DISSERTATION

EVALUATING STRUCTURAL AND PERFORMANCE DYNAMICS OF A DIFFERENTIATED U.S. APPLE INDUSTRY

Submitted by

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ABSTRACT

EVALUATING STRUCTURAL AND PERFORMANCE DYNAMICS OF A DIFFERENTIATED U.S. APPLE INDUSTRY

There is a growing public interest, and consequently, support for public policies and programs to support local food systems. These programs aim to inform consumers about the potential benefits of local foods and influence consumers' choice among differentiable foods. As state promotion and marketing programs have been widely adopted throughout the country, demand for local produce and market opportunities for locally-branded products have increased significantly. Local promotion programs have also started to influence the structure of markets, as demand has stimulated a proliferation of localized, direct marketing supply chains linking growers directly to consumers. However, there are few true examinations focused on the welfare implications surrounding the restructuring of food markets and or the underlying economic performance of market innovations.

The main objective of this study is to explore the structural and performance dynamics of a market as a result of new labeling efforts and promotional campaigns, highlighting the availability of locally grown products (both in direct markets and within more conventional marketing channels). This study develops a partial equilibrium displacement model for Colorado apples to analyze the impacts of local labeling. The information obtained from the result of this model informs how consumer perceptions and marketing channel structure influence market performance. To complement the broader analysis, the market structure and price relationship at different market levels are examined.

The results showed that the Southwest and Northeast retail markets dominated national retail markets and the Northwest retail market dominated western retail markets in terms of its influence on retail prices. Not surprisingly the Yakima Valley and Wenatchee District in Washington significantly affected the price formation process of all other shipping points. If the unknown transaction cost band is allowed to vary according to transportation costs and seasonality, it may more closely mimic suppliers who view more opportunities to adjust their supply between regional markets in search of potential profits.

Overall, local labeling increases consumers' willingness to pay for local apples relative to domestic apples in Colorado, and subsequently, demand will shift toward local apples and the supply will shift toward direct markets in Colorado. In terms of producer surplus, Colorado suppliers for direct markets gain while Colorado suppliers for shipping points lose in short run. In the long run, both suppliers will gain but the suppliers for direct markets will gain more than the suppliers for shipping points. Overall, the Colorado producers lose in the short run while they gain in the long run.

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DEDICATION

This dissertation is lovely dedicated to my grandma, Yuping Deng and my parents, Bingfang Hu and Hailing Wang. Their support, encouragement, and constant love have lighted my life.

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CHAPTER 1 INTRODUCTION

1.1 Background Information and Problem Statement

There is a growing public interest, and consequently, support for public policies and programs to support local food systems including consumer education, relocalization efforts within communities, and promotional campaigns. These programs aim to inform consumers about the potential benefits of local foods and influence consumers' choice among differentiable foods. As state promotion and marketing programs have been widely adopted throughout the country (e.g., Be Californian, From the Heart of Washington, Colorado Proud, New Jersey Fresh, Pride of New York, and South Carolina locally grown campaign), demand for local produce and market opportunities for locally-branded products have increased significantly (Adelaja, Brumfield, and Lininger, 1990; Carpio and Isengildina-Massa, 2010; Costanigro, Kroll, and Thilmany, 2011).

Still, the vast majority of U.S. apples is marketed through traditional, commercial marketing chains that connects growers, shippers, terminal markets (or international markets) and retail outlets. But, it is also true that local promotion programs have started to influence the structure of markets, as demand has stimulated a proliferation of localized, direct marketing supply chains linking growers directly to consumers, such as farmers markets and community supported agriculture organizations (CSAs), farm stands and on-farm sales. According to the 2007 Census of Agriculture, direct sales of agricultural products increased 117.79% relative to 1997 levels. One driving motivation for the locally-focused food policies and programs is the potential gains to farmers, consumers, and local markets from more localized marketing networks. However, there are few true examinations focused on the welfare implications surrounding the restructuring of food markets and or the underlying economic performance of market innovations. This study will fill this gap with market analysis of one fresh produce category, apples, in specific localized market, Colorado.

To rigorously examine specific supply, demand and market relationships with respect to the role of new local promotions and market innovations, a specific product and production source needed to be chosen. Apples are the product focus of this study for some of its unique characteristics: its popularity across U.S. consumers and presence in many local market channels, its semi-perishability which allows for extended marketing seasons, fairly substantial domestic and international trade volumes, and finally, its important role in the U.S. fruit market.

U.S. apple production was 9,515 million pounds in 2008, accounting for 6.4% of world apple production. In 2008, 65.6% of U.S. produced apples entered the fresh market. In 2008, apples were ranked third for consumption of fruits in the U.S., averaging 48.6 pounds per capita (oranges 56.9, grapes 51.3) and were ranked first for consumption of fresh fruit in the U.S. averaging 16.2 pounds per capita. In Colorado, the 2008 production of apples was reported at 18 million pounds, and the supply of fresh apples was reported at 10 million pounds (ERS). Given Colorado's population, state-based production can no longer meet the state demand of 244 million pounds and 81 million pounds of fresh apples, but current supplies of fresh apples do represent 12% to 13% of current demand.

These results will also be somewhat generalizable across the U.S. since apples are grown in all 50 U.S. states. Washington was the largest fresh apple supplying state in 2010, accounting for 72.25% of domestic supplies, followed by New York (9.53%), Michigan (3.34%) and Pennsylvania (3.02%) (USDA, NASS, 2011). Yet, the apple industry has been shrinking in most states since the late 1990s under the pressure of competition, but as the Colorado numbers above show, there is some potential for fresh market demand to be met by local or regional supplies through the country. In this study, the apple market is analyzed from a couple vantage points in order to explore economic and welfare effects of more localized marketing systems. In general, price dynamics, market structure and new market clearing relationships are examined at different market levels. The transmission of market shocks across spatially-distinct markets and along the marketing chain, especially the extent of adjustment and the speed of shock transmission across marketing channels, is a good point of view to study the structure, conduct and performance of the market (Goodwin, 2006). Through a combination of price analysis across spatially distinct shipping points, terminal markets and retail outlets, as well as a disentangling of demand implications for different market shares (gleaned from previously completed consumer analysis), a number of market-based parameters are estimated for this specific market.

Finally, using the state branded definition of local produce, we evaluate the welfare effects of Colorado production that is differentially distributed to leverage local promotion programs. The structural and performance dynamics of fresh apple markets is investigated, while accounting for both demand and supply shocks (assumed to be zero at this stage) that stem from the introduction of local labeling using an equilibrium displacement model (EDM).

1.2 Objectives

The main objective of this study is to explore the structural and performance dynamics of a market as a result of new labeling efforts and promotional campaigns, highlighting the availability of locally grown products (both in direct markets and within more conventional marketing channels). This study develops a partial equilibrium displacement model for Colorado apples that can be used to analyze the impacts of local labeling by segmenting markets by regional-origin labeling with quality control on demand side and segmenting markets by marketing channels on supply side.

One sub-objective of the study is to analyze how consumer perceptions and marketing channel structure influence market performance. The dynamic response to shocks depends on the benchmark estimates of consumer and producer behaviors, the sign and size of shocks, and market structure. Consumer perceptions of local apples compared with domestic apples will be evaluated using survey data that was used to frame more generalized consumer behavior in previous studies (Onozaka, Nurse and Thilmany McFadden, 2010; Onozaka, Nurse and Thilmany McFadden, 2011). As another sub-objective that complements the broader analysis, the market structure and price relationship at different market levels will be examined. Market integration analysis is an important approach to evaluate market structure and examine the performance of a market. The transmission of prices across space at different market levels is key to estimating important transaction costs parameters for the EDM. But, through a symmetric variable threshold autoregression model and a constant threshold autoregression model this study will examine spatial market integration and compare how our understanding of market relationships may vary based on the methods used to analyze the price behavior. These results do contribute to the broader analysis, but are also of value to the field in their own right to forecast market structure.

1.3 Contribution to the Literature

Although Carpio and Isengildina-Massa provided a good point of evaluating the effects of local promotion programs, there are some limitations in their research. First, the parameters used in their study were mostly aggregate demand and supply parameters, which made it difficult to estimate the parameters and lowered the precision of the estimation. Second, they only differentiated on the demand side and did not segment the markets in the supply side (thereby assuming that the costs of marketing in two different channels would not vary). However, the demand shock due to the local campaign will not only affect the performance of the market, but also change the structure of marketing channels. Thus, this study will further their research by investigating a specific market, the fresh apple market in Colorado, and segmenting by marketing channels on the supply side with more differentiation between short run and long run scenarios.

This study contributes to the literature by assessing the impact of local labeling on suppliers in the fresh apple markets (using consumer valuations from a 2008 consumer study) while considering the market-wide reactions in both the short- and long-run. The most important innovation and contribution is the segmentation of marketing channels on the supply side to include direct, short supply chains, in addition to the more conventional grower-shipping point-terminal market-retail chain, which allows one to determine how more localized systems influence the dynamics of apple marketing and evaluate the performance of apple markets in the face of increasing consumer demand.

To assess the economic impacts of local labeling on suppliers more accurately, this study investigates the spatial market structure and price relationship for fresh apples at three different market levels. Specifically, an extended symmetric variable threshold autoregressive regression model is conducted to examine how the transaction costs are affected by different market forces such as transportation costs and seasonality at different market levels. In addition, this study investigated how the price relationships are affected by the model selected and how the thresholds estimation are affected by different market levels.

The results from this study will contribute to the literature by providing insights on how strong consumer responses to local produce offerings (albeit among a relatively small set of buyers) may affect market dynamics. By allowing for segregated markets, akin to what occurs more formally with organic produce, this conceptual framework provides a method to analyze welfare effects within a more differentiated food system.

1.4 Organization of the study

The organization of this study is as follows. Following this introduction chapter, a description of the fresh apple market and a review of previous literature are presented in chapter 2. The first part of chapter 2 gives information on the U.S. apple market, including information on apple supply, apple consumption, fresh apple supply chains, and trends that are emerging from the local food movement. A review of literature related with the methodological approach of this study is provided in the second part of chapter 2, including studies that we draw on for the analysis of the relationship among spatially-distinct markets, work on consumer preferences for local foods, models that explore how various market shocks affect the performance and welfare effects of consumers and producers, and underlying dynamics of the apple market that are important to understand for this particular study.

In chapter 3, the market structure and spatial price relationships at retail market and shipping point levels are examined. Cointegration analysis and Granger causality tests are developed to examine spatial price relationships at the retail market and shipping point levels. Despite the similar patterns shown in shipping points and retail markets, a symmetric variable TAR model is conducted to examine how prices at different market levels are affected by different market forces such as truck rates and time in season. In addition, a constant TAR model is estimated to compare to the symmetric variable TAR model to show how our understanding of market relationships may vary based on the methods used to analyze the price behavior.

In chapter 4, an equilibrium displacement model is developed to explore the structural and performance dynamics of a market as a result of new labeling efforts and promotional campaigns highlighting the availability of locally grown products (both in direct markets and within more conventional marketing channels). This model is driven by many of the supply, demand and transaction costs estimates derived from this and previous studies from a larger research team. Finally, chapter 5 offers a brief discussion of the implications and conclusions of this study, presents the limitations of the approach and results presented, and frames the directions that would seem relevant for future research.

CHAPTER 2: AN OVERVIEW OF THE APPLE INDUSTRY AND LITERATURE REVIEW

2.1 The Apple Market

To allow for more specific market information that will inform our analysis of local food market dynamics, we focus on the fresh apple market. Overall, fresh produce is one of the food product categories gaining significant attention from consumers, producers, government agencies, and media in the context of food miles and the local food movement. Within the fresh produce sector, apples were chose as the focus of this study based on their unique characteristics including: the popularity of apples across U.S. consumers, the presence of apples in many local market channels, its semi-perishability which allows for an extended marketing season but still seasonal supply dynamics, fairly substantial domestic and international trade volumes (demonstrating a myriad of market opportunities), and finally, its important role in the U.S. fruit market.

2.1.1 Apple Supply

U.S. apple production was 9,515 million pounds in 2008, and was commercially valued at $2,206 million in revenue. The U.S. was the third largest among apple-producing countries in the world market (China ranked 1st and EU ranked 2nd), accounting for 6.4% of world apple production in 2008. In 2008, 34.4% of U.S. produced apples were processed to make juice, applesauce, cider, and other processed products and 65.6% of U.S. produced apples entered the fresh market. Although there are a variety of processed apple products, consumers do not consider processed apple products as near substitutes for fresh apples.

Apples are grown in all 50 U.S. states. The production of apples by state in 2008 is given in Figure 2.1. According to the 2010 Agricultural Census, Washington was the largest fresh apple supplying state and accounted for 72.25% of domestic supplies, followed by New York

(9.53%), Michigan (3.34%) and Pennsylvania (3.02%) (USDA, NASS, 2011). The apple industry has been shrinking in most states since the late 1990s under the pressure of competition. In the case of Colorado, where the local analysis will focus for this study, producers have moved either toward organic apple production or have replaced apple orchards with more profitable peach orchards (Agricultural Experiment Station, 2007; Nelson, 2011). The number of Colorado apple orchards had decreased from 330 in 1994 to 180 by 2007 (2007 Census of Agriculture; Colorado Agricultural Statistics Service, 2002). Colorado's production of apples for 2008 was reported at 18 million pounds, including a majority going to the supply of fresh apples (10 million pounds). In short, production could no longer meet the demand of over 5 million Coloradans (81 million pounds if one just considers fresh apples), but still, current supplies of fresh apples are mostly marketed in-state to fill 12% to 13% of current fresh demand.

Figure 2.1 U.S. Production of Apples by States in 2008 (million pounds)
Data Source: USDA, Economic Research Service, 2012. Available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1825

2.1.2 Fresh Apple Consumption

In 2008, apples were ranked third in consumption among fruits for U.S. consumers, averaging 48.6 pounds per capita (compared to oranges at 56.9 pounds per capita and grapes at 51.3 pounds per capita), but were ranked first when one considers only fresh fruit consumption at 16.2 pounds per capita. Red Delicious apples have dominated the apple industry accounting for over 70% of the national market since November 1999 when the Washington Apple Commission carried out the Million Dollar Demo Program[1] to promote Red Delicious apples.

2.1.3 Fresh Apple Supply Chain

As is the case with most fresh produce categories, the supply chain for U.S. fresh apples includes growers, packers, shippers, processors, brokers, and retailers. The apples are delivered by the growers in cases or bins to farmers' markets to supply consumers directly or to packing facilities for wholesale markets after harvest. The majority of apples are marketed by packers through shipping points and terminal markets.

There are seven shipping points that currently carry apples in the U.S. as shown in table 2.1, including: Appalachian District (VA, WV, MD, PA), New York, Michigan, San Joaquin Valley California, Western North Carolina, Yakima Valley and Wenatchee District, Washington, and Port of Entry Philadelphia Area. The Appalachian District, New York, Michigan, Western North Carolina, and Yakima Valley and Wenatchee District, Washington supply fresh Red Delicious apples and most of the Red Delicious apples originate from Washington State. Since it draws from local production, the San Joaquin Valley, California, does not carry fresh Red

[1]The promotion rewarded retailers for selling larger size or better grade of red delicious apples and running promotions on red delicious apples (Karst, 2009).

Delicious apples[2]. The Port of Entry in the Philadelphia Area supplies imported apples from Chile, including Fuji, Granny Smith, Royal Gala, Braeburn, Mutsu/Crispin, and Pink Lady/Cripps Pink apples, but it does not supply fresh Red Delicious apples. The distribution of shipping points and terminal markets that supply apples are listed in figure 2.2.

Table 2.1. Fresh Apple Trade Activities by Shipping Point, 1998-2011

Shipping Points			Trade Years
Domestic Apples	**Current**	Appalachian District	01-02-1998 – 12-31-2011
		Hudson Valley New York New York	01-02-1998 – 07-10-2009 08-31-2009 – 12-31-2011
		Michigan	01-02-1998 – 12-31-2011
		San Joaquin Valley California	01-02-1998 – 10-17-2011
		Western North Carolina	08-27-1998 – 10-31-2011
		Yakima Valley & Wenatchee District Washington	01-02-1998 – 12-31-2011
	Past	Central Coast California	09-14-1999 – 10-13-1999
		Watsonville District California	11-05-1998 – 11-12-1998
		Western Idaho	02-06-1998 – 03-16-1999
Imported Apples	**Current**	Chile Imports-Port of Entry Philadelphia Area	02-23-1998 – 09-12-2011
	Past	Argentina Imports-Port of Entry Los Angeles Area	03-15-2000 – 04-07-2000
		Argentina Imports-Port of Entry Philadelphia Area	02-22-1999 – 09-06-2007
		Chile Imports-Port of Entry Los Angeles Area	04-01-1998 – 07-21-2008
		New Zealand Imports-Port of Entry Los Angeles Area	04-24-2007 – 09-10-2009
		New Zealand Imports-Port of Entry Philadelphia Area	06-22-2004 – 09-10-2009

Data Source: USDA, Agricultural Marketing Service, 2012. Available at http://www.marketnews.usda.gov/portal/fv

[2] California mainly supplies four varieties: Gala, Fuji, Granny Smith, and Cripps Pink Ladies (California Apple Commission, 2006).

Apples vary somewhat from other fresh produce categories because apples are not as perishable as some other crops, and thus, they can be marketed over a longer season using controlled atmosphere (CA) storage. Taking the supply of fresh Red Delicious apples at shipping points as an example, most shipping points supply apples over eight months, far longer than the harvest window in the U.S. The Yakima Valley and Wenatchee District in Washington supplies fresh Red Delicious apples year round, while the other four shipping points only supply seasonally. The Appalachian District, New York, and Michigan markets supply fresh Red Delicious apples in most months except the May to September window before harvest. Western North Carolina only supplies fresh Red Delicious apples in the months when new crops are available, from September to October. The shipping cycles of fresh Washington Red Delicious apples at each shipping point are shown in table 2.2.

Figure 2.2 The distribution of Shipping Points and Terminal Markets that supply apples
Note: red flags denote shipping points and black dots denote terminal markets
Data Source: USDA, Agricultural Marketing Service, 2011. Available at http://explore.data.gov/Agriculture/Farmers-Markets-Geographic-Data/wfna-38ey

There are still fairly competitive market conditions as packers and marketers sell their apples to retailers on the spot market (USITC, 2010), while big retailers like Wal-Mart and Costco use contracts with large suppliers to ensure year-round supplies. So, this has allowed for the apple market to revert to more localized sourcing conditions for short seasons in a number of places in the country. Thus, the apple market is a good case study to examine effects for a localized marketing strategy that could occur in almost every region of the US.

Table 2.2. Supply Seasons of Fresh Washington Red Delicious Apples at Shipping Points

Shipping Points	Supply Seasons
Appalachian District	January-April September-December
Hudson Valley, New York/New York	January-July October-December
Michigan	January-June September-December
Western North Carolina	September-October
Yakima Valley & Wenatchee District, Washington	January-December

Data Source: USDA, Agricultural Marketing Service, 2012. Available at http://www.marketnews.usda.gov/portal/fv

2.2 Local Food Movement

According to the 2007 Census of Agriculture, direct sales of agricultural products amounted to $1.2 billion in 2007, which represented 0.4% of total agricultural sales and indicated a 117.79% increase in sales from 1997. The number of farmers' markets nationwide went up to 6,248 in 2010, representing a 126.71% increase from 1998 (AMS, USDA, 2011). Based on farmers' markets data from the USDA's Agricultural Marketing Service, there were 120 farmers' markets in Colorado in 2010. The map of Colorado farmers' markets are shown in figure 2.3. Not surprisingly, the farmers' markets were concentrated in densely populated regions with the greatest consumer buyer power including Denver and Boulder, and to a lesser degree, in major supply regions for fresh produce, including Colorado's West Slope.

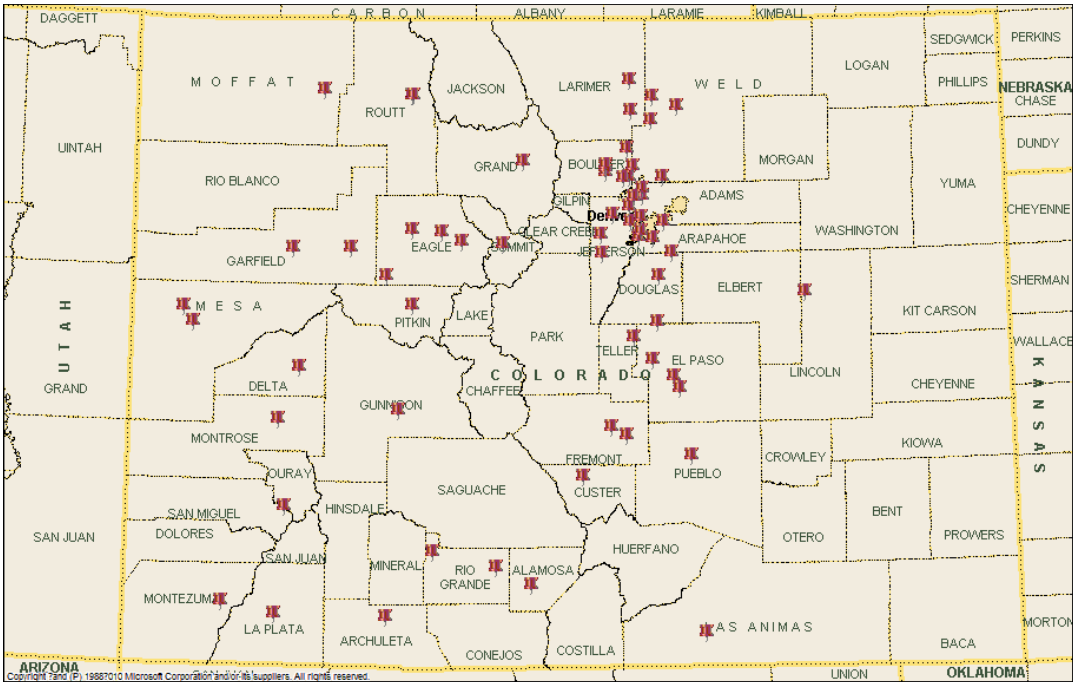

Figure 2.3. Map of Colorado Farmers' Markets
Data Source: USDA, Agricultural Marketing Service, 2011. Available at http://explore.data.gov/Agriculture/Farmers-Markets-Geographic-Data/wfna-38ey

Throughout the study, markets will be divided into regions, and this will partly inform the dynamics that may differ among local markets, including the Colorado case explored here. Following the division of regions used in National Fruit and Vegetable Retail Report (USDA), the U.S. market is divided into six regions: Northeast (Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont), Southeast (Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and West Virginia), Midwest (Iowa, Illinois, Indiana, Kentucky, Michigan, Minnesota, North Dakota, Nebraska, Ohio, South Dakota and Wisconsin), South Central (Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas), Southwest (Arizona, California, Nevada and Utah) and Northwest (Idaho, Montana, Oregon, Washington, and Wyoming).

The distribution of farmers' markets by regions in 2010 (figure 2.4) shows that farmers' markets are concentrated in two regions; the Midwest, where there are still the greatest number of farms (and supplies) and the Northeast, where there are some of the more densely populated metro areas. However, the number of markets may be misleading since it is really sales at market that would define the market size, and markets in some regions may realize greater sales.

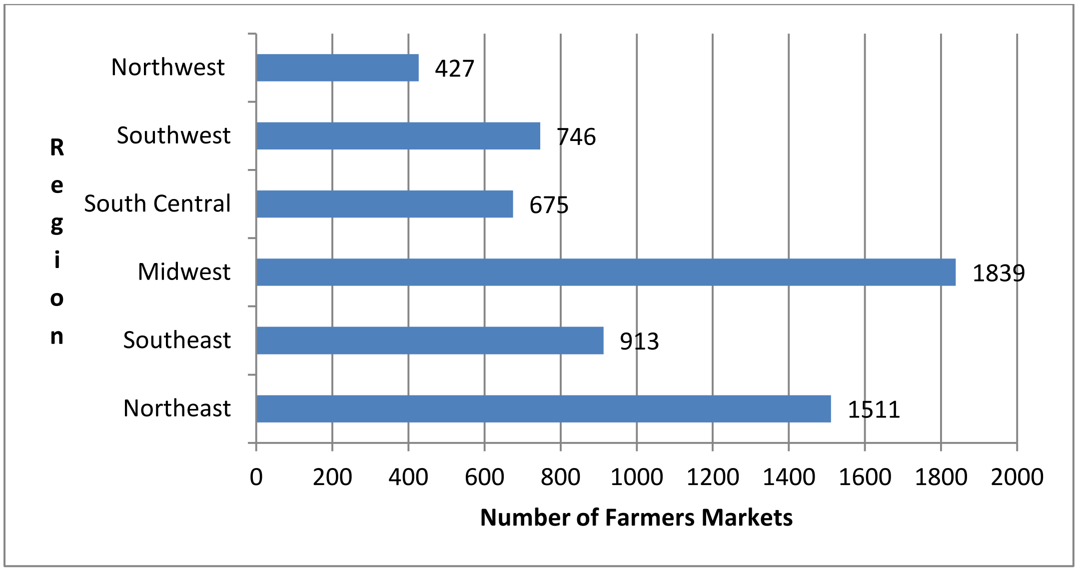

Figure 2.4 Distribution of Farmers' Markets by Regions in 2010
Data Source: USDA, Agricultural Marketing Service, 2011. Available at http://explore.data.gov/Agriculture/Farmers-Markets-Geographic-Data/wfna-38ey

Farmers' markets are only one part of the local food market, even though they are often the most visible. In 2005, there were 1,144 community supported agriculture organizations (CSAs), which represented a 186.00% increase from 2001, and there was a 423.75% increase in the number of farm to school programs that used local farms supplies from 2004 to 2009 (Martinez et al., 2010). According to the 2007 Census of Agriculture, there were 12,549 farms that marketed their products through CSAs in the U.S. in 2007, including 214 farms in Colorado.

Based on the 2007 Census of Agriculture, the distribution of CSAs by regions in 2007 is shown in figure 2.5. The CSAs are concentrated in the Midwest, South Central, and Southeast, a somewhat different pattern than what was seen for markets.

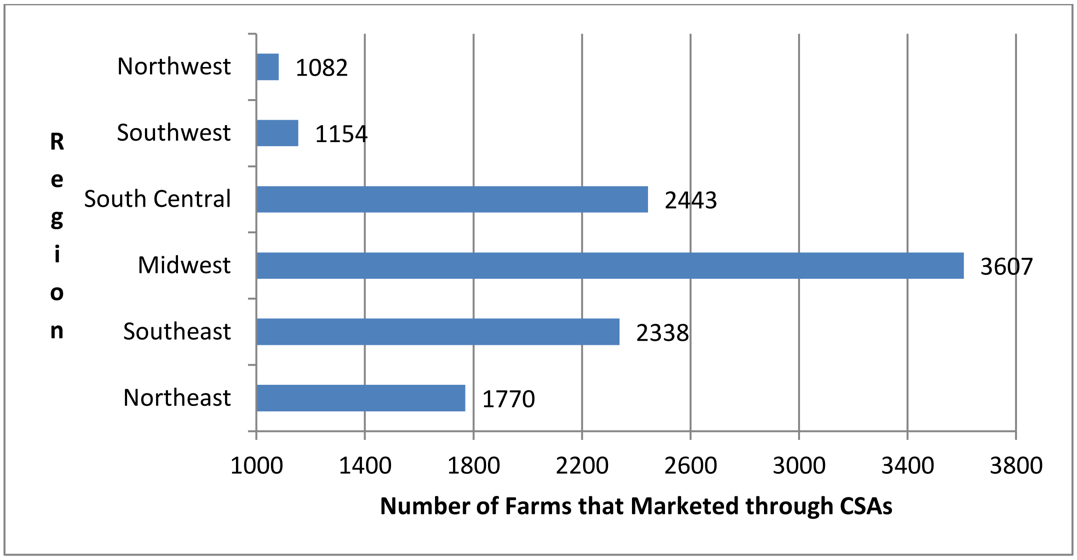

Figure 2.5 Distribution of community supported agriculture organizations (CSAs) in 2007
Data Source: 2007 Census of Agriculture. Available at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_US_State_Level/st99_2_044_044.pdf

2.3 Literature Review and Previous Research

The local food movement has potential impacts on the structure of the food system (Adams and Salois, 2010) which affects the welfare of the players. Consumers' preference for local food, the market relationship, and the response of suppliers to shocks are the key points to analyze the welfare impacts of local food movement.

The methodological approach of this study was influenced by several veins of literature, including work on consumer preferences for local foods, analysis of the relationship among spatially-distinct markets, models that explore how various market shocks (including demand shifts for differentiated products) affect the performance and welfare effects of consumers and producers, and underlying dynamics of the apple market that are important to understand for this particular study.

2.3.1 Preference for Local Attributes

There is a significant amount of work that has been conducted to investigate consumers' demand for local produce, including recent work exploring consumers' willingness to pay for local food. According to Adams and Salois's review of literature on consumers' perceptions and WTP for local and organic food characteristics, studies started to find that consumers were willing to pay a higher premium for local than for organic attributes in the late 1990s (Adams and Salois, 2010).

Kezis et al. (1998) conducted a survey on consumers who shopped at a small farmers' market in the summer/fall market season in Maine in 1995. They found that 72% of respondents were willing to pay more for produce at the farmers' market than for produce at the supermarket and the average premium of WTP was 17%.

Loureiro and Hine (2002) used contingent valuation (CV) techniques to investigate consumers' preference for potato attributes in Colorado. They confirmed that Colorado customers were willing to pay a higher premium for "local" than for "organic" and "GMO-free" attributes in potatoes (a 5% premium) over domestic potatoes.

Mabiso et al. (2005) conducted a Vickrey experimental auction (fifth-priced sealed-bid) with a written questionnaire in Florida, Georgia, and Miami in December, 2003, and January, 2004, to estimate U.S. consumers' willingness to pay for apples with Country-of-Origin Labeling (COOL), which may be considered a more broadly defined "buy local" designation. The mean WTP for COOL in apples was confirmed to be around $0.49/lb. Seventy-nine percent of the consumers were willing to pay more for apples labeled "U.S.A. Grown" and the mean premium of WTP was $0.41/lb in Gainesville, Florida, $0.18/lb in Lansing, Miami, and $0.64/lb in Atlanta, Georgia.

Darby et al. (2008) found that Midwestern customers prefer Ohio locally grown strawberries to domestic strawberries, and consumers that shopped at direct markets were willing to pay a higher premium than grocery store customers per basket of locally grown strawberries ($0.92 vs $0.48 per basket). In a similar study, Hinson and Bruchhaus (2005) conducted a conjoint survey and found that Louisiana local product was ranked the most important attribute and was followed by price, pesticide strategy, and container in consumer preferences, respectively. About 60% of respondents were willing to pay a premium of 20 cents and 20% were willing to pay over 60 cents for Louisiana locally produced strawberries.

Carpio and Isengildina-Massa (2009) conducted a telephone survey on consumers' willingness to pay for South Carolina local produce on March 7 and 8, 2007. They found that 95% of consumers prefer state-grown produce to domestic produce if they have equal prices, while 78% of consumers chose state-grown produce at the 5% premium level, and 30% of consumers preferred state-grown at the 50% premium level. The estimated mean WTP premium for South Carolina grown produce was 27.5%.

Hu, Woods and Bastin (2009) conducted a conjoint stated choice survey to evaluate Kentucky consumer's preference for three nonconventional attributes across differentiated blueberry products including: organic, Kentucky grown, and sugar free. Results showed that consumers prefer Kentucky grown to other attributes. Consumers were willing to pay $1.46 for 10 oz. Kentucky produced pure jam, $2.20 for 10 oz. Kentucky produced blueberry-lime jam, $1.21 for 32 oz. Yogurt, $1.57 for 10 oz. Kentucky produced dry muffin mix, and $1.64 for a 4 oz. Kentucky produced candy similar to "Raisinettes".

James, Rickard and Rossman (2009) examined consumers' preference for organic, local and nutrition attributes in choosing applesauce products. The market was divided into four segments: local, no organic; local, organic; no local, organic; and no local, no organic. Results showed that consumers were willing to pay the highest price (a premium of $0.28 to $0.51 for a locally grown 24 ounce applesauce product relative to products associated with the other attributes.

Yue and Tong (2009) combined a hypothetical experiment and nonhypothetical choice experiment to investigate consumers' WTP for the organic, local, and organic plus local attributes for fresh produce. After a correction for hypothetical bias, the average premiums of WTP for organic, local, and organic plus local attributes of tomatoes were $0.67/lb, $0.67/lb, and $1.06/lb relative to conventional tomatoes, respectively.

Shi, Gao and House (2011) conducted an online stated preference experiment in the Northeast and Southeast region of the United States to investigate consumers' preference for blueberries with different attributes including: freshness, production method, price and place of origin. "Locally produced" was defined as within the state that the respondent resided. The results showed that 89.12% of consumers prefer local blueberries over domestic conventional blueberries ($2.10 per pint using WTP space and $3.25 per pint with preference space).

More specific to this study, Onozaka and Thilmany McFadden (2011) conducted a conjoint choice experiment in 2008 to investigate consumers' preference and interactive effects of domestic fair trade, carbon footprint, organic and international fair trade from varied production locations (local, domestic and international) for Gala apples and red round tomatoes. The results suggested that 82% of respondents had bought local produce and most consumers bought local food for freshness, eating quality, food safety, and nutritional values. U.S.

consumers were found to have a strong positive preference for local apples (within 300 miles) averaging a WTP of $0.22/lb and $0.24/lb premium with respect to domestic apples (details of methodology and results available in Onozaka, Nurse, and Thilmany McFadden, 2010 and Onozaka and Thilmany McFadden, 2011).

Costanigro et al. (2011) conducted an in-store experiment to investigate consumers' valuation of local and organic attributes of Gala apples. They collected data on "real consumers' choices between pairs of local and organic apples versus local-only/ organic-only options". The results revealed that consumers were willing to pay a higher premium for local apples (defined as "Colorado Proud") than for organic apples. In their store experiment, where consumers could trade an endowment of local, organic apples for others without such designations in exchange for varying levels of money, the average premium for local attributes was estimated as $1.18/lb, a premium of 101%.

Across these studies, the premium for local attributes varied from 5% for Colorado potatoes to 101% for Colorado Gala apples. The difference among estimates may reflect differences across product and time, but also, is likely to be linked to differences in the methodology used by each study, the base price, and regional differences (Martinez et. al, 2010).

Carpio and Isengildina-Massa (2009) may have presented the most generalizable results since their study did not focus on a specific product. They were also one of the first studies to go a step further in exploring the welfare implications of any potential shifts to more locally marketed foods. We follow their lead in estimating these same effects for a more specific food category, apples.

2.3.2 Market Relationship

The transmission of market shocks across spatially-distinct markets and along the marketing chain, especially the extent of adjustment and the speed of shock transmission across marketing channels, is a good point of view to study the structure, conduct and performance of the market (Goodwin, 2006). A considerable amount of literature has examined the linkage among markets across space and along the marketing chain for different commodities, such as meat, livestock products, vegetables and fruits. Market relationship analysis can be divided into two distinct approaches: analysis of vertical market relationships and spatial market relationships.

