma' z_i)}{\Phi(\gamma' z_i)}. \tag{2.25}$$

2.4.4 Results

2.4.4.1 Determinants of Food Gifting Behaviour

The estimation results of the food gifting equation (2.16) are reported in Table 2.4. These results allow me to answer my first question: what are the main determinants of inter-household food gifting behaviour? As Table 2.4 shows, most risk-reducing strategies are found to be negatively correlated with the family gifting regime. Households that do not use improved crop varieties, do not adopt intercropping production systems and whose sources of income are less diverse are more likely to be family gifters than autarkists. For non-family gifters, no statistically significant relationships are found between the implementation of risk-reducing strategies and the gifting regime. These two results imply that family gifters are less likely to adopt risk-reducing strategies compared with non-gifters and non-family gifters. This finding supports the results of my theoretical model and suggests that interpersonal empathy may lead to free-riding behaviour. This result is consistent with Di Falco and Bulte (2013) conclusion that kinship has a free-rider effect on self-protection efforts.

Home assets holdings represent household wealth and may have a significant effect on the household decision of risk sharing. Studies have shown that kinship obligations can lead to a distortive asset accumulation (Di Falco and Bulte, 2009). In this study, three asset variables, including land, household physical assets, and livestock, are examined. Out of the three asset variables, only household physical assets have a positive and statistically significant effect (at 1% level) on the decision of gifting with family members, which provides evidence that households who choose to gift with family members possess more home assets, as compared with autarkists. The effect of household physical assets on non-family gifting is positive but only significant at 10% level. There are two possible interpretations for this result. First, wealthier households with more home assets may be more likely to share their output with family members in need, suggesting that kinship has a positive effect on gift giving. Second, this result may indicate evasive gifting behaviour via asset accumulation. Gift receivers can purchase more home assets in anticipation that their relatives will share. While gift givers may tend to purchase more home assets in order to avoid the sharing burden. This distortive asset accumulation behaviour may allow households to evade gifting obligations to family members. This result is in line with recent studies showing distortive behaviour in asset accumulation due to kinship sharing rules. Di Falco and Bulte (2011) find that households with larger kinship networks accumulate more durables and non-sharable home assets and less durable and sharable asset. Marcoul et al (2016) also find that households spend more on consumptive assets (e.g., TV, radio, couch) if they have stronger family gifting ties.

This study also examines the role of previous root crop cultivation and the use of public pipe water on gifting decisions. As expected, I find that households who cultivated cassava/sweet potatoes before are more likely to gift them with either family or non-family members. Households that use pipe water provided at the village are more likely to gift cassava or sweet potatoes with non-family gifters. A possible interpretation for this result is that households, gathering at the public village pipe, have more opportunities to develop social networks based on non-kinship relations.

Among the demographic variables, household size significantly and negatively affects the probability to gift within families. The reason might be that large households often engage in intra-household gifting rather than inter-household gifting. For example, gifting between (adult) children who live with parents in the same house occurs but would not be treated as family gifting in my data. Age of the household head has a negative impact in gifting with non-family gifters, suggesting households with older household heads are less likely to gift outside kinship networks. A possible reason is that older household heads may have less extensive non-kin-based social networks than younger household heads.

2.4.4.2 Implications for Household Food Security

In this section, I examine the effects of food gifting behaviour on household food security as indicated by household FCS. Table 2.5 reports the estimation results of the outcome equations. In Table 2.5, for autarkists, household physical assets are found to have a positive and statistically significant effect on FCS. The adoption of most risk-reducing strategies (e.g., improved variety and intercropping system) are found to be negatively associated with household FCS. As expected, households where the head has formal primary education, are found to have higher FCSs. Households in Mvomero district report significantly higher FCS than those in Kongwa district, as Mvomero is a wealthier district than Kongwa. For family-gifters, I find that household size and age of household head are both negatively correlated with household FCS. Land and household physical assets have a positive and statistically significant effect (at the 1% level) on household FCS. Household cash income is shown to have a significant and positive effect (only at the 10% level) on family gifters' FCSs. For

Table 2.4: Estimated Results of the Selection Equations

	Family Gifters	Family Gifters
Demographics		
Household Size	-0.0943***	-0.0442
	(0.0328)	(0.0585)
Head Age	0.0018	-0.0182***
	(0.0125)	(0.0070)
Head Education	-0.1676	0.0880
	(0.2489)	(0.1501)
Head Gender	-0.3207	-0.0954
	(0.3502)	(0.1656)
Assets		
Land Asset	-0.0071	-0.0068
	(0.0063)	(0.0091)
Home Asset	0.2024***	0.1834*
	(0.0552)	(0.1095)
Livestock Asset	0.0030	-0.0267
	(0.0026)	(0.0344)
Intruments		
Pipe Water	0.5010	0.6820**
	(0.4068)	(0.2785)
Root Crop	0.6287***	0.9147***
	(0.2006)	(0.2178)
Risk-reducing Strategies		
Improved Variety	-0.6797***	-0.4777
	(0.2549)	(0.3605)
Intercropping	-0.6274***	-0.4389
	(0.2319)	(0.3406)
Crop Diversification	0.1342	0.2444*
	(0.1168)	(0.1357)
Income Diversification	-0.1715***	0.0092
	(0.0664)	(0.0347)
District	0.4881	0.3603
	(0.3780)	(0.5917)
Constant	-1.1731	-1.7658***
	(0.7349)	(0.5744)
Observations	382	

Note: Clustered Standard Errors in Parenthesis

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

non-family gifters, the only statistically significant coefficient in the FCS equation is the constant. The coefficients of the inverse Mill's Ratios evaluate the effects of selection bias on household FCS due to the unobserved household characteristics. The estimation results show that coefficients of the IMRs are statistically significant at the 1% level for both autarkists and family-gifters. The positive IMR for autarkists suggests that unobserved household characteristics that are associated with a higher probability of being autarkists are linked to higher household FCS. The coefficient of the IMR for family gifters is significantly negative, suggesting that unobserved household characteristics associated with a higher probability of being family gifters are linked to lower household FCS. This implies that self-selected family gifters are worse off than family gifters randomly chosen. The IMR is insignificant in the estimation of non-family gifters' FCS.

Based on the estimation of the second-stage outcome equations, predicted FCS is calculated after selectivity bias is corrected and summarized in Table 2.6. Table 2.6 shows that family gifters have a lower FCS than non-family gifters; however, the difference is not statistically significant. Figure 2.4 illustrates the Kernel density of the error-corrected FCSs. We can see that more households engaging in family gifting fall into the group of "borderline" (21-35) than those engaging in non-family gifting. A larger population of non-family gifters fall into the group of "acceptable" (above 35). The distribution curve for the family-gifters is flatter than that for the non-family gifters, suggesting that food security status for family gifters is more unpredictable.

I can further evaluate the effects of food gifting on household FCS by using a counterfactual analysis approach. The results in Table 2.7 show that the effect of food gifting on FCS are positive but statistically insignificant, suggesting that kinship-based food gifting does not

Table 2.5: Estimated Results of the FCS Equations

	Autarkists	Family-gifters	Non-family gifters
Demographics			
Household Size	-0.014875	-0.053376*	-0.002945
	(0.009938)	(0.029708)	(0.035692)
Head Age	0.003791	-0.033233*	-0.054655
	(0.008621)	(0.019117)	(0.127612)
Head Age Square	-0.000052	0.000318	0.000661
	(0.000080)	(0.000230)	(0.001550)
Head Education	0.132340***	-0.057738	-0.136048
	(0.049378)	(0.084881)	(0.177757)
Head Gender	0.046466	-0.325783	-0.034613
	(0.034326)	(0.218476)	(0.384120)
Assets			
Land Asset	-0.002026	0.027062***	0.004364
	(0.001992)	(0.007393)	(0.010948)
Home Asset	0.131426***	0.171625***	0.095259
	(0.022757)	(0.057096)	(0.067644)
Livestock Asset	0.002788	-0.002758	0.038371
	(0.005637)	(0.015091)	(0.043529)
Cash Income	0.004913	0.032901*	0.108109
	(0.008848)	(0.019836)	(0.132862)
Risk-reducing Strategies			
Improved Variety	-0.122057***	0.158211	0.089259
	(0.036755)	(0.106160)	(0.162822)
Intercropping	-0.124789***	-0.216535	-0.039585
	(0.031543)	(0.178444)	(0.070566)
Crop Diversification	0.029602	0.036126	-0.012655
	(0.043147)	(0.061697)	(0.048834)
Income Diversification	0.007473	0.095963	0.048297
	(0.019940)	(0.069981)	(0.060657)
District	0.175600***	0.364345***	0.155844
	(0.029906)	(0.140268)	(0.417581)
IMR0	1.321671***		
	(0.454828)		
IMR1		-4.982926***	
		(1.171273)	
IMR2			1.407977
			(1.066996)
Constant	4.183925***	0.952723***	5.673853**
	(0.382014)	(0.361843)	(2.579188)
Observations	305	42	35

Note: Bootstrap Standard Errors in Parenthesis

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 2.6: Predicted FCS After Accounting for Selectivity Bias

	FCS	
Autarkists	Family gifters	Non-family gifters
48.537	49.028	51.482
(11.415)	(18.150)	(13.994)

Figure 2.4: Kernel Density of the Predicted FCS

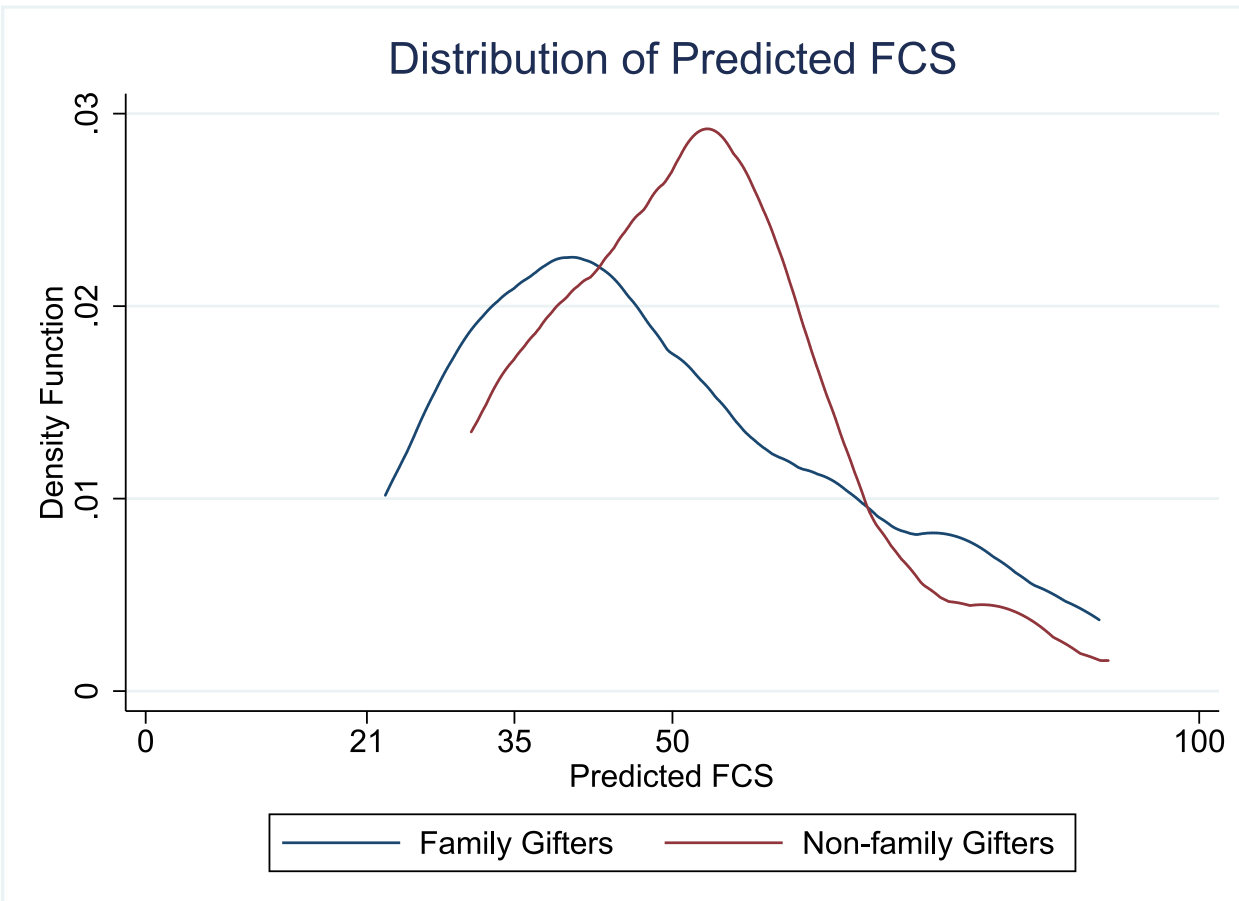


Table 2.7: Effect of Food Gifting Behavior on FCS After Accounting for Selectivity Bias

	FCS		
Gifting	Actual	Counterfactual	Effect
Family gifting	49.028	35.848	13.180
	(18.150)	(13.956)	(15.128)
Non-family gifting	51.483	37.584	13.898
	(13.994)	(11.210)	(11.165)

have a significant effect on household food security. This empirical result does not support the theoretical prediction that kinship obligations have an adverse effect on the aggregate household consumption.

The main findings from the empirical study can be summarized as follows. First, households that choose to gift with family members are less likely to implement risk-reducing strategies, as compared to non-family gifters and autarkists. Kinship sharing obligations can induce free-rider behaviour within family networks and serve as a barrier for family members to protect themselves by implementing risk-reducing strategies. Second, the empirical study does not provide evidence that kinship relations have a significant adverse effect on household food security. After correcting for selection bias, there is no significant difference in household food security observed between family gifters and non-family gifters, and non-gifters. Last, the study shows no evidence that food gifting behaviour has a significant effect on household food security in the rural area of Tanzania. The counterfactual analysis shows that even though food gifting has positive effects on household food security, the effects are not statistically significant.

2.5 Conclusion and Discussion

Informal risk sharing through kinship-based networks is an essential issue for smallholder households in agrarian economies such as SSA. Kinship-based sharing behaviour among small-holder households is crural to counteract income and consumption shocks in a high-risk environment. However, it is also argued that kinship may lower individual incentives to exert productive efforts and result in distortive individual behaviour. Therefore, will kinship-based food sharing improve or impede food security of the rural poor? The results of the theoretical model show that higher level of empathy from the rich household (giver) leads to a lower degree of implementation of risk-reducing strategies by the poor household (recipient), and thus less secure household food consumption. In the empirical analysis, I test the results by examining the effect of food gifting regimes on the household FCS. The data collected in rural areas of Tanzania show households that exchange food gifts with family members tend to invest less effort in risk-reducing strategies. However, no evidence is found that family food gifting has a significant effect on improving or reducing the household food security. Moreover, the results of the empirical investigation show that FCSs of households engaging in gifting within kinship networks are not statistically different from that of households engaging in gifting outside kinship networks. There are several possible reasons for these results. One reason may be that food gifting in this study is limited to cassavas and sweet potatoes, which accounts for a relatively small portion of food gifting in the study area. Another reason could be that this study uses FCS as an indicator of food security, which is a reflection of the food consumption status of the household. However, food consumption can be smoothed over time through informal risk sharing (e.g., food gifting) and may be volatile at different periods of the year. This study only catches household food security status during a specific study period.

The study provides tentative evidence that households engaging in gifting with family members have a lower degree of implementation of risk-reducing strategies than those engaging in gifting with non-family members. This result implies that family gifters tend to exert fewer efforts to protect themselves against exposure to risks. This result also suggests a potential free-rider effect of kinship sharing norms. However, kinship obligations may not be the only driver to the low incentive for risk-reduction efforts. Other factors, such as the accessibility, availability, and affordability, may also be critical in the adoption of risk-reducing strategies.

This study has two limitations. First, only cassava-and-sweet-potato gifting is available as a proxy for food gifting, as these are the only staples that were investigated in the survey. Although they are essential forms of famine-reserve crops and provide a more reliable source of food during drought and hungry season, there are other crops (e.g., maize and rice) which may be more frequently gifted among local households. By only looking at cassava and sweet potatoes as gifts, the nature of households that engage in gifting is small. Another limitation is that the issue of endogeneity may still remain, even though I use an endogenous switching approach to remedy this issue. The identifying variables I employed in the selection equation may also be correlated with the second-stage household food consumption of non-gifters, even though I provide evidence that they are not significantly correlated with household food consumption.

This study has several implications. First, using data collected in rural Tanzania, food gifting, either based on kinship or non-kinship relations, is not found to have a significant effect on household food security. The FCSs for gifters do not statistically differ from that for non-gifters. This is not a surprising result, and it provides evidence to support the conventional wisdom that informal risk sharing is not efficient in fully sharing idiosyncratic risks. Households engaging in food gifting are not more food secure than those who do not, partially because gift-giving is reported not as effective as other informal institutions such as informal loans (Fafchamps and Lund, 2003). The results also find, among the gifters, the FCSs of family gifters are not significantly different from that of non-family gifters, and more specifically, family-gifters are not worse-off than non-family gifters. It appears that kinship sharing norms which are declared to lead to an issue of moral hazard do not matter in affecting local household food security, although moral hazard is found to exist among family gifters. In this study, family gifters are found to tend to be less likely to implement risk-reducing strategies and thus have higher chances to be exposed to risk and bear income fluctuations. One interpretation for this result is that the risk-reducing strategies, which are not widely adopted by local households, are not found to have significant effects on household food security. A household that foregoes risk-reducing effort may not have significantly lower FCSs, because food consumption can be smoothed through gift transfers from their family members. The result also implies that in this circumstance, moral hazard only causes a limited consequence (i.e., food insecurity in this study), among households that engage in a specific form of food gifting (i.e., cassava and sweet potatoes). However, moral hazard may still lead to income fluctuations for households that forgo risk-reducing efforts due to the kinship networks they own.

The results of this study can also draw important policy implications. Although the study shows that food gifting is not an effective informal risk sharing institution in rural Tanzania, the data still show there are a significant number of farming households living in a struggling condition and suffering from food insecurity, especially those engaging in gifting within kinship networks. However, neither kinship-based gifting nor gifting based on other relations (e.g., friendship) can help them to deal with food insecurity. Although spontaneous mutual assistance is active among the poor local households, however, it cannot solve the problem in an effective way. Attention from the entire society, including the governments, NGOs, international organizations, and the private sector are needed to help the poor to improve food security. Social security networks and anti-poverty programs should focus on resilience building to minimize the effect of risks. The local policymakers can consider making the risk-reducing strategies more available, accessible, and affordable for the local farmers, for example, introducing farmers with more advanced crop varieties, intercropping technologies, or preparing farmers for off-farm work opportunities, etc. On the other hand, since the informal risk sharing is shown not efficient in managing risks and improve food security, market-based solutions, such as private insurance and micro-credit programs, need to be developed to help local farmers to counteract high-risk environment. Second, by further exploring the reasons why informal food gifting based on kinship relations fails to secure household food consumption, I find that households that engage in food gifting through family networks are less motivated to alleviate risks through their own effort. Risk-reducing strategies, such as improved crop varieties, intercropping, crop and income diversification, are found rarely adopted by these households. Is it because of the moral hazard effect, or because they are too poor to afford a new strategy? Further research needs to be conducted to detect why this is a case.

Chapter 3

The Effect of Weather on the Use of Private Labels in Retailer-Manufacturer Competition

3.1 Introduction

With the growing power of retailers in the consumer goods markets in the past three decades, the nature of vertical channel interaction has been an important subject in food supply chain literature. In the vertical channel, manufacturers used to be the focus of the literature on market power and consumer welfare (Parker and Connor, 1979; Gisser, 1982; Bliss, 1988). However, in recent years, the shift of power from manufacturers to retailers has become a well-accepted feature (Ailawadi, Borin, and Farris, 1995). One important reason for the power shift is the expansion of private labels (PLs) (Volpe, 2013). Market share for PLs continues to grow in recent years. According to the Private Label Yearbook released by the Private Label Manufacturers Association (PLMA), the dollar share of PLs in the U.S. was 17.7% in 2015, marking the highest level ever (PLMA's 2016 Private Label Yearbook, 2016). Also, the total dollar value of PLs sold in U.S. supermarkets increased by 4% for the period 2012-2014, outpacing a growth of 2% for national brands (NBs) in the same period. PL use, contributing nearly one-quarter of all consumer spending on food, beverages, and personal care items, has become a key component of retailer strategy (Richards, Hamilton, and Patterson, 2010).

The success in gaining market share is not the only benefit retailers derive by selling PLs; PLs can provide great value to retailers in multiple ways. They help to increase store loyalty in horizontal competition with other retail channels (Ailawadi, Pauwels, and Steemkamp, 2008). PLs provide retailers higher retail margins than NBs (Ailawadi and Harlam, 2004). In the vertical competition with manufacturers, a retailer can use PLs to enhance its bargaining power against manufacturers in negotiating for better supply terms for NBs (Meza and Sudhir, 2010). More notably, PLs are the only brands for which the retailer is responsible not only for the retail marketing mix (e.g., promotion, shelf placement, and price), but also for defining the nature of the product (Morton and Zettelmeyer, 2004). Compared to NBs, retailers have more control over PLs in terms of making strategic decisions of brand positioning and marketing. There is also evidence that retailers develop a PL program to deter entry of competing stores (Akçura et al., 2012) and set favourably pricing when initially introducing PLs to the market (Meza and Sudhir, 2010).

Scholars have paid much attention to investigating the factors that facilitate the success of PLs (Hoch and Banerji, 1993; Hoch, 1996; Dhar and Hoch, 1997; Cotterill et al 2000;

Chintagunta, Bonfrer, and Song, 2002; Hoch et al 2000; Lamey et al., 2007; Volpe, 2014). These factors include the lower cost of PLs, consumer demographics and preferences, the proliferation of PL lines, and the impact of the macroeconomic environment. PLs are traditionally seen as lower-quality products at lower prices and are more likely to be purchased by price-sensitive consumers (Hoch, 1996). Volpe (2011) finds that PLs are promoted more frequently than NBs in the U.S. market. However, the quality gap between PLs and NBs is closing and retailers have deliberately introduced high-quality PLs (Verhoef et al., 2002). In recent years, PL proliferation has been occurring at an increasing number of retailers. Retailers introduce multi-tier PL offerings with the intention to reach a broader range of consumers (Geyskens, Gielens, and Gijsbrechts, 2010). Compared to other factors, the effect of macroeconomic or external environment on PL development has been paid less attention. Nevertheless, there is growing evidence showing that PL penetration is a time-variant process and changes with the external environment. Factors such as the business cycle and price inflation can impact PL demand and supply. Lamey et al. (2007) show that the market share for PLs increases when the economy is contracting and shrinks when the economy is expanding. On the supply side, Volpe (2014) finds that the price gap between NBs and PLs narrows, as food prices rise.

Although retailers strive to promote PLs given all their benefits, it is also in a retailer's interest to maintain the market share for NBs. NBs are essential for retailers' success, as they can help increase brand assortment and generate store traffic (Juhl et al. 2006). Hence it may be in the best interest of retailers to develop a balanced retail strategy with PLs and NBs to maximize category profit (Ailawadi and Harlam, 2004). It is crucial to understand how a retailer strategically uses PLs to influence the balance of power in the vertical competition with NB manufacturers (Narasimhan and Wilcox, 1998; Meza and Sudhir, 2010; Steiner, 2004). Profitability and bargaining power are the two most important reasons that retailers desire to expand PLs. A strategic retailer can raise or reduce PL share for different purposes in the vertical competition with NB manufacturers. Narasimhan and Wilcox (1998) show that a strategic retailer will lower PL share and gain profit by selling NBs through price concession from NB manufacturers. In contrast, Meza and Sudhir (2010) empirically show that retailers can gain bargaining power over manufacturers and make favourable pricing strategy for PLs while introducing PLs to the market. Retailers can also utilize brand positioning strategy to make PLs more influential. Morton and Zettelmeyer (2004) and Sayman, Hoch, and Raju (2002) examine the retailer's store brand positioning problem, and they both show that store brands are positioned to target at leading national brands to gain bargaining power.

Given the power the retailer has on PLs, one may wonder if retailers can use PLs to better react to a change in the external environment and gain more bargaining power. For example, how can retailers use PLs in response to the seasonality of demand – high- or low-demand – driven by weather, and how can this strategy affect their interaction with NB manufacturers? Weather is believed to have a significant impact on the food retailing industry (Murray et al., 2010). The impact extends to all players along the food supply chain. Consumer demand notably follows a weather-driven pattern in a wide range of food markets, from ice cream, salad dressing to canned soup (Agnew and Thornes, 1995). It has been acknowledged that weather can shift the overall demand for a commodity; however, evidence from brand-level analysis also shows that the change in demand may not be evenly distributed among brands. Nevo and Hatzitaskos (2006) find in their study on the counter-cyclical pricing issue that consumers are more price sensitive during high-demand periods and opt for low-priced brands. Empen and Hamilton (2013) also show that periodic consumers who are attracted in the high-demand season prefer to purchase low-priced brands. In addition to the demand-side shift driven by weather, firms are also shown to actively respond to the weather change and adjust pricing strategies accordingly (King and Narayandas, 2000; Murray et al., 2010).