Vertical market linkage analysis mainly focuses on the analysis of the price linkages among farm, wholesale, and retail markets. Three aspects of vertical price transmission were examined: the size of adjustment to shocks, the speed of the adjustment, and the extent of asymmetry in adjustment (Goodwin, 2006). Heien's study of the price transmission from free-on-board to retail markets (1980) was a seminal paper in examining vertical price transmission. He found a direction of causality from wholesale to retail markets, but no effect in the other direction.

A growing set of literature concentrates on the asymmetry of price adjustments using a model which was first introduced by Wolffram (1971) and modified by Houck (1977). Yet, the theoretical models have been criticized for their incompleteness and invalidity. For example, Goodwin and Holt (1999) argued for the nonlinearity in the adjustment to market shocks; but, Pelzman (2000) criticized the models for lack of theoretical explanations underlying the asymmetry response. The criticisms of the models led subsequent researchers to concentrate on the time series properties of the price data, such as non-stationary and cointegration. Due to the limited availability of farmers' market price data and based on the parameter requirements for the simulation of the equilibrium displacement model, time series analysis of vertical market relationship is not conducted in this study, but instead, spatial market relationships are examined based on time series properties across regions of the country.

A large number of studies have examined the transmission of market shocks across spatially distinct markets. Spatial price transmission analysis is frequently used in international trade studies drawing on the "Law of one price" (LOP) as a basic theory (Goodwin, 2006). The linkage among spatially distinct markets is generally examined by testing for "spatial market integration".

A key criticism toward spatial market relationship analysis was their omission of transaction costs. To address this problem, allowing for nonlinearity which might reflect the role of transaction costs was introduced to integration models. Tony (1978) originally introduced nonlinearities to threshold time series models. Balke and Fomby (1997) extended the threshold autoregressive models to a cointegration framework. Balke and Fomby (1997) found that the standard unit root testing methods and cointegration testing methods still worked well when threshold effects existed. Several types of models were mostly used to address nonlinearity: the parity bounds models (Spiller and Wood, 1988; Sexton, Kling and Carman, 1991); endogenous switching models (Baulch, 1997a, 1997b, 1997c); and threshold auto-regression models (Goodwin and Piggott, 2001).

2.3.2.1 Econometric Models for Market Relationship Analysis

Earlier literature used static techniques which only used price data to test for market integration (e.g., Mohendru, 1937; Mundlak and Larson, 1992; Gardner and Brooks, 1994). Dynamic models are more efficient in analyzing market integration and price transmission than static models. Dynamic models analyze lead and lag relationships in spatial markets to capture the dynamic price relationship and the asymmetries caused by delivery lags and adjustment costs (Fackler and Goodwin, 2001). In addition to testing the extent of market integration as static models do, dynamic models can be used to estimate the speed of price transmission between markets. Two typical dynamic approaches are the Granger causality test and cointegration analysis.

Granger Causality test

Granger Causality tests are used to test the existence and the direction of price transmission between markets (Granger, 1969). Granger Causality tests are conducted within the framework of a vector auto-regression model to test the response of current price in one market to lagged prices in another market (Baulch, 1997).

Granger Causality tests are typically based on following equations:

(1) $P_t^i = \sum_{k=1}^{n} \alpha_k P_{t-k}^i + \sum_{l=1}^{n} \beta_k P_{t-l}^j + \varepsilon_{it}$

(2) $P_t^j = \sum_{k=1}^{n} \gamma_k P_{t-k}^i + \sum_{l=1}^{n} \theta_k P_{t-l}^j + \varepsilon_{jt}$

Where equation (1) states that the current price in market *i* (P_t^i) is dependent on lagged prices in market *i* (P_{t-k}^i) and market *j* (P_{t-l}^j). Equation (2) states the same for the current price in market *j* (P_t^j). ε_{it} and ε_{jt} are error terms which represent exogenous, serially independent, but unobservable market shocks. There are three potential outcomes of a causality test: no causality ($\sum_{l=1}^{n} \beta_k = 0$), unidirectional causality (e.g. $\sum_{l=1}^{n} \beta_k \neq 0$ while $\sum_{k=1}^{n} \gamma_k = 0$), and bilateral causality ($\sum_{l=1}^{n} \beta_k = 0$ and $\sum_{k=1}^{n} \gamma_k = 0$) (Amikuzuno, 2009).

Granger Causality testing has three weaknesses. One is that the test could only indicate whether there is a relationship between contemporaneous and lagged prices, but offers no conclusion about the nature of the relation that could be drawn without other tests. Thus, Granger Causality tests must be supplemented by other inferential approaches. Besides, the limitations with static models are also applicable to Granger Causality tests. In addition, Granger Causality tests are sensitive to omitted variables. Finally, the forecast is based on the same sample used to estimate parameters for forecasting so a logical inconsistency might arise here (Fackler and Goodwin, 2001).

Cointegration Analysis

If prices in two separated markets contain stochastic trends and are integrated of the same order, the markets are called cointegrated when there is a linear relationship between two price series. The cointegration of two markets indicates that even if the price relationship between two markets does not obey the LOP in the short run, the prices will converge towards the LOP over long run. Cointegration of two markets indicates a long-run equilibrium relationship between two markets and cointegration implies Granger Causality (Fackler and Goodwin, 2001).

Cointegration analysis is based on the following equations:

(3) $P_t^i = \alpha P_{t-1}^i + \varepsilon_t$

(4) $\Delta P_t^i = (\alpha - 1) P_{t-1}^i + \varepsilon_t$ (DF test)

(5) $\Delta P_t^i = \mu + \alpha P_{t-1}^i + T_t + \sum_{k=1}^{n} \beta_k \Delta P_{t-k}^i + \varepsilon_t$ (ADF test)

where ΔP_t^i is the first difference of the price series, T_t is a time trend, and *n* is the number of lags needed to eliminate serial correlations in the price series.

If the prices are revealed to be I(1), but their first differences are I(0)[3], then the tests for cointegration are based on the following OLS estimation:

(6) $P_t^i = \mu + \alpha P_t^j + \varepsilon_t$

[3] If price series are found to be nonstationary at levels but be stationary in first differences, then prices are integrated of order one, I(1), and their first differences are I(0).

Where α measures the long-run linear relationship between prices in market *i* and market j. Since cointegration analysis measures whether the prices in two markets move together, it tests whether the error term, ε_t , is stationary.

There are two approaches to test market cointegration: the two-step approach of Engel and Granger (1987) for bivariate models, and the Johansen (1988) and Johansen and Juselius (1990)'s variance autoregressive approach (VAR) for multivariate models. For each approach, you must first test the stationary properties and the order of integration of the price series.

The Engel and Granger approach is based on the following equations:

(7) $\Delta\widehat{\varepsilon_t} = \gamma\hat{\varepsilon}_{t-1} + e_t$

Where e_t is a white noise term. If the null hypothesis that $|\gamma| = 1$ cannot be rejected, then the residual series contain a unit root and the prices in the two markets are not cointegrated. Otherwise, the prices in the two markets are cointegrated.

The Engel and Granger approaches lack a systematic approach for the separate estimation of multiple cointegration vectors. Thus, these approaches are limited in a multivariable case. In addition, these approaches rely on two steps and when two or more variables are involved, the results of this approach are sensitive to the variables selected for normalization.

The Johansen (1988) and Johansen and Juselius (1990)'s approaches overcome the normalization problem and relax the requirement of series having the same order of cointegration. Besides, VAR treats all markets as endogenous and estimates the responses of different variables to market shocks simultaneously. This approach is especially efficient when the direction of causality of price transmission among markets is unknown (Johansen, 1995). Johansen (1988) and Johansen and Juselius (1990)'s approach is the maximum likelihood estimator of a reduced rank model which starts with the AR(k) model:

(8) $P_t = \mu + \mathrm{A_1 P_{t-1}} + \cdots + \mathrm{A_k P_{t-k}} + \mathrm{e_t}$

(9) $\Delta P_t = \mu + \Gamma_1 \Delta \mathrm{P_{t-1}} + \cdots + \Gamma_{\mathrm{k-1}} \Delta \mathrm{P_{t-k+1}} + \mathrm{BP_{t-k}} + \mathrm{e_t}$

(10) $B = I_n - A_1 - \cdots - A_m$

If the prices are non-stationary but are cointegrated, then the matrix **B** will be of rank *r*, with $0<r<n$. Johansen and Juselius's approach tests the rank of **B**. If the rank is *r*, then there are *r* unique cointegration vectors among the n prices. If long run market integration is confirmed to exist, then the short-run dynamics which are consistent with this long-run dynamic are tested with error correction methods.

Although cointegration analysis has advantages over former methods in handling non-stationary price series, it assumes a linear relationship between price series and stationary transaction costs. This assumption is challenged by the non-linearity in market relationships due to arbitrage conditions, unsynchronized price cycles, discontinuous trade and non-stationary transaction costs (Baulch, 1997a, 1997b, 1997c; Fackler and Goodwin, 2001; Barrett and Li, 2002). The linear cointegration analysis is appropriate only when the long run equilibrium relationship between prices is fixed during the period of study (Amikuzuno, 2009). As Amikuzuno (2009) stated, "cointegration is neither necessary nor sufficient for testing market integration but is only a pretest for other econometric techniques of market integration analysis" (Page 39).

Transaction costs and trade flows will likely lead to nonlinear relationships among prices which contradicts the assumptions of static and dynamic models. Besides, the changes among the networks of potential trading linkages (i.e., a market changing its primary supplier because of seasonal availability) lead to imperfect integration among markets which contradicts the perfect integration assumptions in other methods. Thus, the switching regime regression models (SRM) were developed and introduced. Switching regression models were first introduced to handle structural changes in time series data (Quandt, 1958). One typical SRM for market integration and price transmission analysis is the threshold autoregressive model (TAR).

Threshold Autoregressive Regression (TAR)

The TAR model is one of the nonlinear time series models introduced by Tong (1983). TAR models take the fixed but unknown transaction costs as a threshold. Obstfeld and Taylor (1997) applied TAR models to analyze price transmission across spatially separate markets in the presence of transaction costs. When the price spread between markets exceeds the threshold, it provokes price adjustments toward the threshold which subsequently leads to market integration. However, when the price spread is within the transaction cost band, the prices in separate markets are assumed to behave independently. Due to the “no trade” status within the threshold, TAR assumes that the market is divided by transaction costs (real although possibly unobservable) into two regimes: one with trade and another without trade. In short, TAR describes the dynamic adjustment of price difference between two markets over time.

TAR models provide a probability of being outside the band which is a measure of the extent of violating the spatial arbitrage condition and a measure of the speed of eliminating the violations, which may also offer a measure of market efficiency (Fackler and Goodwin, 2001). Despite these advantages, TAR has some weaknesses. For example, it is highly parameterized and requires modification to capture the regularities in the commodity markets. Besides, the assumption of fixed transactions costs is challenged by the inavailability of actual transactions costs to test such fixity.

The TAR models are constructed based on following equations:

(11) $\delta_t^{ij} = \left|P_t^i - P_t^j\right|$

where P_t^i and P_t^j are prices for a homogenous product in two separate markets. δ_t^{ij} is the price difference between two markets.

(12) $\Delta\delta_t^{ij} = \alpha\delta_{t-1}^{ij} + \varepsilon_t$

where $\Delta\delta_t^{ij} = \delta_t^{ij} - \delta_{t-1}^{ij}$, $\varepsilon_t \sim N(0, \sigma^2)$, and α is the speed of price adjustment which indicates the extent to which the price differences in the prior period are adjusted.

One of the basic TAR models which accounts for the existence of transaction costs is as following:

(13)
$$\Delta\delta_t = \begin{cases} \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} > c \\ \alpha_{in}\delta_{t-1} + \varepsilon_t & \text{if } -c \leq \delta_{t-1} \leq c \\ \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} < -c \end{cases}$$

So now two set of parameters need to be estimated: one for the adjustment inside the transaction band (α_{in}), one for the adjustment outside the transaction band (α_{out}); and the transaction cost (c) (e.g. Goodwin and Piggott, 2001; Mancuso et al., 2003; van Campenhout, 2007).

Based on the assumption that there is no price adjustment within the transaction band ($\alpha_{in} = 0$), equations (19) can be modified to:

(14)
$$\Delta\delta_t = \begin{cases} \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} > c \\ \varepsilon_t & \text{if } -c \leq \delta_{t-1} \leq c \\ \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} < -c \end{cases}$$

<u>van Campenhout (2007)</u>

The assumption of fixed transaction costs can be released by extending the models to include a time trend in both the threshold and the adjustment parameter as illustrated by van Campenhout (2007), where the threshold is modeled as a simple linear function of time:

(15) $c_t = c_0 + \frac{(c_t - c_0)}{T} * t$

where t denotes time from 0 to T, and c_t and c_0 are identified through a grid search. The pair of thresholds which minimizes the sum of squared residuals is used in the final model. A time trend is also added to the adjustment parameter and the whole model can be written as:

(16)
$$\Delta\delta_t = \begin{cases} \alpha_{out}\delta_{t-1} + \alpha'_{out} * t * \delta_{t-1} + \varepsilon_t & \delta_{t-1} > c_t \\ \varepsilon_t \quad \text{if} & -c_t \le \delta_{t-1} \le c_t \\ \alpha_{out}\delta_{t-1} + \alpha'_{out} * t * \delta_{t-1} + \varepsilon_t & \delta_{t-1} < -c_t \end{cases}$$

Bekkerman, Goodwin and Piggott (2009)

Bekkerman, Goodwin and Piggott (2009) extended TAR models by relaxing the assumption of a constant neutral band of transactions costs. They allow the transaction costs threshold (c) to vary according to exogenous variables. This can be illustrated as follows:

(17) $c = \alpha_0 + \alpha_1 F_t + \alpha_2 S_t^1 + \alpha_3 S_t^2$

where F_t is the fuel price index, and S_t^1 and S_t^2 are seasonality components that follow a first order Fourier approximation to an unknown seasonal function with $S_t^1 = \sin(2\pi d_t /260)$ and $S_t^2 = \cos(2\pi d_t /260)$, where d_t represents a weekday of the year (d_t=1,2,…,260). Their comparison of results from the standard TAR model and extended TAR model reveals that the constant transaction costs assumption leads to underestimation of the price effects of the market post-shock. The models for spatial market relationship analysis are summarized in table 2.3-2.5 in the appendix B of this chapter.

2.3.3 Equilibrium Displacement Model

An equilibrium displacement model is a commonly used method to analyze the impacts of exogenous shocks. Using an equilibrium displacement model, it is relatively easy to deal with substitution among markets and segmented markets by examining multiple stages in the supply chain as well as multiple markets (European Commission, 2006). It is not necessary to specify the demand and supply functions for the EDM. Thus, all original results from the EDM are obtained as marginal changes and structural changes can be backed out based on the marginal changes. EDM has been used to measure the performance of food programs and policies, such as food origin labeling and marketing orders in improving social welfare and the distribution of the welfare (Lusk and Anderson, 2004; Brester, Marsh, and Atwood, 2004; Thompson, Anders, and Herrmann, 2005; Balagtas and Kreutzer, 2007; Carpio and Isengildina-Massa, 2010).

There have been a few studies that examined the welfare effects of the Country-of Origin Labeling (COOL) program on the participants in specific industries. Two examples are the examination of the livestock industry (beef, pork, and poultry) by Lusk and Anderson (2003) and Brester, Marsh, and Atwood (2004). Both of these two papers modeled the vertical structure of the livestock industry from producers (farm), to processors (slaughter, wholesale) to consumers (retailer), as well as the horizontal links between beef, pork, and poultry. Both demand shifts and supply shifts were included in those two models. Lusk and Anderson (2003) found that, as COOL costs were shifted from producers and processors to retailers, producers were increasingly better off and consumers were increasingly worse off. Aggregate demand for meat would need to increase 2% to 3% to sufficiently offset the loss of producer surplus due to the costs of COOL. The estimation provided by Brester, Marsh, and Atwood (2004) was a little higher, 4.05% to 4.45%.

Thompson, Anders, and Herrmann (2005) used an EDM to assess the direct and distributional effects of state-financed quality control and regional origin assurance programs. They examined these programs by simulating how changes in own and cross-region advertising expenditures and changes in program participation costs affected producer surplus.

In contrast to the above two studies that evaluated the effects of COOL on different specific products at different stages of marketing chains, Thompson, Anders, and Herrmann assessed the effects on one aggregate product in different region and quality segmented markets. The market was separated into two regions: Bavaria and the rest of Germany, and was segmented by both product quality and regional origin. Each region could produce both for a uniform low-quality market (mass market) and a higher quality market, where products were regionally labeled. Both supply and demand shifts that were estimated effects for the programs were included in the model. Results showed that the promotion of the Bavarian labeled product influenced both regions and products (mass marketed and origin labeled) positively. In short, all market segments could gain from the program.

Balagtas and Kreutzer (2007) evaluated the economic impacts of milk marketing orders for producers and consumers in organic and conventional milk markets in California using an EDM approach. They disaggregated the dairy market horizontally into three segments according to production methods and product type including: conventional and organic: conventional fluid milk, conventional manufactured products and organic fluid milk. For each category, they modeled the vertical structure from farm to processor to retailer. They simulated the effects of two milk marketing regulations: eliminating the organic marketing order only and full elimination of the marketing order. Results showed that under the first regulation, organic farmers were better off but conventional farmers were worse off. However, under the second regulation, both organic farmers and conventional farmers were worse off.

Although EDMs have been widely used in assessing the effects of food programs and policies, there have been a very small number of examinations on the performance of local promotion programs more recently. One example is Carpio and Isengildina-Massa (2010)'s evaluation of the potential economic impacts of a regional promotional campaign in South Carolina by identifying the way that the campaign affected the prices and quantities of labeled and mass marketed products. They investigated two categories of products: fruits and vegetables and animal products. As was the case for Thompson, Anders, and Herrmann's study, Carpio and Isengildina-Massa also separated the whole economy into two regions: the local promoting region and the rest of the country. They disaggregated the markets of each category into two segments: locally labeled marketed and mass marketed with no designation of production source. They assumed that the supply was not affected by the campaign, so they only considered the shifts in demand due to the campaign. The results showed that the producer surplus increased \$3.09 million in the first season of the promotion campaign, which resulted in a benefit-cost ratio of 6.18.

2.3.4 Decomposed Elasticities

There are several methods to get supply elasticities, which include borrowing from previous literatures, estimating, and inducing based on previous results, using economic intuition, and basing them on economic theories (Pendell, 2006). Aggregate supply elasticities are mostly obtained from previous literature or estimated using econometric methods based on price and quantity data. Supply elasticities of differentiable products in segmented markets are not always able to be found from previous studies. These elasticities are mostly estimated using econometric methods based on economic theories. Supply elasticities of differentiable products include vertical elasticities differentiated by origins, marketing channels, and parallel elasticities differentiated by other attributes, such as local, organic and GM labels.

Estimation of supply elasticities of products differentiated by origins were mainly based on the trade elasticity formula given by Alston, Norton, and Pardey (1995) (Lemieux and

Wohlgenant, 1989; Peterson, Evangelou, Orden, and Bakshi, 2004; Wohlgenant, 2005; Pendell, 2006; Schroeder and Pendell, 2007). The total supply of a product consists of production in a region and imports. The elasticities of excess supply are calculated using weights of domestic production and consumption with respect to total production and consumption, imports (exports), the domestic price elasticity of demand for the commodity, and the domestic price elasticity of supply for the commodity.

Wohlgenant (2005) estimated supply elasticities of market hogs, feeder pigs, and weaned pigs with respect to different production origins (North Carolina, other states, and other countries) and individual type/different size categories. He derived supply elasticities of market hogs for North Carolina (NC) and the U.S. using a supply response equation with respect to future hog prices. The U.S. aggregate supply elasticity was a share-weighted sum of elasticities from NC and other states. Thus, the supply elasticity for other states was calculated using U.S. supply elasticities, the NC supply elasticity, weights (market shares) of NC production, and weights of other states' production. The supply elasticities of feeder pigs and weaned pigs for U.S. aggregate production were calculated by multiplying U.S. market hog supply elasticities by the corresponding transmission elasticities. And the supply elasticities of feeder pigs and weaned pigs for NC were obtained by dividing the U.S. elasticities by the weights of NC production with respect to U.S. average production, and then multiplying by the price ratio of NC price to other state's price. The supply elasticities for other states were calculated in the same way as the calculation of the supply elasticity of market hogs for other states.

Wohlgenant (2005) separated the supply of market hogs into two parts: the supply produced domestically and imports. The supply of imported pigs was taken as the excess supply of pigs from Canada, which was the main exporter. The elasticity of excess supply (import supply elasticity) was calculated based on the formula given by Alston, Norton, and Pardey (1995) using shares of market hog imports in Canadian domestic production and consumption of market hogs, and Canadian domestic supply and demand elasticities for market hogs.

Pendell (2006) and Schroeder and Pendell (2007) estimated supply elasticities for wholesale beef, pork, fed cattle, and market hogs. They assumed the own price Kansas market hog supply elasticity was the same as the U.S. own price market hog supply elasticity and obtained the own price elasticity from Lemieux and Wohlgenant (1989). They also separated the supply into domestic production and imports. They calculated import supply elasticities for wholesale beef and pork, fed cattle, and market hogs based on the trade elasticity formula in Alston, Norton, and Pardey (1995) using Canadian production, consumption, export, demand elasticities, and supply elasticities of wholesale beef, pork, fed cattle, and market hogs. The same trade elasticity formula was used by Peterson, Evangelou, Orden, and Bakshi (2004) when calculating aggregate supply elasticities of fresh Hass avocados for California and Chile, which was a main exporter to the United States.

These studies showed that aggregate supply elasticities were always calculated as a sum of weighted supply elasticities with different origins (or different attributes). For example, Wohlgenant (2005) took U.S. aggregate market hogs supply elasticity as a weighted sum of elasticities from NC and other states, and Lemieux and Wohlgenant (1989) took the hog supply elasticity for U.S. processors as a weighted average of the domestic supply elasticity and import supply elasticity.

Estimation of supply elasticities for products of different classes, which were differentiated by special attributes, such as locally produced, organic, GM, and quality level, are mainly based on a formula developed by Armington (1969). The formula was first developed to calculate demand elasticities for differentiable products and extensive studies estimated demand elasticities based on this formula (Duffy, Wohlgenant, and Richardson, 1990; James and Alston, 2002; Johnson, Lin, and Vocke, 2005; Carpio and Isengildina-Massa, 2010). Armington made two assumptions: the expenditure on a class of products was independent of price changes in that segmented market, and the effect of prices of closely related products and the effect of all other prices were small enough to be ignored. Based on these assumptions, Armington (1969) developed a formula that own and cross demand elasticities between different classes were given as a function of the aggregate demand elasticity, elasticity of substitution between classes, and value shares of a class in total demand. Later this formula was modified and applied to the calculation of supply elasticities for differentiable products (James and Alston, 2002; Johnson, Lin, and Vocke, 2005).

James and Alston (2002) made an assumption that low and high quality Australian wines were weakly separable. Under this assumption, own and cross supply elasticities of wines at different quality levels were calculated based on Armington's formula. Supply elasticities for an individual wine with respect to its individual price were given as a function of the aggregate supply elasticity with respect to the group price index, the elasticity of transformation between wines at different quality levels, the expansion elasticity, and the budget share of wines at each quality level. They separated high quality wines into two classes: premium white and premium red wines. Together with low quality wine (cask wine), there were three classes of wines. Own and cross supply elasticities of each class of wine were calculated based on Armington's formula.

Following the model given by James and Alston (2002), Johnson, Lin, and Vocke (2005) derived demand and supply elasticities for different classes of wheat. One innovation of this study is that they separated wheat into different classes on the demand and supply sides. On the demand side, they separated wheat into two classes: hard red spring and hard red winter. However, on the supply side, they separated wheat into another two classes: GM and non-GM wheat. They assumed that there were no direct substitution between hard red spring and hard red winter wheat because different wheat varieties were grown in different regions, but they allowed limited substitutability between GM and non-GM wheat, which meant that they assumed GM and non-GM wheat were weakly separable on the supply side. Supply elasticities of GM and non-GM wheat were estimated as a function of overall supply elasticity for spring wheat, the elasticity of transformation in production between GM and non-GM wheat, and value share of GM and non-GM wheat in spring wheat production.

Carpio and Isengildina-Massa (2010) estimated decomposed supply elasticities for regionally labeled and mass-marketed products from aggregate supply elasticities following the method given by James and Alston (2002). They assumed that regionally labeled products and mass-marketed products were weakly separable. Supply elasticities of regionally labeled and mass-marketed products were estimated as a function of the supply elasticity of aggregate quantity with respect to aggregate price, elasticity of transformation between regionally labeled and mass-marketed products in the production process, expansion elasticity, and demand shares of regionally labeled products and mass-marketed products.

There were also some other methods to calculate supply elasticities of differentiable products. But the accuracy was relative lower than using Armington’s formula (1969), and most of the time it was difficult to calculate the cross supply elasticity. For example, Wohlgenant (2005) obtained supply elasticities for different size categories for North Carolina (NC) produced pigs by dividing the aggregate supply elasticity for NC pigs by the share of pigs in that category in NC with respect to total pigs in that category in U.S. This was calculated in a similar way as the calculation of the NC supply elasticity using the U.S. supply elasticity except that the price ratio was set to be equal to 1. But the result was a relatively rough approximation and it's not possible to calculate cross elasticities between different categories using this method.

Overall, there are two basic models to estimate supply elasticities of weakly separable products: Alston, Norton, and Pardey's formula (1995) to estimate supply elasticities of products from different origins, and Armington's formula (1969) to estimate decomposed supply elasticities of weakly separable products with respect to different attributes. With the combination of these two models, an approach for estimating the supply elasticities for weakly separable apples is derived in appendix C and subsequently used in this study's EDM model.

CHAPTER 3 MARKET STRUCTURE AND PRICE RELATIONSHIPS IN FRESH APPLE MARKETS

3.1 Introduction

This chapter focuses on determining the market linkages among spatially separate apple markets by examining how shocks are transmitted among spatially separate markets at different market levels, retail markets and shipping points. Specific attention will be given to the important influence of unobservable transactions costs on spatial market relationships. The dynamics underlying the market relationships between these markets may be of interest to explore in their own right and the market linkages offer insights to understanding market behavior.

3.2 Data

Due to the dominance of Red Delicious apples on the fresh apple market and the consistent availability of price series, weekly fresh Red Delicious apple prices at different market levels are collected to examine market linkages. Weekly terminal market prices (originating from Washington), shipping point prices, retail prices and domestic truck rate report data (apples) for fresh Red Delicious apples were collected from USDA's Agricultural Marketing Service (AMS, USDA). Weekly Colorado farmers' market prices are collected from Colorado State University Extension's Fresh Produce and Meat Market Reports (http://www.extension.colostate.edu/boulder/ag/abm.shtml#prices). Weekly Midwest, Rocky Mountain, East Coast, and West Coast on-highway diesel fuel prices are collected from the Energy Information Administration to account for direct transportation costs between retail markets. The terminal market price, shipping point price, and on-highway diesel fuel price covered a period from January 10, 1998 to December 31, 2011. The retail price and the domestic truck rate spanned the period from October 5, 2007 to December 31, 2011. All apple price series were converted into terms of dollars per pound, on-highway diesel fuel prices were converted into terms of dollars per mile, truck rates were converted into terms of dollars per pound apples per mile, and all price series were deflated by a consumer price index to 1998 January prices.

3.2.1 Shipping Points

Because this study examines the integration among markets that supply fresh Red Delicious apples, only the five shipping points that supply fresh Red Delicious apples are examined. There are 394 observations in total for the Appalachian District (P_{AP}), 508 observations for Hudson Valley in New York (P_{NY}), 547 observations for Michigan (P_{MI}), 726 observations for the Yakima Valley and Wenatchee District in Washington (P_{WA}), and 92 observations for Western North Carolina (P_{NC}). Due to a small number of observations and the short supply season, which also indicates a small influence on the industry, the Western North Carolina shipping point is not examined in this study.

Table 3.1 shows the summary statistics of weekly shipping point prices for fresh Red Delicious apples. As expected, the highest average price and highest variability is within the Appalachian District, which also has the smallest number of price observations (which indicates a relatively small, seasonal supply) and provides the smallest production among the four states[4]. The high average price in New York is likely due to the relatively high demand given the high population density, and also, the potentially higher labor cost generally associate with large urban markets[5]. The lowest average price and lowest variability is for one primary apple

4 Washington State is the largest apple production region which accounted for 59.4% of domestic production in 2008, followed by New York (12.8%), Michigan (6.2%), and Pennsylvania (4.5%) (ERS, USDA, 2012).

5 $21.75 in Illinois, $14.12 per hour in Michigan, $20.1 per hour in New York, $16.93 per hour in Washington, $14.58 per hour in Colorado, $12.32 in Georgia, and $12.98 per hour in California in 2010 (U.S. Bureau of Labor Statistics, 2010).

production area, Michigan. Despite supplying the largest crop, the average price in the Yakima Valley & Wenatchee District Washington is higher than the price in Michigan. One reason is that the size of apples most commonly reported for Michigan is 2 1/2'', smaller than the 88s commonly reported for Washington[6]. Other explanations might be related with the higher labor cost or inavailability of labor (Karst, 2011) together with the higher transportation cost and inavailable truck (Ohlemeier, 2010) services during the harvest season in Washington, which is not as big of a problem in Michigan (Nelson, 2007).

Table 3.1. Summary Statistics of Weekly Shipping Point Prices for Fresh Red Delicious Apples

Prices	Obs. (week)	Mean ($/lb)	Std. Dev. ($/lb)	Coeff. of Var.	Max. ($/lb)	Min. ($/lb)
Appalachian District	394	0.44	0.15	0.33	0.87	0.23
Michigan	547	0.42	0.13	0.32	0.80	0.21
New York	508	0.44	0.14	0.32	0.78	0.23
Yakima Valley & Wenatchee District Washington	726	0.43	0.15	0.35	1.00	0.22

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Figure 3.1 shows that all shipping point prices followed a similar trend. Higher prices were reported at the end of the previous season and before the new harvest, when the storage inventories are running out, but while the new crop is still unavailable. Bulk apples are sold in the Thanksgiving-to-Christmas period. According to Kevin Steiner, marketing director at Yakima, Wash.-based Sage Fruit Co. LLC, Thanksgiving and Christmas are their biggest time frame for shipping new crop apples (Offner, 2011). Subsequently, lower prices were recorded for the Thanksgiving-to-Christmas period.

[6] The size is selected for the completeness of the data.

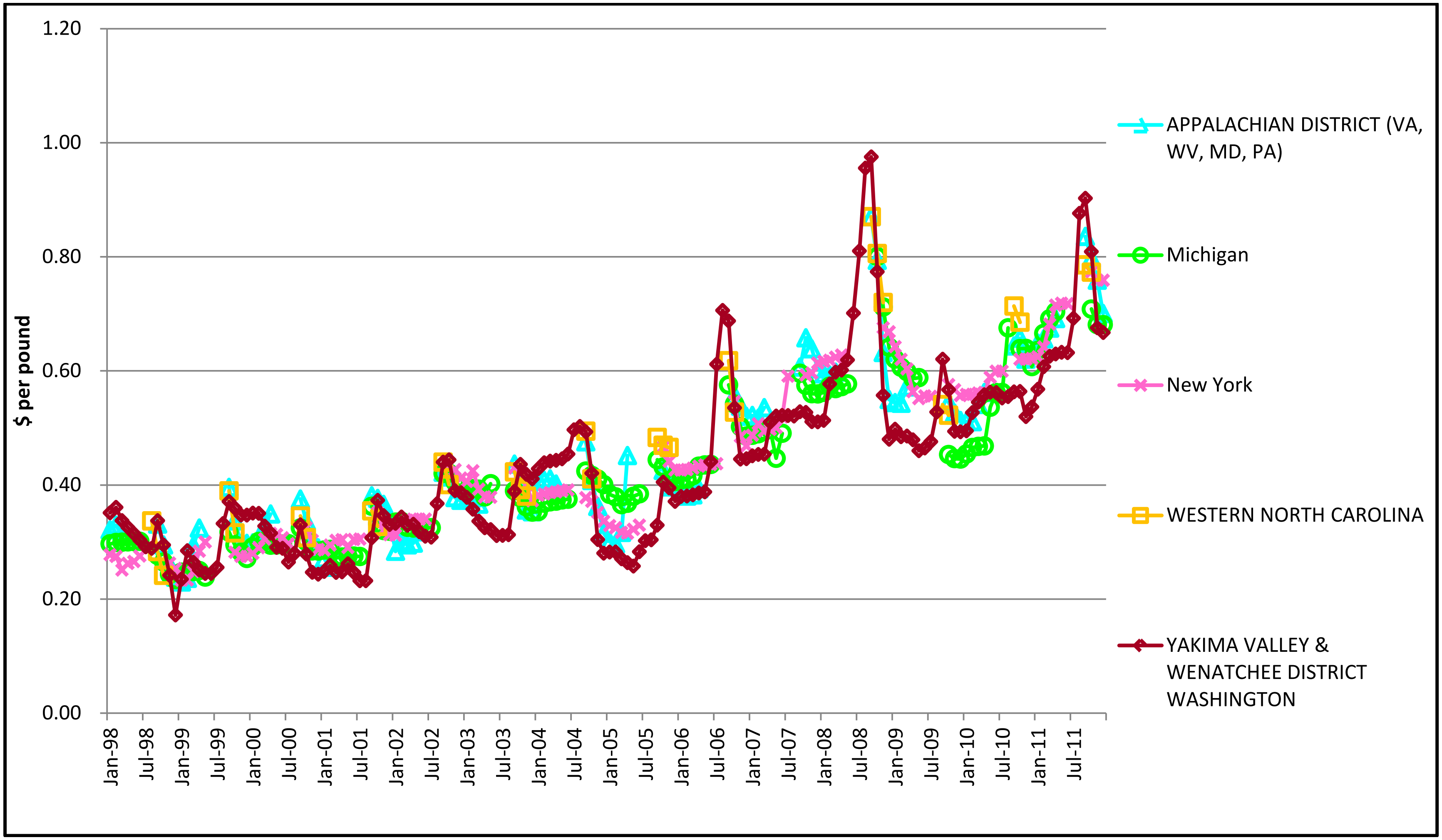

Figure 3.1 Fresh Red Delicious Apples: Monthly Shipping Point Prices

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

3.2.2 Factors Driving Price Trend

Since price relationships will likely be driven by market-specific events and differences, it is important to summarize important aspects of each market and different years covered in this study. During the late 1990s and early 2000s, increasing labor and energy costs, industry wide financial losses, together with greater than sufficient supplies drove retailers to lower the prices they paid for apples to packers and shippers. The prices began to rise again in 2002 as growers and packers consolidated, supply tightened, and consumption of fresh apples increased as more out-of-season apples and new varieties of apples were available, and possibly, due to the increasing concern about healthy diets.