Scholars have extensively investigated how retailers gain power over their upstream manufacturers by introducing PLs to the product line. In a study with a focus on the demand and supply-side changes after the store-brand introduction, Chintagunta, Bonfrer, and Song (2002) find that the store-brand introduction coincides with an improvement of retailer margin for the NBs. Moreover, they point out that one should expect that interactions among channel players also change over time, and hence, it is important to find what factors influence these time-varying interactions. Time-varying competition among firms has been studied with a particular focus on the competitive behavior of manufacturers (see a survey by Sudhir, Chintagunta and Kadiyali, 2005). More specifically, these studies investigate how firm competition varies over time as demand and cost conditions changes. Sudhir, Chintagunta and Kadiyali (2005) define it as the indirect effect of demand and cost changes on competition, that is higher demand cause more competition and, hence, lower prices. Draganska and Klapper (2007) address a similar issue of competitive intensity between manufacturers by focusing on the effect of retailer-side factors. However, fewer studies have focused on the retailer-manufacturer competition over time as demand and cost conditions change.

This study is interested in examining how retailers strategically use PLs in a changing environment that leads to a seasonal pattern of market demand. In a multi-brand market, the response to weather changes may be different among brands, which especially applies to PLs and NBs that follow different paths from the plant to the store. The primary objective of this study is to investigate how a retailer strategically uses PLs in the vertical competition with manufacturers, in response to a change in temperature. This study first focuses on the change on the demand side to examine brand-level demand fluctuations driven by weather, and then moves to the supply side to explore the change in the nature of the interaction between a retailer and their NB manufacturers. I hypothesize that the increase in consumer demand is asymmetric for PLs and NBs; an increase in demand for PLs is faster than for NBs as consumers who are more price sensitive in the high-demand season are more inclined to purchase low-priced PLs. I also hypothesize that a change on the demand side will affect the competitive relationship between the retailer and NB manufacturers, leading to changes in their pricing behavior. I assume the retailer adopts a multi-tier PL strategy and offers PLs of different qualities: premium and standard PLs. Ter Braak, Geyskens, and Dekimpe (2014) show that premium PLs have different strategic purposes than standard PLs. By focusing on two essential reasons that retailers offer PLs – profitability and bargaining power – this study provides answers to the following questions. First, as temperature increases, do PLs expand more aggressively than NBs? Second, how does the relative profitability of PLs and NBs change with a rise in temperature? Third, as temperature increases, how does the relative bargaining power between retailers and NB manufacturers change? Last, how does a retailer uses PLs differently in the high-end and low-end markets in response to temperature changes?

This study has two contributions to the private label literature. First, this study explores the strategic roles of PLs in the retailer-manufacturer competition as an external factor, weather, changes. Studies (e.g.,Chintagunta, Bonfrer, and Song, 2002 and Meza and Sudhir, 2010) have paid attention to the issue that the introduction of PLs can increase a retailer's bargaining power. Nevertheless, the focus of this study is the role of PLs in a changing environment and their effect on the power relations between retailers and NB manufacturers. This study incorporates an external variable, temperature, into the decisions of consumers, the retailer, and NB manufacturers to examine the changing consumer demand and the pricing behavior of retailers and manufacturers. The economic rational is that demand changes, due to changes in external conditions, are not uniformly distributed across brands (Nevo and Hatzitaskos, 2006). The demand-side changes lays a foundation for the analysis of retailer and manufacturer behavior. Instead of simply treating weather as a demand shifter, I conduct brand-level analysis and paid close attention to the relative demand change among different brands in a differentiated food market. Second, this study explores the different roles of PLs in the retailer-manufacturer competition in a multi-tier quality-differentiated market. This study sheds lights on how retailers use multi-tier PLs to improve their bargaining power over manufacturers as external conditions change.

The ice cream industry is chosen as the empirical setting in this paper. Several features make this industry a relevant setting to examine retailer strategy for PLs under the changing temperature. First, the demand for ice cream follows a clear seasonal pattern governed primarily by temperature (Richards, Hamilton, and Patterson, 2010). Second, PLs account for a substantial share of this product category at the retail level. Ice cream is one of the top five categories in terms of private label penetration (Food Marketing Institute, 2006). Third, ice cream offers both premium and standard tiers. To conduct the analysis, I consolidate three sources of dataset for the analysis: (1) store-level scanner data for a major North American retail chain from the SIEPR-Giannini Data Center at the University of California Berkeley; (2) brand-level product information containing information about packaging, labeling, ingredients, provided by Mintel's Global New Product Database (GNPD); and (3) weather information from the National Oceanic and Atmospheric Administration (NOAA).

The results of this study show that PLs perform differently from NBs as temperature changes in terms of market share and prices. As temperature increases, the overall consumer demand for ice cream grows, but PLs are found to expand more aggressively than NBs. The reason is that retailers promote PLs more heavily than NBs in warmer weather. The varying temperature condition does give PLs an opportunity to gain a competitive advantage at the expense of NBs' share in the competition. The findings also show that the retailer can improve both pricing and bargaining power by using a two-tiered PL strategy. As the weather gets warmer, the retailer tends to compete more intensely in the high-end market and more cooperatively in the low-end market. Increasing market share and margin make standard PLs a bigger source of profit for the retailer. However, the premium PLs are more likely to be used as a bargaining chip to negotiate for a better wholesale price for NBs. As temperature increases, manufacturers of the premium NBs, confronted by the head-on competition from the premium PLs, tend to soften the stance by undercutting the wholesale price of the premium NBs.

The paper proceeds as follows. In Section 3.2, a conceptual model is introduced to describe the behaviors of consumers, a retailer, and its upstream manufacturers in a differentiated-product market, as temperature changes. Section 3.3 presents the empirical model employed to examine demand- and supply-side responses with changes in temperature. A comprehensive data set used in this study is introduced in the next section. Section 3.5 shows the results of the demand-supply model estimated. The last section provides conclusion and discussion of this study.

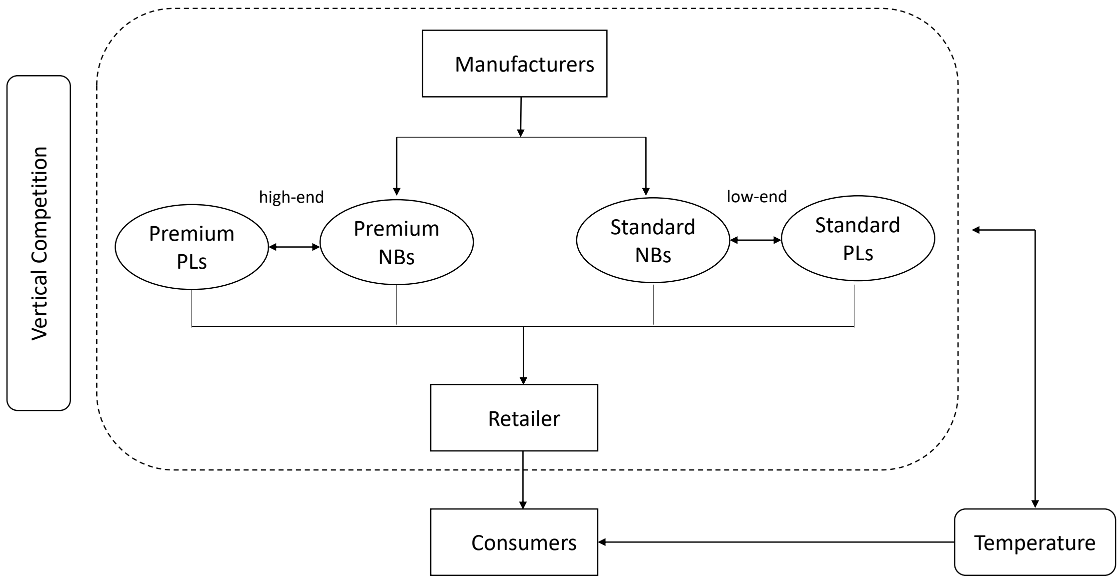
3.2 Conceptual Model

This study examines the role of private labels in the vertical competition between a retailer and manufacturers in a differentiated market where demand follows a weather (temperature)-driven periodical pattern. There are three sets of agents making decisions with different objectives: consumers, a retailer, and multiple manufacturers. Consumers make purchase decisions based on their preferences across products attributes and retail prices. The retailer cares about maximizing its category profits and decide the final prices of both NBs and their own PLs, taking into account demand and the wholesale prices set by the manufacturers. Manufacturers are concerned about their own profits and set the wholesale prices of NBs on the basis of demand conditions and the retailer's strategies. PLs and NBs are differentiated by quality: premium (high-quality) and standard (low-quality) PLs and NBs. The retailer and the manufacturers are both strategic and can make respond to changes on the demand side.

Figure 3.1 illustrates the vertical interaction among consumers, the retailer, and manufacturers with a demand shift due to a change in temperature. In the ice cream market, temperature is a critical driver of ice cream demand (Richards, Hamilton, and Patterson, 2010). As temperature increases, there is a parallel upward shift in overall consumer demand; however, the change in demand is not evenly distributed among brands, particularly between NBs and PLs. According to Nevo and Hatzitaskos (2006), cheaper brands may substitute for higher-priced brands, as consumer price sensitivity increases with demand. Consumers with high price sensitivity tend to purchase more lower-priced products in the high-demand season. I thus hypothesize that as temperature increases, consumer demand for lower-priced PLs increases faster than that for NBs. The change in demand for ice cream is likely to affect decisions of the retailer and NB manufacturers.

My interest is to find out if a temperature-driven change on the demand side will also affect the retailer and manufacturers' pricing behavior and vertical competition on the supply side. Under the assumption of a joint-profit-maximizing retailer, the retailer earns profits by selling both NBs and PLs. Due to the inherently distinguishing characteristics between NBs and PLs, my hypothesis is that the changes in demand for NBs and PLs differ as external conditions change. For example, in this study, a change in temperature may lead to asymmetric changes in demand for NBs and PLs. If consumer demand for PLs increases faster than NBs, the retailer has a competitive advantage in PLs relative to NBs. In response to the asymmetric change on the demand side, the retailer has following alternative strategies. First, the retailer uses PLs as a source of profit, given the increasing sales of PLs. Second, the retailer uses PLs as a strategic tool to gain bargaining power over NB manufacturers, due to the competitive advantage in demand increase for PLs. On the other hand, the manufacturers also need to develop a strategy to deal with the changes on the demand side due to temperature. Facing increasing competition from PLs, one possible strategy for the NB manufacturers is to soften their stance in the vertical competition with the retailer by offering price concessions for NBs (Chintagunta, Bonfrer, and Song, 2002). Moreover, in a quality-differentiated market, the retailer and manufacturers may offer different marketing strategies for brands of different quality tiers. This may lead to distinguishing competitive

Figure 3.1: The Effect of Temperature on the Vertical Interaction Between A Retailer and Multiple Manufacturers



interactions in the high- and low-end markets.

3.3 Empirical Model

The empirical approach captures both the demand- and supply-side changes with temperature variations. The premise of this approach is changes in demand will affect the strategic interaction between the retailer and the manufacturers on the supply-side. The demand-side results build the foundation of the analysis of the vertical interaction between the retailer and their upstream manufacturers. The retailer-manufacturer interaction is modeled as a

Manufacturer-Stackelberg competition (Cotterill and Putsis, 2001; Nevo, 2001; Sudhir, 2001; Villas-Boas and Zhao, 2005; Berto Villas-Boas, 2007). This type of retailer-manufacturer strategic interaction has been found to fit well in a number of product categories (Sudhir 2001; Besanko et al. 2003; Cotterill and Putsis 2001). Under a Manufacturer-Stackelberg, manufacturers are the price leaders in the vertical channel and choose optimal wholesale prices in the first stage. They take into account the retailer's reactions while setting wholesale prices. The retailer is a follower and sets retail price to maximize its category profits in the second stage, given the wholesale price.

3.3.1 Demand

I adopt a nested logit demand model (Macfadden,1978) to quantify brand-level consumer demand for ice cream in the U.S. . This model assumes that consumers make a hierarchical purchase decision. Consumers first choose among brands and then decide on the flavor. There are J brands and I flavors provided by the retailer. The consumer's utility function of choosing product ij, where i belongs to I and j belongs to J, is represented as

$$U_{ij} = X_{ij}\beta - \alpha P_{ij} + \xi_{ij} + \nu_{ij} + (1 - \sigma)\epsilon_{ij}, \tag{3.1}$$

where $\delta_{ij} = X_{ij}\beta - \alpha P_{ij} + \xi_{ij}$ is the mean utility; X_{ij} is a vector of observable product characteristics; P_{ij} is a vector of prices for product ij; ξ_{ij} represents the product characteristics observed by consumers but not researchers, and ν_{ij} is common to all products within group j. $\nu_{ij} + (1 - \sigma)\epsilon_{ij}$ is extreme-value distributed following Cardell (1997). The parameter $\sigma \in [0, 1]$ measures the within-group correlation of utility levels; as σ approaches 1, the within-group correlation of the utility level goes to 1, indicating that flavors within a brand group j are taken as perfect substitutes for consumers. As σ approaches 0, the within-group correlation goes to 0, and the nested structure collapses to a standard logit model.

The market share of product ij is given by

$$s_{ij} = (s_{ij/j})(s_j), \tag{3.2}$$

where $s_{ij/J}$ is the market share of brand i in group j, and s_j is the market share of group j, also known as group share. The market share of brand i in group j is given by

$$s_{ij/j} = \frac{e^{\delta_{ij}/(1-\sigma)}}{E_j}, \tag{3.3}$$

where

$$E_j = \sum_{ij \in j} e^{\delta_{ij}/(1-\sigma)}, \tag{3.4}$$

The group share s_j is written as

$$s_j = \frac{E_j^{1-\sigma}}{\sum_{ij \in j} E_j^{1-\sigma}}. \tag{3.5}$$

Thus the market share of product ij is the product of the within-group share of product ij, $s_{ij/J}$ and the group share of j, s_j

$$s_{ij} = (s_{ij/J})(s_j) = \frac{e^{\delta_{ij}/(1-\sigma)}}{E_j^{\sigma} \sum_{ij \in j} E_j^{1-\sigma}}. \tag{3.6}$$

An outside good is also included in the model, allowing for the possibility that a consumer does not purchase any of the brands included in the study sample. The outside good is all other brands and flavors sold in this retail chain except for the selected ones. For the outside good, $s_0 = 0$, and $E_0 = 1$. The market share for the outside good is

$$s_0 = \frac{1}{\sum_{ij \in j} E_j^{1-\sigma}} \tag{3.7}$$

Normalizing the utility for the outside good to zero, the nested logit model is

$$\ln s_{ij} - \ln s_0 = X_{ij}\beta - \alpha P_{ij} + \sigma \ln s_{ij/J} + \xi_{ij} \tag{3.8}$$

Equation (3.8) is the equation to be estimated to investigate the demand-side change of PLs and NBs under the weather effect.

3.3.2 Supply

On the supply side, this study assumes that manufacturers are the price leaders and the retailer is the follower. The timing of their decisions ais as follows: 1) the manufacturers set the wholesale prices w_{ij}; and 2) the retailer sets the retail price p_{ij}, given w_{ij}. Given this timing, I solve the problems backward.

3.3.2.1 A Model of Retailer Pricing Behavior

The multi-product retailer is assumed to maximize category profits and sets retail prices for both PL and NB ice cream products. Given wholesale prices w_{ij}, the retailer's problem is written as

$$\underset{p_{ij}}{Max}\pi^r = \sum_{i=1}^{I}\sum_{j=1}^{J}(p_{ij} - w_{ij} - r)s_{ij}Q - R, \tag{3.9}$$

where π^r is the retailer's category profit, p_{ij} is the retail price of product ij, w_{ij} is the wholesale price for product ij, r is the retailer's marginal retailing cost, and s_{ij} is the market share. Q is the total market size (including the outside goods), and R is the fixed cost of retail operation. The first-order condition for the retailer's profit function is

$$\frac{\partial \pi^r}{\partial p_{ij}} = Qs_{ij} + Q\sum_{l=1}^{I}\sum_{m=1}^{J}(p_{lm} - w_{lm} - r)\frac{\partial s_{lm}}{\partial p_{ij}} = 0, \tag{3.10}$$

where I is the number of product types (flavor in this study) and J is the number of brands sold by the retailer. The retailer is assumed to jointly maximize profits across all brands it sells. The first-order condition in equation (3.10) suggests that the retailer takes into account not only the own effects of the pricing decision on the demand for one product, but also the cross-effects on other brands sold by the retailer. The retailer's margins can be written in matrix form as follows:

$$\begin{bmatrix} p_{11} - w_{11} - r_{11} \\ p_{21} - w_{21} - r_{21} \\ \vdots \\ p_{IJ} - w_{IJ} - r_{IJ} \end{bmatrix}_{IJ\times 1} = \begin{bmatrix} \frac{\partial s_{11}}{\partial p_{11}} & \frac{\partial s_{21}}{\partial p_{11}} & \cdots & \frac{\partial s_{IJ}}{\partial p_{11}} \\ \frac{\partial s_{11}}{\partial p_{21}} & \frac{\partial s_{21}}{\partial p_{21}} & \cdots & \frac{\partial s_{IJ}}{\partial p_{21}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial s_{11}}{\partial p_{IJ}} & \frac{\partial s_{21}}{\partial p_{IJ}} & \cdots & \frac{\partial s_{IJ}}{\partial p_{IJ}} \end{bmatrix}^{-1}_{IJ\times IJ} \begin{bmatrix} -s_{11} \\ -s_{21} \\ \vdots \\ -s_{IJ} \end{bmatrix}_{IJ\times 1}. \tag{3.11}$$

This can be simplified to matrix notations $(P - W - R) = -\Omega_r^{-1}s$, where Ω_r is the retailer's response matrix, which includes the first derivatives of all brand-level market shares with respect to all retail prices.

The retailer's price-setting behavior in equation (3.11) is derived under the assumption that the retailer is a perfect category profit maximizer in setting prices for the product he carries in the manufacturer Stackelberg model (Villas-Boas and Zhao, 2005). However, empirical evidence shows that there is likely some deviation from the optimal level (i.e., the maximizing level of the retailers' category profits). To allow for a departure from the optimal level, researchers have adopted a conduct parameter approach to evaluate the retailer's price-setting behavior in a more flexible manner (Kadiyali, Chintagunta, and Vilcassim, 2000; Chintagunta, Bonfrer, and Song, 2002, Villas-Boas and Zhao, 2005; Draganska and Klapper, 2007; Richards, Hamilton, and Patterson, 2010). A multiplier φ is incorporated into the retailer margin in equation (3.11), which measures the retailer margin deviation from the optimal level for a category-profit maximizing retailer. Villas-Boas and Zhao (2005) further point out that φ can be an evaluation of the retailer's pricing behavior that captures the impact of the vertical relationship between the retailer and the manufacturers on the retailer's pricing behavior. If $\varphi_{ij} = 1$, the retailer maximizes category profits by setting the optimal prices for all brands in the Manufacturer Stackelberg vertical interaction. If $\varphi_{ij} > 1$, the retailer charges prices above the optimal level. Chintagunta, Bonfrer, and Song (2002) interpret a higher than optimal level retailer margin as evidence that manufacturers behave in a more "accommodating" fashion and thus willing to concede some profit to the retailer due to the introduction of PLs. If $\varphi_{ij} < 1$, the retailer charges prices lower than the optimal level.

There is evidence that the interaction among competing players changes over time. Chintagunta, Bonfrer, and Song (2002) find that the retailer-manufacturer interaction changes after an introduction of PLs. Sudhir, Chintagunta, and Kadiyali (2005) show that there can be substantial variation in pricing behavior over time and that we need to account for both the direct and indirect effects of demand and cost changes on the competition. To capture the changing nature of the vertical interaction, Chintagunta, Bonfrer, and Song (2002) suggest writing conduct parameters as a function of the factors driving time-varying pricing behavior. For example, Richards, Hamilton, and Patterson (2010) model the deviation as a function of product characteristics, while Draganska and Klapper (2007) model the deviation as a function of the retail environment. Following Richards, Hamilton, and Patterson (2010) and Draganska and Klapper (2007), I model the conduct parameter as a function of product characteristics and exogenous demand shifters. In this study, the retailer's conduct parameter is written as a function of product characteristics, temperature, and temperature-brand interaction terms:

$$\varphi_{ij} = \varphi_0 + \varphi_{1m} \sum_{m=1}^{M} X_{ijm} + \varphi_2 Temperature + \varphi_{3n} \sum_{n=1}^{N} Temperature * BRAND_{ijn}, \quad (3.12)$$

where X is a vector of product characteristics. The estimated coefficients φ_0, $\varphi_{1m,}$ φ_2 and φ_{3n} provide information that indicates the deviations from the optimal level for the retailer that maximizes category profits, as well as the direction of these effects (Draganska and Klapper, 2007). For example, if $\varphi_2 > 1$, higher temperature leads to a higher margin than the optimal level for the brand chosen as a reference group.

3.3.2.2 A Model of Manufacturer Pricing Behavior

The retailer-manufacturer vertical model also allows interactions among manufacturers, although manufacturer competition is not the focus of this study. Manufacturers are assumed to engage in Bertrand-Nash competition. I assume that each NB manufacturer sets the wholesale price for NBs to maximize his profit and simultaneously takes into account the retailer's pricing reaction. The profit function for an individual manufacturer from product ij is

$$\underset{w_{ij}}{Max}\ \pi_f^m = (w_{ij} - c_{ij})s_{ij}Q - M, \tag{3.13}$$

where c_{ij} is the supplier's marginal cost for product ij, and M is the fixed cost that depends on exogenous manufacturer characteristics. The first-order condition for the manufacturers is

$$\frac{\partial \pi^m}{\partial w_{ij}} = Qs_{ij} + Q(w_{ij} - c_{ij})\sum_{l=1}^{I_a}\sum_{m=1}^{J_b}\frac{\partial s_{lm}}{\partial w_{ij}} = 0, \tag{3.14}$$

where $\sum_{l=1}^{I_a}\sum_{m=1}^{J_b}\frac{\partial s_{lm}}{\partial w_{ij}}$ includes all the derivatives of the market shares of all products with respect to the wholesale prices of all products. These terms can be written as $\frac{\partial s_{lm}}{\partial w_{ij}} = (\frac{\partial s_{lm}}{\partial p_{sk}})(\frac{\partial p_{sk}}{\partial w_{ij}})$, where $\frac{\partial s_{lm}}{\partial p_{sk}}$ is the retailer's response function that is derived from demand parameters, and $\frac{\partial p_{sk}}{\partial w_{ij}}$ is the derivative of retail price with respect to wholesale price can be obtained by totally differentiating the retailer's first-order conditions with respect to w_{ij} (Sudhir, 2001; Berto Villas-Boas and Zhao 2005; Berto Villas-Boas, 2007; Richards, Hamilton and Patterson, 2010). Differentiating equation 3.10 yields

$$G\begin{bmatrix}\frac{\partial p_{11}}{\partial w_{ij}}\\ \frac{\partial p_{21}}{\partial w_{ij}}\\ \vdots\\ \frac{\partial p_{ij}}{\partial w_{ij}}\end{bmatrix}_{IJ*1} = \begin{bmatrix}\frac{\partial s_{ij}}{\partial p_{11}}\\ \frac{\partial s_{ij}}{\partial p_{21}}\\ \vdots\\ \frac{\partial s_{ij}}{\partial p_{ij}}\end{bmatrix}_{IJ*1}, \tag{3.15}$$

where G is a $IJ * IJ$ matrix with typical element (ij, lm), where

$$g_{ij,lm=}\frac{\partial s_{ij}}{\partial p_{lm}} + \frac{\partial s_{lm}}{\partial p_{ij}} + \sum_{s=1}^{I}\sum_{k=1}^{J}(p_{sk} - w_{sk} - r)(\frac{\partial^2 s_{sk}}{\partial p_{ij}p_{lm}})(\frac{\partial p_{lm}}{\partial w_{ij}}), \tag{3.16}$$

Here the first and second derivatives of the market share can be directly computed using the estimates from the demand models. Inverting equation (3.15) yields

$$\begin{bmatrix} \frac{\partial p_{11}}{\partial w_{ij}} \\ \frac{\partial p_{21}}{\partial w_{ij}} \\ \vdots \\ \frac{\partial p_{ij}}{\partial w_{ij}} \end{bmatrix}_{IJ*1} = G^{-1} \begin{bmatrix} \frac{\partial s_{ij}}{\partial p_{11}} \\ \frac{\partial s_{ij}}{\partial p_{21}} \\ \vdots \\ \frac{\partial s_{ij}}{\partial p_{ij}} \end{bmatrix}_{IJ*1} \tag{3.17}$$

The manufacturer's margin for product ij is

$$w_{ij} - c_{ij} = -\frac{s_{ij}}{\begin{bmatrix} \frac{\partial s_{ij}}{\partial p_{11}} & \frac{\partial s_{ij}}{\partial p_{21}} & \cdots & \frac{\partial s_{ij}}{\partial p_{ij}} \end{bmatrix} G^{-1} \begin{bmatrix} \frac{\partial s_{ij}}{\partial p_{11}} & \frac{\partial s_{ij}}{\partial p_{21}} & \cdots & \frac{\partial s_{ij}}{\partial p_{ij}} \end{bmatrix}'} \tag{3.18}$$

Equation (3.18) expressed in matrix notation is

$$w - c = -s(\Delta_r G^{-1} \Delta_r')^{-1}, \tag{3.19}$$

where Δ_r is a IJ vector that shows how the market share of each product changes with respect to the retail prices of all other products.

The retail price-cost function can now be written as:

$$p - r = c - s(\Delta_r G^{-1} \Delta_r')^{-1} - \Omega_r^{-1} s. \tag{3.20}$$

Similar to the retailer price-cost margin equation, I introduce conduct parameters in the manufacturer margin equation to examine how manufacturers' pricing behavior departs from Bertrand-Nash equilibrium. Similarly, I assume that the manufacturers' conduct parameters depend on product characteristics and temperature. Thus, the conduct parameter for the manufacturers' is written as

$$\theta_{ij} = \theta_0 + \theta_{1m} \sum_{m=1}^{M} x_{ijm} + \theta_2 Temperature + \theta_{3n} \sum_{n=1}^{N} Temperature * BRAND_{ijn}, \quad (3.21)$$

where θ_{ij} test the price-setting behavior of the manufacturers. $\theta_{ij} > 1$ indicates that manufacturers are pricing more cooperatively than under Bertrand-Nash competition. Kadiyali, Chintagunta, and Vilcassim (2000) regarded a higher-than-Nash markup as a "softer-than-Nash" behavior resulting from the dependence of one's own profit on the profits of the other channel members including the retailer and other manufacturers.$\theta_{ij} < 1$ indicates that firms are pricing more competitively than in the Bertrand-Nash level. The individual θs on the right-hand side of equation (3.21) provide information on which characteristics affect manufacturers departure from Bertrand-Nash equilibrium and the direction of these effects. After introducing the manufacturer conduct parameters, equation (3.20) is decomposed into

$$p = \underbrace{r + c}_{\text{marginal cost}} + \underbrace{\theta(-s)(\Delta_r G^{-1} \Delta_r')^{-1}}_{\text{manufacturer margin } (w-c)} + \underbrace{((\frac{1}{\varphi})\Omega_r)^{-1}(-s)}_{\text{retailer margin } (p-w-r)} . \quad (3.22)$$

According to Equation (3.22),the complete retailer-manufacturer pricing model is specified as

$$
\begin{aligned}
& [p_{ij}]_{IJ\times 1} \qquad (3.23)\\
= \; & [z_{ij}]_{IJ\times 1}\gamma \\
& + \left[\theta_{ij} \frac{-s_{ij}}{\begin{bmatrix} \frac{\partial s_{ij}}{\partial p_{11}} & \frac{\partial s_{ij}}{\partial p_{21}} & \cdots & \frac{\partial s_{ij}}{\partial p_{ij}} \end{bmatrix} G^{-1} \begin{bmatrix} \frac{\partial s_{ij}}{\partial p_{11}} & \frac{\partial s_{ij}}{\partial p_{21}} & \cdots & \frac{\partial s_{ij}}{\partial p_{ij}} \end{bmatrix}'} \right]_{IJ\times 1} \\
& + \begin{bmatrix} \frac{1}{\varphi_1}\frac{\partial s_{11}}{\partial p_{11}} & \frac{1}{\varphi_1}\frac{\partial s_{21}}{\partial p_{11}} & \cdots & \frac{1}{\varphi_1}\frac{\partial s_{IJ}}{\partial p_{11}} \\ \frac{1}{\varphi 2}\frac{\partial s_{11}}{\partial p_{21}} & \frac{1}{\varphi_2}\frac{\partial s_{21}}{\partial p_{21}} & \cdots & \frac{1}{\varphi_1}\frac{\partial s_{IJ}}{\partial p_{21}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{\varphi_{IJ}}\frac{\partial s_{11}}{\partial p_{IJ}} & \frac{1}{\varphi_{IJ}}\frac{\partial s_{21}}{\partial p_{IJ}} & \cdots & \frac{1}{\varphi_{IJ}}\frac{\partial s_{IJ}}{\partial p_{IJ}} \end{bmatrix}_{IJ\times IJ} \begin{bmatrix} -s_{11} \\ -s_{21} \\ \vdots \\ -s_{IJ} \end{bmatrix}_{IJ\times 1} + [\delta_{ij}]_{IJ\times 1},
\end{aligned}
$$

where

$$
G = \qquad (3.24)
$$

$$
\begin{bmatrix} \begin{matrix} 2\frac{\partial s_{11}}{\partial p_{11}} \\ +\sum_{k=1}^{IJ}(p_k - w_k - c)\frac{\partial^2 s_k}{\partial p_{11}^2} \end{matrix} & \cdots & \begin{matrix} \frac{\partial s_{11}}{\partial p_{IJ}} \\ +\frac{\partial s_{IJ}}{\partial p_{11}} \\ +\sum_{k=1}^{IJ}(p_k - w_k - c)\frac{\partial^2 s_k}{\partial p_{11} p_{IJ}} \end{matrix} \\ \vdots & \ddots & \vdots \\ \begin{matrix} \frac{\partial s_{IJ}}{\partial p_{11}} \\ +\frac{\partial s_{11}}{\partial p_{IJ}} \\ +\sum_{k=1}^{IJ}(p_k - w_k - c)\frac{\partial^2 s_k}{\partial p_{IJ} p_{11}} \end{matrix} & \cdots & \begin{matrix} 2\frac{\partial s_{IJ}}{\partial p_{IJ}} \\ +\sum_{k=1}^{IJ}(p_k - w_k - c)\frac{\partial^2 s_k}{\partial p_{IJ}^2} \end{matrix} \end{bmatrix}_{IJ\times IJ}
$$

3.4 Data

This study makes use of three datasets. The first dataset contains retailer scanner data from a major North American supermarket chain operating 1678 stores in the United States and Western Canada, and is from the SIEPR-Giannini Data Center at the University of California Berkeley (SIEPER-Giannini, 2013). The dataset contains store-brand level retail information of branded products on a weekly basis. Individual product are identified by unique UPC codes, and there is retail information on retail prices, wholesale prices, quantities sold, and promotions. The dataset also provides information on individual stores, including their physical address, total building size, selling area and division identification. The second dataset is Mintel's Global New Product Database (GNPD), a global database of new consumer packaged goods that provides product records for 46 categories and 271 subcategories in 62 countries. The Mintel's GNPD offers product information such as product description, package type and size, barcode, ingredients, and nutrition information among others. The third dataset contains weather data from the National Centers for Environmental Information (NCEI) at NOAA. NCEI provides public access to weather and climatic information such as day temperature, precipitation, snowfall, and hours of sunshine on a daily basis. In order to investigate the effect of weather on PL-NB competition, I use the average maximum day temperature over a period of one week as a proxy for the mean temperature[1].

Consolidating the three datasets, each observation in the final data set is described in a week/store/brand/flavor format for a 178-week period from January 2005 to July 2007. The dataset provides detailed weekly retail information on products sold in each store, such

[1] This study focuses on the impact of mean temperature on the marketing variables. For the time being, I do not take into account the effect of temperature variability.

as retail and wholesale prices, quantity sold, and discounts. ZIP code-based temperature information is also included in the dataset. The dataset covers a wide geographic spectrum and includes sales in 246 stores located in 10 managing districts, 21 states, and 235 zip code areas. This analysis is based on retail information on 41 ice cream products of from four leading national brands and two private labels offered by the retailer. Although the retailer carries more varieties of products, in this analysis I only focus on a subset of brands available on store shelves that represent the majority of sales in a retail store. The six brands in the focus group are categorized into four groups by quality: premium NBs (NB_1), standard NBs (NB_0), premium PLs (PL_1), and standard PLs (PL_0). NB_1 represents two leading national brands of premium quality, and NB_0 are two leading national brands of standard quality. PL_1 is a premium-branded private label that offers an upscale range of products, and PL_0 is the private label ice cream offering generic quality. The selected leading NBs and PLs account for nearly 90% of the total quantity sold in the retail chain.

The market share for each product is calculated based on the potential market size, which is defined as per capita consumption (in milliliters) in a week multiplied by the estimated population served by one retail store. Table 3.1 lists the summary statistics of the main market mix including retail price, market share, markup, and wholesale price for the four leading NBs and two PLs, which are averaged across 246 stores and 178 weeks. The data set includes two premium NBs (Premium NB_1 and NB_2), two standard NBs (Standard NB_1 and NB_2), one premium PL (PL_1) and one standard PL (PL_0). As shown in Table 3.1, in the U.S. ice cream market, two standard NBs are the market leaders in terms of both share and revenue. They account for nearly half of the share and contribute about 45% of the total revenue. However, the standard PLs are also a significant component of the ice cream market, possessing the second largest share in the ice cream market. The retail markups, measured in a relative form (%), are higher for PLs than NBs, given a lower wholesale price of PLs.

Figure 3.2 illustrates the trend of the major marketing mix variables as temperature changes[2]. As shown in Figure 3.2, the retail prices of ice cream appear to decline for all NBs and PLs, with the exception of the standard NBs (NB_0), as temperature increases. This result suggests that the ice cream market displays the counter-cycle pricing during the high-demand periods (Chevalier, Kashyap, and Rossi, 2003; Nevo and Hatzitaskos, 2006). Consistent with the declining retail prices, the promotional activities for ice cream, especially promotional frequency, become more intense when temperature rises. Consistent with the extant literature (such as Volpe, 2011), PLs are promoted more frequently than NBs. Also, the promotional frequency for PLs appears to significantly increase as temperature goes up, with only a slight increase for NBs. Promotional depth indicators show more volatility for both PLs and NBs as temperature increases; nevertheless, PLs, especially the premium PLs (PL_1), are marked down more deeply compared to NBs. Figure 3.2 also shows that the wholesale price decreases for premium NBs (NB_1) as temperature increases, while price increases for standard NBs (NB_0). In contrast, wholesale prices for PL_1 and PL_0 do not show any obvious changes with temperature. The markups shown in Figure 3.2 also present a different trend for NBs and PLs with a rise in temperature. The figure shows that markups for PLs are higher than NBs, but also more volatile than NBs with a change in temperature.

[2]The x axis in Figure 3.2 represents the average maximum day temperature on a weekly basis over the investigated period from the 1st week of 2004 to 22nd week of 2007. 0-8 are 8 groups depicting the change of the temperature from below zero to above 35 °C. For example, 0 represents the temperature below 0 °C, 1 represents the temperature between 0 °C and 5 °C, 2 represents the temperature between 5 °C and 10 °C, and 8 represents temperature above 35 °C.

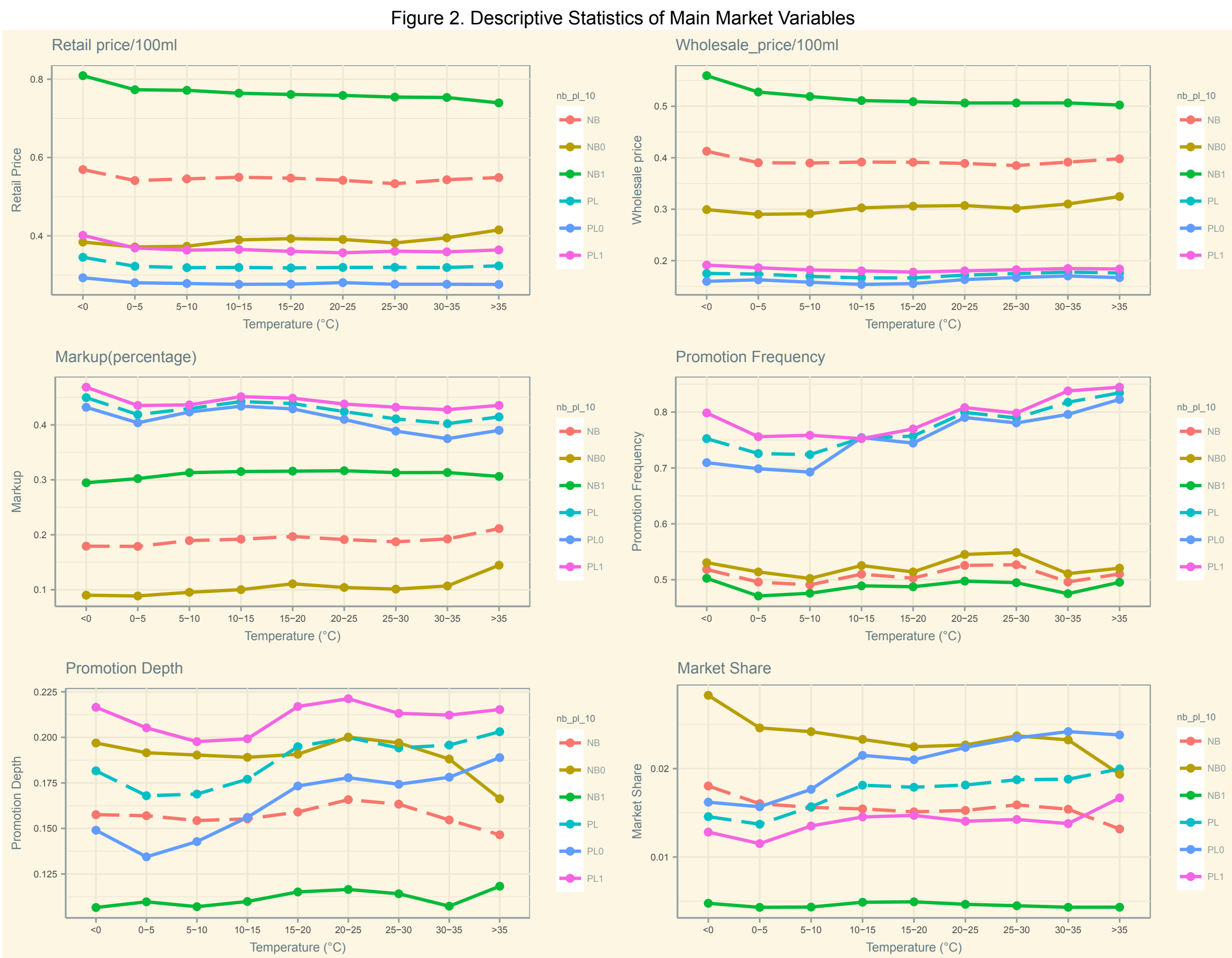
Table 3.1: Summary Statistics of Market Mix data

	Retail Price ($/100ML)	Market Share	Markups($/100ML)	Wholesale Price($/100ML)	Average Weekly Revenue ($)
Premium NB1	0.7667	0.0050	0.2685	0.4983	14.4941
	(0.1253)	(0.0047)	(0.1170)	(0.0644)	(12.0493)
Premium NB2	0.7526	0.0042	0.2244	0.5282	11.7449
	(0.1429)	(0.0043)	(0.1169)	(0.0570)	(10.3482)
Standard NB1	0.2615	0.0279	0.0423	0.2192	25.0874
	(0.0781)	(0.0382)	(0.0749)	(0.0284)	(27.7750)
Standard NB2	0.5298	0.0179	0.1312	0.3987	21.9887
	(0.3421)	(0.0305)	(0.1565)	(0.2105)	(23.8544)
Standard PL	0.2781	0.0214	0.1169	0.1612	16.3601
	(0.1668)	(0.0292)	(0.0819)	(0.1008)	(14.9342)
Premium PL	0.3622	0.0142	0.1808	0.1813	12.9596
	(0.2646)	(0.0167)	(0.1634)	(0.1133)	(10.4462)

Note: a) sd. in parentheses

PLs expand aggressively in the market as temperature rises; the market shares rise for both standard and premium PLs as temperature increases. However, the trends show that the change in the market shares for NBs are more modest, as compared to PLs. It is worth noting that the market shares for standard PLs exceed the standard NBs and keep growing when temperature goes beyond 30 °C in the ice cream market.

Figure 3.2: Descriptive Statistics of the Main Market Variables



3.5 Estimation and Results

3.5.1 Estimation Strategy

I estimate a structural model of demand and supply in two stages. In the first stage, I estimate the demand model (equation (3.8)). Following this, I use the estimated demand parameters from the first-stage estimation to compute retailer and manufacturer margins in the PCM model in the second stage. In the second stage, I also estimate conduct parameters (φ_{ij} and θ_{ij}), which are written as a function of product characteristics, temperature, and the interaction terms of temperature and PL-NB indicators.

Prior to estimating the demand model, I need to address several econometric issues. Following Berry (1994), price and within-group market share are endogenous variables because retailer prices and within-group market shares are correlated with unobserved product characteristics (e.g., shelf-placement, in-store advertising, changing consumer preferences). To eliminate the potential biases due to endogeneity, I utilize two sets of instrumental variables for identification purposes. The first set of instrumental variables are constructed by interacting input price with brand dummies following Chintagunta, Bonfrer, and Song (2002), and Berto Villas-Boas (2007). The interaction terms allow input prices to vary by brand and exhibit sufficient variation to identify the demand parameters. For the endogenous conditional shares (within-group shares), I follow Nevo (2001) and Li and Lopez (2015) and adopt average conditional shares in other areas and weeks. Finally, I employ a Generalized Methods of Moment (GMM) estimator to estimate the demand model and produce unbiased results.

3.5.2 Estimation Results

In this section, I present and discuss the estimation results for the demand and PCM models. The results of demand model allow me to test the hypothesis of asymmetric changes in consumer demand for PLs and NBs of different qualities as temperature changes. The supply model examines the resulting competitive strategy between the retailer and NB manufacturers in response to a change in demand conditions due to temperature.

3.5.2.1 Demand Model

On the demand side, to examine the demand change with temperature, I estimated share equations developed based on the nested structure of consumers' decisions. The estimation results of the demand model are presented in Table 3.2. Nearly all key parameter estimates are highly statistically significant and all have the expected signs. Consumers have a negative response to price ($Retail\ Price = -3.036$), and the coefficient of σ ($sigma = 0.312$) is positive and significantly different from 0. This implies that consumers' utilities are correlated within brands and that consumers substitute among flavors within the same brand. As expected, the retail price is negatively correlated with the market shares. Other parameters provide evidence on how market shares vary with promotional activities, management districts, and brands, and product characteristics (e.g., novelty, diary-based, presence of health claim). For example, promotion ($promotion = 0.328$) is positively correlated with consumer demand, indicating that a temporary discount increases consumer demand for ice cream.

The estimated coefficients of temperature and temperature-PL/NB indicator interaction terms show the relative changes in consumer demand as temperature varies. Table 3.2 shows that all the parameters of temperature and temperature-PL/NB interaction terms are significantly different from zero, indicating that temperature has statistically significant effects on consumer demand for all NB and PL ice cream across different quality tiers. More importantly, PLs and NBs show significantly different trends as temperature changes. For PL_1, a rise in the day temperature ($temperature * PL_1 = 0.0168$) results in a significant increase in the share of PL_1. As temperature increases, the market share for PL_0 increases ($temperature * PL_0 = 0.0009$) at even a slightly faster rate than PL_1. However, as temperature goes up the growth in demand for both NB_0 and NB_1 are slower than PL_1 ($temperature * NB_0 = -0.0039$, and $temperature * NB_1 = -0.0075$)[3]. This result suggests that the change in demand with temperature is not uniform between PLs and NBs. As temperature rises, the increase in demand for PLs is faster than NBs. The summary statistics (Figure 3.2) also show a similar trend that the market share of PLs grows faster than NBs as temperature increases. This finding confirms the hypothesis that consumers tend to increase their consumption of low-priced PLs relative to high-priced NBs as the weather gets warmer, and is also consistent with Nevo and Hatzitaskos (2006) conclusion that consumers are more price sensitive during high-demand periods and opt for low-priced brands. The magnitude of the estimated coefficients provides a more granular weather-sensitive signal: for a 1 °C increase in the mean temperature, I find the market shares of PL_1, PL_0, NB_1 and NB_0 increase by 1.7%, 1.8%, 1.0% and 1.3%, respectively. This result shows that an increase in temperature improve the overall demand for ice cream, and the PL shares appear to grow more aggressively than NBs shares. In addition, it is worth noting that the purpose of this

[3] By the definition, the calculation of market shares is based on the potential market size (total potential purchase of ice cream in a market). This definition allow the market share of the inside brands to expand and contract over different periods with the choice of the marketing mix (Sudhir, 2001). Therefore, we see that market shares of all products in the inside group increase as temperature increases. The outside group that captures consumers' no-purchase option is big in the dataset, including ice cream sold in other supermarkets, grocery stores, convenient stores, and other types of stores, as well as non-ice cream substitutes.

study focuses on the differences in changes in demand among different brands rather than providing an accurate prediction of how temperature changes drive overall demand.

Tables 3.3 and 3.4 report own-price elasticities and cross-price elasticities for products sold in all stores the first week of 2004. Figure 3.3 illustrates the trend of the average own-price elasticities for PLs and NBs over a 52-week (from January to December) period. This study finds that the premium NBs have the highest own-price elasticities, followed by the standard NBs, while PLs have the lowest own-price elasticities. This result indicates that consumers are most price-sensitive to premium NBs, and more brand-loyal to PLs. In addition, the own-price elasticities of PLs show increased volatilities during the summer period (week 25-35). However, the own-price elasticities for NBs do not show a similar seasonal trend. This may be a response to the more aggressive promotions the retailer offers for PLs versus NBs in the summer, which is confirmed by summary statistics of promotional frequency and depth illustrated in Figure 3.2.

Table 3.2: Estimated Results of the Demand Model

Variables	Coefficients
Retail Price	-3.0361***
	(0.0249)
σ	0.3129***
	(0.0036)
Division Fixed Effect	
Dominic	0.2760***
	(0.0052)
Eastern	0.3921***
	(0.0052)
Genuardi	0.3892***
	(0.0048)
North California	0.7607***
	(0.0047)
Phoenix	0.1792***
	(0.0046)
Portland	0.9153***
	(0.0046)
Seattle	0.7216***
	(0.0047)
Texas	-0.6229***
	(0.0046)
Vons	0.0820***
	(0.0042)
Product Characteristics	
Novelty	0.6972***
	(0.0106)
Dairy	0.2832***
	(0.0050)
Health Claim	0.0679***
	(0.0028)
Promotion	0.3289***
	(0.0037)
Brand Fixed Effect	
B&J	0.7874***
	(0.0149)
Breyers	0.8100***
	(0.0079)
Dreyers	0.8479***
	(0.0079)
Haagen Dazs	0.6365***
	(0.0158)
Lucerne	-0.1820***
	(0.0106)

Temperature*NB-PL indicators	
Temperature	0.0168***
	(0.0003)
PL0*temperature	0.0009*
	(0.0004)
NB0*temperature	-0.0039***
	(0.0003)
NB1*temperature	-0.0075***
	(0.0003)
Constant	-4.3709***
	(0.0087)
Observations	725649

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.3: Price Elastisties of Demand

	NB_{11}	NB_{21}	NB_{31}	NB_{12}	NB_{22}	NB_{32}	NB_{42}	NB_{13}	NB_{23}	NB_{33}	NB_{43}	NB_{14}	NB_{24}
NB_{11}	-3.10789	0.41895	0.41895	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816
NB_{21}	0.50299	-3.01478	0.50299	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979
NB_{31}	0.43477	0.43477	-3.09275	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847
NB_{12}	0.00621	0.00621	0.00621	-6.01815	0.62312	0.62312	0.62312	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621
NB_{22}	0.00649	0.00649	0.00649	0.65145	-2.90712	0.65145	0.65145	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649
NB_{32}	0.00658	0.00658	0.00658	0.66086	0.66086	-2.84238	0.66086	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658
NB_{42}	0.00553	0.00553	0.00553	0.55512	0.55512	0.55512	-3.06507	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553
NB_{13}	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	-1.20085	0.31831	0.31831	0.31831	0.02250	0.02250
NB_{23}	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.13275	-1.36982	0.13275	0.13275	0.00938	0.00938
NB_{33}	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.11950	0.11950	-1.35544	0.11950	0.00845	0.00845
NB_{43}	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.11877	0.11877	0.11877	-1.40626	0.00839	0.00839
NB_{14}	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	-1.35223	0.09490
NB_{24}	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.23381	-1.24802
NB_{34}	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.10584	0.10584
NB_{44}	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.06584	0.06584
NB_{54}	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.10389	0.10389
NB_{64}	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.08851	0.08851
NB_{74}	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.11763	0.11763
PL_{11}	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894	0.00894
PL_{21}	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882	0.00882
PL_{31}	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290	0.00290
PL_{41}	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244	0.01244
PL_{12}	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780
PL_{22}	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994
PL_{32}	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980
PL_{42}	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370

Note: NB_{ij} represents flavor i of National Brands j, where $i = 1,2,3, \ldots . j = 1,2,3, and\ 4$. $j = 1$ and 2 represents the premium NBs, $j =$ 3 and 4 represents the standard NBs. PL_{ij} represents flavor i of Private Label j, where $i = 1,2,3, \ldots, and\ j = 1\ and\ 2$. $j = 1$ represents premium PLs, and $j = 1$ represents the standard PLs.