The 2004 apple crop in Washington was the largest recorded for the period from 2000 to 2008 due to the mild spring and ideal growing conditions. The abundant supply led to a price drop in 2004. After 2004, the prices rose due to tighter supply conditions, increases in fresh apple consumption, and inflationary pressures. Due to a hard hailstorm late in the fall of 2006, together with a cold spring which reduced the bloom, the crop in 2007 was the smallest of the 2004 to 2008 period. The significant reduction in supply together with a spiking consumer price index in 2008, led to the highest recorded price in 2008.

The scattered frost and hail late in the spring of 2005 reduced the crop in New York, leading to the increase in price in 2006, while the favorable weather and pollination conditions in 2007 resulted in New York’s largest harvest during 2004-2008. Michigan’s crop fell dramatically in 2008 due to a freeze and hail damage early in the summer. The reduction in supply and the increase in consumption led to an increase in price.

Generally, the price of fresh Red Delicious apple price in the Yakima Valley & Wenatchee District Washington was much lower than the prices in other shipping points in the off-season when only cold stored apples were available. This result is reasonable because Washington as the largest fresh Red Delicious apple supply state and through storage had more sufficient supply in off-season.

Apples were mainly stored with two methods, regular storage (RS) and stored with controlled atmosphere (CA), which provides higher quality. Most of the apples marketed in the fall and early winter are regularly stored in general refrigeration and most of the apples marketed between January and September are stored in CA rooms (Washington State Apple Commission, 2010). The prices in January, the start of the apples marketed out of CA storage, is higher than the prices paid for apples kept in regular storage in previous months. In short, the premium between CA and RS can offset part of the additional cost of CA.

3.2.3 Retail Prices

The U.S. fresh apple retail market is divided into six regions by the USDA Agricultural Market Service including Northeast, Southeast, Midwest, South Central, Southwest, and Northwest regions. In total, there were 198 observations in the Midwest market (P_{MW}), 216 observations in the Northeast market (P_{NE}), 182 observations in the Northwest market (P_{NW}), 211 observations in the South-central market (P_{SC}), 208 observations in the Southeast market (P_{SE}) and 209 observations in the Southwest market (P_{SW}).

Table 3.2 shows the summary statistics of weekly retail prices for fresh Red Delicious apples. As one might expect, retail prices in the Eastern region are higher than the prices in the Western regions where there is more production and a smaller consuming population. The highest average price is for the Northeast market, which may be expected in the region with the highest population density and demand, as well as the highest agricultural labor cost (which indicates a higher local supply price). The lowest average price is for the Southwest retail market.

Although Washington is the largest apple production state, the average price in the Northwest is higher than the price in Southwest. Surprisingly, the Midwest market which includes the lowest shipping point price (Michigan) has a higher retail price than the Southwest market. As discussed above, there is no shipping point in the Southwest region that supplies fresh Red Delicious apples and California only grows a limited supply of Red Delicious apples. So, the lower prices in these regions might due to the more ample supply of other domestic fruits (citrus, for example) and imported fruits at lower prices in the Southwest market which reduces the demand for fresh Red Delicious apples.

Table 3.2 Summary Statistics of Weekly Retail Prices for Fresh Red Delicious Apples

Markets	Obs. (week)	Mean ($/lb)	Std. Dev. ($/lb)	Coeff. of Var.	Max. ($/lb)	Min. ($/lb)
Midwest	198	1.56	0.26	0.16	2.43	1.07
Northeast	216	1.72	0.25	0.15	2.70	1.27
Northwest	182	1.41	0.38	0.27	4.00	0.80
Southcentral	211	1.39	0.35	0.25	4.34	0.73
Southeast	208	1.61	0.29	0.18	2.41	0.92
Southwest	209	1.32	0.32	0.25	2.79	0.34

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

The lower Los Angeles retail price coincides with the research conducted by Richards and Patterson (2003). They examined the retailer market power and consumer market power of retail markets in Los Angeles, Chicago, and Atlanta. Chicago and Los Angeles markets were confirmed to be more competitive than the Atlanta market and consumers in Chicago and Los Angeles had more buying power than Atlanta consumers. Figure 3.2 shows that all retail markets carried fresh Red Delicious apples year round and the prices were relatively stable compared with the shipping point prices in the period from October 2007 to December 2011. The retail prices show a similar seasonality as the shipping point prices. Higher prices were reported at the end of the last season's crop inventory and before the new harvest in mid-August, and subsequently, prices fell as supplies increased during the harvest season. Generally, the price in the Southwest market was lower than other markets and the price in the Northeast market was the highest.

3.2.4 Terminal Market Prices

Taking the records of the destination terminal markets in the truck rate reports into consideration, five terminal markets are studied to examine the price relationship between each terminal market for fresh Red Delicious apples originating from Washington. Los Angeles is selected to represent the Western terminal markets, Chicago is selected for the North Central terminal markets, New York for the Northeast markets, Atlanta for the Southeast markets, and the Seattle terminal market is selected to represent local market. There are, in total, 730 observations for Atlanta (P_{AT}), 729 observations for Chicago (P_{CHI}), 729 observations for Los Angeles (P_{LA}), 728 observations for New York (P_{NY}) and 723 observations for Seattle (P_{ST}).

Table 3.3 shows the summary statistics of weekly terminal market prices for fresh Red Delicious apples. Contrary to our expectations, the highest average price with the lowest price variation is for the Chicago terminal market instead of the New York terminal market, which has a higher population density and longer distance from Washington State. This might be explained by the low supply of fresh apples in Illinois, but that supply should be augmented by nearby Michigan, the third largest apple production state[7]. Despite Seattle's geographical benefit of being the shortest distance from the Washington production area, the lowest average price is

[7] There was no record of fresh apples supplied by Illinois in 2008. 165 million pounds of fresh apples were supplied by Michigan, compared to 520 million pounds in New York and 4,550 million pounds in Washington.

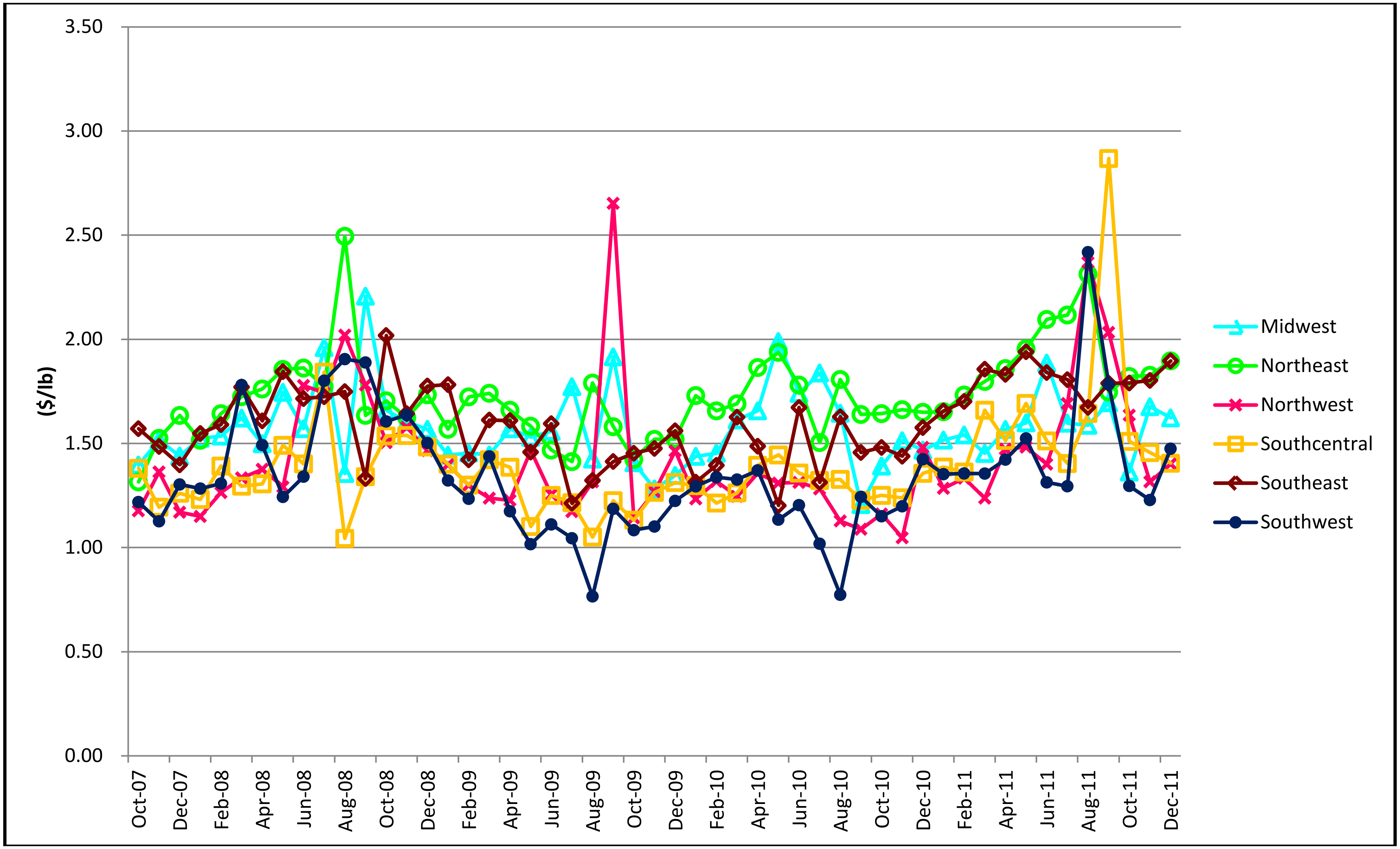

Figure 3.2 Fresh Red Delicious Apple: Monthly Retail Prices

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

reported in the Los Angeles terminal market. This is consistent with the lower Southwest retail price, but again, suggests that either imports or other fruit products may be influencing the price behavior of terminal markets that are relatively distant from supply regions.

Table 3.3 Summary Statistics of Weekly Terminal Market Prices for Fresh Red Delicious Apple Originating from Washington

Markets	Obs. (week)	Mean ($/lb)	Std. Dev. ($/lb)	Coeff. of Var.	Max. ($/lb)	Min. ($/lb)
Atlanta	730	0.60	0.22	0.36	1.27	0.31
Chicago	729	0.64	0.21	0.33	1.32	0.33
Los Angeles	729	0.51	0.18	0.36	1.13	0.15
New York	728	0.60	0.22	0.36	1.39	0.20
Seattle	723	0.56	0.20	0.36	1.24	0.28

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Figure 3.3 shows that all terminal markets carried fresh Washington Red Delicious apples year round and the prices tended to move approximately in synch with shipping point prices. Generally, the price in the Los Angeles market was lower than other markets and the price in the Chicago market was the highest.

3.2.5 Transportation among Markets and Truck Rates

One transaction cost that was able to be estimated and extrapolated for this analysis was transportation costs, since truck hauling is the most common domestic distribution method. Truck rates are estimated based on 48-53 foot refrigerated trailers from the origin shipping area to the destination terminal markets. The origin shipping areas are San Joaquin Valley California, Michigan, New York, and Yakima Valley & Wenatchee District, Washington. The cities of destination are Atlanta, Georgia; Baltimore, Maryland; Boston, Massachusetts; Chicago, Illinois; Dallas, Texas; Los Angeles, California; Miami, Florida; New York, New York; Philadelphia, Pennsylvania; and Seattle, Washington. Despite Yakima Valley & Wenatchee District,

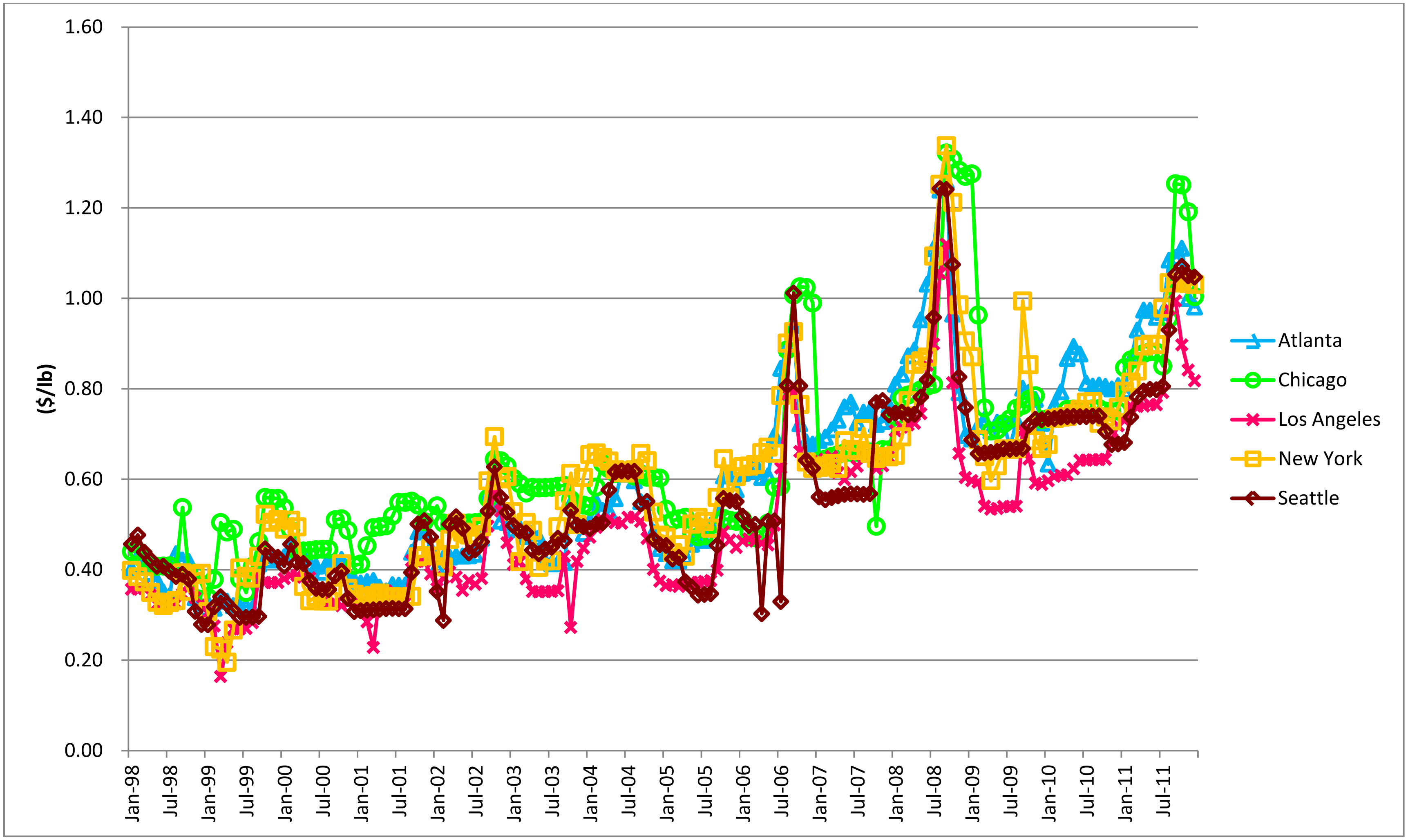

Figure 3.3 Washington Produced Fresh Red Delicious Apples: Monthly Terminal Market Prices
Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.
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Washington (as shown in table 3.4), all other shipping points only supply fresh apples seasonally. Shipping seasons from each shipping area to the destination terminal markets are shown in table 3.4.

Apples from San Joaquin Valley California were shipped to Atlanta, Boston, Chicago, and Los Angeles in 2006, and were shipped to all terminal markets from 2007 to 2009 (except Los Angeles in 2009). There was no record of shipment in 2010, while apples were shipped to all ten terminal markets except Chicago and Los Angeles in 2011. The shipping seasons were from early August to early December from 2006 to 2008, from early October to early December in 2009 and from early August to early October in 2011. This shows that the shipping season from San Joaquin Valley, California, became shorter in recent years.

Apples from Michigan were shipped to Atlanta, Chicago, Dallas, Miami, New York, and Philadelphia from 2006 to 2008. Apples were shipped to all terminal markets except Los Angeles and Seattle in 2009 and 2010. This is as expected due to the dominance of Michigan in the central and east market and Washington in the west market. Apples were only shipped to Atlanta, Chicago, Dallas, and Miami in 2011. The shipping seasons were from January to June, and then from September to December from 2006 to 2009. A longer season was recorded for 2010, from January to August and from September to December, while a shorter season was reported for 2011 from January to March and then from end of September to mid-December.

Apples from New York were shipped to Boston, New York, and Philadelphia from 2006 to 2009, and were shipped more widely to Atlanta, Baltimore, Boston, Miami, New York, and Philadelphia in 2010, and were shipped to all terminal markets except Los Angeles and Seattle in 2011. This suggests the dominance of the Washington shipping point in the western regions. The shipping seasons were mostly from January to June and then from September to December.

Apples from Yakima Valley & Wenatchee District Washington were shipped to almost all ten terminal markets from 2006 to 2011. Apples were shipped from Yakima Valley & Wenatchee District Washington to the destination terminal markets almost all year round.

Figures 3.4-3.7 show the monthly truck rates from San Joaquin Valley California, Michigan, New York, and Yakima Valley & Wenatchee District Washington to each terminal market. In general, the truck rates increased from 2006 to 2011, and we assume that, the closer the terminal markets to the shipping areas, the lower the truck rates. San Joaquin Valley California and New York shows significant seasonality in shipments, while Michigan and Yakima Valley & Wenatchee District Washington districts supply apples all year round.

Based on the shipping point price records and the truck rate report, Yakima Valley & Wenatchee District Washington is the shipping point exhibiting dominance in the west regional markets, and possibly even in the national market. Given this district's longer trade season, the geographical coverage of its shipments, and the complete of data available because market activity occurred each week, it would seem that this is "ground central" for domestic supplies.

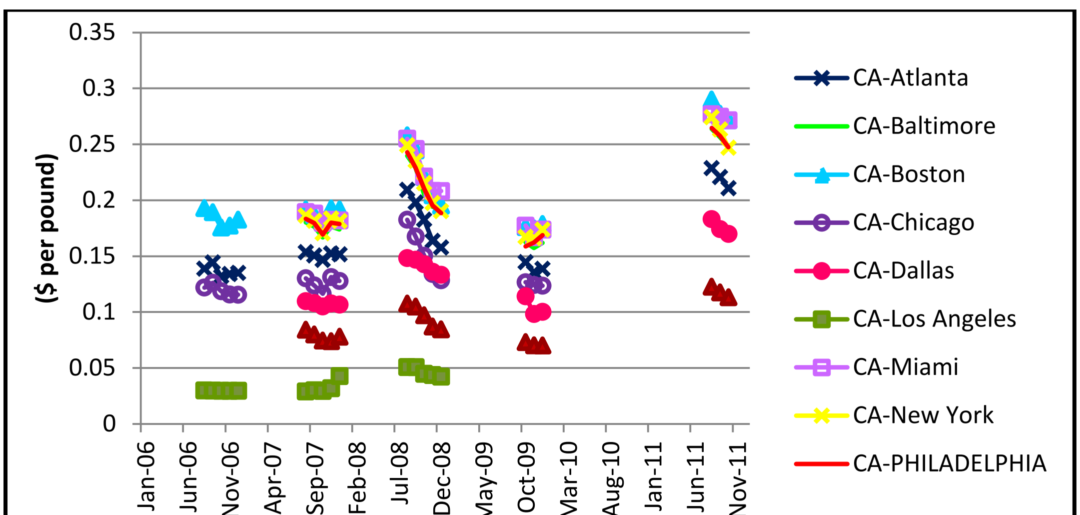

Figure 3.4 Truck Rate of Fresh Apples: Shipped from San Joaquin Valley California
Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

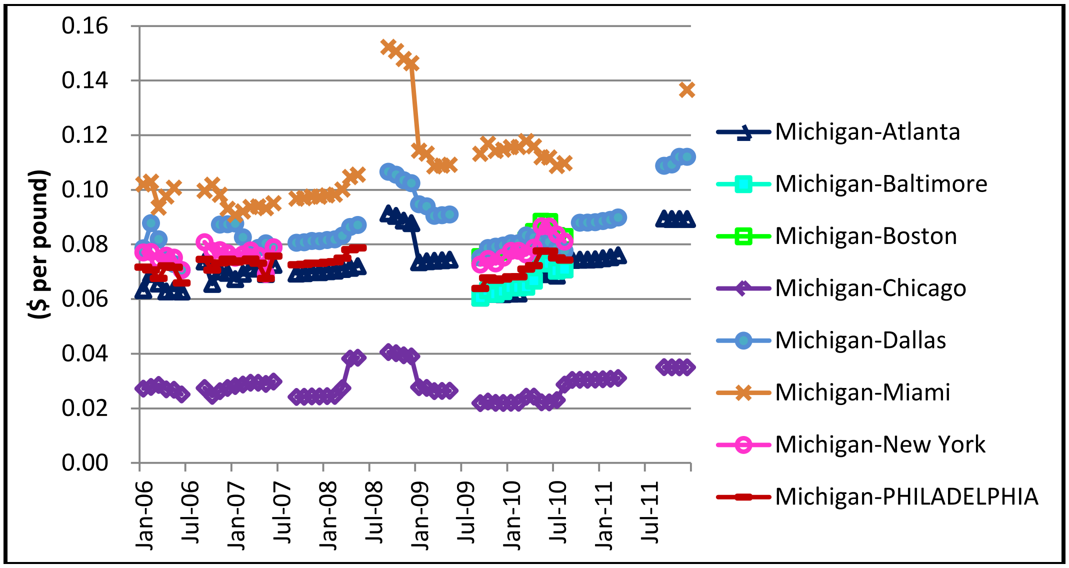

Figure 3.5 Truck Rate of Fresh Apples: Shipped from Michigan
Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

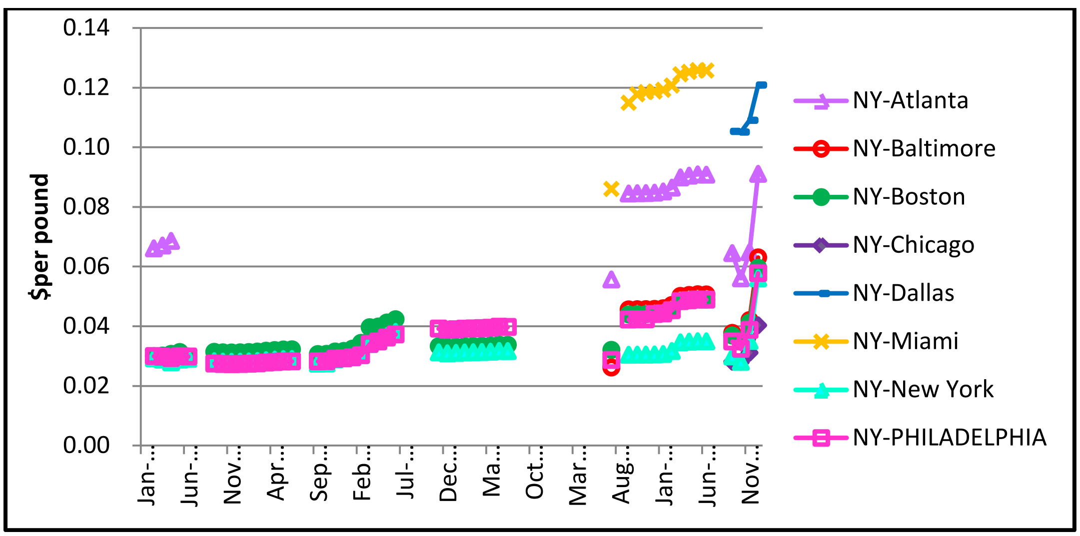

Figure 3.6 Truck Rate of Fresh Apples: Shipped from New York
Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

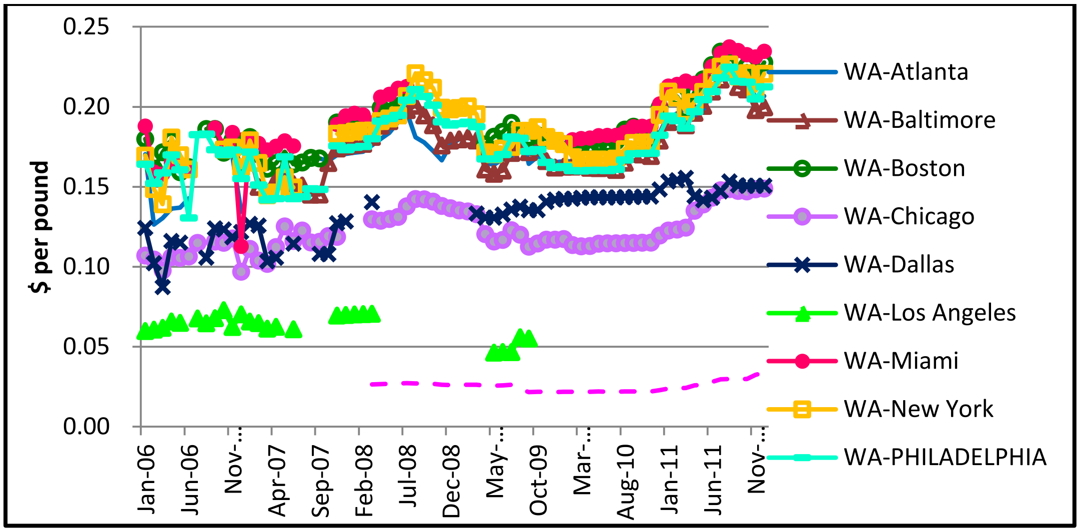

Figure 3.7 Truck Rate of Fresh Apples: Shipped from Yakima Valley &Wenatchee District Washington

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Table 3.4 shows the summary statistics of weekly truck rates for fresh apples originating from Yakima Valley & Wenatchee District Washington from January 2006 to December 2011. In general, the closer the terminal market to the Yakima Valley & Wenatchee District, Washington, the lower the domestic transportation costs. Subsequently, the Miami terminal market reports the highest average transportation cost ($0.20/lb) and the Seattle terminal market reports the lowest average transportation cost ($0.03/lb). The rate reaches a maximum of $0.24/lb for the Boston and Miami terminal markets and a minimum of $0.02/lb for Chicago and Seattle terminal markets.

3.2.6 Colorado Farmers' Market Prices

The weekly fresh apple prices at Colorado farmers markets are estimated from Colorado State University Extension's Fresh Produce and Meat Market Reports (http://www.extension.colostate.edu/boulder/ag/abm.shtml#prices). The data were collected from July to October, 2011. Only 11 weeks of prices were reported, but this is still more data than was available in previous periods, so it provides a benchmark for our analysis. Table 3.5 shows the summary statistics of weekly Colorado farmers' market prices for fresh apples. The mean price at Colorado farmers market was $3.35/lb. The maximum price was $3.73/lb and the minimum price was $2.90/lb.

Table 3.4 Observable Transaction Costs Summary Statistics

Shipping Point and Wholesale Terminal Market	Obs. (week)	Mean ($/lb)	Std. Dev ($/lb)	Coeff. of Var. (Std. D/Mean)	Max. ($/lb)	Min. ($/lb)
From Yakima Valley &Wenatchee District, WA to Atlanta	237	0.18	0.021	0.12	0.22	0.07
From Yakima Valley &Wenatchee District, WA to Baltimore	256	0.18	0.019	0.11	0.22	0.14
From Yakima Valley &Wenatchee District, WA to Boston	242	0.19	0.021	0.11	0.24	0.09
From Yakima Valley &Wenatchee District, WA to Chicago	278	0.12	0.015	0.12	0.15	0.02
From Yakima Valley &Wenatchee District, WA to Dallas	202	0.14	0.015	0.11	0.16	0.08
From Yakima Valley &Wenatchee District, WA to Los Angeles	83	0.06	0.008	0.13	0.08	0.05
From Yakima Valley &Wenatchee District, WA to Miami	178	0.20	0.023	0.12	0.24	0.11
From Yakima Valley &Wenatchee District, WA to New York	263	0.19	0.022	0.12	0.23	0.09
From Yakima Valley &Wenatchee District, WA to Philadelphia	282	0.18	0.022	0.12	0.23	0.08
From Yakima Valley &Wenatchee District, WA to Seattle	197	0.03	0.003	0.12	0.04	0.02

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Table 3.5 Summary Statistics of Weekly Colorado Farmers Market Fresh Apple Prices

Prices	Obs. (week)	Mean ($/lb)	Std. Dev. ($/lb)	Coeff. of Var.	Max. ($/lb)	Min. ($/lb)
Colorado Farmers Market	11	3.35	0.24	0.07	3.73	2.90

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

3.3 Market Relationship Models

In order to examine the market integration among spatially separate retail markets, terminal markets, and shipping points for fresh Red Delicious apples in the U.S., two vector autoregressive (VAR) models were designed and tested for causality. Based on the available data, the models were developed for six retail markets and five shipping point markets for fresh Red Delicious apples.

Stationarity within time series is required for the VAR model and Granger causality test. Thus, the Augmented Dickey-Fuller (ADF) test was applied based on the following equation:

(18) $\Delta P_t = \alpha_0 + \alpha_1 P_{t-1} + \sum_{j=1}^{n} \beta_j \Delta P_{t-j} + \varepsilon_t$

where Δ is the first difference operator, P_t is the observed prices (retail prices, terminal market prices, and shipping point prices), and ε_t is the normally distributed error term. The lag lengths were selected based on the Schwarz Information Criterion (SIC). If the series were confirmed to be stationary, then a VAR model and Granger causality test in levels can be conducted. If the series were found to be non-stationary in levels, then the ADF test needed to be applied to the first difference of the time series.

A VAR model can be estimated based on time series properties. The price series $\{P_t\}$ for each retail/shipping point market is represented as a function of own lagged prices and the other retail/shipping point market's lagged prices for fresh apples. For example, the VAR model for the Northwest retail market is estimated based on the following equation:

(19) $P_{NWt} = \alpha_{NW} + \sum_{f=1}^{l} \beta_{1f} P_{NW,t-f} + \sum_{g=1}^{m} \gamma_{1g} P_{NE,t-g} + \sum_{h=1}^{n} \delta_{1h} P_{MW,t-h} + \sum_{i=1}^{o} \theta_{1i} P_{SC,t-i} + \sum_{j=1}^{p} \varphi_{1j} P_{SE,t-j} + \sum_{k=1}^{q} \lambda_{1k} P_{SW,t-k} + \varepsilon_{1t}$

where P_{NWt}, P_{NEt}, P_{MWt}, P_{SCt}, P_{SEt}, and P_{SWt} are observable retail prices for fresh apples in Northwest market, Northeast market, Midwest market, South-central market, Southeast market, and Southwest market, respectively. α, β, γ, δ, θ, φ, and λ are unknown parameters to be estimated and ε is the stochastic error. The VAR length was determined using the Final Prediction Error (FPE), Schwarz Information Criterion (SIC), Akaike Information criterion (AIC) and Hannan-Quinn Information criterion (HQ) within the specifications among regressions with white noise residuals. Similar equations were specified for other specific retail/shipping point markets.

The Granger Causality test, conducted within the framework of a vector autoregressive model, is used to test the existence and the direction of price transmission between markets (Granger, 1969). It is an F-test of whether changes in one price series affect another price series. Taking the causality relationship between the Northwest retail market and Southwest retail market as an example, the tests are based on the following OLS regression equations:

(20) $$P_{NWt} = \alpha_{NW} + \sum_{f=1}^{l} \beta_{1f} P_{NW,t-f} + \sum_{g=1}^{m} \gamma_{1g} P_{NE,t-g} + \sum_{h=1}^{n} \delta_{1h} P_{MW,t-h} + \sum_{i=1}^{o} \theta_{1i} P_{SC,t-i} + \sum_{j=1}^{p} \varphi_{1j} P_{SE,t-j} + \varepsilon_{1t}$$

(21) $$P_{NWt} = \alpha_{NW} + \sum_{f=1}^{l} \beta_{1f} P_{NW,t-f} + \sum_{g=1}^{m} \gamma_{1g} P_{NE,t-g} + \sum_{h=1}^{n} \delta_{1h} P_{MW,t-h} + \sum_{i=1}^{o} \theta_{1i} P_{SC,t-i} + \sum_{j=1}^{p} \varphi_{1j} P_{SE,t-j} + \sum_{k=1}^{q} \lambda_{1k} P_{SW,t-k} + \varepsilon_{2t}$$

where ε_{1t} and ε_{2t} are white noise residuals. The null hypothesis that the Southwest retail market price (P_{SW}) does not Granger cause the Northwest retail market price (P_{NW}) cannot be rejected if and only if no lagged values of P_{SW} are retained in the regression. Similar equations were specified for testing all causality relationships from respective retail/shipping point markets to a specific retail/shipping point market.

3.3.1 Data Handling

Altogether, 222 weeks of retail price data and 147 weeks of shipping point data were matched by date for each location for the ADF test, VAR model estimation and Granger Causality test among retail markets and among shipping point markets. Some of the observations within the data are missing because the processors and retailers did not report the prices. The date is excluded if the price data at all locations are missing and other missing data are imputed based on the average of the price in the previous week and the price in the following week to maintain a consistent time series. All analysis is done in the logarithmic values of the prices.

3.3.2 Results

3.3.2.1 Regional Retail Prices

3.3.2.1.1 ADF Test

The ADF test confirmed that all price series were stationary at level. The details of ADF tests on these series are summarized in Table 3.6.

Table 3.6 Augmented Dickey-Fuller Unit Root Tests of Regional Retail Prices (Level)

Markets	Lags	ADF Test Statistic (level)
Midwest	1	-7.29***
Northeast	1	-15.03***
Northwest	1	-6.15***
South-central	1	-15.40***
Southeast	1	-6.44***
Southwest	1	-5.54***

Note:

1. ***denotes statistical significance at 1% level.
   ** denotes statistical significance at 5% level.
   * denotes statistical significance at 10% level.
2. The null and the alternative hypotheses are series is non-stationary and series is stationary, respectively.
3. As the coefficient has a non-standard distribution, it is compared with critical values tabulated by Mackinnon (1996).
4. The lag lengths were selected based on Schwarz Info Criterion (SIC).
5. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

3.3.2.1.2 VAR Model Estimation

Given these time series properties, a VAR model in levels with one lag is estimated (Table 3.7). As expected, the one-period lagged own price in all regional retail price equations was positive and statistically significant. A one percent increase in last week's price led to a 0.24, 0.52, 0.36, 0.33, 0.22, and 0.27 percent increase in the contemporaneous price of Midwest, Northeast, Northwest, Southcentral, Southeast, and Southwest retail prices, respectively. The Midwest retail price was sensitive to the Northwest, South-central, and Southeast retail prices. The Northeast and Northwest prices were sensitive to the Southwest retail price. The Southcentral price was sensitive to the Midwest, Northeast, Southeast and Southwest retail prices. The Southeast price was sensitive to the Northeast, Southcentral, Southeast and Southwest retail prices. The Southwest price was sensitive to the Midwest, Northeast, Northwest, and Southwest prices. As theory would suggest, the parameter estimates on one regional retail market's one-period lagged price for another regional retail market was statistically significant, positive, and smaller than the parameter estimate on its own one-period lagged price.

These results show that the Southwest price had a significant influence on all other regional retail prices. This coincides with the lowest prices in Southwest market comparing to other retail markets due to the more ample supply of other domestic fruits (citrus, for example) and imported fruits at lower prices. Moreover, the Northeast (with the highest population density and demand) regional price significantly influenced the price of all regions except the Midwest and Northwest which are two largest apple production areas. The Southcentral regional price significantly influenced the price of all regions except the Northwest and Southwest retail prices, which significantly dominant the price formation process in the western retail markets. The

Table 3.7 Vector Autoregression Estimates for U.S. Regional Retail Prices

Regional Retail	Variable	Dependent Variable: Natural Logarithm of Prices					
		Midwest (P_{MWt})	Northeast (P_{NEt})	Northwest (P_{NWt})	Southcentral (P_{SCt})	Southeast (P_{SEt})	Southwest (P_{SWt})
	Intercept	0.22***	0.22***	0.04	0.01	0.17***	0.01
		(4.14)	(5.12)	(0.63)	(0.16)	(3.00)	(0.13)
Midwest	P_{MWt-1}	0.24***	0.05	0.01	-0.03	-0.06	-0.17*
		(3.39)	(0.86)	(0.13)	(-0.42)	(-0.81)	(-1.59)
	P_{MWt-2}	0.12**	-0.06	0.07	0.11*	-0.01	-0.09
		(1.80)	(-1.07)	(0.87)	(1.40)	(-0.11)	(-0.91)
Northeast	P_{NEt-1}	0.07	0.52***	0.04	-0.15*	0.20**	0.10
		(0.86)	(7.35)	(0.39)	(-1.47)	(2.15)	(0.74)
	P_{NEt-2}	0.04	-0.01	0.14	0.18**	-0.04	0.20*
		(0.51)	(-0.08)	(1.27)	(1.73)	(-0.38)	(1.46)
Northwest	P_{NWt-1}	0.07*	0.01	0.36***	0.07	-0.03	0.22***
		(1.28)	(0.31)	(4.98)	(1.02)	(-0.53)	(2.42)
	P_{NWt-2}	-0.02	0	0.06	-0.08	0	-0.03
		(-0.29)	(-0.03)	(0.79)	(-1.16)	(0.07)	(-0.35)
Southcentral	P_{SCt-1}	0.13**	0	0.02	0.33***	0.03	-0.07
		(2.18)	(0.01)	(0.23)	(4.82)	(0.46)	(-0.74)
	P_{SCt-2}	-0.07	0.07*	0	0.04	0.10*	0.07
		(-1.20)	(1.42)	(-0.05)	(0.64)	(1.63)	(0.82)
Southeast	P_{SEt-1}	-0.14**	-0.05	-0.04	0.08	0.22***	0.07
		(-2.16)	(-1.01)	(-0.45)	(1.04)	(3.22)	(0.72)
	P_{SEt-2}	0.01	0.05	-0.06	0.12*	0.13**	-0.03
		(0.09)	(1.05)	(-0.73)	(1.63)	(1.87)	(-0.31)
Southwest	P_{SWt-1}	0.03	0.08**	0.18***	0.07*	0.09**	0.27***
		(0.56)	(2.13)	(3.24)	(1.40)	(1.94)	(3.90)
	P_{SWt-2}	0.09**	0	0.03	0.09*	0.05	0.24***
		(1.96)	(0.06)	(0.48)	(1.63)	(1.07)	(3.29)
R^2		0.23	0.37	0.37	0.32	0.27	0.36

Note:
1. t-statistics are in parentheses.
2. ***denotes statistical significance at 1% level.
   ** denotes statistical significance at 5% level.
   * denotes statistical significance at 10% level.
3. Critical value at 1% level is 2.326, at 5% level is 1.645, and at 10% level is 1.282.
4. The lag lengths (2) were selected based on Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Info Criterion (SIC), and Hannan-Quinn Information Criterion (HQ).
5. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Southeast retail price had a significant influence on the Midwest and Southcentral retail prices with shorter distance which indicates more trade between these regions. The Northwest (the largest apple production area in U.S.) price significantly influenced the price formation process in the western markets, Midwest and Southwest regional prices. The Midwest price influenced the Southcentral (with shorter distance) and Southwest (with more demand due to small production and high population density) regional price. Thus, the Northeast and Southwest (two markets with the highest population density and demand) regional retail prices had the most influence on the national retail price formation process.

The results of the goodness of fit for the Midwest, Northeast, Northwest, South-central, Southeast, and Southwest retail market models are R^2 values of 0.23, 0.37, 0.37, 0.32, 0.27, and 0.36, respectively.

3.3.2.1.3 Granger Causality Test

The results of Granger causality tests are presented in Table 3.8. All F-statistics for the causality tests of Northeast and Southwest retail prices on other markets were statistically significant. The null hypothesis of no Granger causality is rejected. This indicated that Northeast and Southwest retail markets, both dominant markets likely driven by the demand that emanates from high population density, are significantly affecting the price formation process of all other retail markets. Changes in the Northwest and Southcentral retail markets affected three other retail markets. The Midwest retail price has no influence on the price formation process of other markets. Overall, the Southwest and Northeast retail markets dominated national markets and the Northwest retail market dominated western markets in terms of its influence on retail prices.

According to the Granger causality test, there are unidirectional causalities between the Midwest retail market and Northeast, Northwest, Southcentral, and Southwest markets (four retail markets→Midwest retail market). This suggests that the Midwest retail market is a market follower in the national markets. There is unidirectional causality between the Northeast retail market and Northwest and Southeast retail markets (Northeast→Northwest, Southeast). There are unidirectional causalities between the Northwest and Southcentral retail markets, between the

Southwest and Southcentral retail markets, and between the Southwest and Southeast retail martkets (Northwest→Southcentral, Southwest→Southcentral, Southwest→Southeast).

Table 3.8 Testing for Granger Causality between Regional Retail Prices…

Series and Causal Direction			F tests	Results
Midwest	→	Northeast	0.90 (0.41)	**NC**
Midwest	→	Northwest	0.23 (0.80)	**NC**
Midwest	→	Southcentral	1.23 (0.30)	**NC**
Midwest	→	Southeast	0.00 (1.00)	**NC**
Midwest	→	Southwest	0.46 (0.63)	**NC**
Northeast	→	Midwest	2.32 (0.10)	**C**
Northeast	→	Northwest	2.27 (0.10)	**C**
Northeast	→	Southcentral	3.87 (0.02)	**C**
Northeast	→	Southeast	3.79 (0.02)	**C**
Northeast	→	Southwest	3.11 (0.05)	**C**
Northwest	→	Midwest	5.18 (0.01)	**C**
Northwest	→	Northeast	1.54 (0.22)	**NC**
Northwest	→	Southcentral	2.66 (0.07)	**C**
Northwest	→	Southeast	1.70 (0.19)	**NC**
Northwest	→	Southwest	3.17 (0.04)	**C**
Southcentral	→	Midwest	3.92 (0.02)	**C**
Southcentral	→	Northeast	2.84 (0.06)	**C**
Southcentral	→	Northwest	0.27 (0.76)	**NC**
Southcentral	→	Southeast	3.46 (0.03)	**C**
Southcentral	→	Southwest	0.29 (0.75)	**NC**

Table 3.8 Testing for Granger Causality between Regional Retail Prices…, Continued

Series and Causal Direction			F tests	Results
Southeast	→	Midwest	0.60 (0.55)	NC
Southeast	→	Northeast	1.37 (0.26)	NC
Southeast	→	Northwest	0.08 (0.93)	NC
Southeast	→	Southcentral	5.70 (0.00)	C
Southeast	→	Southwest	0.69 (0.50)	NC
Southwest	→	Midwest	6.84 (0.00)	C
Southwest	→	Northeast	4.76 (0.01)	C
Southwest	→	Northwest	6.93 (0.00)	C
Southwest	→	Southcentral	6.65 (0.00)	C
Southwest	→	Southeast	6.48 (0.00)	C

Note:
1. C denotes Granger cause, NC denotes not Granger cause
2. The lags of the dependent variable used to obtain white-noise residuals are determined using the Schwarz Information Criterion (SIC). Two lags are selected.
3. The numbers inside the parenthesis show the p-values for F-statistics.
4. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

There is bilateral causality between the Northeast market and the Southcentral and Southwest markets, between the Northwest and the Southwest market, and between the Southcentral and Southeast markets. This suggests that there is no clear market leader in the price formation between these markets. There is no causality between the Midwest market and the Southeast market and between the Northwest market and the Southeast market. This suggests that there is little influence between the western regional markets and the Southeast market. This might due to the longer distance between these western markets and the Southeast market and the sufficient supply in the Northeast regions. Overall, all markets except the Midwest significantly influenced the price formation process in the Southcentral market. This result is different from the VAR model results which show that the Midwest market did not influence the Southcentral market within one week but would influence the prices in the Southcentral market in two weeks at 10% significance level. Despite the short distance between the Midwest market and the Southcentral market, this result is reasonable due to the dominance of Northwest market in the west regions which suggests small trade and influence from Midwest to Southcentral regions.

3.3.2.1.4 The Threshold Autoregressive Regression Model

3.3.2.1.4.1 Market Pairs

The Southcentral retail market is selected as a reference location based on our research for the Colorado market. The summary statistics of price pairs are shown in table 3.9. As expected, the price difference between the Southcentral and Northwest markets is the smallest while the price difference between the Southcentral and Northeast is the largest. This result indicates that the price difference between markets increases as the distance increases, as would be expected. The result also shows that the mean price in the Southwest market is mostly lower than the price in the Southcentral market. This might be due to the dominance of the Southwest retail market (and negotiating power of retailers in this region) on national markets.

Figure 3.8 presents monthly price pairs. Generally, the price difference between the Southcentral and Northwest markets is the smallest while the price difference between the Southcentral and Northeast is the largest. The figure suggests seasonality in the price differences. The price differences during the period from May to August were relatively smaller than other periods. This is as expected according to shipping point price data and import data which suggest that cold stored domestic apples and imported apples are mainly supplied during this period. Retail markets are more interacted and result in smaller price difference than other periods.

Table 3.9 Summary Statistics of Price Pairs

Market Location	Obs. (week)	Mean ($/lb)	Median ($/lb)	Std. Dev. ($/lb)	Max. ($/lb)	Min. ($/lb)
Midwest-Southcentral	222	0.15	0.14	0.25	0.88	-1.19
Northeast-Southcentral	222	0.23	0.24	0.23	0.95	-1.14
Northwest-Southcentral	222	0.02	-0.02	0.26	1.19	-0.73
Southeast-Southcentral	222	0.15	0.16	0.23	0.81	-1.14
Southwest-Southcentral	222	-0.04	-0.04	0.28	0.67	-1.37

Note:

1. All prices are logged and then differenced between the two markets.
2. All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

The results of the augmented Dickey-Fuller unit-root test for all market pairs are shown in table 3.10. All price differences are confirmed to be stationary. Ordinary least squares estimation of the cointegrating relationship between prices following Engle and Granger (1987) is conducted and the results are shown in table 3.11. The results suggest that the prices in the Southcentral market are cointegrated with the prices in all other markets except the Midwest market.

3.3.2.1.4.2 TAR Model Specification

Due to the complexity of the costs relevant to analysis of spatial arbitrage and trade, it is difficult to directly estimate the transaction costs from one location to another. Thus, a Threshold Autoregressive Regression (TAR) model is used to estimate the transaction cost bands.

The TAR models are constructed based on following equations:

(22) $\delta_t^{ij} = P_t^i - P_t^j$

where P_t^i and P_t^j are prices for a homogenous product in two separate markets. Here P_t^i is the fresh Red Delicious apple price in the Southcentral market, and P_t^j is the price in another

Table 3.10 Augmented Dickey-Fuller Unit-root Tests for Price Pairs

Market Location	Lag	p-value	t-value
Midwest-Southcentral	0	0.0000	-10.71
Northeast-Southcentral	0	0.0000	-9.44
Northwest-Southcentral	0	0.0000	-9.96
Southeast-Southcentral	0	0.0000	-11.74
Southwest-Southcentral	0	0.0000	-10.37

Note:

1. The lag lengths are selected based on Schwarz Information Criterion (SIC).
2. All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Table 3.11 OLS estimation of Cointegrating Relationship

Market Location	C	β	ADF Test on Residuals	
			Lag	t-value
Southcentral→ Midwest	0.43 (0.02)	0.05 (0.05)	0	-10.63***
Midwest→ Southcentral	0.26*** (0.04)	0.08 (0.08)	0	-8.98***
Southcentral→ Northeast	0.51 (0.02)	0.08 (0.05)	0	-8.07***
Northeast→ Southcentral	0.22*** (0.05)	0.15* (0.09)	0	-9.03***
Southcentral→ Northwest	0.24 (0.03)	0.26 (0.07)	0	-8.77***
Northwest→ Southcentral	0.24*** (0.02)	0.21*** (0.06)	0	-9.39***
Southcentral→ Southeast	0.37 (0.02)	0.27 (0.06)	0	-11.04***
Southeast→ Southcentral	0.15*** (0.04)	0.34*** (0.07)	0	-9.95***
Southcentral→ Southwest	0.14 (0.03)	0.40 (0.09)	0	-9.45***
Southwest→ Southcentral	0.24*** (0.02)	0.22*** (0.05)	0	-9.64***

Note:

1. The estimation is conducted following the equation: $P_t^i = C + \beta P_t^j$.
2. The numbers in parentheses are standard errors.
3. ***indicates significance at the 1% level,
   **indicates significance at the 5% level,
   *indicates significance at the 10% level.
4. The lag lengths are selected based on Schwarz Information Criterion (SIC).
5. All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

retail market (Midwest, Northeast, Northwest, Southeast, and Southwest retail markets). δ_t^{ij} is the price difference between two markets.

(23) $\Delta\delta_t^{ij} = \alpha\delta_{t-1}^{ij} + \varepsilon_t$

where $\Delta\delta_t^{ij}$ is the changes in the price difference from time t-1 to t, which means $\Delta\delta_t^{ij} = \delta_t^{ij} - \delta_{t-1}^{ij}$. The residual term ε_t is a white noise term, $\varepsilon_t \sim N(0, \sigma^2)$. α is the speed of price adjustment, which indicates the response of the price difference at time t to the price difference at time t-1.

One of the basic TAR models, which accounts for the existence of transaction costs, is defined by Balke and Fomby (1997) as following:

(24)
$$\Delta\delta_t = \begin{cases} \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} > c \\ \alpha_{in}\delta_{t-1} + \varepsilon_t & \text{if } -c \leq \delta_{t-1} \leq c \\ \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} < -c \end{cases}$$

Two set of parameters need to be estimated: one for the adjustment inside the transaction band (α_{in}), one for the adjustment outside the transaction band (α_{out}); and then, one can ascertain the threshold that represents transaction costs (c) that causes a regime switch (e.g. Goodwin and Piggott, 2001; Mancuso et al., 2003; van Campenhout, 2007[8]). According to previous studies (van Campenhout, 2006; Bekkerman, Goodwin, and Piggott, 2009), a variable threshold model, especially the asymmetric variable threshold model, provides better estimation than a constant threshold model. A symmetric variable threshold model is estimated in this study, assuming the transaction costs for shipping apples from one market to another market are the same in either direction, with an upper band of c^u and a lower band of c^l.

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[8] I am grateful to Van Campenhout Bjorn to share his Stata code for the TAR models.

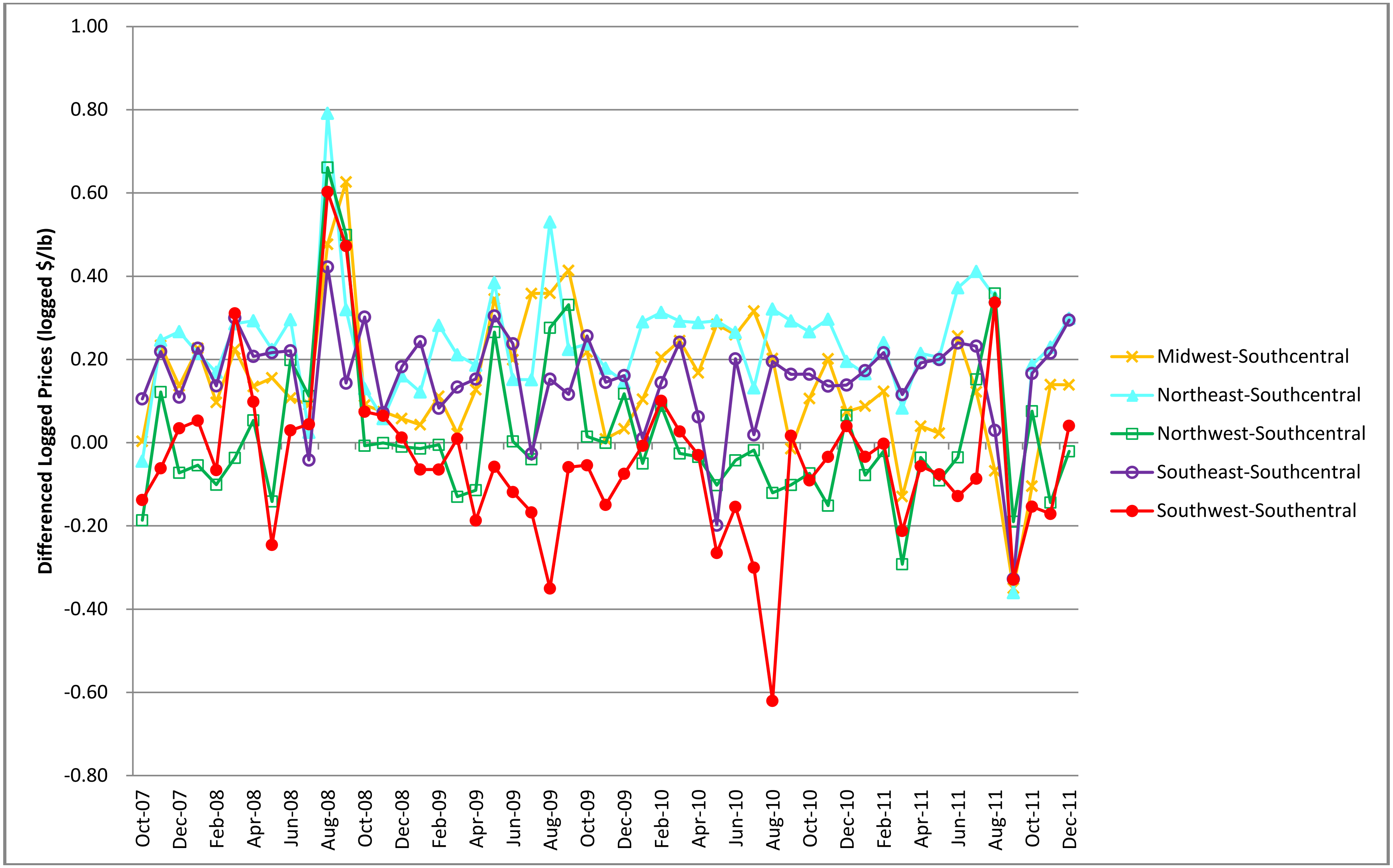

Figure 3.8 Fresh Red Delicious Apple: Monthly Price Pairs

Note: All prices are deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Based on the assumption that there is no price adjustment within the transaction band ($\alpha_{in} = 0$), equations (3) can be modified to:

(25)

$$\Delta\delta_t = \begin{cases} \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} > c^u \\ \varepsilon_t & \text{if } c^l \leq \delta_{t-1} \leq c^u \\ \alpha_{out}\delta_{t-1} + \varepsilon_t & \delta_{t-1} < c^l \end{cases}$$

Following Bekkerman, Goodwin, and Piggott (2009), the thresholds are allowed to vary according to truck rates and seasonality. This can be illustrated as follows:

(26) $c = \beta_0 + \beta_1 TR_t + \beta_2 S_{1t} + \beta_3 S_{2t}$

where TR_t is the on-highway diesel price in dollars per mile, and S_t is a seasonal dummy variable. Based on the price dynamic and records of movement, one year is divided into three seasons, S_{1t}=1 if it is from September to December, the harvest season, 0 otherwise. S_{2t}=1 if it is from January to April, in-season when domestic apples are mostly available, 0 otherwise. The third season is from May to August, at the end of the previous season, but before new crops are available, 0 otherwise. The third season is selected as the base season in this analysis.

Both the standard TAR model with a constant threshold and the TAR model with a variable symmetric threshold are estimated. The thresholds are identified through a grid search with a criterion of the minimal sum of squared residuals for observations in the outer regime. As starting values for the thresholds, at least 20% of the observations were either within or outside the band.

Altogether, 222 observations were matched by date for the retail market pairs and regional on-highway diesel prices for both the constant threshold model and the variable threshold model. The estimates of the threshold bands are presented in table 3.12.

Table 3.12 Threshold Band Parameter Estimates ($c = (P_t^i - P_t^j)/P_t^j$)

Market Pair	Constant Threshold	Symmetric Variable Threshold $c_t = \beta_0 + \beta_1 TR_t + \beta_2 S_{1t} + \beta_3 S_{2t}$			
	c	β_0	β_1	β_2	β_3
Southcentral-Midwest	0.08	0.02***	1.01***	0.85***	0.86***
Southcentral-Northeast	0.26	-0.09***	1.32***	0.85***	0.91***
Southcentral-Northwest	0.05	-0.37***	1.40***	0.91***	0.85***
Southcentral-Southeast	0.09	-0.29***	1.37***	0.98***	1.01***
Southcentral-Southwest	0.13	-0.78***	1.71***	1.06***	1.11***

Note:
1. ***indicates significance at the 1% level
**indicates significance at the 5% level
*indicates significance at the 10% level
2. c is threshold and β_i are parameters of variables.
3. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

For the TAR with a constant band, the neutral band that represents the smallest price difference is between the Southcentral and Northwest at 5%. The largest band is 26% between the Southcentral and Northeast. The neutral band represents the price difference that is required to trigger equilibrium conditions. Thus, the band indicates the linkage between markets in each market pair. For example, the price difference between the Southcentral and Northeast retail market needs to exceed 26% to trigger conditions (price changes, less or more shipments) that will drive the market back to equilibrium, while the price difference between the Southcentral and Northwest only need to exceed 5%. This result is, as expected, that the greater distance between markets, the wider the neutral bands can be. Since Washington is the primary Red Delicious apple production area, the estimated threshold indicates a tight linkage between the Southcentral retail market and Northwest retail market which may suggest a possible discount against transaction costs due to the large volume of trade that moves between these regions.

For the TAR with symmetric variable band, the parameters are estimated using a grid search. Thus, direct analysis of the parameters estimated is not appropriate, but it is useful to understand the effect of each component on the threshold band. As expected, diesel prices have significant positive effects on the threshold for all market pairs. This result suggests that higher diesel prices imply a wider neutral band between markets. This is as expected because higher transportation costs usually lead to increase in prices, but more importantly, more uncertainty about the returns from cross-region shipment of high volume, lower value goods. Moreover, the seasonality components have significant positive effects on the threshold. This suggests a wider threshold band in domestic season (in harvest season and when domestic apples are mostly available while few imports take place) than the off season (when only cold stored domestic apples and imported apples are available).

Figure 3.9a-3.9e shows the threshold bands estimated by constant and symmetric variable TAR models. The symmetric variable thresholds are wider and concentrated around the constant thresholds. This coincides with Bekkerman, Goodwin, and Piggott (2009)'s results that the symmetric variable threshold model yielded wider thresholds than the constant threshold model. In most cases, the thresholds are narrower in the off seasons when only stored domestic apples and imported apples are available and few local produced apples are supplied so there are more market linkages. However, the thresholds are wider in harvest seasons when local produce supplies are available, so more direct marketing may take place relative to the dominance of conventional retail markets in the off-season. This might confirm the better representation of market behavior by the neutral transaction band by the variable threshold model than constant model. This coincides with previous studies (e.g. van Campenhout, 2006; Bekkerman, Goodwin, and Piggott, 2009) that confirmed the variable threshold model better represents the characteristic of market price data.

Table 3.13 shows the probability of observations being located outside and inside the threshold band between market pairs. Three regimes are defined. A large shock to one market will trigger the spatial price difference to exceed the threshold band, then the supply for the retail market will trend to a higher price until the price difference is no longer outside of the bounds of the threshold. The market exhibits the nature of regimes 1 and 3. A small deviation in the price difference will not trigger a price adjustment between markets, thereby signifying an equilibrium as is the case for regime 2.

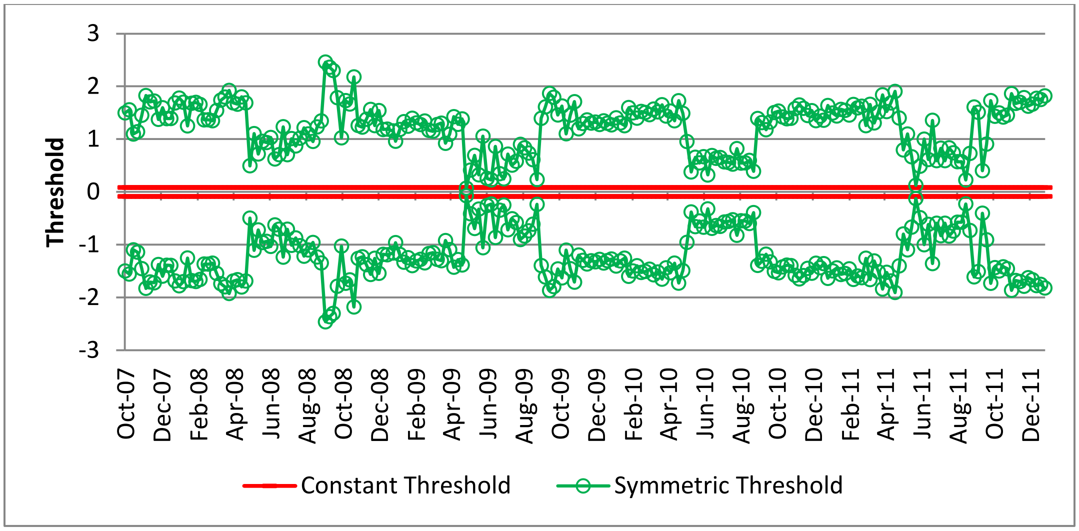

Figure 3.9a Threshold Model Estimation—Southcentral & Midwest

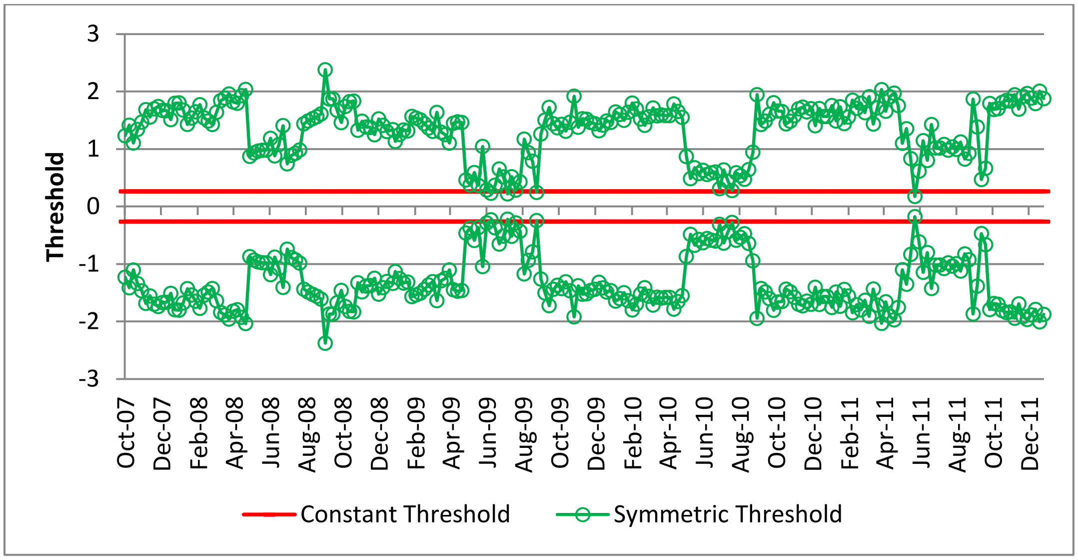

Figure 3.9b Threshold Model Estimation—Southcentral & Northeast

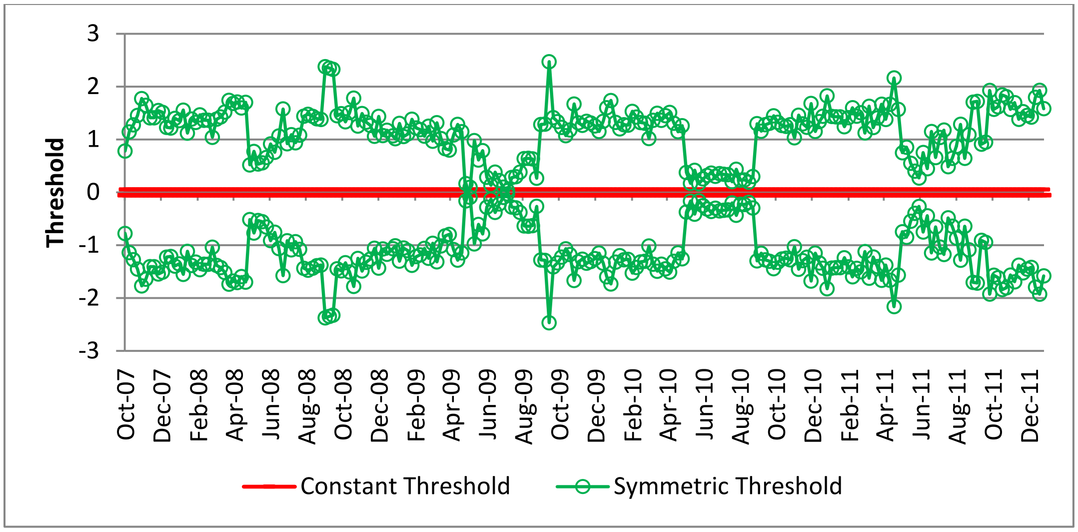

Figure 3.9c Threshold Model Estimation—Southcentral & Northwest

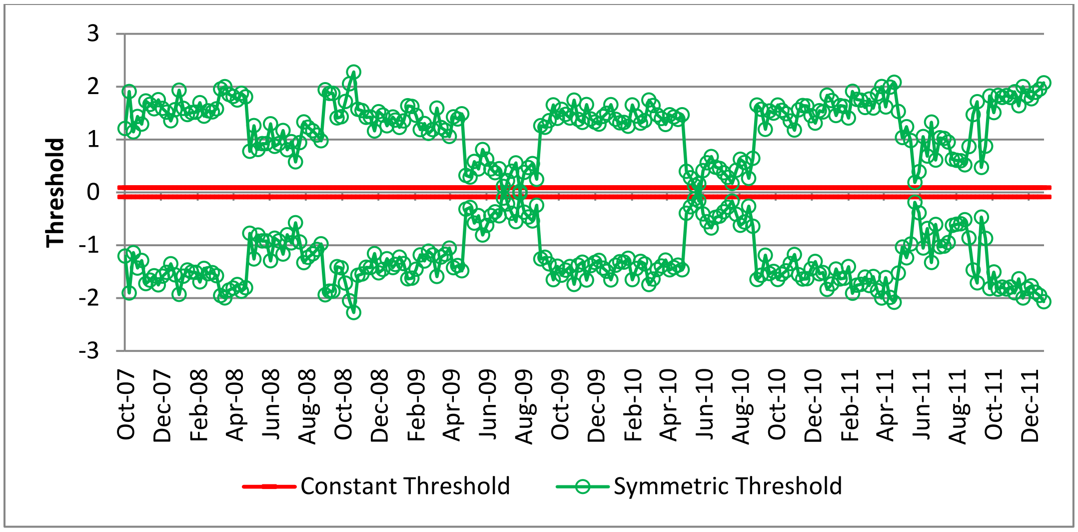

Figure 3.9d Threshold Model Estimation—Southcentral & Southeast

In a constant threshold estimation, there are significant observations in each regime. Specifically, less observations lie in regime 2 between the Southcentral and Northwest and between the Southcentral and Southeast than other market pairs, which indicates the high frequency of adjustment of supply between these markets. For the market pair of Southcentral and Northeast, the probability of regime 1 and regime 2 is half-half. The supply will be shifted toward the Northeast, otherwise there will be no supply adjustment. However, in a symmetric variable estimation, no observation lies in regime 2, and most observations lie in regime 3, which indicates potential shifts of supply toward the Southcentral retail market for its higher price and shortage of supply for locally- produced apples.

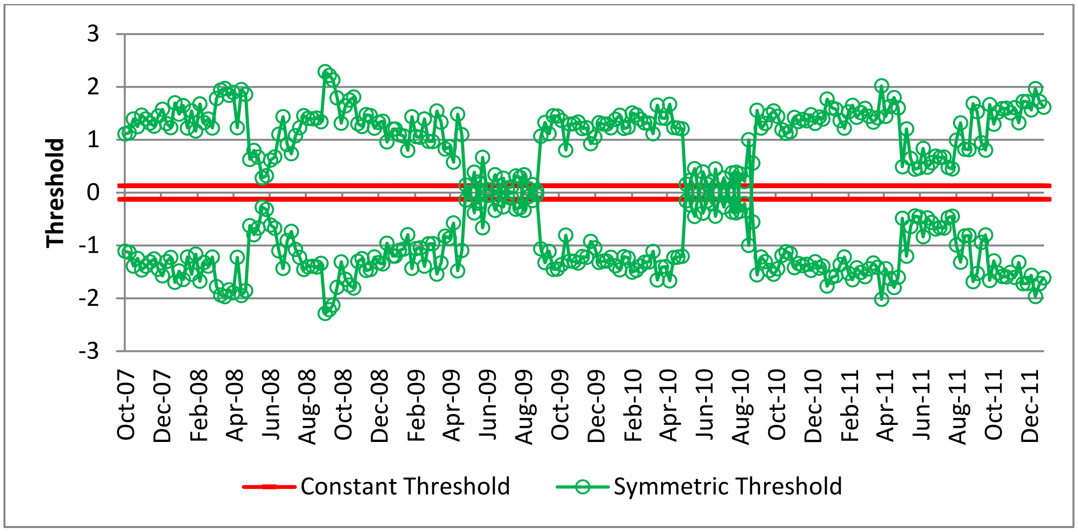

Figure 3.9e Threshold Model Estimation—Southcentral & Southwest

The comparison of the results of the two models indicates that there will be more supply adjustment if the threshold band is allowed to vary with transportation costs and seasonality. This indicates that if the threshold band is flexible, it will follow a similar pattern as the price difference so that more supply adjustments take place. The threshold gets lower when the price difference is smaller and gets wider when the price difference is larger. The comparison of figure 3.8 and 3.9 confirmed this statement. The price difference and threshold band in off-season (when only stored domestic apples and imported apples are available) are both lower than in other periods which suggests more market linkages. Thus, the symmetric variable threshold suggests more opportunities for firms to trade.