Table 3.4: Price Elastisties of Demand (Extended)

	NB_{34}	NB_{44}	NB_{54}	NB_{64}	NB_{74}	PL_{11}	PL_{21}	PL_{31}	PL_{41}	PL_{12}	PL_{22}	PL_{32}	PL_{42}
NB_{11}	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816	0.00816
NB_{21}	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979	0.00979
NB_{31}	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847	0.00847
NB_{12}	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621	0.00621
NB_{22}	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649	0.00649
NB_{32}	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658	0.00658
NB_{42}	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553	0.00553
NB_{13}	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250	0.02250
NB_{23}	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938	0.00938
NB_{33}	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845	0.00845
NB_{43}	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839
NB_{14}	0.09490	0.09490	0.09490	0.09490	0.09490	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752	0.00752
NB_{24}	0.23381	0.23381	0.23381	0.23381	0.23381	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852	0.01852
NB_{34}	-1.33677	0.10584	0.10584	0.10584	0.10584	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838	0.00838
NB_{44}	0.06584	-3.41833	0.06584	0.06584	0.06584	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521	0.00521
NB_{54}	0.10389	0.10389	-3.38754	0.10389	0.10389	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
NB_{64}	0.08851	0.08851	0.08851	-1.37914	0.08851	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701	0.00701
NB_{74}	0.11763	0.11763	0.11763	0.11763	-3.39203	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932	0.00932
PL_{11}	0.00894	0.00894	0.00894	0.00894	0.00894	-2.09309	0.09289	0.09289	0.09289	0.00894	0.00894	0.00894	0.00894
PL_{21}	0.00882	0.00882	0.00882	0.00882	0.00882	0.09162	-0.56333	0.09162	0.09162	0.00882	0.00882	0.00882	0.00882
PL_{31}	0.00290	0.00290	0.00290	0.00290	0.00290	0.03012	0.03012	-0.61839	0.03012	0.00290	0.00290	0.00290	0.00290
PL_{41}	0.01244	0.01244	0.01244	0.01244	0.01244	0.12931	0.12931	0.12931	-0.52917	0.01244	0.01244	0.01244	0.01244
PL_{12}	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	0.00780	-0.60037	0.07829	0.07829	0.07829
PL_{22}	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.00994	0.09975	-2.24213	0.09975	0.09975
PL_{32}	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.00980	0.09836	0.09836	-0.76889	0.09836
PL_{42}	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.01370	0.13742	0.13742	0.13742	-0.62546

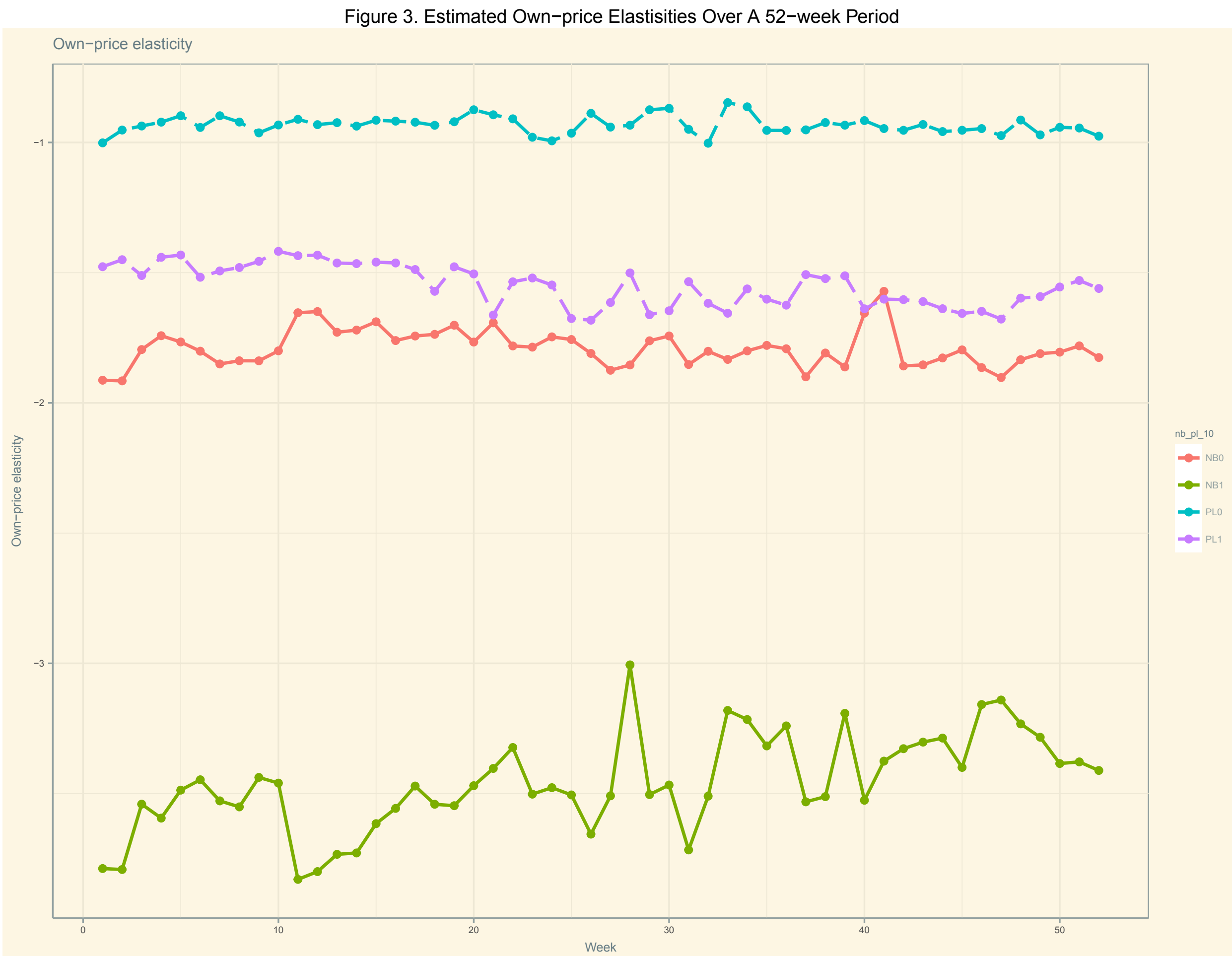
Note: NB_{ij} represents flavor i of National Brands j. $i = 1,2,3, ...$ $j = 1,2,3, and\ 4$, where 1 and 2 are premium NBs, and 3 and 4 are standard NBs. PL_{ij} represents flavor i of Private Label j. $i = 1,2,3, ..., and$ $j = 1\ and\ 2$, where 1 is premium PLs, and 2 is standard PLs.

3.5.2.2 Supply Model

On the supply side, I estimated the Price-Cost Margin (PCM) equations to examine retailer and manufacturers' pricing behavior in response to changing temperature. Table 3.5 summarizes the results of the PCM estimation. The estimated individual conduct parameters, φ and θ in equation (3.12) and equation (3.21), provide information on the change in retailer and manufacturer margins with temperature. In this study, I assume the retailer adopts a differentiated two-tier PL strategy, which is becoming more common in the retail industry (Bazoche, Giraud-Héraud, and Soler, 2005; Geyskens, Gielens, and Gijsbrechts, 2010; Ter Braak, Geyskens, and Dekimpe, 2014). The premium PLs (PL_1) are positioned at the top end of the market and compete with the premium NBs (NB_1), while the standard PLs (PL_0) compete with the standard NBs (NB_0). Table 3.5 shows that the effect of temperature on retailer margin is different for the standard and premium NBs and the standard and premium PLs. Temperature has a significantly negative effect on retailer margin for PL_1 and NB_0 ($PL_1 * temperature_1 = -0.0006$, $NB_0 * temperature = -0.0051$); however, it has a positive effect on retailer margin for PL_0 and NB_1 ($PL_0 * temperature = 0.0045$, $NB_1 * temperature = 0.0053$). These results suggest that retailer margins differ for PL and NB products of different qualities as temperature changes. Next, I discuss how retailer and manufacturer margins change with temperature, with the results summarized in Table 3.5.

On the retailer side, Table 3.5 shows as temperature increases, retailer margin increases for standard PLs (PL_0), but declines for premium PLs (PL_1). As we recall from the summary statistics (Figure 3.2), PL_1 are promoted more frequently by the retailer than PL_0 as temperature goes up. This partly explains the declining retailer margin for PL_1. Sayman, Hoch, and Raji (2002) show that premium PLs are considered to be positioned closer to

Figure 3.3: Estimated Own-price Elasticities Over A 52-week Period



NBs than low-quality PLs, and compete more intensively with NBs. Combining this with the demand-side result that the share of PL_0 increases more aggressively than PL_1, it suggests the retailer gains both margin and share advantages on PL_0 as weather gets warmer. Therefore, PL_0 is more likely sold for profitability by the retailer as temperature increases. Table 3.5 also shows that as temperature increases, retailer margin increases for NB_1, but declines for NB_0, which is the opposite of what happens to the PLs. The main reason for the increase in the retailer margin for NB_1 is that the manufacturers lower the wholesale price for the premium NBs (NB_1)[4]. This may be a response to the retailer's aggressive expansion for PL_1. As weather gets warmer, the retailer promotes PL_1 more aggressively and the head-on competition from PL_1 makes the manufacturers of NB_1 offer a concession by lowering the wholesale price of NB_1.

The results of retailer margins for PL_0 (increasing), PL_1 (decreasing), NB_1 (increasing), and NB_0 (decreasing) together imply that the retailer is more likely to use: (a) PL_0 as a source of profit and (b) PL_1 as a bargaining chip to negotiate better prices of NB_1.

On the manufacturer side, results in Table 3.5 show that temperature has a significant effect on margins for all NBs and PLs, except for PL_1. The effect of temperature on the manufacturers' margin for PL_1 is positive ($PL_1 * temperature = 0.0002$), but not statistically significant. For PL_0, temperature has a significant and negative effect ($PL_0 * temperature = -0.0140$) on manufacturers' margins, suggesting that manufacturers of PL_0 earn lower margins in warmer weather. The significant and positive effect on manufacturer margin ($NB_0 * temperature = 0.0154$) for NB_0 and negative effect

[4]The summary statistics in Figure 3.2 show a declining trend of the wholesale price of the premium NBs with an increase in temperature. A simple equation of wholesale price is estmated and the result shows a similar trend.

($NB_1 * temperature = -0.0175$) on manufacturer margin for NB_1 implies a declining manufacturer margin for NB_1 and increasing manufacturer margin for NB_0 with an increase in temperature. The results show that a change in temperature results in asymmetric changes in manufacturer margins for PLs and NBs. As temperature increases, the manufacturer margin for NB manufacturers increases for NB_0, but decreases for NB_1.

The results of manufacturer margins for NB_0 and NB_1 together suggest that manufacturers are more likely to: (a) lower the wholesale price of NB_1, in response to the intense competition from PL_1; and (b) use NB_0 as a source of profit. Additionally, the manufacturer-side results also suggest that PL_1 is possibly used by the retailer as a negotiation tool for a lower price of NB_1.

Combining the results of margin change (summarized in Table 3.6) on the retailer side with the manufacturer-side results, I can further examine the competitive intensity between the retailer and the manufacturers of NBs at different markets. As Table 3.6 shows, the retailer margin for PL_1 and the manufacturer margin for NB_1 both decline with temperature. This provides some evidence that competition gets more intense in the high-end market as temperature increases. On the contrary, in the low-end market, the retailer margin for PL_0 and the manufacturer margin for NB_0 both increase with temperature, suggesting that the competition between the retailer and manufacturers becomes less intense as temperature increases. In the process of using PL_1 as a bargaining chip in the competition with manufacturers, the retailer loses profitability on PL_1; however, the loss is compensated by earning more profit through PL_0 and NB_1. Manufacturers offers a price concession and thus lose profitability on NB_1, but gains on NB_0 by charging the retailer a higher wholesale price for NB_0. The results imply that an increase in temperature results in intensified competi-

Table 3.5: Estimated Results of the PCM Model

Variables	Coefficients
Cost Shifters	
Corn Syrup	0.0016***
	(0.0002)
Milk	-0.0079***
	(0.0002)
Energy	0.0008***
	(0.00003)
Chocolate	0.0025***
	(0.0001)
Diesel	-0.0563***
	(0.0014)
Wage	0.0004***
	(0.00002)
Retailer's conduct parameter (φ)	
Constant	-0.4446***
	(0.0040)
φ _PL0	-0.4226***
	(0.0080)
φ _NB0	0.1714***
	(0.0043)
φ _NB1	0.2817***
	(0.0052)
φ _temperature	-0.0006***
	(0.0002)
φ _PL0*temperature	0.0045***
	(0.0004)
φ _NB0*temperature	-0.0051***
	(0.0002)
φ _NB1*temperature	0.0053***
	(0.0003)
φ _Novelty	0.7191***
	(0.0032)
φ _Dairy	0.4622***
	(0.0032)
φ _Health Claim	-0.1956***
	(0.0020)
Manufacturer's conduct parameter θ	
Constant	-2.1548***
	(0.0175)
θ _PL0	0.3735***
	(0.0208)
θ _NB0	-0.1986***
	(0.0126)
θ _NB1	1.3403***
	(0.0148)
θ _temperature	0.0002
	(0.0005)

θ _PL0*temperature	-0.0140***
	(0.0010)
θ _NB0* temperature	0.0154***
	(0.0006)
θ _NB1* temperature	-0.0175***
	(0.0007)
θ _Novelty	-0.3695***
	(0.0093)
θ _Dairy	-1.0964***
	(0.0095)
θ _Health Claim	0.5057***
	(0.0057)
Constant	0.4803***
	(0.0169)
Observations	730770

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

tion between the retailer and manufacturers in the high-end market but more cooperative competition in the low-end market.

Additionally, in the case of the PLs, the results show that the manufacturer margin for PL_0 decreases with temperature. In contrast, the manufacturer margin for PL_1 does not show a significant change with temperature. These results provide further support of previous findings that the retailer can gain higher margins by selling PL_0 versus PL_1 in warmer weather. One possible explanation is that an increasing consumer demand for PL_0 gives the retailer an advantage to negotiate a lower wholesale price from PL_0 manufacturers. This is consistent with existing literature that shows that low-quality PLs provide their manufacturers little market power in the interaction with retailers (Ailawadi and Harlam, 2004; Geyskens, Gielens, and Gijsbrechts 2010; Ter Braak, Geyskens, and Dekimpe 2014)[5].

3.5.2.3 Summary of Results

First, the retailer gains a competitive advantage over the NB manufacturers in the sale of PLs. Consumer demand for ice cream expands as weather gets warmer, but the change in demand is not uniformly distributed between PLs and NBs. The results show that as it gets warmer, PLs expand more aggressively than NBs. This finding supports a greater consumer preference for cheaper PL ice cream in high-demand periods and is consistent with Nevo and Hatzitaskos (2006).

Second, in response to the weather-driven change on the demand side, the retailer earns increasing power over their upstream manufacturers by using a two-tier PLs strategy. The

[5] However, understanding the competition between the retailer and their PL suppliers is a different topic and needs to take into account factors such as the types of PL suppliers (Mills, 1995), and the relationship between the retailer and PL suppliers (Braak, Geyskens, and Dekimpe, 2014). It is not a focus of this study.

Table 3.6: The Trend of the Retailer and NB Manufacturers Margins as Temperature Increases

		High-end Market		Low-end Market	
Margin	PL or NB	Quality-differentiated PL/NB	Trend of margin with an increase in temperature	Brands	Trend of margin with an increase in temperature
The retailer ($P_r - P_w$)	PL	Premium PL	–	Standard PL	+
	NB	Premium NB	+	Standard NB	–
NB manufacturers ($P_w - MC$)	NB	Premium NB	–	Standard NB	+

results show that as temperature increases, the retailer gains both share and margin advantages on the standard PLs, and it appears to be more profitable for the retailer to price cooperatively with manufacturers in the low-end market and use the standard PLs as a source of profit. On the other hand, as temperature increases the retailer exerts pressure on manufacturers by promoting the premium PLs aggressively. The retailer suffers from declining margin for the premium PLs, but gains increasing margin from the premium NBs. This implies that the premium PLs are more likely to be used by the retailer as a bargaining chip to negotiate for a better wholesale price for the premium NBs. The retailer's loss on the premium PLs is somewhat compensated by selling the standard PLs and premium NBs.

Third, confronting the head-on competition from the premium PLs as temperature increases, the manufacturers of the premium NBs tend to take "a softer stance" and lower the wholesale price of premium NBs. The price concession could be a response to the slow market share growth for the premium NBs compared to other products. The drop in the premium NB's wholesale price provides the retailer with a higher margin on the premium NBs and increasing bargaining power over NB manufacturers. However, manufacturers can earn higher power by charging the retailer a higher wholesale price for the standard NBs in the low-end market with less intensive competition in the low-end market.

Lastly, the competition between PLs and NBs in the low-end market and in the high-end market responds differently to a change in temperature. As weather gets warmer, the retailer tends to compete more intensely in the high-end market and more cooperatively in the low-end market. One possible reason could be that standard brands make a bigger contribution to retailer's overall profitability than the premium brands. The descriptive statistics (Table 3.1) show that the total net revenue of standard PLs and NBs sold in the market significantly exceeds the revenue of premium PLs and NBs.

3.6 Conclusion and Discussion

The primary objective of this study is to explore how retailers use PLs to compete with NB manufacturers in the vertical channel in response to a change in weather. Weather drives significant changes in consumer demand and accordingly influences the competitive behavior between retailers and upstream manufacturers. This study aims to examine this retailer-manufacturer competition and the role of PLs under a two-tier strategy with the effect of weather.

I develop an approach to empirically model the change on both demand and supply sides with varying temperature. The model I employ not only accounts for the decisions of consumers under the effect of temperature, but also the influence of a change in demand conditions on the competitive behaviour between a retailer and their upstream manufacturers. This study also addresses the issue of PL proliferation, which has recently been a hot topic in PL literature, to see if the weather effect on retailers' PL strategy is asymmetric in a differentiated two-tier setting.

This study confirms some of the results from previous studies that PLs can provide retailers with lower wholesale prices and higher margins on NBs (e.g., Sayman, Hoch and Raju, 2002). More importantly, this study provides insights that retailers and manufacturers react endogenously to a shock that significantly changes the conditions on the demand side through the competition between PLs and NBs. In response to the demand-side change, retailers can take the opportunity to increase their power in the vertical competition with manufacturers by using PLs strategically. The contribution of this study to the existing literature is twofold. First, this study focuses on the changing nature of retailer-manufacturer competition, compared to the static channel competition existing literature assumes. In the supply chain, a demand-side shock (e.g., temperature) can lead to a change in consumers' price sensitivity and then result in the relative change in the retailer and manufacturer power. Second, this study explores the role of PL proliferation in a retailer's competition with manufacturers.

The results of this study provide several important implications. First, this study reveals that the change in the overall consumer demand, due to a change of temperature, is unevenly distributed among PLs and NBs. As temperature increases, PLs expand more aggressively than NBs. This may be caused by the change in consumer price sensitivity (e.g., consumers become more price sensitive in the high-demand season as demand surges). Although this study does not find any evidence of increasing price elasticities with temperature, it shows that brand-level price elasticities vary differently in summer compared with winter. Second, the study also has an implication for retailers. Retailers can utilize the change of demand conditions to bargain more efficiently with NB manufacturers. This is particularly applicable for retailers with strong PLs who have more leverage with manufacturers (Steiner, 2004). *A high market share PL is a threat to manufacturers and enables retailers to get better deals from manufacturers. For retailers with weak PLs, they can still use PLs to increase sales or earn direct profits by selling PLs. Third, the implication for manufacturers is that retailers may pose a greater threat (e.g., increasing PL share) to NB manufacturers as temperature increases. They may need to take a softer stance and command a price concession to retailers who are in a better bargaining position. Last, the results of the study imply that a* *proliferated PL program can be beneficial for both retailers and manufacturers. Retailers and manufacturers can choose to compete intensively in one market and cooperatively in the other market.* For example, the results of this study show that premium PLs are more likely to be used as a negotiation tool and compete aggressively with premium NBs, while standard private labels tend to serve as a source of profit and the competition between standard PLs and NBs is relatively mild. PL proliferation now is a prevalent strategy used by sophisticated retailers (Kumar and Steenkamp, 2007). As the narrowing quality gap between PLs and NBs, the competition between PLs and NBs also become more intensive in recent years, with the introduction of premium PLs.

Using data from the ice cream industry, this study provides an interesting case study on retailer-manufacturer power balance when there is a shock (temperature) leading to demand fluctuations. There is a possibility to extend the study to other food categories such as salad dressing, canned soup, and juice and carbonated soft drinks where weather is a critical condition to drive demand fluctuations. This study also provides an implication for studies on how shocks in the supply chain affect the vertical channel competition and how retailers and manufacturers endogenously react to a shock. It should be noted that the investigation of PL-NB competition in this study does not take the sourcing of PLs into account. PLs are produced through vertical integration, by NB manufacturers, or small regionally-operating manufacturers (Volpe, 2014). Due to the difficulties in identifying the sources of PLs in the retail chain I focus on in this study, PL sourcing is not taken into account in the demand-supply model. However, I have to acknowledge that the sourcing of PLs can affect retailers' and manufacturers' pricing behaviour. In recent years, there is a trend that PLs are produced through vertical integration, which gives retailers more power by overcoming the doublemarginalization problem(Mills 1995). The market power of retailers may be magnified if this is a case.

One limitation worth clarifying is the assumption of the Manufacturer-Stackelberg in the vertical interaction between the retailer and his upstream manufacturers. Under this assumption, retailers take wholesale prices as given when determining retail prices to optimize category profits. The manufacturers take retailers' reactions into account when deciding their wholesale prices. Although this type of vertical competition has been found to fit well the data in a number of product categories (Sudhir 2001; Cotterill and Putsis, 2001), I have to acknowledge that there are other types of interactions to describe the vertical retailer-manufacturer interaction; for instance, the vertical Nash model in which retailers and manufacturers choose their optimal prices simultaneously. Since this study does not examine the vertical interaction per se, I follow studies (e.g., Richards, Hamilton, and Patterson, 2010) which have used the Manufacturer-Stackelberg model in examining the competition between PLs and NBs in a differentiated food market. Another limitation to note is the only proxy I use to represent weather is temperature. A comprehensive weather index may be developed in the future to better capture the effects of external weather conditions on demand and supply.

Chapter 4

Product Line Competition among Retailers and the Halo Effect

4.1 Introduction

Due to perceived risks from product and process innovation in the food industry, more and more public attention has been paid to the health and quality benefits of food. Consumer demand for healthful and high-quality foods seems to be a driving force in the food retail industry. A considerable number of studies using stated preference methods have shown that consumers have a high willingness-to-pay (WTP) for healthy and high-quality food (e.g., Wang et al., 1997). The growth of the organic market also confirms this trend. An Organic Trade Association survey shows that organic growth rate in the U.S. is six times the pace of the overall food market in 2017 (Organic Trade Association, 2018). According to the survey, American organic sales increased 15 times from $3.4 billion in 1997 to over

$45 billion in 2017, now accounting for 5.5 percent of the food sold in retail channels in the U.S. Retailers have implemented strategies to meet consumers' fast-evolving demand for high-quality foods. Organic products are now available in nearly 20,000 natural and fresh food stores and nearly 3 out of 4 conventional grocery stores (USDA, 2019). Premier natural and fresh food stores are a significant provider of organic goods and account for 26% of organic spending (Nielsen, 2017). For example, Whole Foods Market, a natural and organic food retailer, has expanded aggressively to meet the consumer demand for healthier foods. Unlike conventional grocers, Whole Foods Market exclusively provides organic and healthy products and targets a select group of consumers in a few key markets.

However, product proliferation strategy is also a well-adopted approach for most retailers. In the food manufacturing industry, consumers' increasing desire for variety has been motivating manufacturers and retailers to introduce new products continuously. Mintel's Global New Product Database (Mintel GNPD) shows an upward trend of new food and beverage products between 1990 and 2016. However, although the average supermarket size has continued to increase, shelf space still serves as a considerable constraint to how many products a retailer can offer (Chen and Lin, 2007). Messinger and Narasimhan (1995) noted that the number of packaged grocery products produced greatly exceeded the number of the items actually stocked in food stores. In 1991, for example, retailers had chosen only 30,000 items from a list of approximately 231,000 products manufactured. Given all these options, what is the optimal choice of a retailer's product line given the limited shelf space?