Table 3.13 Markets Outside and Inside Bands

Model	Market Pair	Regime1 ($P_{Southcentral} < P_{other}$, trigger increase in supply for other markets)	Regime2 (equilibrium)	Regime3 ($P_{Southcentral} > P_{other}$, trigger increase in supply for Southcentral)
Constant Band TAR	Southcentral-Midwest	128 (57.92%)	64 (28.96%)	29 (13.12%)
	Southcentral-Northeast	95 (42.99%)	123 (55.66%)	3 (1.36%)
	Southcentral-Northwest	73 (33.03%)	58 (26.24%)	90 (40.72%)
	Southcentral-Southeast	144 (65.16%)	56 (25.34%)	21 (9.50%)
	Southcentral-Southwest	55 (24.89%)	86 (38.91%)	80 (36.20%)
SymmetricVariable band TAR	Southcentral-Midwest	65 (29.41%)	0	156 (70.59%)
	Southcentral-Northeast	107 (48.42%)	0	114 (51.58%)
	Southcentral-Northwest	31 (14.03%)	0	190 (85.97%)
	Southcentral-Southeast	82 (37.10%)	0	139 (62.90%)
	Southcentral-Southwest	71 (32.13%)	0	150 (67.87%)

Table 3.14 shows the estimated adjustment speed and half-lives which indicate the speed that market pairs move toward equilibrium after a shock[9]. There are some similarities in the estimates of adjustment speed and half-life using the constant and variable threshold model. The adjustment outside the band formed by the transaction costs band between the Southcentral and Southwest and Northwest regions is the fastest at both in the constant threshold estimation (0.65 and 0.62) and variable threshold estimation (0.67 and 0.63), while the adjustment between the Southcentral and Northeast is the slowest at 0.39 (0.30). This result coincides with expectation that shorter distances yield faster adjustment to market forces (indicating more transparent or

[9] Half life is the time required to eliminate half of the deviation from price parity due to a shock. The half life for an estimated adjustment coefficient $\tilde{\alpha}$ is $h = \frac{\ln(0.5)}{\ln(1+\tilde{\alpha})}$.

easy to access market information to adjust supply for each markets). Variable threshold models indicate smaller half-lives in most market pairs. This is consistent with the result given in Bekkerman, Goodwin, and Piggott (2009).

Table 3.14 Half-Life Estimation

Market Pair	**TAR with Constant Threshold**		**TAR with Variable Threshold**	
	Halflife	**Adjustment Speed**	**Halflife**	**Adjustment Speed**
Southcentral-Midwest	0.95	-0.52***	0.84	-0.56***
Southcentral-Northeast	1.40	-0.39***	1.92	-0.30***
Southcentral-Northwest	0.72	-0.62***	0.70	-0.63***
Southcentral-Southeast	0.92	-0.53***	0.78	-0.59***
Southcentral-Southwest	0.66	-0.65***	0.63	-0.67***

For the constant threshold estimation, the half lives for the Southcentral-Southwest and Southcentral-Northwest market pairs are smaller than for other market pairs. The estimation indicates that after about 0.70 weeks (so approximately 5 days or a typical work week) the deviations in these two market pairs become 50 percent smaller. The estimate for the Southcentral-Northeast indicates the longest half life of about 1.40 (1.80) weeks over 10 days. This result coincides with the estimation of adjustment speed, and is as expected, the wider neutral band indicates the presence of less market interaction and longer distances which thereby implies slower adjustment times. Comparing the two models, the half lives estimated with a constant threshold are longer than the estimates with a variable threshold.

3.3.2.2 Shipping Point Prices

3.3.2.2.1 ADF Test

Figure 3.1 shows that the shipping point price series are not likely to be stationary. The figure suggests structure breaks in the series. The ADF test confirmed that all price series were non-stationary. Thus, Chow tests were used to examine structure breaks.

The Chow test confirmed structural breaks in the first week of harvest season at each shipping point. After removing the structural breaks, all price series became stationary. The details of the ADF tests on these series before and after removing the structural breaks are summarized in Table 3.15.

Table 3.15. Augmented Dickey-Fuller Unit Root Tests of Shipping Point Prices

Prices	ADF Test Statistic (Level)		ADF Test Statistic (Level, Remove Structural Breaks)	
	Lag Length	t-statistic	Lag Length	t-statistic
Appalachian District	0	-2.17	0	-5.14***
Michigan	0	-1.82	0	-5.52***
Hudson Valley-NY	0	-1.48	0	-5.31***
Yakima Valley & Wenatchee District-WA	0	-2.16	0	-3.06 **

Note:

1. ***denotes statistical significance at 1% level.
   ** denotes statistical significance at 5% level.
   * denotes statistical significance at 10% level.
2. The null and the alternative hypotheses are, series is non-stationary and series is stationary, respectively.
3. As the coefficient has a non-standard distribution, it is compared with the critical values tabulated by Mackinnon (1996).
4. The lag lengths were selected based on the Schwarz Information Criterion (SIC).
5. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

3.3.2.2.2 VAR Model Estimation

Given these time series properties, a VAR model in levels, after removing structural breaks, was estimated (Table 3.16) for each market. As expected, the one-period, lagged own price in all shipping point price equations was positive and statistically significant except in the Hudson

Valley, New York. The two-period, lagged own prices in all shipping points except Michigan were positive and statistically significant. A one percent increase in last week's price led to a 1.81, 0.66, and 0.52 percent increase in the contemporaneous price for the Appalachian District, Michigan, and Yakima Valley and Wenatchee District, Washington prices, respectively. All shipping point prices except the Yakima Valley and Wenatchee District in Washington price were sensitive to all other prices. The Appalachian District price and Yakima Valley and Wenatchee District, Washington price both have significant influences on all other market prices.

Table 3.16 Vector Autoregression Estimates for U.S. Shipping Points

Shipping Point	**Variable**	**Dependent Variable: Natural Logarithm of Prices**			
		Appalachian (P_{APt})	**Michigan** (P_{MICHt})	**Hudson-NY** (P_{NYt})	**YV&WD-WA** (P_{WAt})
	Intercept	-0.01 (-0.21)	-0.01 (-0.17)	-0.01 (-0.15)	-0.07*** (-2.45)
Appalachian	P_{Apt-1}	1.81*** (4.41)	0.78** (1.70)	0.87** (2.11)	0.58*** (2.33)
	P_{Apt-2}	-1.08*** (-2.69)	-0.98** (-2.18)	-1.02*** (-2.53)	-0.46** (-1.88)
Michigan	$P_{MICHt-1}$	-0.42 (-1.11)	0.66* (1.55)	-0.43 (-1.12)	-0.20 (-0.85)
	$P_{MICHt-2}$	0.55* (1.46)	0.38 (0.90)	0.52* (1.37)	0.18 (0.76)
Hudson-NY	P_{NYt-1}	-1.02*** (-2.35)	-1.17*** (-2.40)	-0.06 (-0.13)	-0.20 (-0.75)
	P_{NYt-2}	0.62* (1.39)	0.76* (1.51)	0.64* (1.43)	0.30 (1.10)
YV&WD-WA	P_{WAt-1}	0.02 (0.10)	0.03 (0.16)	0.02 (0.11)	0.52*** (5.18)
	P_{WAt-2}	0.40*** (2.63)	0.41*** (2.44)	0.34** (2.22)	0.20** (2.11)
R^2		0.62	0.56	0.58	0.81

Note:

1. t-statistics are in parentheses.
2. ***denotes statistical significance at 1% level.
   ** denotes statistical significance at 5% level.
   * denotes statistical significance at 10% level.
3. Critical value at the 1% level is 2.326, at the 5% level is 1.645, and at the 10% level is 1.282.
4. The lag lengths (2) were selected based on Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and Hannan-Quinn Information Criterion (HQ).
5. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

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These results suggest that the Appalachian District and Yakima Valley and Wenatchee District in Washington play a significant role in the price formation process of other markets. The results of the goodness of fit for the Appalachian District, Michigan, Hudson Valley, and Yakima Valley and Wenatchee District models are R^2 values of 0.62, 0.56, 0.58, and 0.81, respectively.

3.3.2.2.3 Granger Causality Test

The results of the Granger Causality tests are presented in Table 3.17. All F-statistics for the causality tests of the Yakima Valley and Wenatchee District on other shipping points were statistically significant. The null hypothesis of no Granger causality is rejected. This indicates that the Yakima Valley and Wenatchee District in Washington, a dominant market for the largest volumes of U.S. fresh apples, is significantly affecting the price formation process of all other shipping points. In contrast, the changes in other markets only affected two markets.

According to the results of the Granger Causality test, there is bilateral causality between the Appalachian shipping point and New York, between Appalachian and the Yakima Valley and Wenatchee District in Washington, between the Michigan and Washington shipping points, and between New York and the Yakima Valley and Wenatchee District, Washington shipping points. This suggests that there is no clear market leader in the price formation between these markets. There are unidirectional causalities between the Appalachian District and Michigan (Michigan→Appalachian District). This result indicates that Michigan always acts as a market leader in the price formation, while the Appalachian District always acts as a market follower. There is no causality between the Michigan (shipping) and New York (shipping) marketing points. Overall, the Yakima Valley and Wenatchee District in Washington seems to be the dominant player in the price formation process for all other shipping points, which is unsurprising given their dominant market share in the U.S.

Table 3.17 Testing for Granger Causality between Shipping Point Prices

Series and Causal Direction			F tests	Result
Appalachian	→	Michigan	0.41 (0.66)	**NC**
Appalachian	→	Hudson Valley, NY	2.43 (0.09)	**C**
Appalachian	→	YV & WD, WA	4.21 (0.02)	**C**
Michigan	→	Appalachian	4.01 (0.02)	**C**
Michigan	→	Hudson Valley, NY	0.01 (0.99)	**NC**
Michigan	→	YV & WD, WA	2.90 (0.06)	**C**
Hudson Valley, NY	→	Appalachian	6.92 (0.00)	**C**
Hudson Valley, NY	→	Michigan	1.55 (0.21)	**NC**
Hudson Valley, NY	→	YV & WD, WA	3.25 (0.04)	**C**
YV & WD, WA	→	Appalachian	4.24 (0.02)	**C**
YV & WD, WA	→	Michigan	2.44 (0.09)	**C**
YV & WD, WA	→	Hudson Valley, NY	4.21 (0.02)	**C**

Note:
2. C denotes Granger cause, NC denotes not Granger cause
2. The lags of the dependent variable used to obtain white-noise residuals are determined using the Schwarz Information Criterion (SIC). Two lags are selected.
3. The numbers inside the parenthesis show the p-values for F-statistics.
4. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

3.3.2.2.4 The Threshold Autoregressive Regression Model

3.3.2.2.4.1 Market Pairs

The Yakima Valley and Wenatchee District in Washington is the shipping point that is selected as the reference location based on the previous research on price relationships among shipping points. The summary statistics for each price pair are shown in table 3.18. As expected, the price difference between the Yakima Valley and Wenatchee District in Washington and Michigan is the smallest while the price difference between the Yakima Valley and Wenatchee District in Washington and Hudson Valley in New York is the largest. This result indicates that the price difference between markets increases as the distance increases.

Table 3.18 Summary Statistics of Price Pairs

Market Location	Obs. (week)	Mean ($/lb)	Median ($/lb)	Std. Dev. ($/lb)	Max. ($/lb)	Min. ($/lb)
Appalachian-Washington	147	0.09	0.08	0.07	0.27	0.09
Michigan-Washington	147	0.06	0.09	0.12	0.31	0.24
New York-Washington	147	0.12	0.12	0.08	0.38	0.06

Note:
1. All prices are logged and then differenced.
2. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Figure 3.10 presents monthly shipping point price pairs. Generally, the price difference between the Yakima Valley and Wenatchee District in Washington and Michigan is the smallest while the price difference between the Yakima Valley and Wenatchee District in Washington and Hudson Valley in New York is the largest. The figure suggests seasonality in the price differences. The price differences during the harvest season when local produce sources are available and less intra-region trade takes place were relatively larger than other periods. This is as expected because more areas have sufficient supplies to meet both local demand and demand of other areas, thus, the interaction between markets are less than other periods.

The results of the augmented Dickey-Fuller unit-root test for all market pairs are shown in table 3.19. All price differences are confirmed to be stationary. Ordinary least squares estimation of the cointegrating relationship between prices, following Engle and Granger (1987), is conducted and the results are presented in table 3.20. The results suggest that the price in the Yakima Valley and Wenatchee District in Washington shipping point is cointegrated with the prices in all other shipping points.

Table 3.19 Augmented Dickey-Fuller Unit-root Tests for Price Pairs

Market Location	Lag	p-value	t-value
Appalachian-Washington	0	0.0016	-4.04
Michigan-Washington	0	0.0158	-3.32
New York-Washington	0	0.0044	-3.74

Note:

1. The lag lengths are selected based on Schwarz Information Criterion (SIC).
2. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

Table 3.20 OLS estimation of the Cointegrating Relationship

Market Location	C	β	ADF Test on Residuals	
			Lag	t-value
Washington→ Appalachian	0.05 (0.04)	0.92 (0.06)	1	-6.37***
Washington← Appalachian	-0.28 (0.03)	0.67 (0.04)	1	-5.13***
Washington→ Michigan	-0.06 (0.05)	0.79 (0.08)	1	-5.04***
Washington← Michigan	-0.34 (0.03)	0.55 (0.05)	1	-3.94***
Washington→ New York	0.04 (0.04)	0.86 (0.06)	1	-6.11***
Washington← New York	-0.29 (0.03)	0.70 (0.05)	1	-4.98***

Note:

1. The estimation is conducted following the equation: $P_t^i = C + \beta P_t^j$.
2. The numbers in parentheses are standard errors.
3. ***indicates significance at the 1% level,
   **indicates significance at the 5% level,
   *indicates significance at the 10% level.
4. The lag lengths are selected based on the Schwarz Information Criterion (SIC).
5. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics..

3.3.2.2.4.2 TAR Model Specification

All specifications and estimation of the TAR model for shipping points are the same as the TAR model for retail markets except for the price series used and the estimation of market-specific thresholds. In the TAR model of shipping points, P_t^i and P_t^j are prices for a homogenous product in two separate shipping points. P_t^i is the fresh Red Delicious apple price in the Yakima Valley and Wenatchee District, Washington shipping point, and P_t^j is the price in one of the other shipping points (Appalachian District, Michigan, and Hudson Valley in New York shipping points).

The variable thresholds are allowed to vary according to truck rates and seasonality. This can be illustrated as follows:

(27) $c = \beta_0 + \beta_1 TR_t + \beta_2 S_{1t}$

where TR_t is the estimated transportation cost between shipping points in dollars per pound apples per mile. The truck rate of shipping apples from one shipping point to another shipping point ($/pound apples/mile) is used to represent the transportation costs. S_t is a seasonal dummy variable. Based on the price dynamics and records of movement, one year is divided into two seasons, S_{1t}=1 if it is from September to December, the harvest season, 0 is all other months of the year. S_{2t}=1 if it is from January to April, 0 is all other months of the year. Season two is selected as the based season in this study. This is different from the specification for retail markets because the retail price series and diesel prices are available year round, while truck rates and shipping points are only available for the U.S. in-season. Thus, the third season (off season) is deleted here. Although the influence of imports into the market is likely to affect the overall dynamics of the market, it is beyond the scope of this study and a topic for future research. It is likely that those imports are the sole competitive supply against CA apples from the Washington shipping point during the off-season which is left out of this analysis.

Altogether, 147 observations were matched by date for the shipping point pairs and truck rates for both the constant threshold model and the variable threshold model. The estimates of the threshold band are shown in table 3.21.

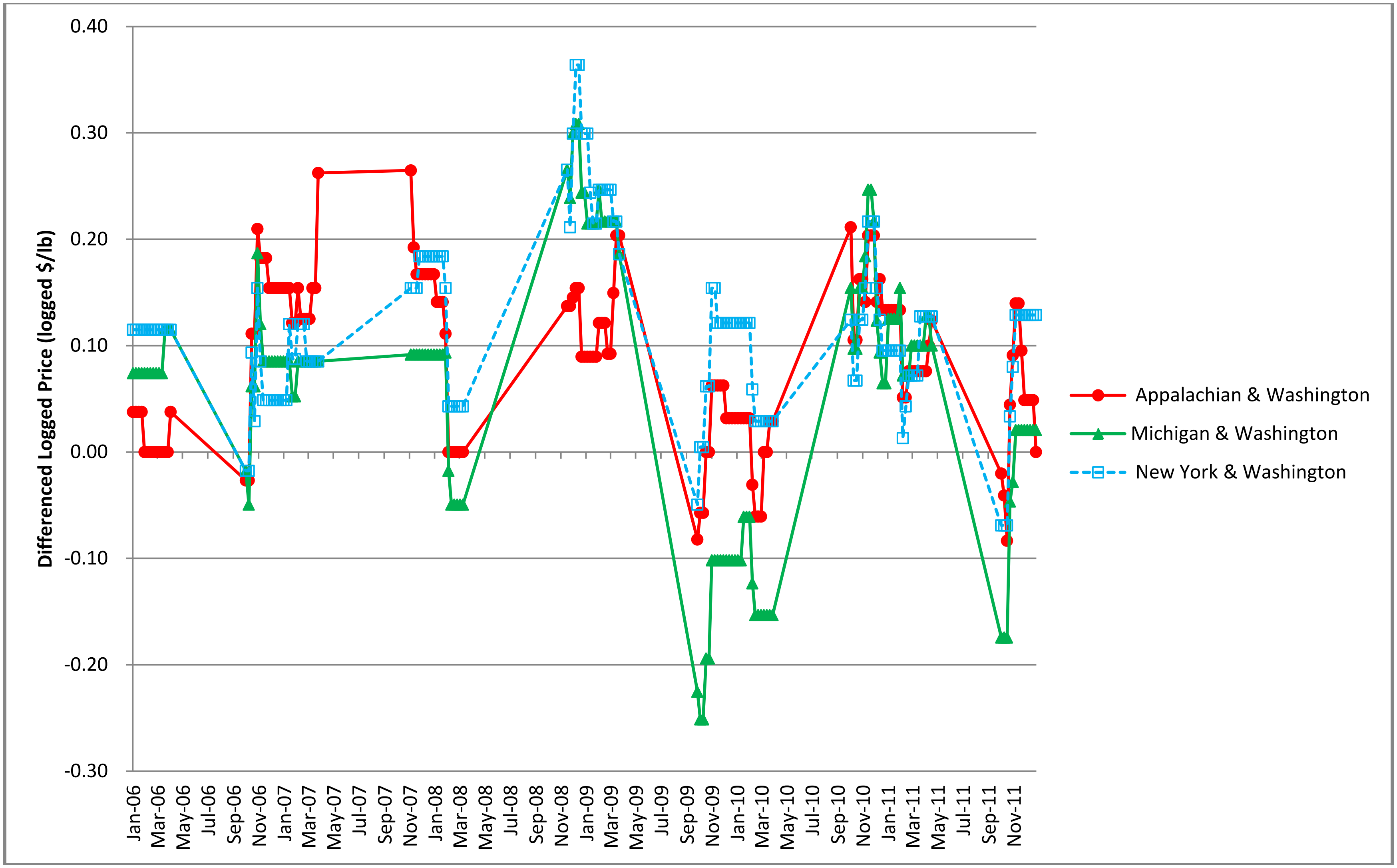

Figure 3.10 Fresh Red Delicious Apple: Monthly Shipping Point Price Pairs

3. Note: All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

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Table 3.21 Threshold Band Parameter Estimates ($c = (P_t^i - P_t^j)/P_t^j$)

Market Pair	Constant Threshold	Symmetric Variable Threshold		
		$c_t = \beta_0 + \beta_1 TR_t + \beta_2 S_{1t}$		
	c	β_0	β_1	β_2
Appalachian- Washington	0.14	-0.66***	1.53***	0.98***
Michigan- Washington	0.09	-0.37***	1.14***	1.04***
New York- Washington	0.09	-0.59***	1.39***	1.01***

Note:

1. ***indicates significance at the 1% level
   **indicates significance at the 5% level
   *indicates significance at the 10% level

2. c is the threshold and β_i are parameters of variables.

4. 3. All prices have been deflated by the U.S. January 1998 Consumer Price Index (CPI), U.S. Bureau of Labor Statistics.

For TAR with a constant band, the neutral band between Washington and Michigan and New York (9%) are relative lower than the band between the Washington and Appalachian (14%) markets. This result is as expected given the greater distance between markets, since the wider neutral bands indicate larger transaction costs.

For the TAR with symmetric variable band which assumes same transaction costs regardless the direction of trade between two markets, the results are similar to those reported for the retail markets; diesel prices have significant positive effects on the threshold for all market pairs. The result suggests that higher truck rates imply a wider neutral band between shipping points. This is as expected because higher transportation costs usually lead to increase in prices. The seasonality components have a significant positive effect on the threshold which suggests a wider band in harvest season than other months. Overall, the threshold bands estimated for the shipping points are larger than the estimates for retail markets. This is as expected because the market information at the retail level is more readily available and may be more efficient because it is coordinated through a relatively small number of players[10]. All of these factors serve to increase market integration and reduce price deviations from the competitive market expectations.

Figure 3.11a-3.11c shows the threshold bands estimated by the constant and symmetric variable TAR models. The symmetric variable thresholds are wider and concentrated around the constant thresholds. This coincides with the results for retail markets. What does differ from the results for retail markets is that in most cases, the thresholds were wider in the harvest season when local produce sources are available and less intra-region trading takes place. This is as expected because more areas have sufficient supplies to meet both local demand and demand of other areas, thus, the number of factors influencing whether apples will be shipped to shipping points during the harvest season is greater and will lead to a broader range of possible thresholds. As was the case for retail markets, the estimates imply that the variable threshold model yields a wider threshold than the constant threshold model.

Table 3.22 shows the probability of observations located outside and inside the threshold band between shipping point pairs. As in the analysis for retail markets, three regimes are defined. A large shock to one market will trigger the spatial price difference to exceed the limits of the threshold band, then the supply for the shipping points with the higher price will increase until the price difference is no longer outside of the bounds of threshold. The market exhibits the nature of regimes 1 and 3. A small deviation in the price difference will not trigger price adjustments between shipping points, thereby signifying an equilibrium as is the case when a market is in regime 2.

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[10] According to USDA, ERS estimation, top 8 largest food retailers amounted to 49.6 percent of U.S. grocery store sales in 2009. Although the market share decreased slightly from 2008 (50.8%), there is a long term increasing consolidation trend of sales by largest retailers.

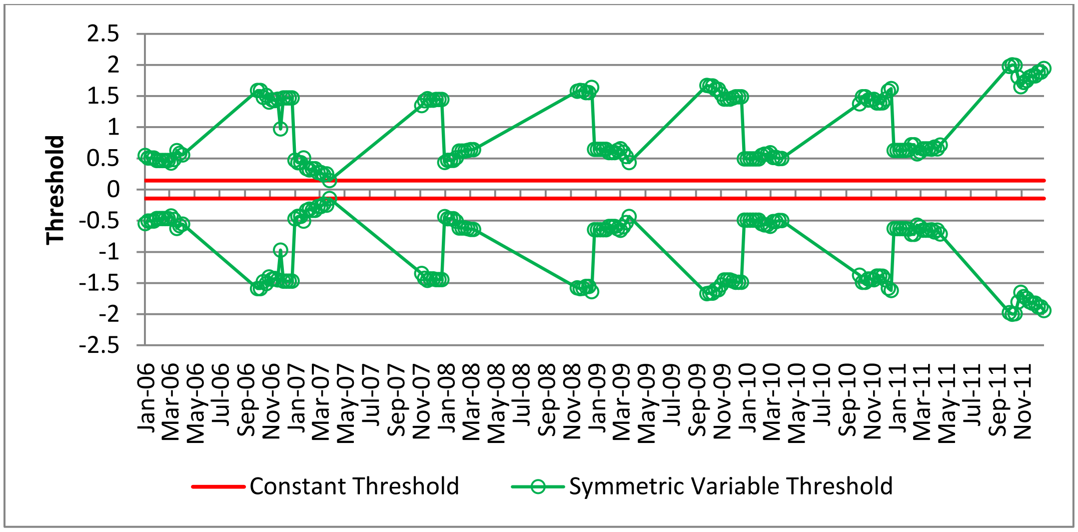

Figure 3.11a Threshold Model Estimation—Washington & Appalachian

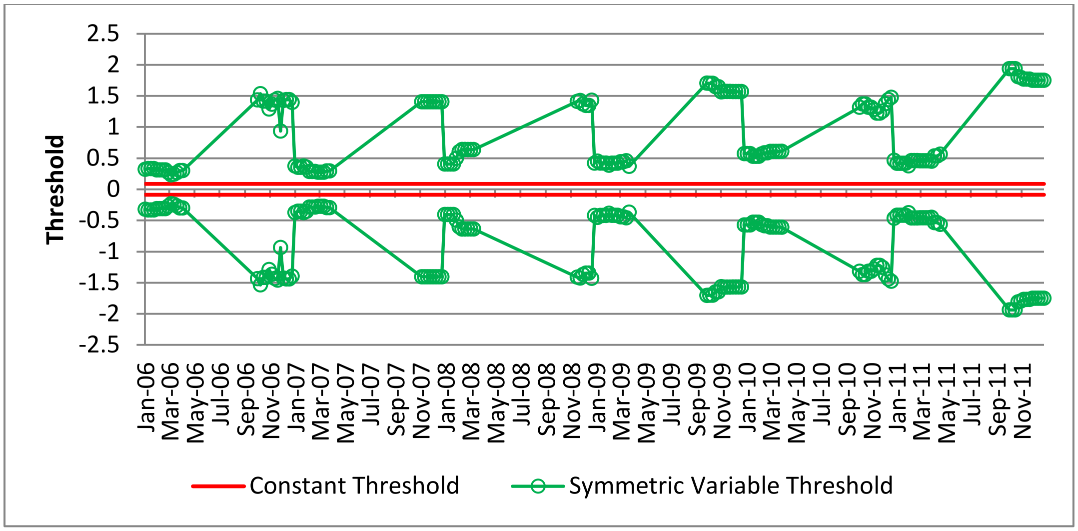

Figure 3.11b Threshold Model Estimation—Washington & Michigan

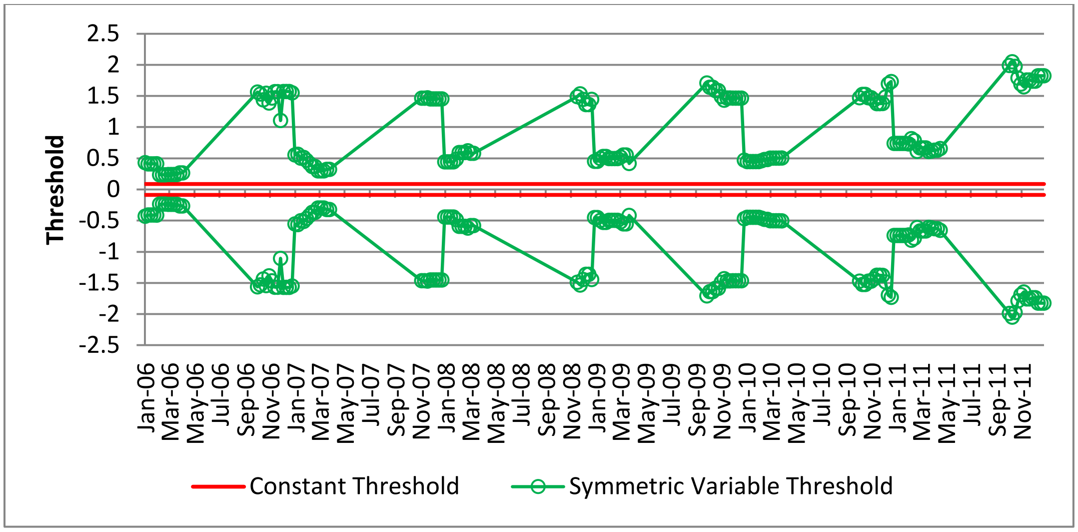

Figure 3.11c Threshold Model Estimation—Washington & New York

Table 3.22 Markets outside and inside Bands

Model	**Market Pair**	**Regime1 ($P_{washington} < P_{other}$, trigger equilibrium conditions, suppliers increase supply for other shipping points)**	**Regime2 (equilibrium)**	**Regime3 ($P_{washington} > P_{other}$, trigger equilibrium conditions, suppliers increase supply for Washington)**
Constant Band TAR	Appalachian-Washington	30 (20.55%)	116 (79.45%)	0
	Michigan-Washington	61 (41.78%)	69 (47.26%)	16 (10.96%)
	New York-Washington	89 (60.96%)	57 (39.04%)	0
Variable band TAR	Appalachian-Washington	146 (100%)	0	0
	Michigan-Washington	146 (100%)	0	0
	New York-Washington	146 (100%)	0	0

In the constant threshold estimation, the probability of lying in each regime varies across shipping point pairs. For the market pair of Appalachian-Washington and New York-Washington, due to the dominance of Washington in Red Delicious apple production, there is no observation that lies in regime 3. The market is in equilibrium most of the time. There is 50-50 split of regime 1 and 2 for those participating in the Michigan-Washington markets. Overall, there is little probability of increasing supplies to the Washington shipping point. However, in symmetric variable estimation, all observations lie in regime 1, which indicates potential shifts of supply from Washington to other shipping points.

The comparison of the results of the two models indicates that there will be more supply adjustment toward other shipping points due to the dominance of Washington in Red Delicious apple production if the threshold band is allowed to vary with transportation costs and seasonality. As the analysis for retail markets, the comparison of figure 3.10 and 3.11 suggests that the price difference and threshold band in harvest season are higher than in other months which suggest less market linkage. This indicates that the flexibility of threshold induces a similar pattern in price difference and threshold band which will bring more trade opportunities. This may suggest the Washington supply points are vulnerable to increasing energy costs, which is a tenet of the relocalization campaigns some markets are experiencing.

Table 3.23 shows the estimated adjustment speed and half-lives. The estimates of fastest adjustment speed and shortest half-life using the constant and variable threshold model are different. The adjustment outside the band formed by the transaction costs band for the Appalachian-Washington market pair is the fastest in the constant threshold estimation (0.15), while the adjustment for the Michigan-Washington market pair is the fastest in the variable threshold estimation (0.12). However, the adjustment between New York and Washington is the slowest in both estimations (0.07 and 0.05, respectively). This result indicates that shorter distance yields faster adjustment, as was the case for retail markets. Contrary to the results for retail markets and the Bekkerman, Goodwin, and Piggott (2009)'s results, variable threshold models indicate larger half-lives in all market pairs. This may be related to the specific supply seasonality and unique role of local produce suppliers in shipping points compared with retail markets.

Table 3.23 Half Life Estimation

Market Pair	TAR with Constant Threshold		TAR with Variable Threshold	
	Halflife	Adjustment Speed	Halflife	Adjustment Speed
Appalachian-Washington	4.39	-0.15***	7.48	-0.09***
Michigan-Washington	4.88	-0.13***	5.58	-0.12***
New York-Washington	9.65	-0.07***	12.40	-0.05***

For the constant threshold estimation, the half life for the Appalachian-Washington market pair is shorter than for other market pairs. The estimation indicates that, after about 4 weeks, the deviations in this market pair becomes 50 percent smaller. For the symmetric variable threshold estimation, the half life for the Michigan-Washington pair is the shortest. This is as expected because a wider neutral band indicates less market interaction and a longer distance implies slower adjustment. The estimate for the New York-Washington pair indicates the longest half life in both estimations (9.65 and 12.40, respectively). Comparing the two models, the half lives estimated with a constant threshold are shorter than the estimates with a variable threshold. The half-lives for shipping points are longer than the results for retail markets for the same reason as analyzed above.

3.4 Conclusion

This chapter conducted market structure and price relationship analysis at different market levels. Cointegration analysis and Granger causality tests are employed to examine spatial price relationships at retail market and shipping point levels. The results showed that the Southwest and Northeast retail markets dominated national markets and the Northwest retail market dominated western markets in terms of its influence on retail prices, and the Yakima Valley and Wenatchee District in Washington significantly affected the price formation process of all other shipping points.

Despite the similar patterns shown in shipping points and retail markets, a symmetric variable TAR model is conducted to examine how prices at different market levels are affected by different market forces such as truck rates and time in season. Truck rates and seasonality are confirmed to have significantly impact on the threshold band of each market pair. In addition, a constant TAR model is estimated to compare to the symmetric variable TAR model to show how our understanding of market relationships may vary based on the methods used to analyze the price behavior. Symmetric variable TAR model is suggested to have a better representation of the price behavior. In addition, the estimation of market structure, price relationship, and transaction costs at different market levels will inform subsequent welfare analysis about the changes in market structure, which will be shown in chapter 4.

CHAPTER 4 MARKET DYNAMIC AND PERFORMANCE

4.1 Introduction

There is growing public interest in local foods as a result of interest in and expectations that connecting stakeholders in a more localized food systems may have positive environmental outcomes, enhance some elements of food-security, address sentiments that there is too much corporate control of the food system, and support more locally appropriate economic development strategies (Martinez et al., 2010). In 2011, the local foods movement was ranked as a top story by several relevant media outlets including *the Packer* and The National Restaurant Association's annual *What's Hot* list. Subsequently, there are an increasing array of activities targeted to support the development of local food systems, including federal and community-based policies and programs. These include the USDA's Know your Farmer, Know your Food Programs, Farmers' Market Promotion Program, locally focused Value Added Development grants, as well as consumer education, relocalization efforts, and promotional marketing programs (e.g. Be Californian, From the Heart of Washington, Colorado Proud, New Jersey Fresh, Pride of New York, and South Carolina locally grown campaign) to influence buyers about some potential benefits of local foods.

Within markets, the interest and promotion surrounding local foods has significantly increased the demand for local produce (Adelaja, Brumfield, and Lininger, 1990; Carpio and Isengildina-Massa, 2010; Costanigro, Kroll, and Thilmany, 2011). The structure of markets has also been affected, as demand has stimulated a proliferation of localized, direct marketing supply chains linking growers directly to consumers, such as farmers' markets and community supported agriculture organizations (CSAs), farm stands and on-farm sales.

According to the 2007 Census of Agriculture, direct sales of agricultural products amounted to $1.2 billion in 2007, a 117.79% increase in sales from 1997, but still only 0.4% of total agricultural sales. This small market size may be one of the primary reasons that local foods did not integrate well into traditional food retail channels, and instead, grew through sales in scale-appropriate farmers' market channels. Subsequently, the number of farmers' market went up to 6248 in 2010, representing a 126.71% increase from 1998 (AMS, USDA). The number of community supported agriculture organizations (CSAs) increased 186% from 2001 to 2005 and the number of farm to school programs that used local farms supplies increased 423.75% from 2004 to 2009 (Martinez et al., 2010). Additionally, large grocery stores like Wal-Mart and Meijer are increasingly committing to buy more directly from growers (Riemenschneider, 2009; Blythe, 2010; Galbraith, 2011). There is great interest in what the 2012 Ag Census will show in terms of sales growth and number of producers using more direct marketing channels.

One driving motivation for the locally-focused policies and programs relates to potential gains to farmers, consumers and local markets from having more food choices available. However, there are few true examinations focused on how a restructured food sector may perform or affect the welfare of consumers and producers. This study contributes to the literature by filling this gap with analysis of one fresh produce category in a localized market, apples in Colorado. Apples are an interesting and generalizable case though, as it is one produce category where some supplies still remain in most U.S. states, but generally, with reduced production volume since most areas did not fare well in the face of competition from global trade partners and dominant U.S. production areas in the late 1990's. Moreover, apples are not highly perishable, so that the local harvest can be stretched across a longer season with some post-harvest handling, but supply response is constrained by the long lead time for apple orchard establishment. Each of these characteristics makes this a particularly interesting case with which to explore the market dynamics.

Although there is no legal or unanimous definition of local food, a geographical definition about the distance between food producers and consumers is popularly used. Besides the definition on exact distance between production area and consumption area, such as 100 miles used by the New Oxford American Dictionary (NOAD) and 400 miles used by the 2008 USDA Farm Bill, state branded products are also used as a proxy for local food (Martinez et al., 2010). In this study, we use the state branded definition of local produce, specifically apples produced in Colorado, to evaluate the welfare effects of Colorado local promotion programs.

The structural and performance dynamics of fresh apple markets is investigated, while accounting for both demand and supply shocks (assumed to be zero at this stage) due to the introduction of local labeling using an equilibrium displacement model (EDM). This study contributes to the literature by assessing the overall impact of local labeling on fresh apple markets (using consumer valuations from a 2008 nationwide consumer study conducted by CSU) while considering the market-wide reactions in both the short- and long-run. The most important innovation and contribution is the segmentation of marketing channels on the supply side to include direct, short supply chains, in addition to the more conventional grower-shipping point-terminal market-retail chain, which allows one to determine how more localized systems influence the dynamics of apple marketing and evaluate the performance of apple markets in the face of increasing consumer demand.

The results from this study will provide insights on how strong consumer responses to local produce offerings (albeit among a relatively small set of buyers) may affect market dynamics. By allowing for segregated markets, akin to what occurs more formally with organic produce, this conceptual framework provides a method to analyze welfare effects or conduct other policy analysis within a more differentiated food system.

4.2 Economic Model

A number of assumptions are made in order to implement the conceptual model, econometric and empirical models:

1. The U.S. apple industry is considered to be perfectly competitive. The Colorado sector is a small player and has no market power in the apple market.
2. Colorado consumers and suppliers of apples are assumed to be risk neutral such that the risk associated with the consumption of differentiable apples and risk with the supply through different marketing channels is not an issue. The objective of consumers is to maximize their expected utility and the objective of suppliers is to maximize their expected profit.
3. Domestic apple prices are assumed to be lower than Colorado prices (assuming comparative advantages for larger production regions); thus, trade will take place.
4. Colorado is assumed to be both a potential importer and exporter of apples. But, since Colorado cannot currently meet its own demand, it will likely import apples. Based on the estimation of Colorado consumption of local apples, most of Colorado produced apples are marketed out of Colorado. But, we assume all locally labeled apples are consumed in Colorado, where such designation would be most valued.
5. The effects of the local marketing initiatives are assumed to be concentrated in Colorado.
6. The price of domestic apples is assumed to be the same across the other states of the U.S.
7. Colorado apples and domestic apples are weakly separable. Apples marketed through different market channels are weakly separable. Based on these assumptions, the decomposed

demand and supply elasticities can be estimated as functions of fundamental demand and supply parameters.

8. Technology and other factors are assumed to be constant such that only the effects of local marketing initiatives bring demand and supply shocks. It should be noted that the effects of local marketing initiatives could also be integrated with extra costs in the supply functions, but since the primary data used here is an analysis of consumer willingness to pay and the costs associated with local labeling efforts is not available, only the shocks on the demand side are taken into consideration but that approach is consistent with the empirical question on the impacts of increased promotional and marketing programs.

4.2.1 The Structural Economic Model

4.2.1.1 Determination of Prices in Colorado (no trade)

As in figure 4.1, the current equilibrium market price of fresh apples in Colorado (P_A^l) is significantly higher than that of the rest of the country (P_B^d) due to comparative advantage for larger production regions. The local price under autarky (P_A^l) is determined by the intersection of local supply (S_A) and local demand curves (D_A), where S_A=D_A=Q_A^l. The local demand curve represents consumers' willingness to pay for local apples. The apple price under autarky (P_B^d) in other states is given by the intersection of the demand curve (D_B) and supply curve (S_B) in other states, where S_B=D_B=Q_B^d. The national domestic price (P_d) is given by the intersection of the Colorado excess demand curve (ED_A) and the excess supply curve of the rest of the country (ES_B) (D_A-S_A=S_B-D_B). The national domestic price (P_d) is lower than Colorado local price (P_A^l) and higher than price in other states (P_B^d). As price increases from P_B^d to P_d in other states, the supply in other states will increase from Q_B^d to Q_B^S, while the demand will decrease from Q_B^d to Q_B^D. This results in an excess supply of (Q_B^S- Q_B^D).

Taking into account transaction costs, the domestic apple price in Colorado is given by $P_A^d = P_d(1 + t_A^d)$, where t_A^d is the transaction cost ratio relating the rest of the U.S. to Colorado prices. With trade flows from the rest of the country to Colorado, local price will fall to $P_A^{l'}$=P_A^d assuming the local apple price and domestic apple price are the same. This results in local demand increasing from Q_A^l to Q_A^D, local supply decreasing from Q_A^l to Q_A^S, and creating Q_A^D- Q_A^S excess demand. Thus, Colorado will import Q_A^D- Q_A^S, and other states will export Q_B^S - Q_B^D. At market clearing conditions, imports will be equal to the exports, which means Q_A^D- Q_A^S= Q_B^S - Q_B^D. Colorado consumes Q_A^S local apples and Q_A^D- Q_A^S domestic apples.

4.2.1.2 Demand Shifts:

The availability of information regarding the origin of an apple's production was found to have a significant impact on consumers' willingness to pay (Onozaka, Nurse and Thilmany McFadden, 2010). Their work suggests that increased local labeling will shift the local apple demand curve right from D_A to $D_A^{'}$. The local price under autarky increases from P_A^l to $P_A^{l'}$ which is determined by the intersection of unchanged local supply (S_A) and new demand curve ($D_A^{'}$). In response, the demand for local apples will increase from Q_A^l to $Q_A^{l'}$. The shift in the demand curve in Colorado will increase excess demand in the whole economy, which will shift the excess demand curve right from ED_A to $ED_A^{'}$. As we assume technology, costs and all other factors are constant, the supply curves (S_A, S_B, ES_A) do not change. The new domestic price $P_d^{'}$ is given by the intersection of the new excess demand curve ($ED_A^{'}$) and original supply excess supply curve (ES_B) and is higher than the original domestic price P_d.

Since the effects of the local marketing initiatives are assumed to be concentrated in Colorado, the demand curve in other states (D_B) does not shift. As the national domestic price increases from P_d to $P_d^{'}$, excess supply in other states changes from Q_B^S - Q_B^D to $Q_B^{S'}$ - $Q_B^{D'}$.

Assuming a constant transaction cost ratio between Colorado and the rest of U.S., the absolute transaction costs will increase because $P_d^{'}$ is higher than P_d, which means $T_d = P_d * t_d < T_d = P_d{'} * t_d$. As a result, the domestic apple price in Colorado will increase from P_A^d to $P_A^{d'}$. The price relationship is: $P_A^d = P_d * (1 + t_d)$, $P_A^{d'} = P_d{'} * (1 + t_d)$, $P_A^{d'} - P_A^d$=$(P_d^{'} - P_d) * (1 + t_d)$. As trade flows from the rest of the country to Colorado, local price will fall from $P_A^{l'}$ and arrive at $P_A^{l'} = P_A^{d'}$. In response, the total supply in Colorado will increase from Q_A^S to $Q_A^{S'}$ and the total demand will increase from Q_A^D to $Q_A^{D'}$. Excess demand in Colorado will change from Q_A^D- Q_A^S to $Q_A^{D'}$- $Q_A^{S'}$. As a result, imports will change from IM= Q_A^D- Q_A^S to IM'= $Q_A^{D'}$- $Q_A^{S'}$. Thus, Colorado consumes $Q_A^{S'}$ local apples and $Q_A^{D'}$- $Q_A^{S'}$ domestic apples.

4.2.1.3 Welfare Analysis

The Colorado apple market is shown in Figure 4.2. We can analyze three cases:

First, local equilibrium: no trade, no shift. The Colorado apple market is an autarky. The equilibrium price and quantity is given as P_A^l and Q_A^l. In this market situation, the consumer surplus is given by A+B and producer surplus is given by C+D+E+N. Total welfare is A+B+C+D+E+N.

Second, trade equilibrium: trade, no shift. By allowing trade between Colorado and other states, a fall in the local market price (P_A^l) to the domestic apple price in Colorado (P_A^d) would occur and results in local demand increasing from Q_A^l to Q_A^D and local supply decreasing from Q_A^l to Q_A^S. This results in a higher level of consumer surplus as given by A+B+C+D+I+J+K+L+N+P and a reduced level of producer surplus to E. Total welfare is A+B+C+D+E+I+J+K+L+N+P. The net change in the total welfare is the change in producer surplus (negative) plus the change in consumer surplus (positive), given by I+J+K+L+P, which is known as the "gains from trade triangle" (Anderson and James, 1998).

Third, trade equilibrium with shift: trade, demand shift. The availability of information from local labels will increase consumers' willingness to pay for local apple which is represented in figure 4.2 as an upward shift in the demand curve from D_A to D_A'. The supply curve (S_A) intersects with the new domestic apple price in Colorado ($P_A^{d\prime}$)at a higher level. The local supply quantity increases from Q_A^S to $Q_A^{S\prime}$ and local demand increases from Q_A^D to $Q_A^{D\prime}$. Imports will change from Q_A^D- Q_A^S to $Q_A^{D\prime}$- $Q_A^{S\prime}$. In the long run, when producers can respond to the increase in demand by increasing quantity supplied, producer surplus is increased to D+E+N, and consumer surplus is changed to A+B+C+F+G+H+I+J+M. Total welfare is A+B+C+D+E+F+G+H+I+J+M+N. The net change in total welfare with respect to trade but no demand shift is F+G+H+M-K-L-P. In the short run, producers cannot react to an increase in demand. The increase in producer surplus only comes from the increase of price (from P_A^d to $P_A^{d\prime}$), which result in an increase of D. The consumer surplus changes in the same way as in long run. Total welfare is A+B+C+D+E+F+G+H+I+J+M. The net change in total welfare is F+G+H+M-K-L-N-P.

The details of welfare changes in three cases are shown in table 4.1. In this paper, we focus on the magnitude and conditions of future potential changes of welfare as the market dynamics may shift this state from the second to the third case.

4.2.2 The Equilibrium Displacement Model

Because most of the local promotion programs are supported by the government, if other changes such as costs and technology are neglected, the supply curve is kept unchanged. But the program will affect consumers' willingness to pay for promoted products, thus the demand curve will shift upwards and the initial equilibrium will be displaced by a new equilibrium. Thus, an equilibrium displacement model (EDM) based on the model developed by Carpio and

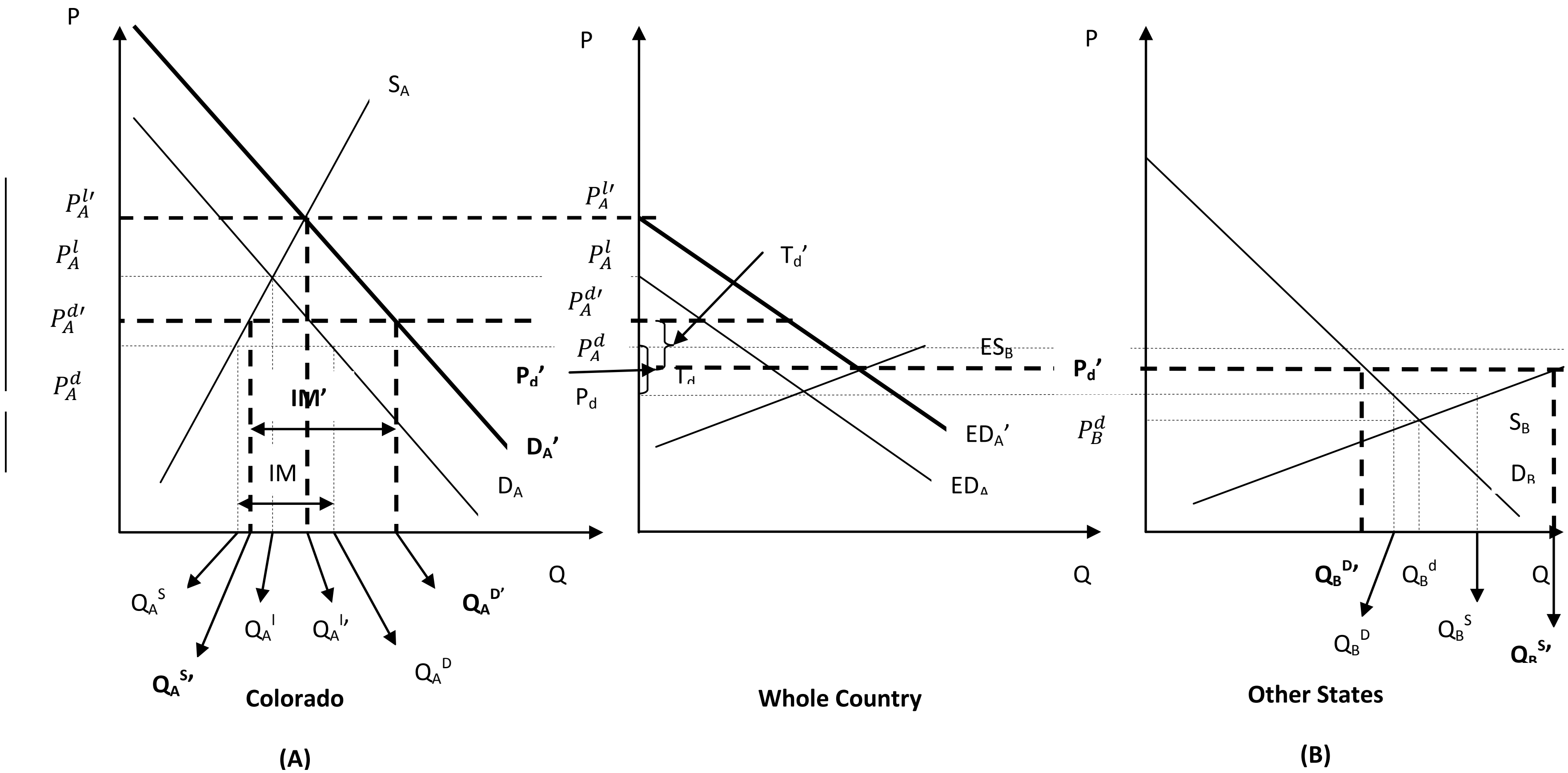

Figure 4.1 Apple Markets with Demand Shock

Table 4.1. Colorado Market Welfare Changes

Welfare	No Trade, No Shift	Trade, No Shift	Trade, Shift	Changes (Trade, Shift &Trade, No shift
Consumer Surplus	A+B	A+B+C+D+I+J+K+L+N+P	A+B+C+F+G+H+I+J+M	F+G+H+M-D-K-L
Producer Surplus (long run)	C+D+E+N	E	E+D+N	D+N
(short run)			E+D	D
Total Surplus (long run)	A+B+C+D+E+N	A+B+C+D+E+I+J+K+L+N+P	A+B+C+D+E+F+G+H+I+J+M+N	F+G+H+M-K-L-P
(short run)			A+B+C+D+E+F+G+H+I+J+M	F+G+H+M-K-L-N-P

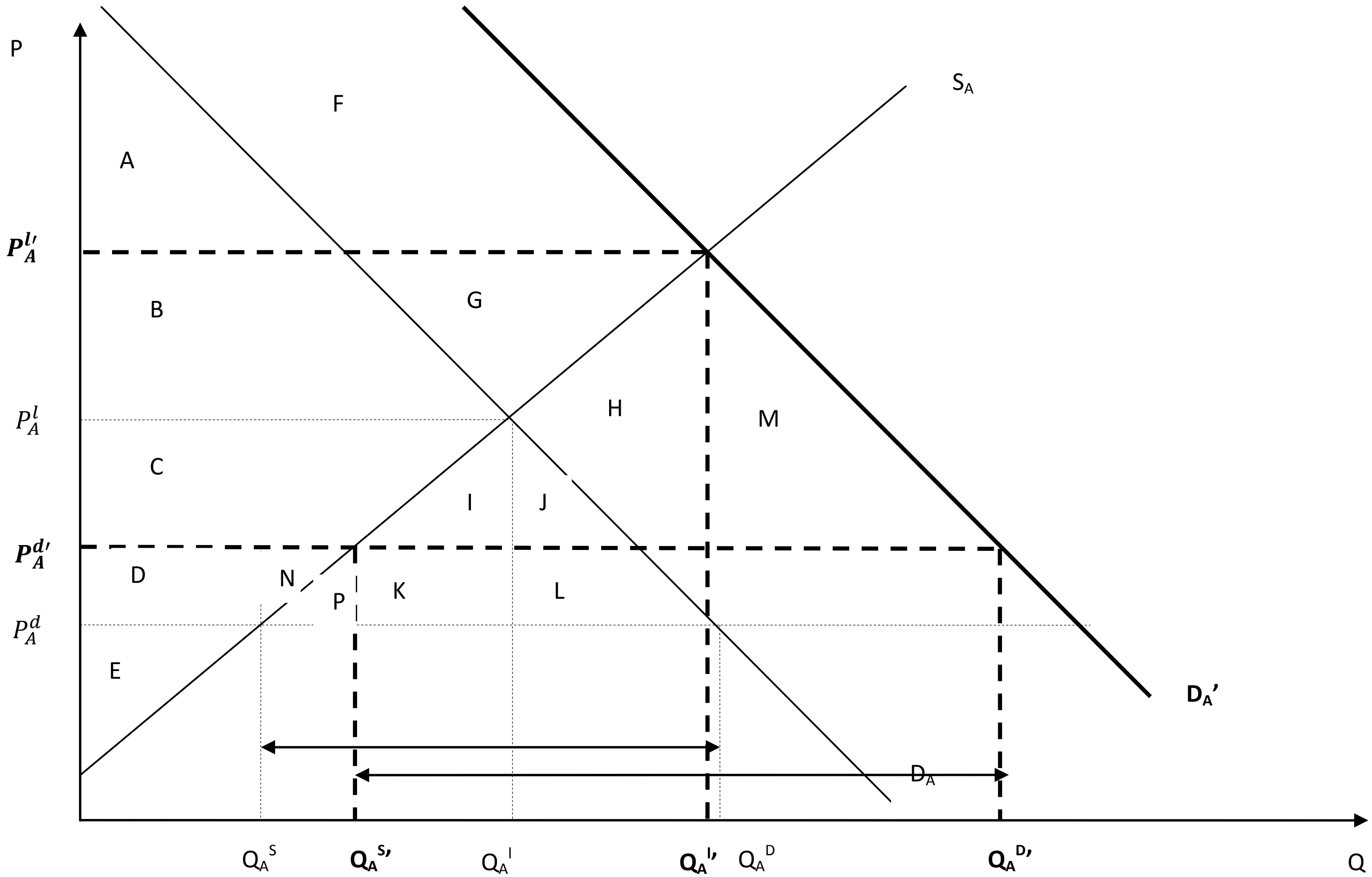

Figure 4.2 Colorado Apple Market Welfare Analysis

Isengildina-Massa (2010) to assess the welfare impact of a regional promotional campaign in South Carolina is used here. The new equilibrium is computed using parameters, such as shocks, weights, and demand and supply elasticities. The changes of equilibrium prices and quantities depend on the shift of the demand curves and the shapes of the demand and supply curves (elasticities).

The market in this study is separated into two regions: Colorado (Region A) and the rest of the United States (Region B), which has a supply and demand relationship with the Colorado apple sector. The two-region model can be described in the following structural model:

Region A (Colorado):

Demand:

(28) $$D_A^l = D_A^l(P_l, P_d, c_l)$$

(29) $$D_A^d = D_A^d(P_l, P_d, c_d)$$

Supply:

(30) $$S_A^l = S_A^l(P_l, P_d)$$

(31) $$S_A^d = S_A^d(P_l, P_d)$$

Region B (rest of the United States):

Demand:

(32) $$D_B^d = D_B^d(\, P_d)$$

Supply:

(33) $$S_B^d = S_B^d(P_d)$$

Market-Clearing Conditions:

(34) $$D_A^l = S_A^l$$

(35) $$D_A^d + D_B^d = S_A^d + S_B^d$$

D_i^k is the demand for *k* apple (*k* = *l*, *d*, where *l* denotes local product, *d* denotes domestic product) in region *i* (*i* = A (Colorado), B (rest of U.S.)). P_k is the price of product *k*, and c_l and c_d denotes the price difference related to assurances that consumers perceive through the local labeling efforts. It should be noted that this price differential could also be integrated with extra costs in the supply functions, but since the primary data used here is an analysis of consumer willingness to pay, this structure is more consistent with the empirical question. In equilibrium, local price (P_l) equals domestic price in region A (P_A^d in figure 4.4), which means P_l= P_A^d and is higher than the domestic price (P_d). The sum of demand for local apples and demand for domestic apples in region A will represent the aggregate demand for apples in region A, which is represented as Q_A^D (before shift) and $Q_A^{D\prime}$ (after shift) in figure 4.4.

S_i^k is the supply for apple *k* (*k* = *l*,*d*) in region *i* (*i* = A,B). The supply for local apples in region A moves along the supply curve S_A in figure 4.4. The supply for domestic apples is the imports in region A, which equals D_A -S_A in figure 4.4. In equilibrium, the supply for local apples is Q_A^S and for imports is Q_A^D-Q_A^S. All apples consumed in region B are taken as domestic apples, so k is set equal to d in region B.

In this study, it is assumed that all the effects of the local marketing initiatives are concentrated only in Colorado and locally labeled apples are only consumed in Colorado, which leads to the equation (34). However, the excess supply from Colorado can be sold in the domestic market as domestically produced apples. Also, in this model, we leave out imports from foreign countries, thus, the total domestic demand for fresh apples is assumed to be met by total domestic supplies (equation (34) + equation (35)). Totally differentiating equations (28)-(35) yields:

(28’) $dln(D_A^l) = \varepsilon_A^{ll} dln(P_l) + \varepsilon_A^{ld} dln(P_d) + \gamma$

(29’) $dln(D_A^d) = \varepsilon_A^{dl} dln(P_l) + \varepsilon_A^{dd} dln(P_d) - \frac{\omega_{AA}^{Dl}}{\omega_{AA}^{Dm}} \gamma$

(30’) $dln(S_A^l) = \beta_A^{ll} dln(P_l) + \beta_A^{ld} dln(P_d)$

(31’) $dln(S_A^d) = \beta_A^{dl} dln(P_l) + \beta_A^{dd} dln(P_d)$

(32’) $dln(D_B^d) = \varepsilon_B^{dd}\ dln(P_d)$

(33’) $dln(S_B^d) = \beta_B^{dd}\ dln(P_d)$

(34’) $dln(D_A^l) = \ dln(S_A^l)$

(35’) $\omega_{AT}^{Dd} dln(D_A^d) + \omega_{BT}^{Dd} dln(D_B^d) = \omega_{AT}^{Sd} dln(S_A^d) + \omega_{BT}^{Sd} dln(S_B^d)$

All the changes are in percentage terms (*dln*), γ denotes the demand shock related to assurances that consumers perceive through the local labeling efforts, ε_k^{ij} denotes the price elasticity between product *i* and product *j* in region *k*, and β_k^{ij} denotes the supply elasticity between product *i* and product *j* in region *k.* The demand and supply market shares are denoted as ω_{kh}^{Di} and ω_{kh}^{Si}, respectively, where *i* denotes either local (*l*) or domestic (*d*), and *k* denotes either regions A or B, and *h* represents the regions A, B, or the aggregate market (A+B) denoted as T. For example, ω_{AA}^{Dl}denotes the demand share of local product in region A within the regional market. The system of linear equations (1’)-(8’) can be written using matrix form as:

(36) $\mathbf{AY} = \mathbf{X}$

where **A** is a 8 × *8* matrix that contains parameters on demand shock, elasticities and market shares, **Y** is the 8 × 1 vector of endogenous variables, and **X** is the 8 × 1 vector of exogenous variables. The changes in the endogenous variables due to the exogenous changes can be calculated by solving the linear equation (36) by $\mathbf{Y} = \mathbf{A}^{-1}\mathbf{X}$.

4.2.3 The Empirical U.S. Apple Equilibrium Displacement Model

4.2.3.1 Colorado Apple Market

The willingness to pay and market share data of demand for local and domestic apples in Colorado (based on Onozaka et al. 2008 survey data) show that the demand for fresh local apples in Colorado is a kinked demand due to the segmentation of the market (figure 4.3). The horizontal axis is the percent of consumers that would purchase local apples under a specific price. The vertical axis is the price of local apples. As we can see in figure 4.3, the kinked point is at price level of around $1.80/lb. It is close to the price of conventional Washington Red Delicious apples given in the survey's choice experiment as $1.89/lb. If the local apple price is lower than the kinked point (price of local apples is lower than the price of domestic apples), almost all consumers would buy local apples. If local apple price is higher than the kinked point (the price of local apples is higher than the price of domestic apples), only a segment of the consumers would buy local apples. As expected, when the price of local apples goes up (the premium of local apples goes up), the share of consumers that would buy local apples goes down. Because market shares are used here, instead of absolute quantities, the demand for domestic apples and local apples are symmetric.

Figure 4.4 shows the market share of consumers preferring local apples to domestic apples at each price premium of local apple price with respect to the domestic apple price. If the local apple price is at the same level as domestic apple price, almost all consumers would buy local apples. As the premium goes up, the share of consumers that buy local apples goes down. It suggests that about ten percent consumes are relatively insensitive to price changes which suggests they are relative loyal local apple consumers. This is consistent with the results given in Onozaka, Nurse and Thilmany McFadden (2011): 11% of the sample in 2008 survey shop at direct markets and 31% shop primarily at conventional supermarkets for local products, given a total of 42% of the sample who shop for local apples at relatively higher prices and different marketing channels. Based on the kinked demand curves, the Colorado apple market is illustrated in figure 4.5.

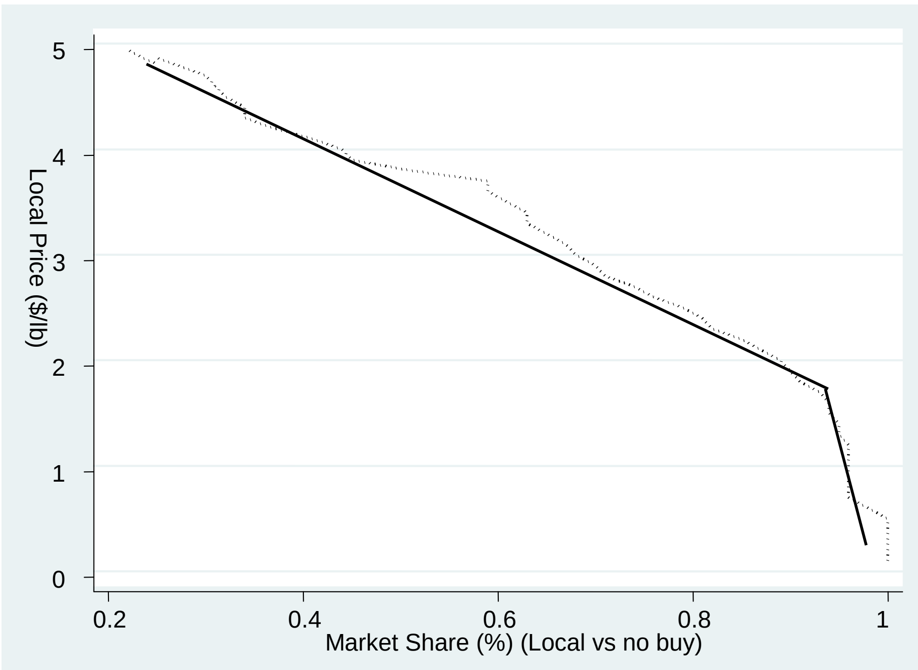

Figure 4.3 Demand for Local Apples

Note: The solid line is the real demand curve based on 2008survey data, while the dashed line is a trend line.

As illustrated in figure 4.5, the autarky equilibrium price of local apples is P_A^l and is determined by the intersection of supply of Colorado apples for Colorado (S_A) and Colorado demand for local apples (D_A^l). Point A stands for this equilibrium, where local apple supply equals the demand for local apples. Point A can be at any point along the demand curve. In this study, the price of Colorado local apples is assumed to be higher than the price of domestic apples in Colorado, thus the supply curve would cross the demand curve above the kinked point. The equilibrium price and quantity analysis is the same as the analysis for figure 4.2.

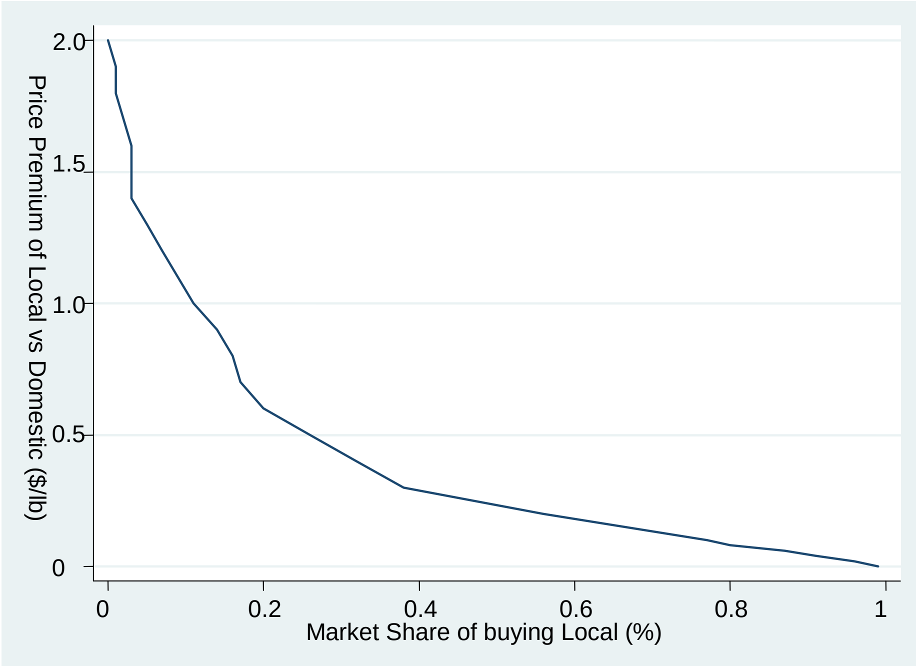

Figure 4.4 Price Premium vs Market Share

Local promotion has two effects. First, it gives information on the benefits of consuming local apples, such as any evidence about eating quality, freshly harvested and impacts on local farms. Second, the promotion will make local apples and domestic apples more differentiable. These effects may encourage some people to start buying local apples, which will shift the demand curve up to B'C' in figure 4.5. At the same time, the promotion will make the demand for local apples less elastic to prices, which leads to a rotation of the demand curve. The new demand curve will become B'C''.

Assuming the premium between local apple price and domestic apple price in Colorado is t_A^l at equilibrium, the new equilibrium price is $P_A^{l'*}$=$P_A^{d'*}(1+t_A^l)$ in figure 4.5, which is higher than the equilibrium price before local promotion P_A^{l*}=$P_A^{d*}(1+t_A^l)$ due to the increase in consumer's willingness to pay for local apples because of the assurances that consumers perceive through the local labeling efforts. Colorado demand for local apples is $Q_A^{D'}$, the supply (consumption) of local apples in Colorado is $Q_A^{S\prime}$, and the supply (consumption) of domestic apples in Colorado is $Q_A^{D\prime}$-$Q_A^{S\prime}$.

4.2.3.2 Welfare Analysis

As we developed in the theoretical section, the welfare analysis of Colorado's apple market is shown in figure 4.6. We can analyze three cases:

First, local equilibrium: no trade, no shift. The Colorado apple market is an autarky. The equilibrium price and quantity is given as P_A^l and Q_A^l. In this market situation, the consumer surplus is given by A+B+H+K and producer surplus is given by C+D+E+J+L+M. Total welfare is A+B+C+D+E+H+J+K+L+M.

Second, Trade equilibrium: trade, no shift. By allowing trade between Colorado and other states, a fall in the local market price (P_A^l) to the lower level (P_A^{l*}) would occur and results in demand for apples increasing from Q_A^l to Q_A^D and local supply decreasing from Q_A^l to Q_A^S. This results in a higher level of consumer surplus as given by A+B+C+D and a reduced level of producer surplus to E. Total welfare is A+B+C+D+E. The net change in the total welfare is the change in producer surplus (negative) plus the change in consumer surplus (positive), given by H+J+K+L+M, which is known as the "gains from trade triangle" (Anderson and James, 1998).

Third, Trade equilibrium with local demand shift: trade, demand shift. The local labeling and marketing efforts will increase consumers' willingness to pay for local apples which is represented in figure 4.6 as an upward shift in the demand curve from D_A^l to $D_A^{l\prime}$. The supply curve (S_A^l) intersects with the new apple price point in Colorado ($P_A^{l\prime*}$) at a higher level. The supply quantity of Colorado local apples increases from Q_A^S to $Q_A^{S\prime}$ and Colorado demand for local apples increases from Q_A^D to $Q_A^{D\prime}$. The Colorado supply (consumption) of domestic apples will change from Q_A^D- Q_A^S to $Q_A^{D\prime}$- $Q_A^{S\prime}$. In the long run, when producers can respond to the increase in demand by increasing quantity supplied, producer surplus is increased to D+E+M, and consumer surplus is changed to A+B+C+F+G+H+I+J. Total welfare is changed to A+B+C+D+E+F+G+H+I+J +M. The net change in total welfare with respect to trade but no demand shift is F+G+H+I+J+M-C.