Studies also show that product proliferation comes at a cost. Cost increase is always associated with a broader product line dominate any potential demand increases (Bayus and Putsis, 1999). Wide product variety has a negative impact on consumers' motivation to purchase (Matsubayashi et al., 2009). In the real-world, some retailers such as Whole Foods Market choose to restrict their product lines and specialize in the high-quality niche market. Is it because more and more consumers state that they prefer healthier food? Several studies on consumer behavior have found that consumers' stated preferences do not always match their revealed preferences (Olsen and Smith, 2001; Homburg et al., 2005; Laroche et al., 2001). In most cases, it is in the best interest of the retailers to follow what consumers actually do – as opposed to what they say – to determine what to provide. However, there are also good reasons to listen to what consumers say, and not necessarily to what they actually do. This is especially true in the case of products that receive high levels of public scrutiny, such as genetically modified goods. Fernandes and Srinivasan (2018) identify several reasons people shop at Whole Foods Market. First, consumers want the best for their family; second, consumers are health and socially conscious; third, it is "cool" to buy organic. By providing exclusively organic products, organic retailers may want to improve their image and signal to consumers that they are better than rival retailers. Retailer/store image is an essential factor for retailers to develop a distinctiveness vis-à-vis their competitors (Park et al., 2011; Wu and Petroshius, 1987). Store image also influences purchase behaviour (Mazursky and Jacoby, 1986), and lead consumers to have a favourable perception about a particular product or brand (Baugh and Davis, 1989). Particularly, retailer's image can serve as a halo for its private brand when consumers have insufficient information and knowledge about the retailer's private brand (Park et al., 2011). Studies have shown that routine food shopping constitutes a type of consumer behavior which entails low involvement activities such as negligible information search and little deliberation in brand choice (Beharrell and Denison, 1995; Silayoi and Speece, 2004). The limited cognitive involvement makes consumers prone to a psychological phenomenon known as the "halo effect" (Lee et al., 2013). The halo effect is a cognitive bias where an individual's evaluation of one attribute influences or biases other attributes. A strongly positive impression of a retailer that is held by consumers may have a halo effect on consumers' choice of retailers, stores, or products. Studies have confirmed the existence of a halo effect in consumers' evaluation of the store image (Wu and Petroshius, 1987), store brands (Huang 2009; Park et al., 2011), and consumer purchase behavior, for example, between online and traditional supermarkets (Degeratu et al., 2000).

The motivation of this study is to explore the halo effect on a retailer's product line strategy. Product line is usually differentiated vertically to capture consumers' different willingness to pay for quality, however, many firms also offer products with horizontal differentiation such as colour, or flavour (Draganska and Jain, 2005). The product line strategy of retailers in this study focuses on the vertical differentiation, which is a high-quality line versus a low-quality line. By examining two retailers' product offerings in a differentiated product market, this study examines why a retailer chooses to specialize in the high-quality niche market. My hypothesis is that this type of activity can induce the halo effect that helps to differentiate the retailer from its competitors and further establish its own reputation as a purveyor of high-quality products and service to attract consumers who are health and/or socially conscious. Huang (2009) shows that the delivery of high service quality by retailers may yield positive halo effects and increase the perceived quality of their store brands. In this study, I model two retailers' decisions with respect to product line offerings in the presence of the halo effect. With the halo effect, the retailer earns higher reputation than his rival and this has a direct impact on a consumer's choice of retailers. This study answers the following questions: (1) Can a retailer benefit from a product line specialization strategy relative to a product line proliferation strategy in the presence of the halo effect? (2) How does product line specialization affect market structure and retailer performance?

The results show that without the halo effect, both retailers choose a full product line. In the presence of the halo effect, a retailer can be better off with product line specialization, i.e., providing a restricted product line that specializes in the high-quality niche market. I examine two games where retailers make product offering decisions simultaneously or sequentially. I find that regardless of the order of retailer action, an asymmetric equilibrium where one retailer chooses to proliferate and the other chooses to specialize in the high-end niche market is the end result. In the asymmetric equilibrium, the retailer who chooses specialization makes more profit and owns a dominant market share over the one who chooses proliferation. In order to get this result, cost- and demand-side factors need to be taken into account. Sufficient conditions for a favourable asymmetric equilibrium is that the cost differential between providing the high- and low-quality products is high, and more importantly, consumers' perception of the quality differential between the high- and low-quality is high. If the cost and quality differentials are both low, each retailer may choose to provide a full product line, split the market, and earn equal profit.

This study contributes to the product-line design literature by examining the halo effect on retailers' product line strategy. In this study, I assume the halo effect manifests itself through the consumer's perception of the retailer's reputation. Specifically, the consumer perceives that a product offered by a retailer that specializes in high quality products offers greater utility than an identical product offered by a retailer that offers a full product line. The halo effect is endogenously incorporated into the theoretical model where the retailer who chooses to specialize in providing only high-quality products is assumed to send a signal that she has a higher reputation than the rival retailer who provides both high- and low-quality products. Higher retailer reputation is attractive to quality-conscious consumers and may change the market structure in the duopolistic market. Katz (1984) and Gilbert and Matutes (1993) also introduce firm-specific reputation into their model, where reputation is treated as a horizontal-differentiation characteristic to differentiate products manufactured by two firms. In my study, high reputation serves as not only a firm-specific differentiation but also a signal for high quality, especially for quality-conscious consumers. In addition, most existing product line studies focus on competition between manufacturers[1], while this study attempts to explore how retailers design their product lines in a multi-product setting. Instead of investigating product proliferation, the focus of this study is to identify under what conditions firms choose to restrict their product line and specialize in a niche market.

The structure of this paper is as follows. In Section 4.2, I review the literature related to this topic. Section 4.3 presents my theoretical model of product line competition between two retailers. Simultaneous and sequential games are both examined to find the subgame perfect Nash equilibrium behavior of the two retailers. Discussions and concluding remarks are presented in Section 4.4.

4.2 Related Literature

Product line rivalry among manufacturing firms has been extensively studied both theoretically and empirically. Mussa and Rosen (1978) systemically analyze the issue of product line choice of a monopolistic manufacturing firm in a vertically differentiated industry where

[1]See studies by Katz (1984), Brander and Eaton (1984), Moorthy (1984), Gilbert and Matutes (1993), and Canoy and Peitz (1997).

firms can choose from a spectrum of qualities. In the early studies of product line competition in a monopolistic market, researchers usually impose the single-product assumption for analytical convenience (e.g., the Hotelling model). Nevertheless, multi-product firms are ubiquitous in most industries and more recent studies have focused on product-line design and pricing strategy of multi-product firms. In the spirit of Mussa and Rosen's study of a monopolistic manufacturer, Champsaur and Rochet (1989) extend the study to a duopoly case where firms choose to offer quality intervals. They find that the incentive for a firm to differentiate its products from those of its rivals dominates the incentive to engage in price discrimination, and show that the firms do not provide identical product lines. Later studies show that product line proliferation is a favourable strategy, as it enables price discrimination, and helps firms to maintain consumer loyalty (Draganska and Jain, 2005).

The product line design literature shows that a firm's product line strategy is determined by a great number of factors. The main factors include cost-side consideration, demand-side correlation, the order of player decisions, relationship with players along the supply chain, and firm reputations.

Early studies on product line choice of multiproduct firms theoretically explore these factors. They first focus on the cost-side considerations. They assume production exhibit strong economies of scope and products have related cost functions (Brander and Eaton, 1984). Most recent multi-product competition studies assume that the variants of a good are related on the demand side. They are at least partial substitutes for one another. Katz (1984) and Brander and Eaton (1984), respectively, incorporate this consideration into their examination of the issue of product line rivalry. Katz (1984) analyzes multiproduct-firm competition in markets where the products produced by each firm are related on the demand side. He claims that the degree of competition of one market can be affected by a related market. The consequence is that firms may choose not to provide full product lines. In his study, Katz also introduces firm-specific reputation that serves as an important element for consumers, who have imperfect information about the attributes of the products, to make purchase decisions. Due to the firm-specific reputation, firms may not produce full product lines in order to maximize the profits they earn from firm-specific advantages.

The order of decisions is also a key element for a firm to make product decisions. First-movers can make higher profits and deter entry of the followers, which also influence their product line choice. Brander and Eaton (1984) model a three-stage duopoly game to examine product line rivalry. They examine the choice of scope (how many products to produce) and the choice of line (which particular products to produce). They find that the order of decision making is crucial for product line choice, and the equilibrium outcome is market segmentation when the game is sequential. Gilbert and Matutes (1993) use a two-dimensional model to look at whether commitment, reflected in a sequential game where first-movers take prior action to invest in resources to produce a product, can affect a multiproduct firm's choice of product line. Their conclusion is that in the presence of commitment the smaller the degree of brand-specific differentiation, the more likely the firm specializes. In the absence of commitment, firms produce a full product line. Canoy and Peitz (1997) model a differentiation triangle where the low quality good is not subject to horizontal differentiation. They model competition among firms in the differentiation triangle with sequential entry. Their main finding is that incumbents have different motivations to develop a niche or full line strategy. Incumbent 1 who has a first-mover advantage chooses products for profit, while incumbent 2 has a strategic incentive to determine the product line, either for the purpose of deterring entry or accommodating entry. Cheng, Peng, and Tabuchi (2011) investigate a two-stage competition in a vertically differentiated market and show that each firm has an incentive to produce a range of qualities under the assumption of an increasing and quadratic marginal cost of quality.

Relationship among the supply chain players is also studied by scholars in the product line competition. De Fraja (1996) constructs a model of product line competition in a vertically differentiated market. He finds that only in a non-cooperative game, firms will compete "head-to-head" with identical product lines and also produce the same quantity of each product. Avenel and Caprice (2006) analyze the link between upstream market power and retailers product line choice. They build up a model of two-dimensional differentiation with the assumption that high-quality products are purchased from a monopolist, while low-quality products are produced by a competitive industry. By considering vertical contracting with upstream suppliers, they find that in the absence of upstream market power, retailers tend to offer identical product lines.

Reputation, albeit not receiving as much attention as other factors, is also an important consideration when firms decide their product offerings. Reputation is an important incentive for a firm to conduct product/brand differentiation. Katz (1984) may be the first to introduce the firm-specific reputation as an advantage for product line designing. In his two-dimensional model, firm-specific is treated as a horizontal characteristics that can differentiate one firm from another. His results show that firm-specific differentiation is an important condition for firms not to choose a full product line. Similar with Katz (1984), Gilbert and Matutes (1993) introduce brand-specific differentiation as to the horizontal dimension of a product. They find that firms specialize if the degree of brand-specific differentiation is small, and proliferate if brand-specific differentiation is large.

More recent product line competition literature has placed more attention on discussing whether product assortment, mostly in the horizontal dimension, benefit firms. Product assortment or variety can be used as a competitive tool. Draganska and Jain (2005a) endogenously include the length of the product line into the competition of oligopolistic firms and find that there are decreasing returns to product-line length. Draganska et al. (2009) show that the product assortment strategies, which can be considered as strategic variables to the firm in a demand-supply model, is essential for policy simulations. For example, They estimate the impact of product assortment decisions in the context of a merger where the results show that both the merging firm and consumers benefit from the merger through the reduced number of competitors, or higher product variety. Draganska and Jain (2005b) examine both line (quality) and flavor differential and show that consumers value line attributes more than flavour attributes. The current strategy that firms use product lines for price discrimination and price all flavours within a line the same price is optimal. Product proliferation can also be used as a quality cue and thus influences which brand consumers choose (Berger et al., 2007). In their study, they show that brands that offer a greater variety tend to be perceived have higher quality and produces a greater choice share of these brands.

This study extends the focus of existing literature on firms' product line choice to retailers product offering strategy. As a special type of multi-product firm, retailers also face the issue of choosing a limited number of products to offer from a wide range of products manufactured by producers. With the increasing competition in food retailing, retailers have made efforts to improve store image and differentiation. More importantly, this study specifically examines a retailer's decision to offer a specialized or restricted product line after accounting for the halo effect. The main hypothesis is that specialization in the high-end market yields a halo effect that in turn improves retailer reputation and affects consumer choice.

The halo effect has been explored in retailing literature to capture the cognitive bias in consumer experience of rating a store or a brand. Degeratu et al. (2000) examine consumer choice behavior between online and traditional supermarkets and show that brand name is important online in some categories when information on fewer attributes is available. By investigating the effects of the interplay between a multi-channel retailer's offline and online store images on consumers' online perceived risk and online loyalty toward the retailer, Kwon and Lennon (2009) show that the offline store image of a multi-channel retailer has a halo effect by biasing consumers' perceptions of the retailer's online brand image, and in turn affects online perceived risk, and online customer loyalty. Some research has explored the halo effect of retailer image on consumers' store brand attitudes. Richardson et al. (1996) investigate the role of store aesthetics in the formation of perceptions of store brand quality and find that store aesthetics have a positive halo effect and increase consumers' evaluation of the quality of store brands. Huang (2009) examines the impacts of retail service quality on the perceived quality of store brands and show that the delivery of high service quality of retailers yield positive halo effects and increases the perceived quality of their store brands.

Few studies on retailers' product line choice focus on the halo effect and retailer reputation. Katz (1984) and Gilbert and Matutes (1993) investigate firm-specific differentiation which can be considered as the closest alternative of retailer reputation. Unlike Katz (1984) and Gilbert and Matutes (1993), my model incorporates reputation into the vertical dimension of a product and assumes that reputation can improve consumers' evaluation of product quality from a higher-reputation retailer and offer higher utility versus an identical product from a retailer without a high reputation. Studies also show that consumers especially the ones with lower level of involvement (i.e., negligible information search) is prone to give high evaluation of product quality provided by a retailer with high reputation (Lee et al., 2013).

4.3 Model

In this section, a duopoly model is constructed to describe the product line and price competition between two retailers. I assume that the products provided by the retailers are differentiated both vertically and horizontally. The model builds on Katz (1984) and Gilbert and Matutes (1993) by incorporating a halo effect.

4.3.1 General Setting

4.3.1.1 Retailers

Two retailers A and B are located at opposite ends of a linear city of length 1, where $l^A = 0$ and $l^B = 1$. They compete in a duopolistic market with one product, which is differentiated by vertical characteristics (i.e., quality) and horizontal characteristics (e.g., location). Let $i \in \{L, H\}$ index the vertically-differentiated variants of the product, where H denotes the high-quality variant and L the low-quality variant. The two retailers can choose a full product line by providing both variants, or they can specialize and sell only one variant. My main assumption is that specialization in the high-quality variant generates a higher reputation for the retailer who provides it, via the halo effect. The retailers' optimization problem is

$$Max\ \pi_i^j = \sum_{i=1,2} (p_i^j - c_i)\varphi_i^j, \tag{4.1}$$

where π is profit, $j \in \{A, B\}$ denotes the firm, P denotes the price, c is the cost of selling a product with $c_H > c_L$, and φ is the market share of the variants of the good provided by the retailers[2].

4.3.1.2 Consumers

Consumers in the duopolistic market consider three factors before they make their purchase decision: quality of products, location of the retailer, and the retailer's reputation. Following Katz (1984), the utility function $U_i^j = (1 + r)\theta s_i - t|\delta_i - l^j| - p_i^j$ characterizes a consumer's utility from purchasing product i from retailer j. In this utility function, s_i is quality, t is the transportation cost, p_i^j is the price of product j, and l represents the location of the retailer. Retailer location, l, is a horizontal characteristic, and quality, s, is a vertical characteristic. The main difference between this model and Katz's model is how retailer reputation is incorporated. In my model, r takes a value 0 or 1 depending on the retailer's choice of product offerings. If a retailer sells only high-quality products, she is assumed to have high reputation due to the halo effect. That is, the consumer sees that the retailer only offers a high quality variant and this affects her impression of the overall quality of the retailer, which manifests itself in higher perceived reputation[3]. When a consumer (located at δ) purchases product i from retailer j (located at l) with high reputation ($r = 1$), her utility

[2] For a retailer, c is the wholesale price of a product.

[3] Instead of increasing the reputation of the retailer specializing in the high quality product, an alternative way to interpret the halo effect in my model is that it degrades the reputation of the full-line retailer. The retailer who sells a low quality quality together with a high quality product has lower reputation than the retailer who exclusively sells the high quality product.

function is $U_i^j = 2\theta s_i - t|\delta_i - l^j| - p_i^j$. When a consumer purchases from a retailer with low reputation ($r = 0$), her utility function is $U_i^j = \theta s_i - t|\delta_i - l^j| - p_i^j$. This utility function shows that the consumer receives greater utility by purchasing from the high-reputation retailer than purchasing from the low-reputation retailer. This is attributed to the retailer halo which has been shown to be a factor affecting where and what consumers shop (Degeratu et al., 2000; Kwon and Lennon, 2009). The utility function also shows that the reputation of a retailer can signal product quality (Chu and Chu, 1994). If a consumer is quality-conscious, she may be fastidious about retailer reputation and tend to shop at a reputable retailer.

4.3.2 The Duopoly Game

This subsection describes the game and derives prices and profits under two scenarios. One game is a simultaneous game in which two retailers choose product offerings and prices simultaneously. In the second game, one retailer chooses its product offering first and is then followed by the other retailer.

4.3.2.1 The Simultaneous Game

In the one-stage game, retailers A and B choose products and prices simultaneously. They can choose to provide one variant of the product (e.g., high- or low-quality variant) or a full product line (e.g., both high- and low-quality variants). When deciding what products to provide, Retailer A's choice set is $\{(AH), (AL), (AH, AL)\}$, where AH represents the high-quality variant offered by Retailer A and AL represents the low-quality variant strategy. Similarly, Retailer B's strategy set is $\{(BH), (BL), (BH, BL)\}$. Since each retailer has three possible strategies, the combined set of Retailer A and B's decisions include nine possible scenarios: $\{(AH),(BH)\}$, $\{(AL),(BL)\}$, $\{(AH),(BL)\}$, $\{(AL),(BH)\}$, $\{(AH),(BH,BL)\}$, $\{(AL),(BH,BL)\}$, $\{(AH,AL),(BH)\}$, $\{(AH,AL),(BL)\}$, and $\{(AH,AL),(BH,BL)\}$. In cases where only one retailer offers only the high-quality product, that retailer can gain a reputation advantage. In the following scenarios, $\{(AH),(BH)\}$, $\{(AL),(BL)\}$, $\{(AH,AL),(BL)\}$, $\{(AL),(BH,BL)\}$, and $\{(AH,AL);(BH,BL)\}$, the two retailers engage in symmetric competition in which they choose to provide identical product lines that generate no reputation differential. In cases where only one retailer offers only the high-quality product, that retailer can gain a reputation advantage. In the scenarios of $\{(AH);(BH,BL)\}$, $\{(AH,AL),(BH)\}$, $\{(AH),(BL)\}$, and $\{(AL,),(BH)\}$, the two retailers engage in asymmetric competition where they provide different product lines that generate differential reputations. In the following subsections, only three scenarios that represent all possible competition patterns are examined: (a) $\{(AH,AL),(BH,BL)\}$ as the baseline symmetric scenario with no halo effect; (b) $\{(AH),(BH,BL)\}$ as the first asymmetric scenario with a halo effect; and (c) $\{(AH,),(BL)\}$ as the second asymmetric scenario with a halo effect[4]. The Nash equilibrium of the simultaneous duopoly game will be derived.

4.3.2.2 The Sequential Game

Compared with the simultaneous game, the sequential game entails a three-stage decision process where one of the retailers can pre-commit to her product offerings and this action is observed by the other retailer. As Gilbert and Matutes (1993) show in their study, a firm can withhold a product from the market and convey this intent to its rivals. The

[4]The same results will be generated from the following scenarios: (a) $\{(AH,AL);(BH,BL)\},\{(AH),(BH)\}, and\{(AL,),(BL)\}$; (b)$\{(AH),(BL)\}$ and $\{(AL),(BH)\}$; (c)$\{(AH),(BH,BL)\}$ and $\{(AH,AL),(BH)\}$; (d) $\{(AL,),(BH,BL)\}$ and $\{(AH,AL),(BL)\}$.

sequential decision deters product line proliferation and facilitates market segmentation and specialization (Gilbert and Matutes, 1993; Brander and Eaton, 1984). In the first stage of the sequential game, Retailer A chooses a strategy from her choice set $\{(AH), (AL)$ and $(AH, AL)\}$. In the second stage, Retailer B observes Retailer A's action and then chooses from his set $\{(BH), (BL)$ and $(BH, BL)\}$. In the third stage, retailers A and B choose prices simultaneously. I later find the subgame perfect Nash equilibrium (SPNE) for the game and look at different scenarios of the product line competition.

4.3.2.2.1 *Baseline scenario: symmetric competition with identical product lines*

My duopoly model draws on Gilbert and Matutes (1993) who model product line competition in a two-dimensional differentiated market where firms can commit to restrict their product offering. They conclude that product line specialization or proliferation depends on the degree of horizontal differentiation; i.e., brand-specific differentiation. My model is different from their model in the way reputation (usually treated as a firm/brand-specific variable) is incorporated in the model. Compared with the brand-specific differentiation in Gilbert and Matutes (1993), my model incorporates retailer reputation as a vertical characteristic. In the baseline scenario, symmetric competition with identical product lines will be analyzed. In this scenario, the halo effect is not present because reputation arises when only one retailer sells high-quality products exclusively. In the following subsections, I look at the consumer decision under horizontal and vertical differentiation, respectively. Then I combine horizontal and vertical differentiation and derive the conditions for market segmentation given consumers location and preferences for quality.

Horizontal differentiation In the setting of horizontal differentiation, a consumer's choice of a particular product is decided by the location of the retailers. Consumers are indifferent between buying product i from Retailer A or B if $\theta s_i - p_i^A - t|\delta - l^A| = \theta s_i - p_i^B - t|\delta - l^B|$, where $l^A = 0$ and $l^B = 1$. Solving this yields

$$\widehat{\delta}_i = \frac{p_i^B - p_i^A + t}{2t}. \tag{4.2}$$

Equation (4.2) shows that if a consumer is located in the interval $[0, \widehat{\delta}_i)$, she buys the product from Retailer A. If she is located in the interval $(\widehat{\delta}_i, 1]$, she purchases from Retailer B. At $\widehat{\delta}_i$ the consumer is indifferent between buying from Retailer A or B. Since $0 < \widehat{\delta}_i < 1$, then $|p_i^B - p_i^A| \leqslant t$, indicating that the price differential for the product i between the two retailers cannot be greater than the transportation cost t. If $p_i^B = p_i^A$, then $\widehat{\delta}_i = \frac{1}{2}$, implying that Retailer A and B split the market equally.

Vertical differentiation In the setting of vertical differentiation, a consumer's choice of product is decided by her preferences for quality. The consumer is indifferent between buying product H and L from a given retailer j if $\theta s_L - p_L^j - t|\delta - l^j| = \theta s_H - p_H^j - t|\delta - l^j|$. Solving this yields

$$\widehat{\theta}^j = \frac{p_H^j - p_L^j}{s_H - s_L}. \tag{4.3}$$

Equation (4.3) shows that if a consumer's taste for quality falls between $[0, \widehat{\theta}^j)$, she buys a low-quality product from a retailer j. If her taste falls between $(\widehat{\theta}^j, 1]$, she chooses the high-quality product. At $\widehat{\theta}^j$, she is indifferent as long as $0 \leqslant p_H^j - p_L^j \leqslant s_H - s_L$, which ensures that $\widehat{\theta}^j$ is between 0 and 1. If $p_H^j - p_L^j > s_H - s_L$, the market share for the high-quality product is zero. If $p_H^j - p_L^j = 0$, retailer j charges the same price for both products and the market share of the low-quality product is zero. Thus, the price differential between the two products should be no greater than the quality differential to ensure that market shares for both products are positive.