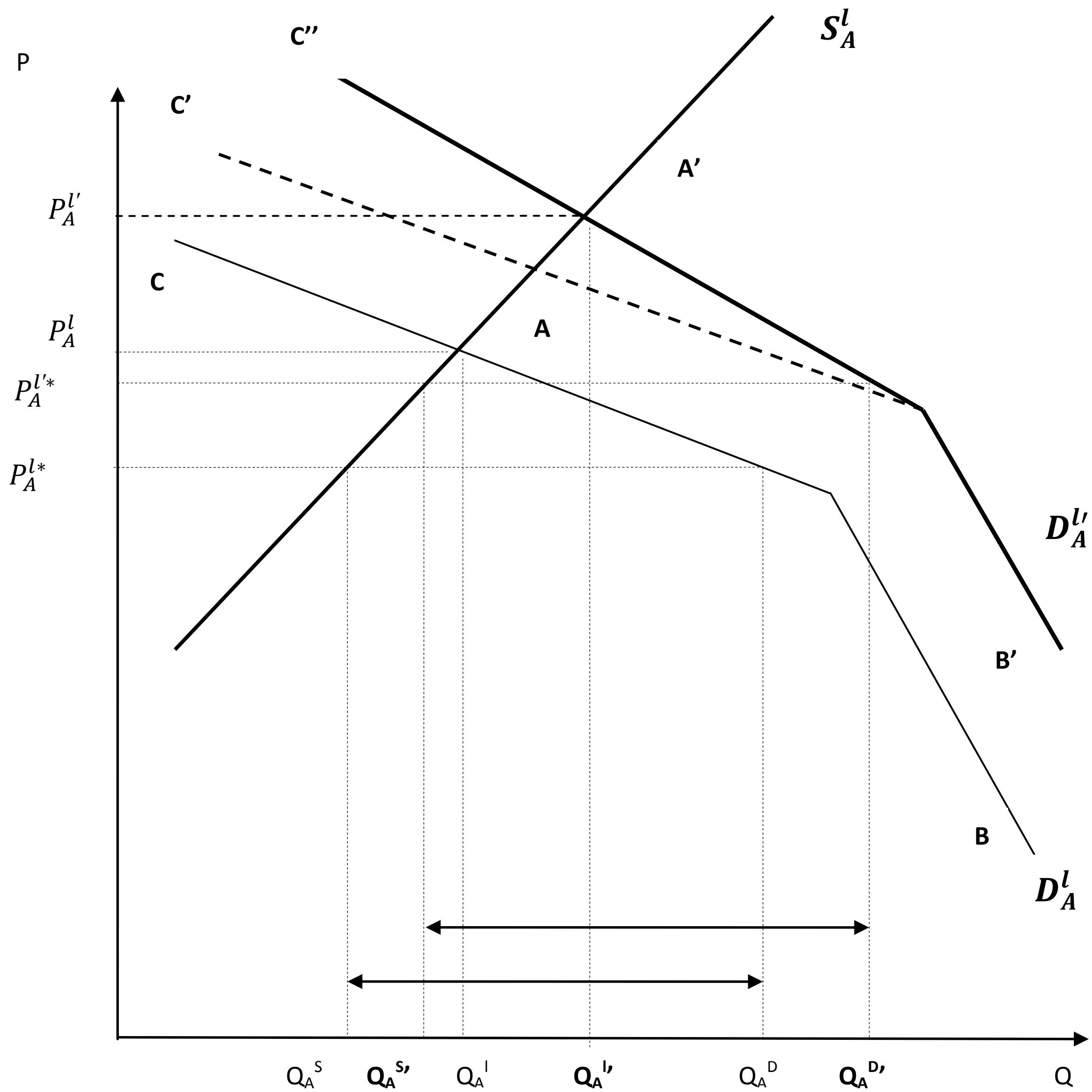

Figure 4.5 Demand and Supply for Local Apples in Colorado Market

In the short run, producers can not react to an increase in demand. The increase in producer surplus only comes from an increase of price (from P_A^{l*} to $P_A^{l\prime*}$), which results in an increase of E+D. The consumer surplus changes in the same way as in the long run. Total welfare is A+B+C+F+G+H+I+J. The net change in total welfare is F+G+H+I+J-C.

Overall, the estimation of producer surplus of supplies for local apples in our case with an estimated kinked demand is similar to the estimation of the theoretical model with a normal demand curve. But the consumer surplus estimation is larger than the estimation from a more theoretical model, based on the expected changes of elasticity of demand for local apples. This means that local labeling and marketing efforts will benefit consumers of local apples more than in non-segmented markets. The changes in consumer surplus and producer surplus are shown in table 4.2. In this paper, we focus on the magnitude and conditions of future potential changes of welfare from the second to the third case.

4.2.3.3 Equilibrium Displacement Model

This study will develop a partial equilibrium displacement model (EDM) for Colorado fresh apples that can be used to analyze the impacts of local labeling by segmenting markets by estimation of the increased consumer valuation that appears to occur with local-origin labeling with quality control on the demand side. The econometric model developed in the previous chapter is modified in order to account for the available data and take the segmentation on the supply side into consideration. A number of assumptions are made in order to implement the EDM:

1. Based on complementary price analysis, Yakima Valley and Wenatchee District is significantly affecting the price formation process of all other shipping points. All shipping point prices out of Colorado are assumed to be the same, so to simplify, the Yakima Valley and

Wenatchee District shipping point price represents the national shipping point price. Based on the price relationship between shipping points, the Colorado shipping point price (if exists) is estimated.

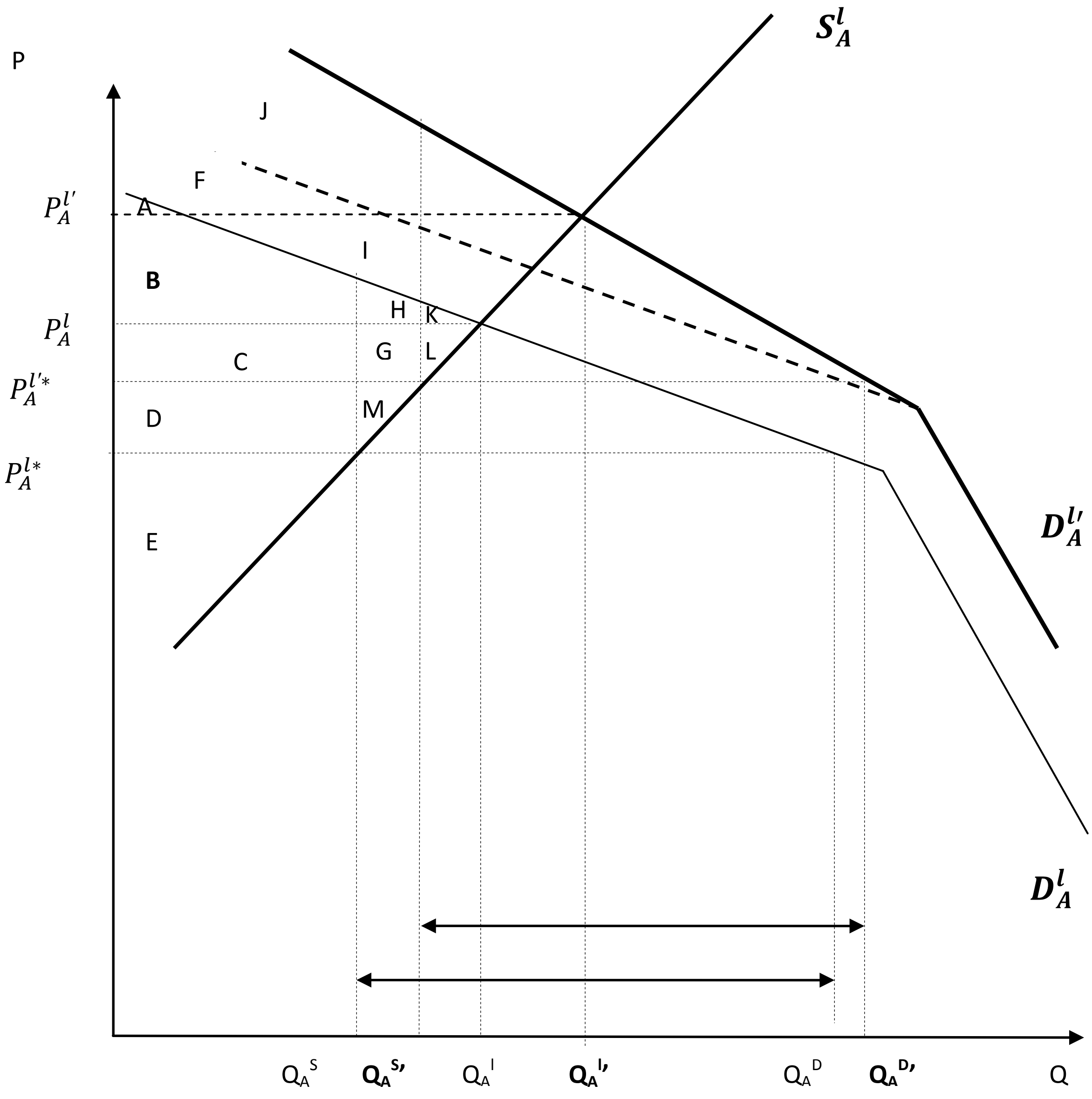

Figure 4.6 Welfare Analysis of Colorado Local Apple Market

Table 4.2. Colorado Local Apple Market Welfare Changes

Welfare	No Trade, No Shift	Trade, No Shift	Trade, Shift	Changes (Trade, Shift vs Trade, No shift
CS_{Al}	A+B+H+K	A+B+C+D	A+B+C+F+G+H+I+J	F+G+H+I+J-C-D
PS_A^l(long run)	C+D+E+J+L+M	E	D+E+M	D+M
(short run)			D+E	D
TS_A^l (long run)	A+B+C+D+E+H+J+K	A+B+C+D+E	A+B+C+D+E+F+G+H+I+J+M	F+G+H+I+J +M-C
(short run)	+L+M		A+B+C+D+E+F+G+H+I+J	F+G+H+I+J -C

2. Colorado supplies of Colorado produced fresh apples can be marketed directly in local markets or marketed through shipping points in or outside the state. All Colorado consumed, locally labeled apples are marketed through direct markets and shipping points. If the apples are marketed through shipping points, they can be shipped back to the Colorado market (through traditional food retail channels) or shipped to other states.

3. Domestic apples (from other regions of the U.S.) can only be marketed through shipping points and cannot enter direct markets. Although domestic apples may enter some direct markets, this would be rare and the assumption simplifies the solution. The apple market relationship is illustrated in figure 4.7.

4.2.3.3.1 Model Specification

The farmers' market price and retail market price data used on the demand side is intended to represent the local and domestic apple prices. On the supply side, producers choose between selling their products directly (marketed in direct markets) or distributed through shipping points (marketed to conventional retailers). There is not concern about where the apples will be marketed beyond the shipping points. The prices that affect their decisions are not the retail price, but rather, the price they expect to receive from direct markets and the shipping points. The demand shock associated with local labeling efforts will increase the demand for local apples, which will indirectly impact the supply of apples in segmented markets. Since there are no reported marketing costs for local food systems, direct market prices and shipping point prices are used to estimate these costs based on changes in prices and quantities in the various supply functions.

The whole economy is separated into two regions: Colorado (A) and the rest of the United States (B) which has supply and demand relationships with the Colorado apple sector.

The EDM framework specifies demand and supply equations for each region, market clearing conditions, and price relationships (price margins), yielding a total of 13 linear equations. The Model can be described as follows:

Region A (Colorado)

Demand:

(37) $$D_A^l = D_A^l(P_A^l, P_A^d, \propto_l)$$

(38) $$D_A^d = D_A^d(P_A^l, P_A^d, \propto_d)$$

Supply:

(39) $$S_A^F = S_A^F(P_A^F, P_A^S, \xi_F)$$

(40) $$S_A^S = S_A^S(P_A^F, P_A^S, \xi_s)$$

(41) $$S_A^{SA} = S_A^{SA}(P_A^F, P_A^S, P_A^l, P_A^d, P_B^d, \xi_{SA})$$

Region B (rest of the United States)

Demand:

(42) $$D_B^d = D_B^d(P_B^d)$$

Supply:

(43) $$S_B^S = S_B^S(P_B^S)$$

Market-Clearing Conditions

(44) $$D_A^l = S_A^F + S_A^{SA}$$

(45) $$D_A^l + D_A^d + D_B^d = S_A^F + S_A^s + S_B^s$$

Price Relationships

(46) $$P_A^d\left(1 + t_A^l\right) = P_A^l$$

(47) $$P_B^d\left(1 + t_A^d\right) = P_A^d$$

(48) $$P_A^S(1 + t_A^F) = P_A^F$$

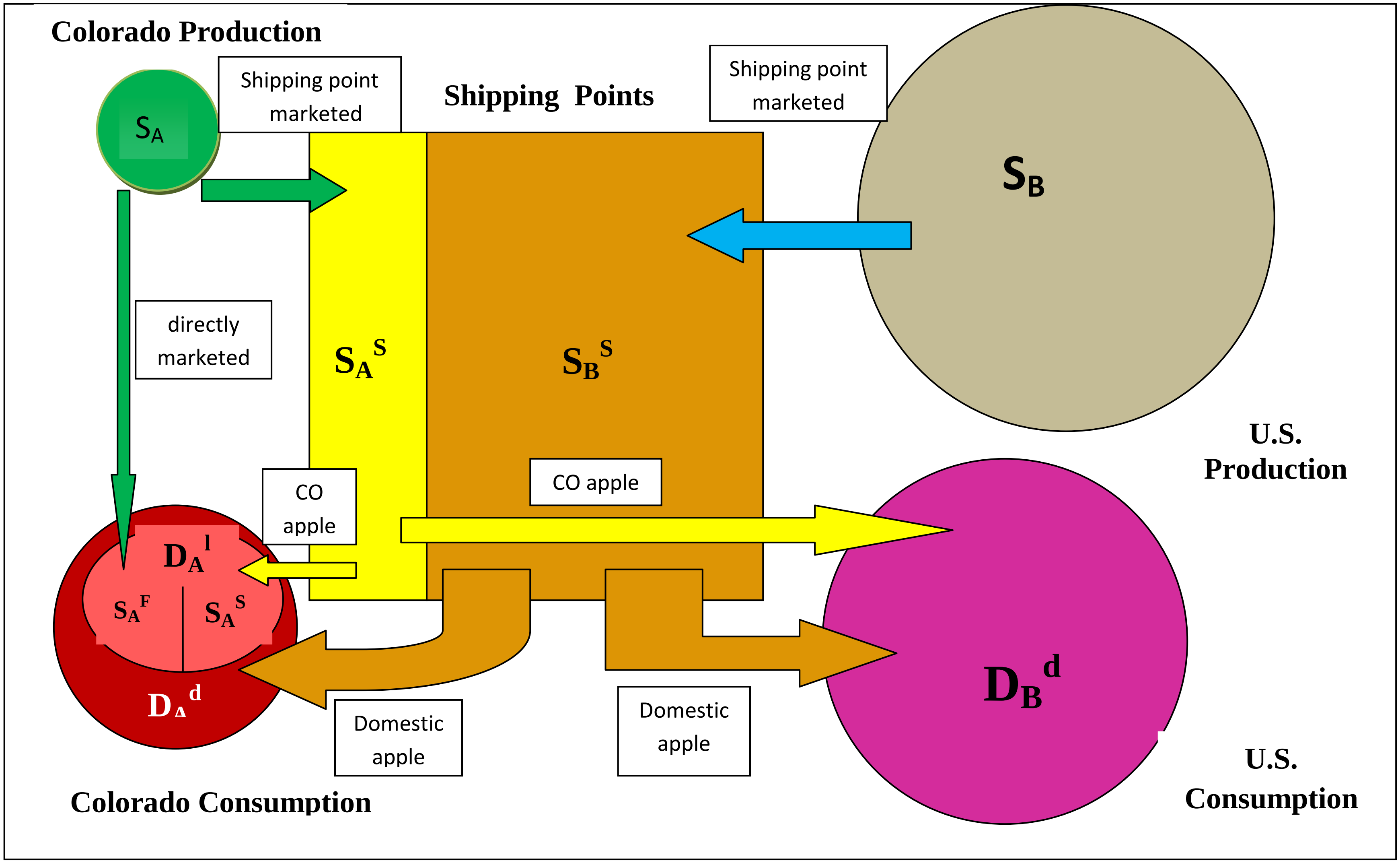

Figure 4.7 U.S. Apple Market

(49) $$P_B^S(1+t_A^S) = P_A^S$$

The price parameters P_i^k, k=l, d, F, S; i=A,B are derived from different sources to construct the demand and supply equations. $\propto_k$, k=l, d represents the price difference related to assurances that consumers perceive through the local labeling efforts and ξ_h, h=F,S represents the costs associates with the local labeling efforts. (At this stage, we assume $\xi_h = 0$, which means that only the demand shocks are examined). D_i^k (k=l,d) represents the demand for apple k in region i. S_i^k (k=S, F, SA) represents the supply of fresh apples through channel k in region i. t_A^l is the marketing margin between farmers' market and retail market in Colorado. t_A^d is the market margin between Colorado and domestic retail markets. t_A^F is the supply price difference between selling in direct markets and selling to shipping points in Colorado (if such a difference exists). t_A^S is the supply price difference between Colorado and domestic shipping points.

For the demand equations, P_i^k represents retail price for apple k in region i. In Colorado, the demand for local apples and domestic apples is a function of the local apple price (which is represented by the farmers' market price) (P_A^l) and retail price of domestic apples (P_A^d). In equilibrium, there is a premium (t_A^l) between the local apple price (P_A^l) and domestic apple retail price (P_A^d), $P_A^l = P_A^d\left(1+t_A^l\right)$. Due to transaction costs, there is a difference (t_A^d) between Colorado and other regions' retail price of domestic apples (P_A^d and P_B^d), $P_A^d = P_B^d\left(1+t_A^d\right)$. The demand for domestic apples in other regions is a function of domestic apple retail price in other regions (P_B^d).

On the other hand, the supply price for direct markets (which is estimated by the farmers' market apple price) (P_A^F) and supply price for shipping points (P_A^S) determines the Colorado supply equations. In equilibrium, P_A^F= P_A^S(1+t_A^F). Taking transaction costs into consideration, the relationship between the supply price for Colorado shipping points and for domestic shipping points is $P_A^S = P_B^S(1 + t_A^S)$.

It is important to note that equation (41) shows that the supply for Colorado apples marketed through shipping points and shipped back to Colorado ($S_A{}^{SA}$) is a function of direct market prices (P_A^F), Colorado shipping point price (P_A^S), farmers' market prices for local apples (P_A^l), and domestic apple retail prices in Colorado (P_A^d), and domestic apple retail prices in the rest of the U.S. (P_B^d) . P_A^F and P_A^S determine whether to market directly or through shipping points. Then processors need to decide whether it is economical to ship apples back to Colorado or to other states (since we assume they will not be differentiated as Colorado grown once they are in wholesale channels). The share marketed through different channels ultimately depends on the farmers' market price of local apples and domestic apple retail prices. All apples in the rest of the U.S. are assumed to be marketed through shipping points. The supply for apples marketed through shipping points in the rest of the country is a function of the domestic shipping point price (P_B^S).

In equilibrium, the demand for local apples in Colorado equals the supply of Colorado apples in direct markets plus the supply of Colorado apples through shipping points to Colorado, which means $D_A^l = S_A^F + S_A^{SA}$ (equation (44)). In the equilibrium of the whole U.S. economy, total apple demands equals total apple supply (since we assume no imports or exports of fresh apples and no storage left in this case) (equation (45)).

Totally differentiating equations (37)-(49) yields:

(37') $dln(D_A^l) = \varepsilon_A^{ll} dln(P_A^l) + \varepsilon_A^{ld} dln(P_A^d) + \gamma$

(38') $dln(D_A^d) = \varepsilon_A^{dl} dln(P_A^l) + \varepsilon_A^{dd} dln(P_A^d) - \frac{w_{AA}^{Dl}}{w_{AA}^{Dd}} \gamma$

(39') $dln(S_A^F) = \beta_A^{FF} dln(P_A^F) + \beta_A^{FS} dln(P_A^S) + \zeta$

(40') $dln(S_A^S) = \beta_A^{SF}dln(P_A^F)+\beta_A^{SS}dln(P_A^S) - \frac{w_{AA}^{SF}}{w_{AA}^{SS}}\zeta$

(41') $dln(S_A^{SA}) = \beta_A^{SA,F}dln(P_A^F)+\beta_A^{SA,S}dln(P_A^S)+\beta_A^{SA,l}dln\left(P_A^l\right)+\beta_A^{SA,d}dln\left(P_A^d\right) +$
$+\beta_A^{SA,d}dln\left(P_B^d\right) - \frac{w_{AA}^{SF}}{w_{AA}^{SSA}}\zeta$

(42') $dln(D_B^d) = \varepsilon_B^{dd}dln(P_B^d)$

(43') $dln(S_B^S) = \beta_B^{SS}dln(P_B^S)$

(44') $dln\left(D_A^l\right) = w_{AA}^{SFl}dln(S_A^F) + w_{AA}^{S,SAl}dln(S_A^{SA})$

(45') $\omega_{AT}^{Dl}dln\left(D_A^l\right) + \omega_{AT}^{Dd}dln\left(D_A^d\right) + \omega_{BT}^{Dd}dln\left(D_B^d\right) = \omega_{AT}^{SS}dln(S_A^s) + \omega_{BT}^{SS}dln(S_B^s) +$
$\omega_{AT}^{SF}dln(S_A^F)$

(46') $dln(P_A^l) = dln\left(P_A^d\right) + t_A^l$

(47') $dln(P_A^d) = dln\left(P_B^d\right) + t_A^d$

(48') $dln(P_A^F) = dln(P_A^S) + t_A^F$

(49') $dln(P_A^S) = dln(P_B^S) + t_A^S$

The variables and parameters are defined in Table 4.3.

Table 4.3 Variables and Parameters Definition…

Variables	**Definition**
Demand	
P_i^k	Retail (farmers' market) price for apple *k* in region *i*
D_i^k	The demand for apple *k* in region *i*
Supply	
P_i^k	The supply price for apples marketed through channel *k* in region *i*
S_i^k	The supply of apples through channel *k* in region *i*
Transaction costs ratio	
t_A^l	Market margin between farmers' market and retail market in Colorado
t_A^d	Market margin between Colorado and domestic retail markets
t_A^F	The supply price difference between selling in direct markets and selling to shipping points in Colorado.
t_A^S	The supply price difference between Colorado and domestic shipping points.

Table 4.3 Variables and Parameters Definition…, Continued

Variables	Definition
Weights	
w_{ii}^{Dk}	Region *i* share of demand for apple *k* (or apples marketed through channel *k*) with respect to Region *i* total demand
w_{iil}^{Dk}	Region *i* share of demand for local apples marketed through channel *k* with respect to region *i* total demand for local apples
w_{iT}^{Dk}	Region *i* share of demand for apple *k* with respect to U.S. total demand
w_{ii}^{Sk}	Region *i* share of supply for apples marketed through channel *k* with respect to Region *i* total supply
w_{AA}^{Skl}	Region *i* share of supply for apples marketed through channel *k* with respect to region *i* total supply of local apples
w_{iT}^{Sk}	Region *i* share of supply for apples marketed through channel *k* with respect to U.S. total supply
Elasticities	
$\boldsymbol{\varepsilon_i^{kk}}$	Apple *k* own price demand elasticity in region *i*
$\boldsymbol{\varepsilon_i^{kh}}$	Apple *k* cross price demand elasticity with respect to apple *h* price in region *i*
$\boldsymbol{\beta_i^{kk}}$	Apples marketed through channel *k* own price supply elasticity in region *i*
$\boldsymbol{\beta_i^{kh}}$	Apples marketed through channel *k* cross price supply elasticity with respect to price marketed through channel *h* in region *i*
$\boldsymbol{\beta_A^{SAk}}$	Colorado shipping point marketed local apple cross price supply elasticity with respect to price of apple *k* (or price of apples marketed through channel *k*)
Other Parameters	
$\boldsymbol{\gamma}$	Demand shock to local apples: $\gamma = -\frac{\text{Premium}}{\text{domestic price}} * \varepsilon_A^{ll}$
$\boldsymbol{\alpha_k}$	Expenditure elasticity of apple *k*
$\boldsymbol{\rho_k}$	Expansion elasticity of apples marketed through channel *k*
$\boldsymbol{\rho_{SA}}$	Expansion elasticity of shipping point marketed local apples
$\boldsymbol{\vartheta}$	Elasticity of substitution
$\boldsymbol{\tau}$	Elasticity of transformation
$\boldsymbol{\varepsilon}$	Aggregate own price elasticities of demand
$\boldsymbol{\beta}$	Aggregate own price elasticities of supply

4.2.3.3.2 Data for Equilibrium Displacement Model

Prices and Quantities

The Colorado farmers' market apple price is used to represent retail price of local apples and the fresh Red Delicious apple retail price in the USDA AMS' designated Southcentral retail market (which includes Colorado) is used to represent the retail price of domestic apples in Colorado.

The fresh Red Delicious apple price in the USDA AMS' designated Northwest retail market was used to represent the retail price of domestic apples in the rest of U.S. The Northwest retail market is selected based on the results from retail market relationship analysis. Although the Southwest market was a market leader in the price formation of all other retail markets, it was not chosen as a supply driver due to the limited production of Red Delicious apples in this region. The Northwest retail market significantly affected the price formation process of other retail markets except the Southeast market. More importantly, the Northwest region is the main production area for fresh apples in the U.S.

The Colorado farmers' market apple price is used to represent the direct market price. Due to the lack of Colorado shipping point price data (there is no shipping point that carries apples in Colorado), the Colorado shipping point price was estimated. The Washington shipping point price for Red Delicious apples was used to represent the domestic shipping point price. The Washington Red Delicious apple supply was chosen as a benchmark in this case due to its dominant market position, the relatively short distance to Colorado compared to other major production regions, and, the consistent availability of data in that series.

Weekly shipping point price, retail price and domestic truck rate report data (apples) for fresh Red Delicious apples are collected from USDA's Agricultural Marketing Service (AMS, USDA). Weekly Colorado farmers' market prices are collected from Colorado State University Extension's Fresh Produce and Meat Market Reports (http://www.extension.colostate.edu/boulder/ag/abm.shtml#prices). Weekly Midwest, Rocky Mountain, East Coast, and West Coast on-highway diesel fuel prices are collected from the Energy Information Administration's weekly retail gasoline and diesel prices (http://www.eia.gov/dnav/pet/pet_pri_gnd_a_epd2d_pte_dpgal_w.htm) to adjust the retail price to account for direct transportation costs for the period from October 5, 2007 to December 31, 2011. The shipping point price and truck rates are collected to account for direct transportation costs for the period from October 5, 2007 to December 31, 2011. The seasonal Colorado farmers' market price covered a period from August 20, 2011 to October 30, 2011, so the farmers' market price is only used as base prices for estimation of price relationship parameters and the estimation of the EDM (but not integrated into the time series analysis of price relationships). All price series are converted into dollars per pound (truck rate was converted into dollars per pound of apples per mile) and are deflated to 1998 January prices.

Domestic truck rate and shipping point prices are used to estimate the price relationship between shipping points using a symmetric variable TAR model. Due to the seasonality of truck rate records, year round diesel price is used to estimate the price relationship between retail markets. To match the 2008 consumer survey data and available shipment and supply volume data, 2008 prices are used as base prices in the estimation of parameters and welfare analysis of EDM. As mentioned above, comparing with 2008 retail prices, shipping point prices, diesel prices, and truck rates, but only 2011 Colorado farmers' market price is available. The lack of 2008 farmers' market price data is one limitation of this study which may influence the estimation of price premiums and the estimation of welfare changes.

The utilized production of apples for fresh use in Colorado in 2008 was 10 million pounds (S_A), while the utilized production for fresh use for the U.S. was 6,245 million pounds (S). The U.S. per capita consumption of fresh apples in 2008 was 16.2 pounds (ERS, USDA), while the population of Colorado and the U.S. was estimated as 4.94 million and 304.37 million in 2008, respectively (2008 U.S. Census Bureau). Thus, the estimated consumption of fresh apples for Colorado and the U.S. in 2008 was 80 million pounds (D_A) and 4,931 million pounds (D), respectively. Based on these estimates, the production and consumption of the rest of the country are estimated as 6,235 million pounds ($S_B{}^s$) and 4,851 million pounds ($D_B{}^d$), respectively.

Since there are no reported data on directly marketed apples in Colorado, the amount of directly marketed apples is calculated assuming apples are equivalent to the proportion of directly marketed fruits in Colorado. But, since direct marketing data is county based, and only a few counties account for 90% of the total fruit production in Colorado ($23,192,000), they were considered good representation for fruit production and marketing in Colorado including; Mesa (ranked first with $10,184,000 in sales), Delta (ranked second with $8,851,000 in sales), Montezuma (ranked third with $879,000 in sales), and Montrose (ranked fourth with $852,000 in sales).

In the same way, the consumption of local apples in Colorado was calculated using the proportion of local food sales through all channels within the U.S. (0.0168), which is equal to the proportion of direct crop and livestock sales through all channels divided by all crop and livestock revenues in the U.S. for 2007. The estimations of locally marketed demands and supplies are presented in Table 4.4.

One thing that needs to be pointed out is that although the Census of Agriculture is available for 2007, which was used for the estimation of the proportion of directly marketed fruits and consumption of local apples, Colorado production of apples for fresh use in 2007 (6.0 million pounds) was below the normal level (over 10 million pounds each year from 2000 to 2009). Thus, the production and consumption of fresh apples are estimated for 2008 and the proportions of direct marketed apples and consumption of local apples are assumed to be stable from 2007 (when Census data was available) to 2008. Again, this is a simplifying assumption, but necessary for this empirical study that is somewhat reliant on secondary data.

Market Shares

The market share parameter values needed for the EDM are estimated as follows:

(50) $w_{AT}^{Dd} = \frac{Colorado\ consumption - colorado\ consumption\ of\ local\ apples}{U.S. consumption}$=0.0159

(51) $w_{AT}^{Dl} = \frac{Colorado\ consumption\ of\ local\ apples}{U.S.\ consumption}$=0.0003

(52) $w_{BT}^{Dd} = 1 - w_{AT}^{Dd} - w_{AT}^{Dl}$=0.9838

(53) $w_{AA}^{Dl} = \frac{Colorado\ consumption\ of\ local\ apples}{Colorado\ consumption}$=0.0168

(54) $w_{AA}^{Dd} = 1 - w_{AA}^{Dl}$=0.9832

(55) $w_{AA}^{DF} = \frac{Colorado\ consumption\ of\ directly\ marketed\ apples}{Colorado\ consumption}$=0.0067

(56) $w_{AA}^{Ds} = 1 - w_{AA}^{DF}$=0.9933

(57) $w_{AA}^{D,SA} = \frac{Colorado\ consumption\ of\ local\ apples\ through\ shipping\ points}{Colorado\ consumption}$=0.0101

(58) $w_{AAl}^{DF} = \frac{Colorado\ consumption\ of\ local\ apples\ through\ direct\ markets}{Colorado\ consumption\ of\ local\ apples}$=0.4015

(59) $w_{AAl}^{DS} = \frac{Colorado\ consumption\ of\ local\ apples\ through\ shipping\ points}{Colorado\ consumption\ of\ local\ apples}$=0.5985

(60) $w_{AT}^{Ss} = \frac{Colorado\ supply\ of\ fresh\ apples - Colorado\ directly\ marketed\ apples}{U.S. supply\ of\ fresh\ apples}$=0.0015

(61) $w_{BT}^{Ss} = \frac{the\ rest\ of\ the\ country\ supply\ of\ fresh\ apples}{U.S. supply\ of\ fresh\ apples}$ =0.9984

(62) $w_{AT}^{SF} = 1 - w_{AT}^{Ss} - w_{BT}^{Ss}$=0.0001

(63) $w_{AA}^{SFl} = \frac{Colorado\ directly\ marketed\ apples}{Colorado\ supply\ of\ local\ consumed\ apples}$=0.4015

(64) $w_{AA}^{S,SAl} = 1 - w_{AA}^{SFl}$=0.5985

(65) $w_{AA}^{SF} = \frac{Colorado\ directly\ marketed\ apples}{Colorado\ supply\ of\ apples}$=0.0530

(66) $w_{AA}^{SS} = 1 - w_{AA}^{SF}$=0.9470

(67) $w_{AA}^{S,SA} = \frac{Colorado\ consumed\ local\ apples\ through\ shipping\ points}{Colorado\ supply\ of\ apples}$=0.0790

(68) $w_{BB}^{Ds} = 1$

Table 4.4 Supply and Demand Quantities Calculation …

Variables	Values of Variables	Calculation		
Supply				
U.S. utilized fresh apple (S)	6243.9 million pounds	*Production of the rest of the country (S_B^S) 6233.9 million pounds (99.84% of U.S. sup)*		
Colorado utilized fresh apple (S_A)	10 million pounds (0.16% of U.S.sup)			*Colorado shipping point marketed apples (S_A^S): 9.47 million pounds (94.73% of CO total supply)*
Delta directly sold ag products proportion	3.267%			
Weights of Delta fruit production w.r.t. Colorado fruit production	38.164%		*Colorado directly marketed apples (S_A^F): 0.53 million pounds* (5.27% of CO total supply) *(39.94% of local apple consumption)*	
Mesa directly sold ag products proportion	7.723%			
Weights of Mesa fruit production w.r.t. 4 counties total fruit production	43.912%	*4 counties weighted proportion of direct fruit sale: 5.27%*		
Montezuma directly sold ag products proportion	1.166%			*Colorado consumption of local apple through shipping points (S_A^{SA}) : 0.79 million pounds (60.06% of local apple consumption)*
Weights of Montezuma fruit production w.r.t. 4 counties fruit production	3.790%			
Montrose directly sold ag products proportion	0.901%			
Weights of Montrose fruit production w.r.t. 4 counties fruit production	3.674%			

Table 4.4 Supply and Demand Quantities Calculation …, Continued

Variables	Values of Variables	Calculation		
Demand				
U.S. population	304,797,761	*U.S. apple consumption (D): 4846.28 million pounds*	*the rest of the country apple consumption (D_B^d): 4767.75 million pounds (98.38% of U.S. total consumption)*	
U.S. per capita consumption of fresh apples	15.9 pounds			
Colorado population	4,939,456	*Colorado apple consumption (D_A): 78.54 million pounds (1.62% of U.S. total consumption)*	*Colorado consumption of local apples (D_A^l): 1.32 million pounds (1.68% of CO total consumption)*	*Colorado consumption of domestic apples (D_A^d): 77.22 million pounds (98.32% of CO total consumption)*
U.S. local food sales through all channels	5000 million dollars			
U.S. all food sales	297220.491million dollars	*Proportion of local food sales : 1.68%*		

Demand Elasticities

Demand elasticities are estimated using willingness to pay and market share data from a 2008 national consumer survey (details of methodology and results available in Onozaka and Thilmany McFadden, 2011). Within the survey, choice experiments were conducted asking respondents' choices on sets of apples that varied by labels, prices and production locations. Panel mixed logit models were used to estimate individual-level WTP (Onozaka and Thilmany McFadden, 2011). The market share was derived as the share of respondents willing to pay for the specified apples at various price points. Based on the median consumer (estimation for median market buyers (MMB)) and 11% market share (the estimation for current market buyers in local marketing channels (CMB)) the representative consumer WTP estimated from the 2008 national survey data, premia for local apples with respect to domestic apples is set as $0.20/lb[11] and $1.00/lb[12], respectively. Based on the 2008 mean price in the Southcentral and Northwest retail markets, the base prices of domestic apples in Colorado and other states are set as $1.61/lb and $1.56/lb. The own price elasticities are estimated using the formula:

(69) $$\varepsilon_h^{ii} = \frac{\Delta Market\ Share\ i}{\Delta WTPi} * \frac{WTPi}{Market\ Share\ i}$$

The cross-price elasticities were estimated using:

(70) $$\varepsilon_{\mathrm{h}}^{\mathrm{ij}} = \frac{\Delta \mathrm{Market\ Share\ i}}{\Delta \mathrm{WTPj}} * \frac{\mathrm{WTPj}}{\mathrm{Market\ Share\ i}}$$

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[11] The premium suggested by the median representative consumer premium of WTP in 2008 survey data ($0.20/lb) is different from the premium estimated by historical price data ($0.81/lb). This may reflect the specific situation of Colorado, where the supply of local apples could not meet the demand for local apples which drives up the price of local apples above median consumers' willingness to pay, so supplies may go to the most fervent local consumers. Ad hoc evidence from local markets, with common stock outs, would support this concept.