Horizontal and vertical differentiation Now I combine horizontal and vertical differentiation to investigate the scenario of symmetric competition where both retailers choose a full product line. Let $ij \succ \overline{ij}$ denote that a consumer who prefers product i from retailer j to product $\bar{i}$ from retailer $\bar{j}$. A consumer is indifferent between buying good i from retailer j and buying good $\bar{i}$ from retailer $\bar{j}$ if $\theta s_i - p_i^j - t|\delta - l^j| = \theta s_i - p_{\bar{i}}^{\bar{j}} - t|\delta - l^{\bar{j}}|$. For example, for a consumer who is indifferent between buying low-quality from Retailer A (AL) and high-quality from Retailer B (BH), her physical location and taste for quality is:

$$\widehat{\theta} = \frac{2t(\widehat{\delta}_l - \widehat{\delta})}{s_H - s_L} + \widehat{\theta}^B. \tag{4.4}$$

Using equation (4.2) and (4.3), I can show that

$$\widehat{\theta} = \frac{P_L^B - P_L^A + P_H^B - P_L^B + t - 2t\widehat{\delta}}{s_H - s_L}. \tag{4.5}$$

Equation (4.5) shows that the consumer's choice between AL and BH is determined by the following factors: (1) price differential; (2) transportation cost t; and (3) the quality differential $s_H - s_L$. The effect of price differential occurs at two levels: within-retailer but across quality ($P_H^B - P_L^B$) and across retailers but within quality $p_L^B - p_L^A$. Therefore, the consumer's choice between AL and BH may follow a two-step procedure. First, the consumer chooses quality; i.e., BL or BH. If $p_H^B - p_L^B > s_H - s_L$, she goes for the low-quality product. Then, she chooses between Retailer A and B. If $p_L^B - p_L^A > t$, she chooses Retailer A. Thus we have $AL \succ BL \succ BH$, and the consumer purchases AL instead of BH. A general form of equation (4.5) can be written as

$$\widehat{\theta} = \frac{2t(\widehat{\delta}_L - \widehat{\delta})}{s_{\bar{i}} - s_i} + \widehat{\theta}^{\bar{j}}. \tag{4.6}$$

Equation (4.6) describes the relationship between θ and δ when $ij \succ \overline{ij}$.

So far, I have described how consumers choose between AL and BL (see equation (4.2)), AL and AH (see equation (4.3)) and AL and BH (see equation (4.5)). The following conditions summarize the conditions under which AL is chosen. A consumer located at $\widehat{\delta}$ with taste parameter for quality $\widehat{\theta}$ will purchase AL if and only if

1. $\widehat{\delta} \leq \widehat{\delta}_L$, which means $AL \succ BL$;
2. $\widehat{\theta} \leq \widehat{\theta}^A$, which means $AL \succ AH$;
3. $\widehat{\theta} \leq \frac{2t(\widehat{\delta}_L - \widehat{\delta})}{s_H - s_L} + \widehat{\theta}^B$, which means $AL \succ BH$.

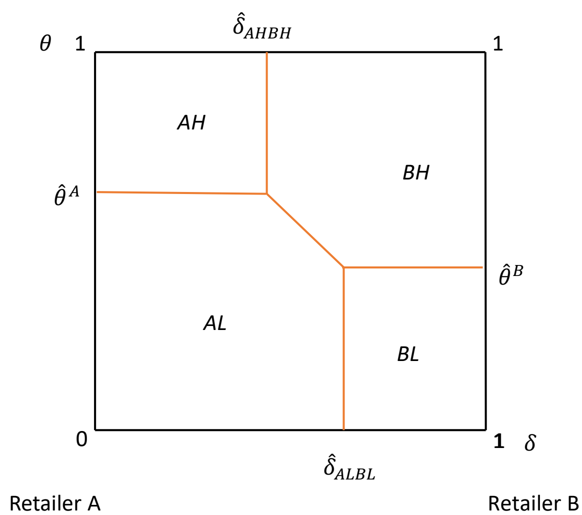
$\widehat{\delta}_L$ is where consumers are indifferent between AL and BL, $\widehat{\theta}^A$ and $\widehat{\theta}^B$ represent the locus of points where consumers are indifferent between AL and AH, and BL and BH, respectively. In summary, a consumer located at δ with taste parameter θ will purchase the low-quality product from Retailer A if and only if

$$\widehat{\delta} \leq \widehat{\delta}_L; \text{ and } \widehat{\theta} \leq \min[\widehat{\theta}^A, \frac{2t(\widehat{\delta}_L - \widehat{\delta})}{(s_H - s_L)} + \widehat{\theta}^B]. \tag{4.7}$$

Given $\widehat{\theta}^A > \widehat{\theta}^B$ and $\widehat{\delta}_L > \widehat{\delta}_H$, the market share of AL is illustrated in Figure 4.1.

Similarly, the consumer will purchase the AH if and only if

Figure 4.1: Market Segmentation in the Baseline Scenario



1. $\widehat{\delta} \leq \widehat{\delta}_H$, or $AH \succ BH$

2. $\widehat{\theta} \geq \widehat{\theta}^A$, or $AH \succ AL$

3. $\widehat{\theta} \geq -\frac{2t(\widehat{\delta}_H - \widehat{\delta})}{s_H - s_L} + \widehat{\theta}^B$, or $AH \succ BL$

This can also be written as

$$\widehat{\delta} \leq \widehat{\delta}_H; \text{ and } \widehat{\theta} \geq \max[\widehat{\theta}^A, \widehat{\theta}^B - \frac{2t(\widehat{\delta}_H - \widehat{\delta})}{s_H - s_L}]. \tag{4.8}$$

Given $\widehat{\theta}^A > \widehat{\theta}^B$ and $\widehat{\delta}_L > \widehat{\delta}_H$, the market share of AH is illustrated in Figure 4.1. The market shares for BL and BH can be derived in the same figure, in a similar manner. The market share for each product is

$$\varphi_L^A = \widehat{\delta}_{ALBL}\widehat{\theta}^A - \frac{1}{2}(\widehat{\delta}_{ALBL} - \widehat{\delta}_{AHBH})(\widehat{\theta}^A - \widehat{\theta}^B), \tag{4.9}$$

$$\varphi_H^A = \widehat{\delta}_{AHBH}(1 - \widehat{\theta}^A), \tag{4.10}$$

$$\varphi_L^B = (1 - \widehat{\delta}_{ALBL})\widehat{\theta}^B, \tag{4.11}$$

and

$$\varphi_H^B = (1 - \widehat{\delta}_{AHBH})(1 - \widehat{\theta}^B) - \frac{1}{2}(\widehat{\delta}_{ALBL} - \widehat{\delta}_{AHBH})(\widehat{\theta}^A - \widehat{\theta}^B), \tag{4.12}$$

where φ_L^A, φ_H^A, φ_L^B and φ_H^B are market shares for product $AL, AH, BL,$ and BH.

My model assumes that the two retailers engage in Bertrand-Nash competition in each submarket. To simplify the computation, I assume unit transportation cost, i.e. $t = 1$.

Retailer A's profit-maximization problem is then

$$\underset{p_L^A, p_H^A}{Max}\ \pi^A = \pi_L^A + \pi_H^A = (p_L^A - c_L)\varphi_L^A + (p_H^A - c_H)\varphi_H^A, \tag{4.13}$$

and Retailer B's profit-maximization problem is

$$\underset{p_L^B, p_H^B}{Max}\ \pi^B = \pi_L^B + \pi_H^B = (p_L^B - c_L)\varphi_L^B + (p_H^B - c_H)\varphi_H^B. \tag{4.14}$$

The computational details are shown in Appendix 2. After solving Retailer A and B's problems, the equilibrium prices are $p_H^A = p_H^B = c_H + 1$ and $p_L^A = p_L^B = c_L + 1$. The market shares are $\varphi_H^A = \varphi_H^B = \varphi_L^A = \varphi_L^B = \frac{1}{2}$ and the profit of each firm is $\frac{1}{2}$, given $c_H - c_L = \frac{s_H - s_L}{2}$, where $c_H - c_L$ is the cost differential of providing high- and low-quality products. $s_H - s_L$ is a consumer's perception of the quality differential between the high- and low-quality products. I use k and s to denote marginal cost differential and quality differential hereafter. k and s later play essential roles in the asymmetric competition. From the equilibrium prices, we can see that the price-cost markup is identical for each good. This result is the same as in the single-product competition where Retailer A and B provide only products of the same quality[5]. Gilbert and Matutes (1993) also show that price-cost markups are independent of the number of goods provided, which means that profit is independent of the number of products provided. This implies that a multi-product strategy for a retailer cannot be more

[5]The single-product competition is that both retailers provide products of the same quality, for example, AH V.S. BH, and BH V.S. BL. They are named as scenario 2 and 3. Actually the single-product symmetric competition is the special cases of the symmetric competition and produce the same result. Thus they are not shown in this study. The first three scenarios consist of all scenarios of the symmetric competition where both retailers provide an identical product line (single or full).

profitable than a single-product one. This result also suggests that the markup for a given quality is also independent of consumer taste for quality attributes. The Bertrand-Nash equilibrium is that both retailers offer the full product line, and retailers are not any better off by offering the product line vis-à-vis a single product. This is because if one firm is producing a single variant, it can always generate additional sales without losing profit by introducing a second variant with the same price-cost margin. The additional profit made by the single-product retailer has two sources: (1) from the consumers that switch from the old variant to the new one without switching retailers; and (2) from the consumers who used to buy the new variant from the other Retailer And now switches.

4.3.2.2.2 *Scenario 2: asymmetric competition with partially overlapping product line*

In the asymmetric competition case, Retailer A specializes in the high-quality submarket and acquires a higher reputation, through specialization, than Retailer B who offers the full product line. Next I derive the market shares and profits for the two retailers.

Market shares A consumer who purchases from Retailer A gains higher utility due to the reputation-induced halo effect. The utility function of this consumer is $U_i^j = 2\theta s_i - t|\delta_i - l^j| - p_i^j|$, as $r = 1$. If she purchases from Retailer B, her utility function is $U_i^j = \theta s_i - t|\delta_i - l^j| - p_i^j|$, as $r = 0$.

The consumer is indifferent between buying AH and BH when

$$2\theta s_H - t|\delta - l^A| - p_H^A = \theta s_H - t|\delta - l^B| - p_H^B|. \quad (4.15)$$

The resulting indifference curve between AH and BH is

$$\widetilde{\delta}_{AHBH} = \frac{\widetilde{\theta} s + p_H^B - p_H^A + t}{2t}. \tag{4.16}$$

The consumer is indifferent between BH and BL when

$$\theta s_L - p_L^B - t(1-\delta) = \theta s_H - p_H^B - t(1-\delta). \tag{4.17}$$

Consumers are indifferent between the high quality and low quality products when

$$\widetilde{\theta}^B = \frac{p_H^B - p_L^B}{s}. \tag{4.18}$$

Lastly, the consumer is indifferent between AH and BL when

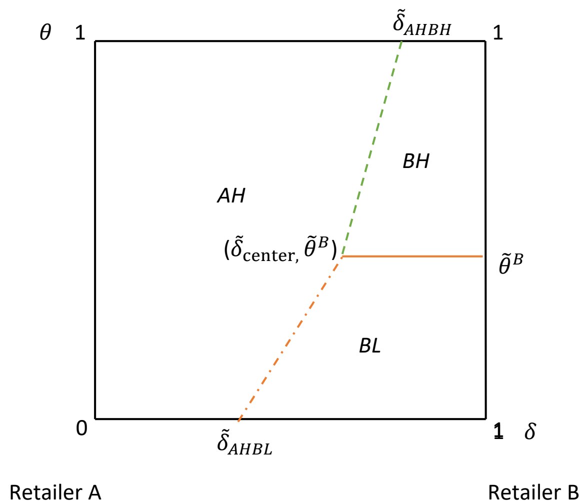
$$\theta s_H - t|\delta - l^A| - p_H^A = \theta s_L - t|\delta - l^B| - p_L^B. \tag{4.19}$$

The resulting indifference curve is

$$\widetilde{\delta}_{AHBL} = \frac{2\widetilde{\theta} s + p_H^A - p_L^B + t}{2t}. \tag{4.20}$$

Figure 4.2 shows how the entire market is segmented by AH, BH, and BL. The green dashed line is the indifference curve between AH and BH, and the red dashed line is the indifference curve between AH and BL. The consumers who are located at ($\widetilde{\delta}_{center}$, $\widetilde{\theta}^B$) are indifferent between AH, BH and BL. Figure 4.2 illustrates the market segmentation when $-t - s < p_H^B - p_H^A < t - s$ (Condition 1) and $-t < p_H^A - p_L^B < t$ (Condition 2). These two conditions define the location of the indifference curves in Figure 4.2. As the first condition

Figure 4.2: Market Segmentation in Scenario 2



shows, consumers who are more quality conscious (higher θ) are less likely to switch to the low-quality products, and instead compare prices of the high-quality products provided by the two retailers. Both quality differential and transportation cost influence their decisions. The second condition shows that for consumers who are less quality conscious (lower θ), they can switch between both qualities and retailers and take into account the prices of both qualities offered by the two retailers. Here, the factor more important for them is the transportation cost.

The market shares for Retailer A and B are

$$\varphi^A = \varphi^A_H = 1 * \widetilde{\delta}_{center} + \frac{1}{2} * (\widetilde{\delta}_{AHBH} - \widetilde{\delta}_{center}) * (1 - \widetilde{\theta}^B) - \frac{1}{2} * (\widetilde{\delta}_{center} - \widetilde{\delta}_{AHBL})\widetilde{\theta}^B, \quad (4.21)$$

and

$$\varphi^B = \varphi^B_H + \varphi^B_H = (1 - \widetilde{\theta}^B) * (1 - \widetilde{\delta}_{center}) - \frac{1}{2} * (\widetilde{\delta}_{AHBH} - \widetilde{\delta}_{center}) * (1 - \widetilde{\theta}^B) \quad (4.22)$$

$$+(1 - \widetilde{\delta}_{center}) * \widetilde{\theta}^B + \frac{1}{2} * (\widetilde{\delta}_{center} - \widetilde{\delta}_{AHBL}) * \widetilde{\theta}^B. \quad (4.23)$$

I can now solve the profit maximization problems for both retailers. Appendix 3 provides more details on the computation. The results, which are derived using numerical methods through MATLAB, dependent on two parameters: the cost differential k and the quality differential s. k represents the differential in the cost of providing the high-quality product relative to the low-quality product. The higher k is, the more costly the high-quality products are relative to the low-quality products. s reflects the difference in consumers' valuation of the high-quality products over the low-quality products. The higher s is, the greater the quality difference between the high- and low-products perceived by consumers. Table 4.1 shows the results of the case of asymmetric competition, for specific values of k and s. k and s are subject to that all market variables to be positive and their domains are restricted to be [0, 1]. Based on the constrains, specific values are given to k and s to examine changes in the market variables (e.g., markup, market share, and profit). Table 4.1 shows the market equilibria, given two pairs of k and s which fall in the ranges of [0,0.5) and (0.5,1], respectively.

The results can be summarized as follows. First, compared with symmetric competition,

Table 4.1: Scenario 2 Results for Specific Parameters

k	s	Markups			Market Shares			Profits	
		AH	BH	BL	AH	BH	BL	Retailer A	Retailer B
0.35	0.58	1.063	0.907	0.968	53.14%	18.49%	28.37%	0.57	0.44
0.75	0.69	1.037	1.042	1.152	52.96%	1.39%	45.65%	0.55	0.54

retailers have a chance to make higher profits in the asymmetric competition in the presence of the halo effect effect. Table 4.1 shows when $k = 0.35$ and $s = 0.58$, only Retailer A is better off compared to the symmetric competition; when the cost differential and consumers' perception of the quality differential between the high and low qualities increase to $k = 0.75$ and $s = 0.69$, both retailers are better off compared with the symmetric competition. This implies that larger values of k and s are an important condition for both retailers to be better off versus the symmetric competition. A large s is important for Retailer A to earn higher profitability by specializing in the high-end of the quality spectrum. The greater the perceived quality differential, the greater the payoff to Retailer A providing only high-quality product. A large k makes Retailer B more willing to replace BH with BL to develop his own monopoly power in the low-end market. The results show that BL is the major source of profit for Retailer B, with BH mainly used for strategic purposes. The markup of BH is higher than that of AH, suggesting that the price of high-quality products charged by a full-line retailer is higher than that charged by a single-product competitor. A possible reason could be that the full-line retailer does not want to induce fierce internal competition and cannibalize its own sales.

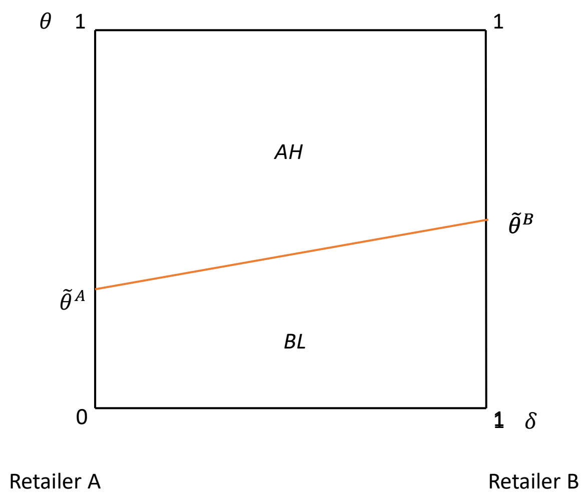
Second, in the asymmetric competition, Retailer A is found to be better off than Retailer B. The result in Table 4.1 shows that Retailer A that specializes in the high-quality market earns more profit than Retailer B. Retailer A dominates the market by capturing more market share and make more profit than Retailer B. With the product specialization strategy, there may be three types of consumers who purchase high-quality products from Retailer A: (a) quality-conscious consumers switching from Retailer B; (b) less quality-conscious consumers from Retailer A; (c) less quality-conscious consumers switch from Retailer B. Specifically, if $s > k$ ($k = 0.35$ and $s = 0.58$), that is consumers perceive the quality differential is greater than the cost differential, Retailer A earns higher market power in the high-quality market, a larger market share, and higher profit than Retailer B; however, when the cost differential increases ($s < k$), the competitive advantages Retailer A has are shrinking.

Third, retailers have strategic considerations while choosing product lines. Gaining a positive halo (higher reputation) by selling only the high-quality products, Retailer A not only improves her profitability, but also dominates the market. In contrast, Retailer B is worse-off than Retailer A in terms of both profitability and market share. Given that Retailer B's profit is mainly contributed by selling the low-quality products, she may use high-quality products as a strategic tool, for example, to conduct price discrimination through a full product line, or to deter entry of other retailers, if there are potential competitors.

Last, the results show that the prices of each product along a full product line demonstrate changes in the same direction. The price of BH and BL both go down or up with different values of k and s. This is consistent with Katz's finding (1984) of the spillovers between high- and low-quality markets. This suggests that in the submarkets where demands are related to each other the degree of competition in one market affects the degree of competition in another market.

4.3.2.2.3 ***Scenario 3: asymmetric competition with non-overlapping product lines*** In this scenario, Retailer A specializes in the high-end market and gains higher

Figure 4.3: Market Segmentation in Scenario 3



reputation due to the halo effect, while Retailer B specializes in the low-end market. The market segmentation is illustrated in Figure 4.3. Table 4.2 shows markups, shares, and profits under certain values for k and s. Details on the computation can be found in Appendix 4. The main findings are summarized as follows.

Table 4.2: Scenario 3 Results for Specific Parameters

k	s	Markups		Market Shares		Profits	
		AH	BL	AH	BL	Retailer A	Retailer B
0.35	0.58	0.66	0.50	53.6%	46.4%	0.37	0.22
0.75	0.69	0.67	0.71	48.6%	51.4%	0.33	0.37

First, compared with symmetric competition, neither retailer is better off in the asymmetric competition where both retailers choose specialization.

Second, Retailer A makes more profit than Retailer B and dominates the market by owning more market share than Retailer B if s and k are relatively small and $s > k$ ($k = 0.35$ and $s = 0.58$). On the contrary, if s and k are relatively big and $s < k$ ($k = 0.75$ and $s = 0.69$), Retailer B makes more profit than Retailer A and captures a bigger market share in the low-end market. This suggests that consumers' valuation of high quality and the retailer's cost of improving quality are two critical factors for the retailers to consider when making a product line decision. If consumers value high quality-products relatively more than the additional cost of providing high-quality products, specializing in the high-quality market is more profitable than specializing in the low-quality market. However, if providing high-quality is costly relatively more than the perceived differential in quality, it is more profitable for the retailers to specialize in the low-end market.

4.3.2.3 Equilibrium of the Simultaneous Game

The Nash equilibria of the simultaneous game is found based on the results of the scenarios discussed previously. Tables 4.3 and 4.4 summarize the equilibria of the simultaneous game with different quality (s) and cost differentials (k). Table 4.3 shows that the game ends up with a symmetric competition where both retailers choose either high-quality or low-quality products, given small s and k, and $s > k$ ($k = 0.35$ and $s = 0.58$). The equilibrium suggests that retailers end up selling either high- or low-quality products. However, this result relies on the assumption of full market coverage by the two retailers. Since a single product and a full product line have identical profits, thus, if the assumption of a full market coverage

Table 4.3: Payoff Matrix for the Simultaneous Game, as k=0.35 and s=0.58

		Retailer B		
		H	L	$H\&L$
Retailer A	H	0.5,0.5	0.37,0.22	0.57,0.44
	L	0.22,0.37	0.5,0.5	0.36,0.35
	$H\&L$	0.44,0.57	0.35,0.36	0.5,0.5

Table 4.4: Payoff Matrix for the Simultaneous Game, as k=0.75 and s=0.69

		Retailer B		
		H	L	$H\&L$
Retailer A	H	0.5,0.5	0.33,0.37	0.55,0.54
	L	0.37,0.33	0.5,0.5	0.43,0.31
	$H\&L$	0.54,0.55	0.31,0.43	0.5,0.5

is relaxed, retailers are always better off by introducing a new product. Therefore, retailers have no incentive to withhold a product, and the Nash equilibrium is that both retailers choose a full product line in the long run, if consumers' perception of the quality differential is big and providing high quality is not highly costly. This is summarized in Proposition 4.1.

Proposition 4.1 *In the simultaneous game, a symmetric Nash equilibrium exists where both retailers choose to provide a full product line. In this equilibrium both retailers have identical mark-ups for both products and identical profits.*

When s and k increase and $k > s$ ($k = 0.75$ and $s = 0.69$), which suggests that the additional cost of providing high quality outpaces the quality differential between the high-and low-quality perceived by consumers, the nature of retailer competition changes accordingly. As shown in Table 4.4, multiple equilibria are possible. Compared with the symmetric equilibrium with $k = 0.35$ and $s = 0.58$, an asymmetric equilibrium is one of the possibilities. If Retailer A decides to produce a full product line, the best response for Retailer B is to

Table 4.5: Payoff Matrix for the Sequential Game, as k=0.35 and s=0.58

		Retailer B		
		H	*L*	*H&L*
Retailer A	*H*	0.5,0.5	0.37,0.22	0.57,0.44
	L	0.22,0.37	0.5,0.5	0.36,0.35
	H&L	0.44,0.57	0.35,0.36	0.5,0.5

Table 4.6: Payoff Matrix for the Sequential Game, as k=0.75 and s=0.69

		Retailer B		
		H	*L*	*H&L*
Retailer A	*H*	0.5,0.5	0.33,0.37	0.55,0.54
	L	0.37,0.33	0.5,0.5	0.43,0.31
	H&L	0.54,0.55	0.31,0.43	0.5,0.5

provide only high quality and vice versa. Another equilibrium is that both retailers choose to produce only low-quality goods. The reason is that the high cost differential prevents the retailers from providing high-quality products. Retailers both choose a conservative strategy by selling only low-quality products with low cost, rather than both choose an aggressive strategy by providing full product lines. However, due to the halo effect (i.e., one specializing in the high-quality niche market will gain higher reputation), it is also possible that one specializes in the low-quality and the other retailer will provide both qualities. This is summarized in Proposition 4.2.

Proposition 4.2 *When cost differential increases faster than quality differential, both symmetric and asymmetric equilibria exist where both retailers choose to specialize in low quality; or one retailer specializes in high quality and the other one provides a full line.*

4.3.2.4 Equilibrium of the Sequential Game

Unlike in the simultaneous game where the retailers choose product line and price simultaneously, the sequential game describes a three-stage decision process where one retailer can pre-commit to her product offerings and this action is observed by the other retailer. The existing literature (Gilbert and Matutes, 1993; Brander and Eaton, 1984) shows that firms tend to specialize or segment under certain conditions, given sequential entry. My study provides a similar result in the presence of the halo effect on retailers' product line decisions.

Using a backward-induction, I find that the results of the sequential game are similar to the simultaneous game. Quality and cost differential (k and s) play a key role in the product offering decisions. Table 4.5 shows that when consumers value high-quality products relatively more than the additional cost of providing high-quality products (i.e., $k = 0.35$ and $s = 0.58$), the game ends up with a symmetric competition in which both retailers provide the full product line. This result is the same as the simultaneous game. As Table 4.6 shows, when s and k increase and $k > s$ ($k = 0.75$ and $s = 0.69$), the game ends up with an asymmetric competition where Retailer A sells only high-quality and Retailer B sells both qualities. In this situation Retailer A has the first-mover advantage and will choose to specialize in the high-end product.

4.3.3 Summary of Results

First, the halo effect has an essential impact on consumers' purchase behavior, and on retailers' choice of product line and prices. In the absence of the halo effect, only symmetric competition with identical product lines will be chosen by retailers. Asymmetric competition with overlapping product lines occurs only in the presence of the halo effect. When the additional cost of providing high-quality is bigger than the additional value consumers place on high quality, the retailer who moves first will choose to specialize in the high-quality niche market, while the retailer who follows will choose to provide a full product line in the remaining market.

Second, retailers' choice of product lines (identical product lines, overlapping product lines, or completely different product lines) is sensitive to the cost and quality differentials. This result is consistent with the finding by Avenel and Caprice (2006). If the cost differential between providing high and low quality is low, retailers opt for the full product line. If the quality differential is low suggesting retailers have little incentive to provide the high-quality products. When the quality and cost differentials both increase to a higher level, the first-mover will choose to specialize in the high-quality niche submarket, gain a higher reputation, and attract the quality-conscious consumers. The follower will choose to provide a full product line. The leader dominates the market and ultimately earns more profit than the follower.

Third, both simultaneous and sequential games have similar results. This finding is different from other studies. Brander and Eaton (1984) and Gilbert and Matutes (1993) both find that segmentation occurs if firms can sequentially decide their product offerings. My model shows that if specializing in high-quality products can generate a positive halo for retailers, then retailers will be in favour of specialization even if they simultaneously decide their product line offerings. The results also show that in the equilibrium of the sequential game, the first-mover will choose to sell high-quality products only. The follower will then choose to offer only the low-quality product, or a full product line depending on cost and quality differentials.

4.4 Conclusion and Discussion

This study analyzes product line competition among retailers in a differentiated product market. The main objective is to identify why some retailers, such as Whole Foods Market, choose to sell only premium goods and serve a specific group of consumers in a niche market. Compared to a product proliferation strategy that can accommodate greater price discrimination, this study shows that product specialization in a high-quality niche market can also be an optimal strategy for retailers since a halo effect can help retailers gain higher reputation than their competitors. By providing only high-quality products, the retailers attempt to signal a positive reputation and attract quality-conscious shoppers. In this study, I examined both simultaneous and sequential games in a two-dimensional differentiated market where two retailers can choose to provide identical product lines, overlapping, or completely different product lines. This study finds that in presence of the halo effect, retailers can be better off through specialization than providing a full product line. This study also finds that the retailer who chooses to specialize will dominate the market by capturing more than half of the total market share.

The study has an important implication for retailers' product line choice. First, retailers' decisions of product and service quality have a direct impact on their reputation and then on consumer perception of the quality of product and service, especially when consumers have insufficient information and knowledge about retailers' products or low involvement activities in routine grocery shopping. Thus, the retailer halo effect is an important factor that influences consumer purchase behaviour and should be taken into retailers' account with respect to product line design. The retailers that gain positive reputation (positive retailer halo) and better performance in market share, markups, and profits. The retailer halo effect is not only applicable to just Whole Foods Market but also other retailers, especially the emerging unconventional format retailers in the food retail industry such as Whole Foods Market and Trader Joe's that target at serving a specific group of customers. The products and service they provide differentiate them from conventional retailers and gain a reputation that can produce a halo effect on consumer perception for product quality. The study of the halo effect helps to explain the emergence of retail stores of this type.

The most important contribution of this study is the introduction of the halo effect into retailers' product line choice. The halo effect manifests itself through the consumer's perception of the retailer's reputation which is differentiated by the retailer's choice of a product line. Another contribution of this study is the treatment of retailer reputation. Unlike most studies in which retailer reputation is considered as a horizontal-differentiation characteristic, this study assumes that retailer reputation has an impact on consumers' sensitivity to quality. The reason for this is that high reputation can be used as a signal for high product quality, rather than being only a firm-specific differentiator. This is especially true for quality-conscious consumers.

This study is an initial attempt to shed light on how reputation and the halo effect affect consumer behavior and retailer strategies. However, this study has several limitations. First, I have to acknowledge that this study does not consider the effect of cost-side factors, e.g., the fixed cost, on retailers' decision. Economies of scope is a critical reason for firms to produce a line of products. As the focus of this study is a retailer behavior, this assumption is relaxed. Another weakness is that this study examines only a duopoly market and does not take entry of a third retailer into account, while deterring entry is also an important reason for a retailer to offer multiple products.

There are two directions for potential future extension of this study. First, I can consider adding horizontal differentiation into the model. In this study, a product sold by the two retailers is assumed to be differentiated in both vertical and horizontal dimensions. However, in order to focus on the vertical dimension differentiation where the halo effect is incorporated, the horizontal differentiation is assumed to be the distance between the two retailers (following the Hotelling model) which is limited to 1. I will next think about a more general setting where horizontal differentiation between the two high- or low- quality products is incorporated. The horizontal differentiation can be interpreted as the horizontal characteristics of products (see Canoy and Peitz, 1997) or firm-specific differentiation (see Katz, 1984). Another extension to conduct is to test the results of the theoretical model empirically using data. For the empirical investigation, store-level scanner data from both a premium and traditional retailers can be used to explore the effect of the retailer halo effect by comparing the prices, sales, and profits of the two retailers with distinguished product line strategies. Another avenue is to explore the retailer halo effect on consumer perception on retailers with two distinguished product line strategies using a stated-preference approach and identify.

Chapter 5

Conclusion

5.1 Thesis Introduction

This dissertation explores two economic issues in development economics and industrial organization, respectively. The first issue in, most relevant in development economics, is how households cope with risks and improve food security when the market system is not well-established. This is discussed in the first study in Chapter 2. The primary objective of the first study is to examine the role of food gifting and kinship networks on household food security in rural Tanzania. This study has important implications on the effects of gift-giving and kinship networks as a form of informal risk-sharing in rural economies.

The second issue, most relevant in industrial organization, is how retailers compete with each other and with upstream manufacturers in the supply chain in response to changing consumer demand. Competition among retailers and the vertical relation between retailers and manufacturers have been active and essential topics in supply chain studies. The second and third studies address, respectively, a) retailers' private label (PL) strategy in the competition with manufacturers; and b) retailers' product line design in the competition with other retailers. Study 2 examines how a retailer strategically uses PLs in the vertical competition with manufacturers, as temperature changes. This study provides insights on the role of multi-tier PLs in the retailer-manufacturer relationship in a changing environment. In the third study, my objective is to explore retailers product line strategy and shed light on why some retailers choose to serve a niche market.

5.2 Summary of Results

The first study explores the gift-giving behaviour of the rural poor, the role of kinship networks, and their effects on food security at household level in rural Tanzania. Although gift-giving as an effective risk sharing mechanism has drawn much interest, few studies have empirically examined the nature of gift-giving behaviour of the rural poor; for example, gift-giving within versus outside kinship networks. In the first study, a theoretical risk-sharing model is constructed to examine the effect of a rich household's empathy on a poor household's self-protection effort and the total well-being of both households. The results show there is a negative relationship between the empathy from the rich household to the poor household and the poor household's effort in self-protection and aggregate food consumption. Using data collected from rural Tanzania, I investigate the linkage between food gifting and the implementation of risk-reducing strategies, and the effect of food gifting on household food security. The results of the empirical investigation show that higher degree of empathy leads to low propensity to implement risk-reducing strategies, whereas the results do not provide evidence that family gifters are doing worse-off than non-family gifters and non-gifters.

The second study examines how retailers use PLs to improve power in the vertical competition with the NB manufacturers, as the external conditions change. By incorporating a weather variable, this study aims to capture the changing nature of retailer-manufacturer vertical interactions where PLs play a key role. By estimating a structural demand-supply model accounting for both the demand and supply-side decisions, I find that with a rise in temperature, the retailer earns both share and margin advantages, compared to the upstream manufacturers. As temperature rises, the increase in consumer demand for PLs is larger than for NBs. The results also show that PLs and NBs of different qualities are used differently by the retailer and manufacturers. As temperature goes up, manufacturers of the premium NBs appear to soften their stance and provide the retailer with a price concession. As a result, the retailer earns increasing margins on the premium NBs but decreasing margins on the premium PLs. In the low-end market, retailer margin rises for the standard PLs, but declines for the standard NBs, with a rise in temperature.

The third study investigates retailers' product line strategy and examines how a halo effect may affect their product offerings choice. The key assumption of my model is that providing exclusively high-quality products can induce a halo effect that helps to differentiate the retailer from its competitors and further establish its reputation as a purveyor of high-quality products. A theoretical model describing two retailers' decisions with respect to product line offerings in the presence of the halo effect is constructed to address the objectives. The results of this study show that, without the halo effect, both retailers choose a full product line. In the presence of the halo effect, a retailer can be better off with product line specialization, i.e., providing a restricted product line that specializes in the high-quality niche market.

5.3 Implications, Limitations and Extensions

5.3.1 Implications

By exploring household and firm behaviour in an ever-changing world, this dissertation provides useful insights into how individuals cope with shocks in their lives and how firms adjust their strategies in response to external changes within market and non-market environments. The results of the studies have three important implications.

First, the gift-giving study in Chapter 2 suggests that food gifting may not be an effective means for individuals in less developed economies to share risk and to improve food security, regardless of whether it occurs within or outside kinship networks with different enforcement mechanisms (e.g., altruism versus reciprocity). Kinship relations accommodate interhousehold transfers due to a higher level of empathy between kins, especially when the income inequality between the rich and poor households is high. However, kinship sharing norms also have a free-rider effect on the poor households self-protection behaviour. The results show that households engaging in food gifting within family networks, or family gifters, tend to forego risk-reducing strategies. This may lead to the outcome that family gifters are worse off compared to non-family gifters. This is confirmed by the theoretical model, but not supported by the empirical analysis. The empirical results suggest that food gifting both within and outside kinship networks do not have a statistically significant effect on household food consumption.

Second, the results of the retailer-manufacturer competition study in Chapter 3 imply that the competitive relationship between retailers and their upstream manufacturers change as the external weather condition changes. PLs become an essential strategy for retailers to win in the vertical retailer-manufacturer power struggle. Because of the difference in nature between PLs and NBs (e.g., product design, price, and promotion), unbalanced changes in consumer demand occur as temperature increases. My study provides evidence of the asymmetric change in consumer demand for PLs and NBs as temperature increases and further shows that retailers and manufacturers use PLs and NBs for different purposes in the high-end market and low-end markets.

Last, the product line choice study in Chapter 4 shows that product specialization in a high-quality niche market can be an optimal strategy for retailers if a perceived halo effect can help retailers gain higher reputation than their competitors. The high-reputation retailer who exclusively provides high-quality products is better off by dominating the market and earning higher markups. By incorporating a positive retailer halo into consumer choice, this study provides useful insight into explaining retailers' product line choice of specialization.

5.3.2 Limitations and Extensions

The primary limitation of the first study is the data collected in the study areas of rural Tanzania. Only cassava and sweet potatoes are included as a proxy of food gifting in the survey; however, there are other crops (e.g., maize and rice) which may be more frequently gifted among local households. Another limitation is the issue of endogeneity. I use an endogenous switching approach to reduce the selection bias, and I provide evidence that they are not significantly correlated with household food consumption of non-gifters. However, these econometric methods at mitigating the effects of endogeneity are not perfect, and problems due to endogeneity may still be present. Future studies can focus on improving these limitations.

The second study can be improved in several ways. First, in this study I assume the Manufacturer-Stackelberg in the vertical interaction between the retailer and his upstream manufacturers would make it more realistic. The Vertical-Nash and Retailer-Stackelberge competition are alternative scenarios to describe the retailer-manufacturer relationship (Choi, 1991). In the future, I will investigate these two possible scenarios to determine which model fits the ice cream data better than the Manufacturer-Stackelberg interaction. Second, instead of using temperature solely as a proxy for weather, a more comprehensive weather index could be developed in the future to better capture the effects of external weather conditions on demand and supply.

In the third study, I will relax two assumptions imposed on the setting of the model. The first assumption is there is absence of economy of scope. Following Katz (1984), this study assumes the production technology exhibits no economies of joint production or economies of scope, in order to focus more sharply on the effects of demand-side interactions among a firm's products. However, economies of scope is a critical reason for firms to produce a line of products (Canoy and Peitz, 1997). Another limitation of Study 3 is that it examines only a duopoly market and does not take entry of a third retailer into account, while deterring entry can be an important strategic reason for a retailer to offer multiple products.

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Appendices

Appendix 1: Proof of Proposition 2.2 in Chapter 2

Let's now take a look at household consumption. The poor household's expected consumption is

$$c^p = (\pi - s)(y_l + \hat{t}) + (1 - \pi + s)(y_h) + \ln(\pi - s) - \ln \pi$$

If $\alpha \leq \overline{\alpha} = \frac{y_l}{y_h}$ and $\hat{t} = 0$

$$\begin{aligned} c^p &= (\pi - s)(y_l + 0) + (1 - \pi + s)(y_h) + \ln(\pi - (s)) - \ln \pi \\ &= (\pi - s)(y_l) + (1 - \pi + s)(y_h) + \ln(\pi - (s)) - \ln \pi \end{aligned}$$

If $\alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h}$ and $\hat{t} = \frac{\alpha y_h - y_l}{1+\alpha}$

$$
\begin{aligned}
c^p &= (\pi - s)(y_l + \frac{\alpha y_h - y_l}{1+\alpha}) + (1 - \pi + s)(y_h) + \ln(\pi - (s)) - \ln \pi \\
&= (\pi - s)\frac{\alpha(y_h + y_l)}{1+\alpha} + (1 - \pi + s)(y_h) + \ln(\pi - s) - \ln \pi
\end{aligned}
$$

I combine the two cases and get

$$
c^p = \begin{cases} (\pi - s)(y_l) + (1 - \pi + s)(y_h) + \ln(\pi - (s)) - \ln \pi \text{ if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ (\pi - s)\frac{\alpha(y_h + y_l)}{1+\alpha} + (1 - \pi + s)(y_h) + \ln(\pi - s) - \ln \pi \text{ if } \alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h} \end{cases}
$$

The rich household's consumption is

$$
c^r = (\pi - s)(y_h - t) + (1 - (\pi - s))y_h
$$

If $\alpha \leq \overline{\alpha} = \frac{y_l}{y_h}$and $\hat{t} = 0$

$$
c^r = (\pi - s)(y_h - 0) + (1 - (\pi - s))y_h = y_h
$$

If $\alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h}$and $\hat{t} = \frac{\alpha y_h - y_l}{1+\alpha}$

$$
c^r = (\pi - s)(y_h - \frac{\alpha y_h - y_l}{1+\alpha}) + (1 - (\pi - s))y_h \tag{5.1}
$$

I combine the two cases and get

$$
c^r = \begin{cases} y_h \quad \text{if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ \frac{(1+\alpha-\pi\alpha+s\alpha)y_h+(\pi-s)y_l}{\alpha+1} \quad \text{if } \alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h} \end{cases}
$$

Then I aggregate the consumption of both the rich and poor households. When $\alpha \leq \overline{\alpha} =$

$\frac{y_l}{y_h}$, the total consumption of both households is

$$
\begin{aligned}
c^p + c^r &= (\pi - s)(y_l) + (1 - \pi + s)(y_h) + \ln(\pi - (s)) - \ln\pi + y_h \\
&= 2y_h + \ln(\pi - s) - \ln\pi - \pi y_h + \pi y_l + s y_h - s y_l
\end{aligned}
$$

When $\alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h}$, the total consumption of both households is

$$
\begin{aligned}
c^p + c^r &= (\pi - s)\frac{\alpha(y_h + y_l)}{1+\alpha} + (1 - \pi + s)(y_h) + \ln(\pi - s) - \ln\pi + \frac{(1 + \alpha - \pi\alpha + s\alpha)y_h + (\pi - s)y_l}{\alpha + 1} \\
&= 2y_h + \ln(\pi - s) - \ln\pi - \pi y_h + \pi y_l + s y_h - s y_l
\end{aligned}
$$

To summarize, the total consumption of both households is

$$
c^p + c^r = \begin{cases} 2y_h + \ln(\pi - s) - \ln\pi - \pi y_h + \pi y_l + s y_h - s y_l \\ \qquad \text{if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ 2y_h + \ln(\pi - s) - \ln\pi - \pi y_h + \pi y_l + s y_h - s y_l \\ \qquad \text{if } \alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h} \end{cases}
$$

Similarly, I compute the optimal level of the poor household's risk reduction s. When $\alpha \leq \overline{\alpha} = \frac{y_l}{y_h}$,the optimal risk reduction is

$$
s = \pi - \frac{1}{ln\frac{y_h}{y_l}}
$$

When $\alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h}$,the optimal risk reduction is

$$s = \pi + \frac{1}{\ln\left(y_l - \frac{1}{\alpha+1}\left(y_l - \alpha y_h\right)\right) - \ln y_h}$$

To summarize, we have

$$s = \begin{cases} \pi - \frac{1}{\ln \frac{y_h}{y_l}} & \text{if } \alpha \leq \overline{\alpha} = \frac{y_l}{y_h} \\ \pi + \frac{1}{\ln\left(y_l - \frac{1}{\alpha+1}(y_l - \alpha y_h)\right) - \ln y_h} & \text{if } \alpha \geqslant \overline{\alpha} = \frac{y_l}{y_h} \end{cases}$$

Appendix 2: Proof of Scenario 1 in Chapter 4

In this appendix, the equilibrium prices, market shares and profits are derived by solving Retailer A and B's problems, respectively. To simplify the computation process, I assume unit transportation cost. According to the market share segmentation in Figure 4.1

$$\begin{aligned} \widehat{\delta}_{AHBH} &= \frac{p_H^B - p_H^A + 1}{2}, \\ \widehat{\delta}_{ALBL} &= \frac{p_L^B - p_L^A + 1}{2}, \\ \widehat{\theta}^A &= \frac{p_H^A - p_L^A}{s}, \end{aligned}$$

and

$$\widehat{\theta}^B = \frac{p_H^B - p_L^B}{s},$$

where A and B represents Retailer A and B. h and l refers to high quality and low quality. p is price. So p_H^A means the price of high-quality product sold by Retailer A.

Retailer A's problem is

$$\begin{aligned}
Max\ \pi^A &= (p_L^A - c_L)\widehat{\delta}_{ALBL}\widehat{\theta}^A + (p_H^A - c_H)\widehat{\delta}_{AHBH}(1 - \widehat{\theta}^A) \\
&= (p_L^A - c_L)\frac{p_L^B - p_L^A + 1}{2}\frac{p_H^A - p_L^A}{s} \\
&\quad +(p_H^A - c_H)\frac{p_H^B - p_H^A + 1}{2}(1 - \frac{p_H^A - p_L^A}{s})
\end{aligned}$$

The first order condition with respect to p_L^A is

$$\left[\begin{array}{c}
\frac{1}{2s}\left(p_L^A - p_H^A\right)\left(p_L^A - c_L\right) \\
-\frac{1}{2s}\left(2p_L^A - c_L - p_H^A\right)\left(1 - p_L^A + p_L^B\right) \\
-\frac{1}{2s}\left(c_H - p_H^A\right)\left(1 - p_H^A + p_H^B\right)
\end{array}\right] = 0.$$

The reaction function is:

$$p_L^A = \frac{1}{3} + \frac{1}{3}c_L \pm \frac{1}{3}\sqrt{\begin{array}{c}
3c_H p_H^B - 3c_H p_H^A - c_L p_H^A - c_L p_L^B + 3c_H - c_L + c_L^2 \\
-3p_H^A p_H^B - p_H^A p_L^B \\
-4p_H^A + 2p_L^B + 4p_H^A + p_L^B + 1
\end{array}} + \frac{1}{3}p_H^A + \frac{1}{3}p_L^B$$

The first order condition with respect to p_H^A is

$$\begin{bmatrix} \frac{1}{2}\left(\frac{1}{s}\left(p_H^A - p_L^A\right) - 1\right)\left(p_H^A - c_H\right) \\ -\frac{1}{2}\left(\frac{1}{s}\left(p_H^A - p_L^A\right) - 1\right)\left(1 - p_H^A + p_H^B\right) \\ -\frac{1}{2s}\left(p_H^A - c_H\right)\left(1 - p_H^A + p_H^B\right) \\ -\frac{1}{2s}\left(c_L - p_L^A\right)\left(1 - p_L^A + p_L^B\right) \end{bmatrix}$$
$$= 0,$$

The reaction function is:

$$\begin{aligned} p_H^A &= \frac{1}{3} + \frac{1}{3}s + \frac{1}{3}c_H + \frac{1}{3}p_H^B + \frac{1}{3}p_L^A \\ &\pm \frac{1}{3}\sqrt{\begin{array}{c} 3c_L - c_H - s - c_H p_H^B - c_H p_L^A - 3c_L p_L^A + 3c_L p_L^B \\ -sc_H + c_H^2 + 2p_H^B - 4p_L^A - p_H^B p_L^A \\ -3p_L^A p_L^B - sp_H^B + 2sp_L^A \\ +p_H^B + 4p_L^A + s^2 + 1 \end{array}}. \end{aligned}$$

Retailer B's problem is

$$\begin{aligned} Max\ \pi^B &= (p_L^B - c_L)(1 - \widehat{\delta}_L)\widehat{\theta}^B + (p_H^B - c_H)(1 - \widehat{\delta}_H)(1 - \widehat{\theta}^B) \\ &= (p_L^B - c_L)(1 - \frac{p_L^B - p_L^A +}{2})\frac{p_H^B - p_L^B}{s_H - s_L} \\ &\quad +(p_H^B - c_H)(1 - \frac{p_H^B - p_H^A +}{2})(1 - \frac{p_H^B - p_L^B}{s}). \end{aligned}$$

The first order condition with respect to p_L^B is

$$\begin{aligned} & \left[\begin{array}{c} \frac{1}{s}\left(\frac{1}{2}\left(p_L^B+1-p_L^A\right)-1\right)\left(p_L^B-c_L\right) \\ +\frac{1}{s}\left(p_L^B-p_H^B\right)\left(\frac{1}{2}\left(p_L^B+1-p_L^A\right)-1\right) \\ +\frac{1}{s}\left(\frac{1}{2}\left(1-p_H^A+p_H^B\right)-1\right)\left(c_H-p_H^B\right) \\ +\frac{1}{2s}\left(p_L^B-p_H^B\right)\left(p_L^B-c_L\right) \end{array} \right] \\ = \; & 0. \end{aligned}$$

The reaction function is:

$$\begin{aligned} & p_L^B = \frac{1}{3}+\frac{1}{3}c_L \\ & \pm\frac{1}{3}\sqrt{\begin{array}{c} 3c_H p_H^A - 3c_H p_H^B - c_L p_H^B - c_L p_L^A + 3c_H \\ -c_L + c_L^2 - 3p_H^A p_H^B - p_H^B p_L^A - 4p_H^B \\ +2p_L^A + 4p_H^B + p_L^A + 1 \end{array}} \\ & +\frac{1}{3}p_H^B + \frac{1}{3}p_L^A. \end{aligned}$$

The first order condition with respect to p_H^B is

$$
\begin{aligned}
& \left[\begin{array}{c}
\left(\frac{1}{s}\left(p_H^B - p_L^B\right) - 1\right)\left(\frac{1}{2}\left(p_H^B + 1 - p_H^A\right) - 1\right) \\
+\frac{1}{2}\left(\frac{1}{s}\left(p_H^B - p_L^B\right) - 1\right)\left(p_H^B - c_H\right) \\
+\frac{1}{s}\left(\frac{1}{2}\left(p_H^B + 1 - p_H^A\right) - 1\right)\left(p_H^B - c_H\right) \\
+\frac{1}{s}\left(\frac{1}{2}\left(1 - p_L^A + p_L^B\right) - 1\right)\left(c_L - p_L^B\right)
\end{array}\right] \\
= \;& 0.
\end{aligned}
$$

The reaction function is:

$$
\begin{aligned}
p_H^B \;=\;& \frac{1}{3} + \frac{1}{3}c_H + \frac{1}{3}s + \frac{1}{3}p_H^A + \frac{1}{3}p_L^B \\
& \pm\frac{1}{3}\sqrt{\begin{array}{c}
3c_L - c_H - s - c_H p_H^A - c_H p_L^B - 3c_L p_L^B \\
+3c_L p_L^A - sc_H + c_H^2 + 2p_H^A - 4p_L^B - p_H^A p_L^B \\
-3p_L^B p_L^A - sp_H^A + 2sp_L^B + p_H^A + 4p_L^B + +s^2 + 1
\end{array}}.
\end{aligned}
$$

The equation system of $p_L^A, p_H^A, p_L^B, p_H^B$ is

$$
\begin{aligned}
p_L^A &= \frac{1}{3}+\frac{1}{3}c_L+\frac{1}{3}p_H^A+\frac{1}{3}p_L^B \\
&\pm\frac{1}{3}\sqrt{\begin{array}{c} 3c_Hp_H^A-3c_Hp_H^B-c_Lp_H^B-c_Lp_L^A+3c_H-c_L \\ +c_L^2-3p_H^Ap_H^B \\ -p_H^Bp_L^A-4p_H^B+2p_L^A+4p_H^B+p_L^A+1 \end{array}} \\
p_H^A &= \frac{1}{3}+\frac{1}{3}s+\frac{1}{3}c_H+\frac{1}{3}p_H^B+\frac{1}{3}p_L^A \\
&\pm\frac{1}{3}\sqrt{\begin{array}{c} 3c_L-c_H-s-c_Hp_H^B-c_Hp_L^A-3c_Lp_L^A \\ +3c_Lp_L^B-sc_H+c_H^2+2p_H^B-4p_L^A-p_H^Bp_L^A \\ -3p_L^Ap_L^B-sp_H^B+2sp_L^A+p_H^B+4p_L^A+s^2+1 \end{array}} \\
p_L^B &= \frac{1}{3}+\frac{1}{3}c_L+\frac{1}{3}p_H^B+\frac{1}{3}p_L^A \\
&\pm\frac{1}{3}\sqrt{\begin{array}{c} 3c_Hp_H^A-3c_Hp_H^B-c_Lp_H^B-c_Lp_L^A+3c_H-c_L \\ +c_L^2-3p_H^Ap_H^B \\ -p_H^Bp_L^A-4p_H^B+2p_L^A+4p_H^B+p_L^A+1 \end{array}} \\
p_H^B &= \frac{1}{3}z+\frac{1}{3}c_H+\frac{1}{3}s_H-\frac{1}{3}s_L+\frac{1}{3}p_H^A+\frac{1}{3}p_L^B \\
&\pm\frac{1}{3}\sqrt{\begin{array}{c} 3c_L-c_h-s-c_Hp_H^A-c_hp_L^B-3c_Lp_L^B \\ +3c_Lp_L^A-sc_h+c_h^2+2p_H^A-4p_L^B-p_H^Ap_L^B \\ -3p_L^Bp_L^A-sp_H^A+2sp_L^B+p_H^A+4p_L^B++s^2+1 \end{array}}.
\end{aligned}
$$

From (1) and (3) we can see that the two equations are symmetric, which implies $p_L^A = p_L^B$. Similarly, from (2) and (4), we know that $p_H^A = p_H^B$. If we impose $p_L^A = p_L^B$ and $p_H^A = p_H^B$,the equation system becomes

$$
\begin{aligned}
p_L^A &= \frac{1}{3} + \frac{1}{3}c_L + \frac{1}{3}p_H^A + \frac{1}{3}p_L^A \\
&\pm \frac{1}{3}\sqrt{\begin{array}{c} p_H^A + p_L^A - p_H^A p_L^A - c_L p_H^A \\ -4p_H^A - c_L p_L^A + 2p_L^A + 3c_H + c_L^2 - c_L + 1 \end{array}} \\
p_H^A &= \frac{1}{3} + \frac{1}{3}s + \frac{1}{3}c_H + \frac{1}{3}p_H^A + \frac{1}{3}p_L^A \\
&\pm \frac{1}{3}\sqrt{\begin{array}{c} p_H^A + p_L^A - p_H^A p_L^A - c_H p_L^A - 4p_L^A \\ -c_H p_H^A + 2p_H^A + 3c_L + c_H^2 - c_H \\ -s p_H^A + 2s p_L^A - s c_H - s + s^2 + 1 \end{array}} .
\end{aligned}
$$

Notice that equations (1) and (3) are symmetric. Likewise, equations (2) and (4) are symmetric. So we simplify the equation system above by imposing symmetry and yield

$$
\begin{aligned}
2p_L^A &= 1 + c_L + p_H^A \\
&\pm \sqrt{\begin{array}{c} p_H^A + p_L^A - p_H^A p_L^A - c_L p_H^A \\ -4p_H^A - c_L p_L^A + 2p_L^A + 3c_H + c_L^2 - c_L + 1 \end{array}} \\
2p_H^A &= 1 + s + c_H + p_L^A \\
&\pm \sqrt{\begin{array}{c} p_L^A + p_H^A - p_L^A p_H^A - c_H p_L^A - 4p_L^A \\ -c_H p_H^A + 2p_H^A + 3c_L + c_H^2 - c_H \\ +1 - s p_H^A + 2s p_L^A - s c_H - s + s^2 \end{array}} .
\end{aligned}
$$

The equation system has a solution if $p_L^A = c_L + 1$ and $p_H^A = c_H + 1$

Proof:

$$\begin{aligned} 2p_L^A &= 1 + c_L + p_H^A \\ &\quad \pm \sqrt{\begin{array}{c} p_H^A + p_L^A - p_H^A p_L^A - c_L p_H^A - 4p_H^A \\ -c_L p_L^A + 2p_L^A + 3c_H + c_L^2 - c_L + 1 \end{array}}. \end{aligned}$$

Rearranging it yields

$$\begin{aligned} & 2p_L^A - 1 - c_L - p_H^A \\ = \; & \pm \sqrt{\begin{array}{c} p_H^A + p_L^A - p_H^A p_L^A - c_L p_H^A - 4p_H^A - c_L p_L^A \\ +2p_L^A + 3c_H + c_L^2 - c_L + 1 \end{array}}. \end{aligned}$$

Then plug $p_L^A = c_L + 1$ and $p_H^A = c_H + 1$ into $(1)'$, yielding

$$\begin{aligned} & 2(c_L + 1) - 1 - c_L - (c_H + 1) \\ = \; & \pm \sqrt{\begin{array}{c} (c_H + 1)^2 + (c_L + 1)^2 - (c_H + 1)(c_L + 1) - c_L(c_H + 1) \\ -4(c_H + 1 - c_L(c_L + 1) + 2(c_L + 1) + 3c_H + c_L^2 - c_L + 1 \end{array}}. \end{aligned}$$

For the right-hand side

$$
\begin{aligned}
& \sqrt{\begin{array}{c}(c_H+1)^2+(c_L+1)^2-(c_H+1)(c_L+1)-c_L(c_H+1)\\ -4(c_H+1)-c_L(c_L+1)+2(c_L+1)+3c_H+c_L^2-c_L+1\end{array}} \\
= & \sqrt{\begin{array}{c}c_L-c_H-c_L\left(c_H+1\right)-c_L\left(c_L+1\right)+c_L^2\\ -\left(c_H+1\right)\left(c_L+1\right)+\left(c_H+1\right)^2+\left(c_L+1\right)^2-1\end{array}} \\
= & \sqrt{\left(c_H-c_L\right)^2}.
\end{aligned}
$$

For the left-hand side

$$
2(c_L+1)-1-c_L-(c_H+1)=c_L-c_H.
$$

Then we have

$$
c_L-c_H=\pm\sqrt{\left(c_H-c_L\right)^2}.
$$

$$
c_L-c_H=-\sqrt{\left(c_H-c_L\right)^2}.
$$

Similarly, we can prove that the second equation also holds at $p_L^A=c_L+1$ and $p_H^A=c_H+1$.

To summarize, $p_L^A=c_L+1$ and $p_H^A=c_H+1$ is the solution to the equation system $(1)'$ and $(2)'$. I cannot guarantee that it is the unique solution for this equation system; it guarantees only a local maximum. Similarly, I get $p_L^B=c_L+1$ and $p_H^B=c_H+1$ as the solution to Retailer B's problem. Therefore, the solution to the entire equation system is $p_L^A=p_L^B=c_L+1$ and $p_H^A=p_H^B=c_H+1$. Now I plug this solution into the profit functions, yielding

$$
\begin{aligned}
\pi^A &= (p_L^A - c_L)\widehat{\delta}_L\widehat{\theta}^A + (p_H^A - c_H)\widehat{\delta}_H(1-\widehat{\theta}^A) \\
&= (p_L^A - c_L)\frac{p_L^B - p_L^A + 1}{2}\frac{p_H^A - p_L^A}{s} \\
&\quad +(p_H^A - c_H)\frac{p_H^B - p_H^A + 1}{2}(1 - \frac{p_H^A - p_L^A}{s}) \\
&= \frac{1}{2},
\end{aligned}
$$

and

$$
\begin{aligned}
\pi^B &= (p_L^B - c_L)(1-\widehat{\delta}_L)\widehat{\theta}^B + (p_H^B - c_H)(1-\widehat{\delta}_H)(1-\widehat{\theta}^B) \\
&= (p_L^B - c_L)(1 - \frac{p_L^B - p_L^A +}{2})\frac{p_H^B - p_L^B}{s_H - s_L} \\
&\quad +(p_H^B - c_H)(1 - \frac{p_H^B - p_H^A +}{2})(1 - \frac{p_H^B - p_L^B}{s}) \\
&= \frac{1}{2}.
\end{aligned}
$$

We can see that the two retailers earn the same profit if they both provide the full product line. The profit they make in this situation is the same as they both offer the same single quality and the mark-ups remain unchanged. For example, if Retailer A and B both produce the high-quality product,

$$\pi^A = (p_H^A - c_H)\widehat{\delta}_H * 1 = (p_H^A - c_H) * \frac{1}{2} * 1 = \frac{1}{2},$$

and

$$\pi^B = (p_H^B - c_H)(1 - \widehat{\delta}_H) * 1 = (p_H^B - c_H) * (p_H^B - c_H)(1 - \widehat{\delta}_H) * \frac{1}{2} * 1 = \frac{1}{2}.$$

Appendix 3: Proof of Scenario 2 in Chapter 4

The consumer's utility function is $U_i^j = (1+r)\theta s_i - p_i^j - |\delta - L^j|$,where $i = H$ or L, $j = A$ and B,and $r = 0$ or 1. Retailer A specializes in the high-quality product and obtains high reputation. Retailer B provides a full product line and earns no reputation. To make the computation process less complicated, I assume $s_H = s$ and $s_L = 0$. Thus s represents consumers' perceived quality differential between the high- and low-quality products. Similarly with the symmetric competition case, I assume $t = 1$.

A consumer is indifferent between BH and BL if and only if

$$(1+r)\theta s_H - p_H^B - \left|\delta - L^B\right| = (1+r)\theta s_L - p_L^B - t\left|\delta - L^B\right|$$

Then I calculate $\widehat{\theta}^B$ which is where consumers are indifferent between BH and BL, yielding

$$\widehat{\theta}^B = \frac{p_H^B - p_L^B}{s}.$$

Similarly, a consumer is indifferent between AH and BH, if and only if

$$(1+r)\theta s_H - p_H^A - \left|\delta - L^A\right| = (1+r)\theta s_H - p_H^B - \left|\delta - L^B\right|.$$

The retailer gains higher reputation by selling only the high-quality product; or, $r = 1$

for Retailer A and $r = 0$ for Retailer B, yielding

$$(1+1)\theta s_H - p_H^A - \left|\delta - L^A\right| = (1+0)\theta s_H - p_H^B - \left|\delta - L^B\right|.$$

The relationship between θ and δ is expressed by

$$\delta = \frac{\theta s + p_H^B - p_H^A + 1}{2}.$$

Plugging in different values of θ ($\theta = 1$ and $\widehat{\theta}^B$), I obtain values for the points $\widetilde{\delta}_{AHBH}$ and $\widetilde{\delta}_{center}$ in Figure 4.2

$$\widetilde{\delta}_{AHBH} = \frac{s + p_H^B - p_H^A + 1}{2},$$

and

$$\widetilde{\delta}_{center} = \frac{2p_H^B - p_H^A - p_L^B + 1}{2}.$$

Similarly, the consumer is indifferent between AH and BL, if and only if

$$(1+r)\theta s_H - p_H^A - t\left|\delta - L^A\right| = (1+r)\theta s_L - p_L^B - t\left|\delta - L^B\right|.$$

The I derive the relationship between θ and δ as

$$\delta = \frac{2\theta s - p_H^A + p_L^B + 1}{2}.$$

Plugging the $\theta = 0$ yields $\widetilde{\delta}_{AHBL}$ in Figure 4.2 as

$$\widetilde{\delta}_{AHBL} = \frac{1}{2} - \frac{(p_H^A - p_L^B)}{2}.$$

The market shares (φ) of AH, BH, and BL are presented as follows:

$$\varphi_{AH} = 1 * \widetilde{\delta}_{center} + \frac{1}{2}(\widetilde{\delta}_{AHBH} - \widetilde{\delta}_{center})(1 - \widehat{\theta}^B) - \frac{1}{2}(\widetilde{\delta}_{center} - \widetilde{\delta}_{AHBL})\widehat{\theta}^B$$

$$\varphi_{BH} = (1 - \widehat{\theta}^B)(1 - \widetilde{\delta}_{center}) - \frac{1}{2}(\widetilde{\delta}_{AHBH} - \widetilde{\delta}_{center})(1 - \widehat{\theta}^B)$$

$$\varphi_{BL} = (1 - \widetilde{\delta}_{center}) * \widehat{\theta}^B + \frac{1}{2}(\widetilde{\delta}_{center} - \widetilde{\delta}_{AHBL})\widehat{\theta}^B$$

Next, I maximize Retailers A' profit function:

$$\pi^A = \pi_H^A = (p_H^A - c_H)(1 * \widetilde{\delta}_{center} + \frac{1}{2}(\widetilde{\delta}_{AHBH} - \widetilde{\delta}_{center})(1 - \widehat{\theta}^B) - \frac{1}{2}(\widetilde{\delta}_{center} - \widetilde{\delta}_{AHBL})\widehat{\theta}^B).$$

I plug $\widetilde{\delta}_{center}, \widetilde{\delta}_{AHBH}$ and $\widetilde{\delta}_{AHBL}$ into the profit function and solve for the first order condition with respect to p_H^A :

$$
\begin{aligned}
0 &= \frac{1}{2}\left(1-p_H^A+2p_H^B-p_L^B\right)-\frac{1}{2}\left(p_H^A-c_H\right) \\
&\quad -\frac{1}{2}\left(\frac{1}{s}\left(p_H^B-p_L^B\right)-1\right)\left(\begin{array}{c}\frac{1}{2}\left(s+1-p_H^A+p_H^B\right) \\ -\frac{1}{2}\left(1-p_H^A+2p_H^B-p_L^B\right)\end{array}\right) \\
&\quad -\frac{1}{2s}\left(p_H^B-p_L^B\right)\left(\begin{array}{c}\frac{1}{2}\left(p_H^A-p_L^B\right) \\ +\frac{1}{2}\left(1-p_H^A+2p_H^B-p_L^B\right)-\frac{1}{2}\end{array}\right).
\end{aligned}
$$

Retailer A's reaction function is

$$
p_H^A=\frac{1}{4s}\left(2sc_H+2p_H^Bp_L^B+2sp_H^B-p_H^B-p_L^B+2s+s^2\right).
$$

Similarly, I solve retailers B' problem with Retailer B's profit expressed as

$$
\begin{aligned}
\pi^B &= \pi_H^B+\pi_L^B=(p_H^B-c_H)((1-\widehat{\theta}^B)(1-\widetilde{\delta}_{center})-\frac{1}{2}(\widetilde{\delta}_{AHBH}-\widetilde{\delta}_{center})(1-\widehat{\theta}^B)) \\
&\quad +(p_L^B-c_L)((1-\widetilde{\delta}_{center})*\widehat{\theta}^B+\frac{1}{2}(\widetilde{\delta}_{center}-\widetilde{\delta}_{AHBL})\widehat{\theta}^B).
\end{aligned}
$$

Similarly, I plug $\widetilde{\delta}_{center}, \widetilde{\delta}_{AHBH}$ and $\widetilde{\delta}_{AHBL}$ into B's profit function and solve for the first order condition with respect to p_H^B :

$$
\begin{aligned}
0 &= \left(c_L - p_L^B\right)\begin{pmatrix} \frac{1}{s}\left(\frac{\left(1+2p_H^B-p_H^A-p_L^B\right)}{2}-1\right) \\ -\frac{1}{2s}\left(\frac{\left(1+2p_H^B-p_H^A-p_L^B\right)}{2}+\frac{\left(p_H^A-p_L^B\right)}{2}-\frac{1}{2}\right)+\frac{\left(p_H^B-p_L^B\right)}{2s} \end{pmatrix} \\
&\quad +\frac{1}{2}\left(\frac{\left(p_H^B-p_L^B\right)}{s}-1\right)\begin{pmatrix} \frac{\left(s+1+p_H^B-p_H^A\right)}{2} \\ -\frac{\left(1+2p_H^B-p_H^A-p_L^B\right)}{2} \end{pmatrix} \\
&\quad +\left(p_H^B-c_H\right)\begin{pmatrix} \frac{1}{s}\left(\frac{\left(1+2p_H^B-p_H^A-p_L^B\right)}{2}-1\right)+\frac{3}{4}\left(\frac{\left(p_H^B-p_L^B\right)}{s}-1\right) \\ +\frac{1}{2s}\left(\frac{\left(s+1+p_H^B-p_H^A\right)}{2}-\frac{\left(1+2p_H^B-p_H^A-p_L^B\right)}{2}\right) \end{pmatrix} \\
&\quad +\left(\frac{\left(1+2p_H^B-p_H^A-p_L^B\right)}{2}-1\right)\left(\frac{\left(p_H^B-p_L^B\right)}{s}-1\right).
\end{aligned}
$$

The reaction function for Retailer B with respect to p_H^B is

$$
\begin{aligned}
p_H^B &= \frac{2}{9}s+\frac{2}{9}t+\frac{1}{3}c_H-\frac{2}{9}c_L \\
&\quad -\frac{1}{9}\sqrt{\begin{array}{c} 13s^2-10st-6sc_H-8sc_L-10sp_H^A+24sp_L^B \\ +4t^2-6tc_H+10c_L+8p_H^A-12p_L^B+9c_H^2-12c_Hc_L \\ -6c_Hp_H^A+4c_L^2+10c_Lp_H^A-6c_Lp_L^B+4p_H^A-12p_H^Ap_L^B+9p_L^B \end{array}} \\
&\quad +\frac{2}{9}p_H^A+\frac{2}{3}p_L^B.
\end{aligned}
$$

The first order condition with respect to p_L^B is

$$
\begin{aligned}
0 &= \left(p_L^B - c_L\right)\left(\frac{1}{s}\left(\frac{1}{2}\left(1-p_L^B-p_H^A+2p_H^B\right)-1\right)+\frac{1}{2s}\left(\frac{1}{2}\left(p_L^B-p_H^A\right)-\frac{1}{2}\left(1-p_L^B-p_H^A+2p_H^B\right)+\frac{1}{2}\right)\right) \\
&\quad -\left(c_H-p_H^B\right)\left(\begin{array}{c} \frac{1}{4}\left(\frac{1}{s}\left(p_L^B-p_H^B\right)+1\right)-\frac{1}{s}\left(\frac{1}{2}\left(1-p_L^B-p_H^A+2p_H^B\right)-1\right) \\ +\frac{1}{2s}\left(\frac{1}{2}\left(1-p_L^B-p_H^A+2p_H^B\right)-\frac{1}{2}\left(s+1-p_H^A+p_H^B\right)\right) \end{array}\right) \\
&\quad +\frac{1}{2s}\left(p_L^B-p_H^B\right)\left(\frac{1}{2}\left(p_L^B-p_H^A\right)-\frac{1}{2}\left(1-p_L^B-p_H^A+2p_H^B\right)+\frac{1}{2}\right) \\
&\quad +\frac{1}{s}\left(p_L^B-p_H^B\right)\left(\frac{1}{2}\left(1-p_L^B-p_H^A+2p_H^B\right)-1\right).
\end{aligned}
$$

The reaction function with respect to p_L^B is

$$
p_L^B = \frac{1}{2+c_H+2p_H^A-3p_H^B}\left(\begin{array}{c} -c_Hp_H^A+2c_Hp_H^B+c_Lp_H^A-c_Lp_H^B \\ -c_H+c_L+2p_H^Ap_H^B+2p_H^B-3p_H^B \end{array}\right).
$$

My objective is to derive p_H^A, p_H^B, and p_L^B by solving the system of equations that consists of the reaction functions derived previously.

Let's make $p_H^A = c_H + a$, $p_H^B = c_H + b$, and $p_L^B = c_L + c$, where a,b, and c are markups of AH, BH and BL, respectively. This yields the following equation system:

$$
\begin{aligned}
0 &= b^2+c^2-2bc+4sa+(2k-2s)b-2kc+k^2-2s-s^2 \\
0 &= -36ab^2+36ac-108bc+81b^2+27c^2-(18k-18s)A+(72k-36s-36)b \\
&\quad -(36k-36)c-18k+18s+9k^2-9s^2 \\
0 &= -2ab+2ac-3bc+3b^2-ka+(2k-2)b+2c-k
\end{aligned}
$$

I solve this equation system for a, b and c under different values of s and k and derive prices, market shares and profits. The results are summarized in Table 4.1.

Appendix 4: Proof of Scenario 3 in Chapter 4

In this scenario, Retailer A sells only the high-quality product, and Retailer B sells only the low-quality product.

A consumer is indifferent between buying AH and BL if and only if

$$(1+r)\theta s_H - p_H^A - \left|\delta - L^A\right| = (1+r)\theta s_L - p_L^B - \left|\delta - L^B\right|.$$

Retailer A gains higher reputation than Retailer B by selling only the high-quality product, so:

$$(1+1)\theta s_H - p_H^A - \left|\delta - L^A\right| = (1+0)\theta s_L - p_L^B - \left|\delta - L^B\right|.$$

From this equation, we have the following relation between θ and δ,

$$\theta = \frac{p_H^A - p_L^B - 1 + 2\delta}{2s}.$$

Let $\delta = 0$ to yield $\widetilde{\theta}^A = \frac{p_H^A - p_L^B - 1}{2s}$,and let $\delta = 1$ to yield $\widetilde{\theta}^B = \frac{p_H^A - p_L^B + 1}{2s}$

The market shares of AH and BL are

$$\begin{aligned}\varphi_H^A &= 1*(1-\widetilde{\theta}^B)+\frac{1}{2}*1*(\widetilde{\theta}^B-\widetilde{\theta}^A)\\ &= 1*(1-\frac{p_H^A-p_L^B+t}{2s})+\frac{1}{2}*1*(\frac{p_H^A-p_L^B+t}{2s}-\frac{p_H^A-p_L^B-t}{2s}).\end{aligned}$$

and

$$\begin{aligned}\varphi_L^B &= 1*\widetilde{\theta}^A+\frac{1}{2}*1*(\widetilde{\theta}^B-\widetilde{\theta}^A)\\ &= 1*\frac{p_H^A-p_L^B-t}{2s}+\frac{1}{2}*1*(\frac{p_H^A-p_L^B+t}{2s}-\frac{p_H^A-p_L^B-t}{2s}).\end{aligned}$$

Retailer A's profit maximization problem is

$$\begin{aligned}\pi^A &= (p_H^A-c_H)*\varphi_H^A\\ & (p_H^A-c_H)*(1*(1-\frac{p_H^A-p_L^B+t}{2s})+\frac{1}{2}*1*(\frac{p_H^A-p_L^B+t}{2s}-\frac{p_H^A-p_L^B-t}{2s})).\end{aligned}$$

Retaier B's profit maximization problem is

$$\begin{aligned}\pi^B &= (p_H^B-c_H)*\varphi_H^B\\ &= (p_H^A-c_H)*(1*\frac{p_H^A-p_L^B-t}{2s}+\frac{1}{2}*1*(\frac{p_H^A-p_L^B+t}{2s}-\frac{p_H^A-p_L^B-t}{2s}))\end{aligned}$$

The first order condition with respect p_H^A is

$$\frac{1}{4s}\left(1-p_H^A+p_L^B\right)-\frac{1}{4s}\left(1+p_H^A-p_L^B\right)-\frac{1}{2s}\left(p_H^A-c_H\right)+1=0.$$

The reaction function of Retailer A is

$$p_H^A = s+\frac{1}{2}c_H+\frac{1}{2}p_L^B.$$

Similarly, I derive Retailer B's reaction function as

$$p_L^B = \frac{1}{2}c_L+\frac{1}{2}p_H^A.$$

Setting $p_H^A = c_H + a$ and $p_L^B = c_L + c$ yields the following equation system

$$\begin{aligned} a-\frac{1}{2}c-s+\frac{1}{2}k &= 0 \\ c-\frac{1}{2}a-\frac{1}{2}k &= 0 \end{aligned}$$

Then I solve for a and c under different values of t, s and k.

I first try the same values as in scenario 2, which is $k=0.35$ and $s=0.58$, we get

$$\begin{aligned} a &= 0.657 \\ c &= 0.503 \end{aligned}$$

Then I plug a and c into the market shares φ^{AH} and φ^{BL}, and get $\varphi^{AH} = 0.565\,52$, and $\varphi^{BL} = 0.434\,48$. Since markups and market shares are known, I can calculate the profits, which are $\pi^A = 0.657 * 0.565\,52 = 0.371\,55$ and $\pi^B = 0.503 * 0.434\,48 = 0.218\,54$

Then I let $k = 0.75$ and $s = 0.69$

$$\begin{aligned} a - \frac{1}{2}c - 0.69 + \frac{0.75}{2} &= 0 \\ c - \frac{1}{2}a - \frac{0.75}{2} &= 0 \end{aligned}$$

Solving the equation system above yields

$$\begin{aligned} a &= 0.67 \\ c &= 0.71 \end{aligned}$$

Based on the values of a and c, market shares φ^{AH} and φ^{BL}, and profits π^A and π^B can be also calculated. The results are summarized in Table 4.2.