[12] Based on Onozaka, Nurse, and Thilmany McFadden (2011), 11% of the sample shopped primarily at direct markets. This market share is close to the kinked point of demand based on the 2008 survey data. The premium suggested by the 11% representative consumer premium in the 2008 survey data ($1.00/lb) is close to the premium estimated by historical price data ($0.81/lb).

The distribution of estimated individual-level WTP among Colorado consumers compared against respondents from the remainder of the U.S. were not found to be significantly different, thus, domestic own price elasticities in Colorado and the rest of the country are set equal.

Supply Elasticities

On the supply side, elasticities are estimated as:

(71) $\beta_A^{ij} = \omega_{AA}^{Di}(\rho_i\beta + \tau) - \delta_{ij}\tau$ *i*=*S*,*F*,*SA*

(72) $\beta_B^{ij} = w_{BB}^{Di}(\rho_i\beta + \tau) - \delta_{ij}\tau$ i=*S*,*F*

Both short run and long run scenarios are considered in this study. Based on the available data in the 2008 consumer survey, the demand parameters in long run and short run models are assumed to be identical. In contrast, the supply parameters in the short run model and long run model are differentiated. For long run EDM model, the aggregate own-price supply elasticity (β) is chosen to be 1.0 based on previous literature and economic theory (Carpio and Isengildina-Massa, 2010; Chavas and Cox, 1995). In the short run, when producers have a limited ability to react to changes in demand by changing their supply, the aggregate own-price supply elasticity is chosen to be 0.44 based on Chavas and Cox's estimation. The expansion elasticity of directly marketed apples (ρ_F) is assumed to be 1.0 both in short run and in long run. Apples marketed through shipping points have expansion elasticities that are recovered from equation (38):

(73) $\rho_S = (1 - \rho_F * \omega_{AA}^{DF})/(1 - \omega_{AA}^{DF})$=1.00

(74) $\rho_{SA} = (1 - \rho_F * \omega_{AAl}^{SF})/(1 - \omega_{AAl}^{SF})$=1.00

The elasticity of transformation (τ) was chosen to ensure local marketed apples and apples marketed through shipping points are substitutes (following Carpio and Isengildina-Massa (2010)), which is -1.8 in long run and -0.5 in short run. δ_{ij} is the Kronecker delta ($\delta_{ij} = 1$ when *i*=*j*; $\delta_{ij} = 0$ when *i*≠*j*) (James and Alston, 2002).

Demand Shocks

The premium associated with WTP ($0.20/lb for MMB and $1.00/lb for CMB) for local apples with respect to domestic apples based on the premium estimated by Onozaka and Thilmany McFadden (2011) was assumed to be an exogenous shock (γ) because the production source was not commonly known by households before local labels were established and promoted. Here we assume:

(75) $\gamma = -\frac{\text{Premium}}{\text{domestic price}} * \varepsilon_A^{ll} ==0.019$ MMB

(76) $\gamma = -\frac{\text{Premium}}{\text{domestic price}} * \varepsilon_A^{ll} ==0.372$ CMB

Shocks to domestic apples in Colorado:

(77) $-\frac{w_{AA}^{Dl}}{w_{AA}^{Dd}}\gamma$ = -0.0003 MMB

(78) $-\frac{w_{AA}^{Dl}}{w_{AA}^{Dd}}\gamma$ = -0.006 CMB

Price Premium & Market Margin

The market margin between the farmers' market and retail market in Colorado are estimated based on the price relationship between farmers' markets and retail markets. Colorado local apple price and domestic apple price is estimated based on Colorado farmers' market price and Southcentral retail price. The Colorado farmers' market price was used to represent the local apple price and the 2008 annual mean retail price in Southcentral market is used to represent domestic apple price in Colorado. The market margin between farmers' market and retail market in Colorado is:

(79) $t_A^l = \frac{P_A^l}{P_A^d} - 1 = \frac{3.35}{1.61} - 1=1.08$

The market margin between the Colorado retail market and domestic retail market was obtained by estimating the price difference between Southcentral retail market and Northwest retail market using a symmetric variable Threshold Autoregressive Regression Model developed and presented in chapter 3. Based on a grid search, the estimated upper and lower bounds of the estimated threshold between Southcentral retail market and Northwest retail market that minimizes a sum of squared errors are:

(80) $t_A^{du} = 0.27$

(81) $t_A^{dl} = 0.17$

The market margins between the Colorado shipping point (if it were to exist) (t_A^S) and the domestic shipping point (t_B^S) and the supply price difference between selling in Colorado farmers' markets (t_A^F) and selling to Colorado shipping points (t_A^S) were estimated by estimating the price difference band between shipping points using the symmetric variable Threshold Autoregressive Regression Model. Again, using a grid search, the upper and lower price difference bands (in percent) between the Yakima Valley & Wenatchee District Washington and Michigan shipping points that minimizes a sum of squared errors are estimated as:

(82) $t^u = t^l = 0.35$

The threshold variable between Washington and Michigan is confirmed to vary according to truck rates (in dollars per pound of apples per mile) and a seasonality adjustment as estimated in chapter 3. The effect of the truck rate on the threshold band between Washington and Michigan is confirmed to be significant.

Thus, the price difference band between Colorado markets and the Yakima Valley & Wenatchee District Washington shipping point is estimated based on the distance between these shipping points:

(83) $t_A^S = 0.35 * \frac{1200}{1680}$ =0.25

The Colorado shipping point price is estimated based on the 2008 annual average price in the Yakima Valley & Wenatchee District Washington:

(84) $P_A^S = P_B^S * (1 + t_A^S) = 0.68 * (1 + 0.25)$ =0.85

The price difference between the farmers' market and retail market is assumed to be a function of the intermediary marketing activities performed by middlemen, such as shippers, packers, and retailers. Thus, the supply price difference between the Colorado farmers' market and Colorado shipping point is estimated as:

(85) $t_A^F = \frac{P_A^F - (P_A^F - P_A^d)}{P_A^S} - 1 = \frac{3.35 - (3.35 - 1.61)}{0.85} - 1$ =0.89

Upper and lower bounds are only estimated for the short run scenarios. In the long run, all transaction costs and other factors that affect the price difference can be adjusted, thus the price difference is assumed to be constant and the average value of the lower and upper bound is used.

All the parameters used in the model are summarized in Table 4.5. As expected, the own-price demand elasticities are negative and the cross-price demand elasticities are positive for each segment of apples. All segments of the apple market are inelastic to their own prices. This coincides with our expectation that, given its popularity as a fruit, there is little substitution between other fruits and apples, and consumers will not always change their consumption habits due to price changes.

Overall, the demand of local apples is more own price elastic than domestic apples. This is reasonable according to consumers' WTP given food origin information. Consumers are found to be willing to pay a higher price for local apples, which makes the demand for local apples more elastic to price. The demand for local apples is more sensitive to own price changes using the CMB compared to the MMB given the higher WTP for local apples using CMB, which induces the higher demand shock for CMB[13]. Using MMB, the demand for local apples is elastic to domestic apple price and vice versa. However, the demand for local apples is elastic to the domestic apple price while the opposite is true using CMB. Colorado domestic own price demand is more elastic to own price than the U.S. domestic demand.

There will also be a production response to this market shock. The own-price supply elasticities are positive and the cross-price supply elasticities are negative for each group of apples, both in the short and long run. The supply for direct markets and supply for shipping points are more likely to substitute for each other both in short run and in the long run. As expected, the supply of apples is more elastic to price changes in the long run than in short run. The supply of each group of apples is more elastic to its own price change rather than to other segments' price change. There are asymmetric supply elasticities between supplies for direct markets and shipping points. The results suggest that the supply for the direct markets is more elastic to the price of shipping points than the other way around. This is as expected because the supply for direct markets is more highly priced than the supply for shipping points.

Given the increasing interest in designated promotions for local produce offerings, these relationships are important to understand, so that apple marketers can determine whether investments in local promotion will benefit them in the marketplace.

[13] MMB is estimation for median market buyers (MMB) and CMB is the estimation for current market buyers in local marketing channels (CMB) based on the representative consumer WTP estimated from the 2008 national survey data.

Table 4.5 Parameter Values Used for Model of Colorado Locally Marketed and Shipping Points Marketed Apple…

Parameter Values	**Local Marketed (i=F)**		**Shipping Point Marketed (i=S)**
Demand			
Farmers' market price (P_A^l) ($/lb)		3.35	
Southcentral retail price (P_A^d) ($/lb)		1.61	
Northwest retail price (P_B^d) ($/lb)		1.56	
CO aggregate quantity demanded (D_A) (mil.lbs.)		78.54	
REST aggregate quantity demanded (D_B^d) (mil.lbs.)		4767.75	
CO consumption of local apple (D_A^l) (mil.lbs)		1.32	
CO consumption of domestic apple (D_A^d)		77.22	
Market Shares			
w_{AT}^{Dd}		0.0159	
w_{AT}^{Dl}		0.0003	
w_{BT}^{Dd}		0.9838	
w_{AA}^{Di}	0.0067		0.9933
w_{AA}^{DSA}		0.0101	
w_{BB}^{Di}	--		1
w_{AA}^{Dl}		0.0168	
w_{AA}^{Dd}		0.9832	
w_{AAl}^{Di}	0.4015		0.5985(S_A)
Elasticities of Demand			
Colorado&Colorado(ε_A^{ll})		-0.16 (MMB) -0.60 (CMB)	
Colorado&Domestic(ε_A^{ld})		5.31 (MMB) 2.84 (CMB)	
Domestic&Domestic(ε_A^{dd})		-0.35 (MMB) -0.35 (CMB)	
Domestic&Colorado(ε_A^{dl})		7.73 (MMB) 0.56 (CMB)	
Domestic&Domestic(ε_B^{dd})		-0.05 (MMB) -0.05 (CMB)	
Demand shock (γ)		0.019 (MMB) 0.372 (CMB)	
Supply			
Aggregate own price elasticity of supply(β)		1.00(LR) 0.44(SR)	
Elasticity of transformation(τ)		-1.80(LR) -0.50(SR)	
Expansion Elasticity(ρ_i)	1.00(LR) 0.50(SR)		1.00 (LR) 1.00(SR)
Supply price (P_B^i) ($/lb)			0.68

Table 4.5 Parameter Values Used for Model of Colorado Locally Marketed and Shipping Points Marketed Apple…,Continued

Parameter Values	Local Marketed (i=F)	Shipping Point Marketed (i=S)
Supply price (P_A^i) ($/lb)	3.35 (farmers' market price) 1.61 (real supply price)	0.71 (LR) 0.75^U 0.68^L(SR)
CO aggregate quantity supply (S_A) (mil.lbs.)	10	
REST aggregate quantity supply (S_B^S) (mil.lbs.)	6233.90	
CO directly marketed (S_A^F) (mil.lbs)	0.53	
CO shipping point marketed (S_A^S) (mil.lbs)	9.47	
CO SP marketed local consumed (S_A^{SA}) (mil.lbs)	0.79	
Market Shares		
w_{AT}^{Si}	0.0001	0.0015
w_{AA}^{SF}	0.0530	
w_{AA}^{SSA}	0.0790	
w_{AA}^{SS}	0.9470	
w_{AA}^{SFl}	0.4015	
w_{AA}^{SSAl}	0.5985	
w_{BT}^{Si}	--	0.9984
Elasticity of supply		
Colorado grown(β_A^{Fi})	1.79 (LR) 0.50 (SR)	-0.01 (LR) 0 (SR)
Colorado grown(β_A^{Si})	-0.79 (LR) -0.06 (SR)	1.01 (LR) 0.44 (SR)
Colorado grown ($\beta_A^{SA,i}$)	-0.01 (LR) 0 (SR)	-0.01 (LR) 0 (SR)
Colorado grown ($\beta_A^{SA,l}$)	-0.01(LR) 0(SR)	
Colorado grown ($\beta_A^{SA,d}$)	-0.01(LR) 0(SR)	
Other States grown(β_B^{Si})	--	1.00 (LR) 0.44 (SR)
Transfer Costs Ratio		
t_A^l	1.08	
t_A^d	0.22(LR) 0.27^U 0.17^L (SR)	
t_A^F	0.89	
$\boldsymbol{t_A^S}$	0.25	

Note: l stands for local apples and d stands for domestic apples. F stands for supply through direct markets and S stands for supply through shipping points. S_A stands for consumption of local apples through shipping points. L stands for lower band and U stands for upper band.

4.3 EDM Simulation

4.3.1 Producer Surplus Estimation

In the short run, producers cannot react to an increase in demand by increasing quantity supplied. The increase in producer surplus is due only to the price change. It's calculated using the following equation:

(86) $\Delta PS = \Delta P * S$.

where ΔPS is the changes in producer surplus, ΔP is the changes in supply prices, and S is the supplied quantities. In long run, producers can react to the changes in retail price (WTP). The changes in producers' surplus are calculated using the following equation:

(87) $\Delta PS = \Delta P * S + \frac{\Delta P * \Delta S}{2}$.

where ΔS is the changes in supplied quantities. In this case, Colorado producers sell their apples through two channels: direct markets, such as farmers' market and roadside stands, and shipping points. Thus, the increase in Colorado producer surplus is the sum of the producer surplus through both direct markets and shipping points. In the short run, the change in Colorado producer surplus through direct markets ($\Delta \mathrm{PS}_{\mathrm{A}}^{\mathrm{F}}$) is calculated using the following equation:

(88) $\Delta \mathrm{PS}_{\mathrm{A}}^{\mathrm{F}} = \Delta \mathrm{P}_{\mathrm{A}}^{\mathrm{F}} * \mathrm{S}_{\mathrm{A}}^{\mathrm{F}}$.

where $\Delta \mathrm{P}_{\mathrm{A}}^{\mathrm{F}}$ is the changes in supply price for direct markets and $\mathrm{S}_{\mathrm{A}}^{\mathrm{F}}$ is Colorado supply for direct markets. The change in Colorado producer surplus through shipping points ($\Delta \mathrm{PS}_{\mathrm{A}}^{\mathrm{S}}$) is calculated using the following equation:

(89) $\Delta \mathrm{PS}_{\mathrm{A}}^{\mathrm{S}} = \Delta \mathrm{P}_{\mathrm{A}}^{\mathrm{S}} * \mathrm{S}_{\mathrm{A}}^{\mathrm{S}}$.

where $\Delta \mathrm{P}_{\mathrm{A}}^{\mathrm{S}}$ is the changes in supply price for shipping points in Colorado and $\mathrm{S}_{\mathrm{A}}^{\mathrm{S}}$ is Colorado supply for shipping points. Thus, the total change in Colorado producer surplus is:

(90) $\Delta \mathrm{PS}_{\mathrm{A}} = \Delta \mathrm{P}_{\mathrm{A}}^{\mathrm{F}} * \mathrm{S}_{\mathrm{A}}^{\mathrm{F}} + \Delta \mathrm{P}_{\mathrm{A}}^{\mathrm{S}} * \mathrm{S}_{\mathrm{A}}^{\mathrm{S}}$.

The change in the rest of U.S. producer's surplus is:

(91) $\Delta PS_A = \Delta P_B^S * S_B^S$.

In long run, the increase in Colorado producer surplus through direct markets is calculated using the following equation:

(92) $\Delta PS_A^F = \Delta P_A^F * S_A^F + \frac{\Delta P_A^F * \Delta S_A^F}{2}$.

where ΔS_A^F is the changes in Colorado supply for direct markets. The change in Colorado producer surplus through shipping points is calculated using the following equation:

(93) $\Delta PS_A^S = \Delta P_A^S * S_A^S + \frac{\Delta P_A^S * \Delta S_A^S}{2}$.

where ΔS_A^S is the changes in Colorado supply for shipping points. Thus, the total change in Colorado producer surplus is:

(94) $\Delta PS_A = \Delta P_A^F * S_A^F + \frac{\Delta P_A^F * \Delta S_A^F}{2} + \Delta P_A^S * S_A^S + \frac{\Delta P_A^S * \Delta S_A^S}{2}$.

The change in the rest of U.S. producer's surplus (ΔPS_B^S) is:

(95) $\Delta PS_B^S = \Delta P_B^S * S_B^S + \frac{\Delta P_B^S * \Delta S_B^S}{2}$.

where ΔP_B^S is the changes in supply price for shipping points in rest of U.S., S_B^S is rest of U.S. supply for shipping points, and ΔS_B^S is the changes in rest of U.S. supply for shipping points.

4.3.2 Empirical Results

The EDM was simulated using the Matlab program (7.11.0 version). The price, quantity and producer surplus changes due to new local labeling efforts and promotions are presented in Table 4.6[14]. Two scenarios were considered. The first scenario was assuming "fixed supply", which

[14] The willingness to pay and market share data in Colorado (2008 survey data) show that the demand for fresh local apples in Colorado exhibits kinked demand due to the segmentation of the market where there are some consumers with more inelastic demand. The demand curve will not only shift but also rotate due to the local promotion. The specific demand curve (equation) is not available, thus it is difficult and

analyzed the effects in the very short run when suppliers could not react to the increase in consumer demand (suppliers could not change their marketing channels). In this scenario, the increase in producer surplus was only due to the price change. The second scenario allowed for "elastic supply", which analyzed the effects in a relatively long run when suppliers could react to the shocks in demand. In this scenario, both the prices and quantities adjusted to demand shifts. Within each scenario, simulations based on MMB and CMB are compared. For the "fixed supply" scenario, lower and upper bound of estimated transaction cost ratios are used to compare.

The local labeling increases consumers' willingness to pay for local apples relative to domestic apples in Colorado, and subsequently, the supply price for direct markets increased compared to the supply price for shipping points, both in the short run and in long run. As a result, in Colorado, demand for both local and domestic apples increases in the long run, but the increase is larger for domestic apples. This is due to the relatively low production volumes from Colorado which cannot even meet the current state demand. The demand for domestic apples in the rest of U.S. decreases in the short run, but is estimated as having a small increase in the long run.

On the supply side, as a result of the increase in the direct market price compared to the shipping point price, the Colorado supply for direct markets increases relative to the supply for shipping points in the long run. In terms of producer surplus, Colorado suppliers for direct markets gain while Colorado suppliers for shipping points lose in short run. In the long run, both suppliers will gain, but the suppliers for direct markets will gain more than the suppliers for shipping points. Overall, the Colorado producers lose in the short run while they gain in the long

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inaccurate to estimate the changes of consumer surplus. Thus, only the producer surplus is examined in this study.

run due to the shift of demand toward local apples in direct markets, where higher prices can be secured.

The big change in prices and quantities and subsequently, the big loss in the short run is due to the high premium between supply price for the direct market and shipping point based on historical prices and the high cross price demand elasticity between local apples and domestic apples derived from 2008 survey data (which is significantly higher than the general cross price demand elasticity used in Carpio and Isengildina-Massa (2010)). These market forces drive the shipping point price much lower but the suppliers cannot reduce supply due to “fixed supply” assumptions (and the practical limitations of how much volume can move through direct marketing channels). Due to the relatively lower volume of direct sales of apples in Colorado compared with supplies for shipping points, the gain of suppliers for direct markets could not offset the loss of suppliers for shipping points. Thus, there is a big loss in Colorado in the short run.

Overall, there is no big difference in the results for lower bound parameters and upper bound parameters. This is due to the fact that the lower bound and upper bound are estimated for the short run parameters, and only exists for the market margin between the Colorado retail market and domestic retail market. In the EDM, the suppliers are assumed not to be able to react to the changes in demand in the short run. Thus, the lower bound and upper bound estimates are close enough they would not differentiate the results. However, this does not imply that the results are not sensitive to supply prices and price differences. On the other hand, most of the changes based on CMB are similar to the changes based on MMB except the changes in

Table 4.6 Price, Quantity, and Producer Surplus Changes…

Variables	**Fixed Supply (MMB)** lower t_A^d=0.17	**Fixed Supply (MMB)** upper t_A^d=0.27	**Fixed Supply (CMB)** lower t_A^d=0.17	**Fixed Supply (CMB)** upper t_A^d=0.27	**Elastic Supply (MMB)**	**Elastic Supply (CMB)**
	γ = 0.019		γ = 0.372		γ = 0.019	γ = 0.372
$\%\Delta D_A^l$	-0.10	-0.10	0.01	0.02	12.07	10.78
$\%\Delta D_A^d$	849.29	849.03	62.46	62.46	874.14	63.48
$\%\Delta D_B^d$	-6.40	-6.15	-0.38	-0.13	0.83	0.24
$\%\Delta S_A^F$	0	0	0	0	230.97	206.84
$\%\Delta S_A^S$	0	0	0	0	-62.33	-65.17
$\%\Delta S_A^{SA}$	0	0	0	0	-2.19	-2.25
$\%\Delta S_B^S$	0	0	0	0	14.82	1.33
$\%\Delta P_A^l$	110.02	109.99	120.34	120.34	113.33	125.14
$\%\Delta P_A^d$	2.92	2.92	12.33	12.34	5.33	17.14
$\%\Delta P_B^d$	-13.72	-23.71	-4.64	-14.62	-16.67	-4.86
$\%\Delta P_A^F$	67.67	67.67	67.67	67.67	128.82	115.33
$\%\Delta P_A^S$	-21.33	-21.33	-21.33	-21.33	39.82	26.33
$\%\Delta P_B^S$	-46.33	-46.33	-46.33	-46.33	14.82	1.33

Table 4.6 Price, Quantity, and Producer Surplus Changes…, Continued

Variables	Fixed Supply (MMB)		Fixed Supply (CMB)		Elastic Supply (MMB)	Elastic Supply (CMB)
	lower $\boldsymbol{t_A^d}$=0.17	upper $\boldsymbol{t_A^d}$=0.27	lower $\boldsymbol{t_A^d}$=0.17	upper $\boldsymbol{t_A^d}$=0.27		
ΔPS_A^F (mil.$)	0.58	0.58	0.58	0.58	2.37	2.00
	(0.11, 1.15)	(0.20, 2.03)	(0.38, 0.66)	(0.31,0.74)	(1.42, 34.54)	(1.98, 4.61)
ΔPS_A^S (mil.$)	-1.37	-1.52	-1.37	-1.52	1.84	1.19
	(-3.68, 0.67)	(-8.08, 0.37)	(-2.28, 0.40)	(-2.11, -0.53)	(-90.04, 2.67)	(-0.12, 0.39)
ΔPS_A (mil.$)	-0.79	-0.94	-0.79	-0.94	4.21	3.19
	(-4.17, 1.12)	(-4.19, 1.11)	(-4.16, 1.10)	(-4.14,1.11)	(-245.78, 14.56)	(-23.15, 12.78)

Note: All simulations are based on 2008 average prices and quantities.

1. The shock to demand for local apples due to origin labeling efforts was estimated to be 0.019 using MMB.
2. The shock to demand for local apples due to origin labeling efforts was estimated to be 0.372 using CMB.
3. In the "fixed supply" scenario, a perfectly inelastic supply situation, suppliers cannot react to the changes in demand by changing the quantities supplied.
4. In the "elastic supply" scenario, suppliers can adjust their supply to the changes in the demand.
5. In the "lower t_A^d" scenario in "fixed supply", lower bound estimated t_A^d is used in the simulation, while upper bound estimated t_A^d is used in the simulation for "upper t_A^d" scenario.
6. ΔPS_A^F is changes in producer surplus of Colorado suppliers for direct markets, ΔPS_A^S is changes in producer surplus of Colorado suppliers for shipping points, and ΔPS_A is the total changes in producer surplus of Colorado suppliers.
7. The values in brackets are 95% probability intervals of producer surplus changes.

Colorado demand for domestic apples. This coincides with the fact that CMB consumers are more loyal to local apples, and thus, their effect on the market yields a larger shock to the demand for local apples. The significant difference in changes in Colorado demand for domestic apples is due to the big difference in the elasticity of demand for domestic apples with respect to local apple price using CMB (inelastic) and MMB (significantly elastic) assumptions about how the shock will affect different types of consumers in the market.

4.4 Sensitivity Analysis

One may question how robust the estimated welfare estimates are with respect to changes in the values of the parameters. An extensive nonstochastic sensitivity analysis becomes unmanageable and cannot quantify the likelihood of deviation from the most likelihood values of parameters for a model with a large number of uncertain parameter (Zhao et al., 2000). In this study there are twelve base parameters: elasticity parameters(ε_{A}^{ll}, ε_{A}^{ld}, ε_{A}^{dl} , ε_{A}^{dd},β, τ, ρ_F), transaction cost ratios (t_l, t_d, t_F, t_S), and the difference in WTP (ΔWTP). Thus, an alternative method of sensitivity analysis, developed through a subjective distribution for the parameters, is used in this study.

Based on the approach proposed by Zhao et al. (2000), truncated normal distributions are assigned to the twelve parameters which specify the possible values of each parameter and the corresponding probabilities. σ is specified using the coefficient of variation (CV): $\sigma = \mathrm{CV} * \mu$. Due to the limited empirical studies on these parameters, a 100% CV is used for the base distribution specification equal to the CV used by Carpio and Isengildina-Mass (2010).

4.4.1 Distribution of Changes in Colorado Producer Surplus

The graph of the probability density functions of the total Colorado producer surplus change and its two components in the short run and in the long run are shown in figure 4.8. Figure 4.8a, 4.8b, and 4.8c show that, in short run, changes in Colorado producer surplus for those who market

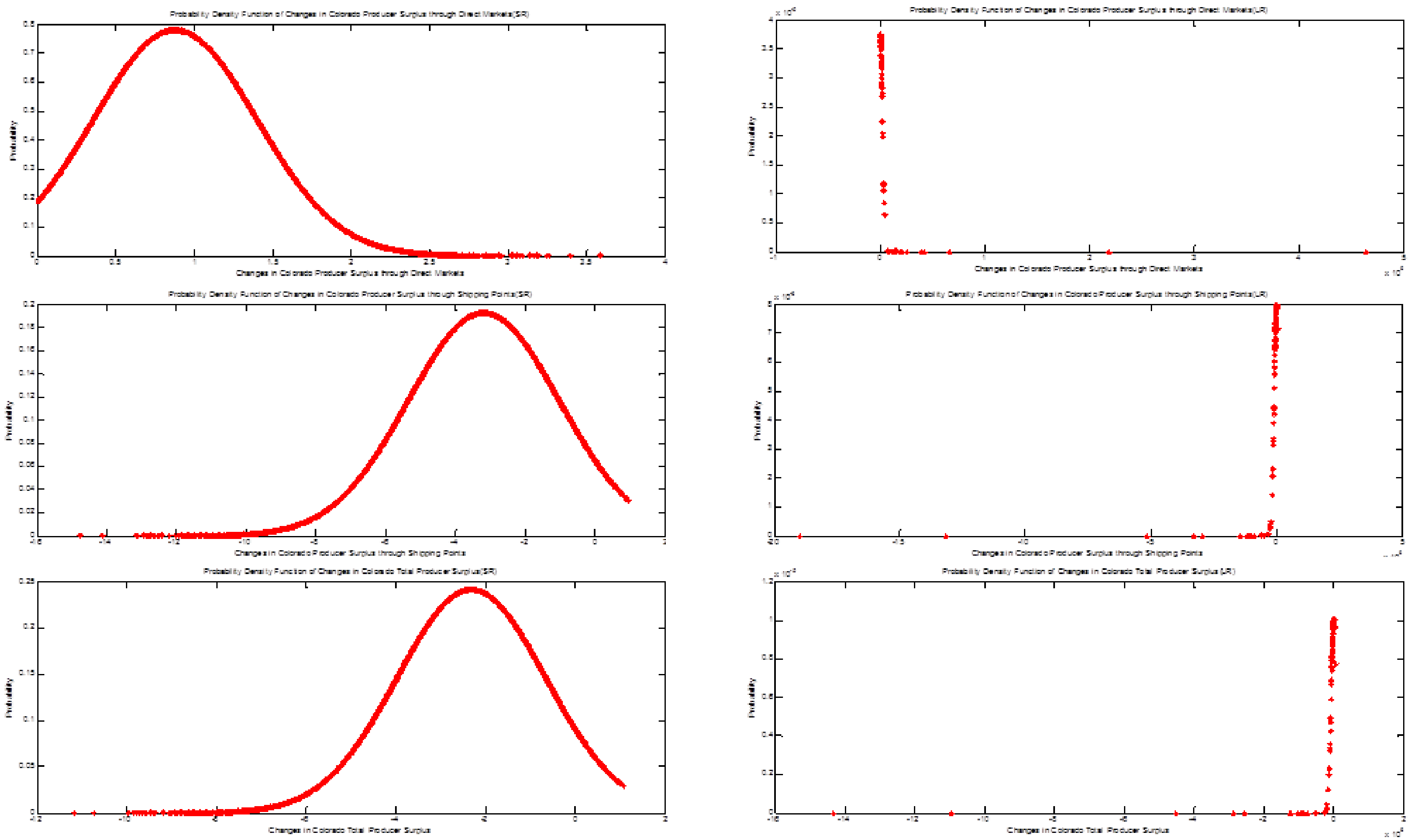

Figure 4.8 (4.8a, 4.8b, 4.8c, 4.8d, 4.8e, 4.8f) Probability Density Functions of Changes in Colorado Producer Surplus

through direct markets are mostly positive and lie between \$0 and \$2.50 million, changes in Colorado producer surplus for those who market through shipping points are mostly negative and lie between -\$10.00 and \$1.00 million, and changes in Colorado producer total surplus lie between \$-8.00 and \$1.00 million. The disperse nature of the distributions is based on the simulation results.

Figure 4.8d, 4.8e, and 4.8f show that, in the long run, changes in Colorado producer surplus for those distributing through direct markets are mostly positive and lie between \$0 and \$2 trillion, changes in Colorado producer surplus for those distributing through shipping points are mostly negative and lie between -\$2 and \$0 trillion, and changes in Colorado producer total surplus are mostly positive and lie between -\$2000 billion and \$50 billion. These results suggest that suppliers for direct markets would always gain with the local labeling efforts, while suppliers for shipping points would always lose due to the shift of demand toward local apples and subsequently, supply toward direct markets. Whether the gain by suppliers for direct markets could offset the loss by suppliers for shipping points depends on the market conditions. In addition, the distribution of Colorado total producer surplus and its two components are more disperse in the long run than in short run.

4.4.2 Sensitivity in Individual Parameters

The simulation of the economic welfares defines a relationship between a particular welfare measure (W) and a set of parameters $(\Theta = (\theta_1, \theta_2, \ldots, \theta_n))$:

(96) $W=W(\Theta)=f(\theta_1, \theta_2, \ldots, \theta_n)$

This relationship is used to estimate the probability density function for W based on the joint probability density function forΘas illustrated in figure 4.7. The sensitivity of W to changes in a particular parameter θ_i (i=1,2,…,n) can also be measured based on this relationship.

Following Zhao et al. (2000), a measure of the sensitivity of W to changes in a particular parameter is defined, which include both the importance of W to θ_i and the probable variation of θ_i.

Due to the large number of simulated observations (100,000) and the complexity of the relationship between the changes in economic welfare and changes in parameters, a response surface is used to estimate the relationship[15]:

(97) $W_k = \alpha_0 + \sum_{i=1}^{12} \alpha_i\theta_i + \sum_{i=1}^{12} \beta_i\theta_i^2 + \sum_{i,j=1,i<j}^{12} \gamma_{ij}\theta_i\theta_j + e_k$ k=1,2,3

where W_k (k=1,2,3) represent the changes in Colorado producer surplus through direct markets, the changes in Colorado producer surplus through shipping points, and the changes in Colorado total producer surplus. θ_i (i=1,2,…,12) represents the demand and supply elasticities, the transaction cost ratios, and the price premiums. α_0, α_i, β_i, and γ_{ij} (i,j=1,2,…,12) are coefficients to be estimated. e_k (k=1,2,3) are error terms.

The three equations in (97) are estimated using the 100,000 simulated observations for both the short run and long run scenarios. The results are shown in Table 4.7. Due to the large numbers of regressions (53,421 data are left for the short run and 59,691 are left for the long run after eliminating data that do not satisfy substitution restrictions), details of the estimated coefficients are not presented. The R^2 for the regressions for changes in Colorado total producer surplus are very high, both in the short and long run, however, are very low for the regressions for the two components. This means that the model fits the changes in Colorado total producer surplus well, while the fitness to the two components is low. This indicates that the changes in producer surplus through direct markets and shipping points are more affected by other factors

[15] This is a quadratic function. Other second degree polynomial specifications are the pure quadratic function and interaction function.

such as the demand quantity, the supply quantity, and the selling price. The effect of these factors are opposite for the two changes and can cancel out each other when one considers the total producer surplus that results.

Table 4.7 R^2 for the Estimation of Response Surface

R^2	Short Run	Long run
ΔPS_A^F	0.002	0.0004
ΔPS_A^S	0.002	0.0005
ΔPS_A	1.000	0.9978

To find the sensitivity of the economic welfare estimates to individual parameters, a sensitivity elasticity using the estimated response function and the probability density functions of the parameters are defined following the approach proposed by Zhao et al. (2000). This sensitivity index represents the average sensitivity of an economic welfare measure across all possible values of all parameters. The sensitivity index takes both the variation of the parameters and the possibility of a parameter value to be true into consideration.

The sensitivity elasticity of each economic welfare change W_k (k=1, 2, 3) to parameter θ_i (i=1, 2,…, 12) at any parameter point Θ is estimated by partial differentiating the response surface equation (64):

$$(98)\quad E_{ki} = \left(\frac{\partial W_k}{\partial \theta_i}\right)\left(\frac{\theta_i}{W_k}\right) = \left(\alpha_i + 2\beta_i\theta_i + \sum_{j=1, j\neq i}^{12} \gamma_{ij}\theta_j\right)\left(\frac{\theta_i}{W_k}\right) = g_{ki}(\Theta)$$

(k=1,2,3; i=1, 2,…,12)

The sensitivity elasticity E_{ki} is a function of all parameters Θ and is different at different points of Θ. The possible values and the probability distribution of E_{ki} can be defined once the possible values of$\Theta$and the probability of each value occurring $p(\Theta)$ are specified. The mean and standard deviation of E_{ki} are:

$$(99)\quad \mu(E_{ki}) = \int_{\Theta} g_{ki}(\Theta)\, p(\Theta)\, d\Theta$$

(100) $\sigma(\mathrm{E_{ki}}) = (\int_{\Theta} \left[\mathrm{g_{ki}}(\Theta) - \mu\big(\mathrm{g_{ki}}(\Theta)\big)\right]^2 \mathrm{p}(\Theta)\,\mathrm{d}\Theta)^{1/2}$

$\mu\big(\mathrm{g_{ki}}(\Theta)\big)$ is the mean of $\mathrm{g_{ki}}(\Theta)$

There are two steps to estimate the mean sensitivity elasticities for the long run and short run scenarios. First, 53,421 for short run and 59,691 for long run observations of E_{ki} are estimated using equation (98) based on the simulated observations of Θ. Second, the sample means and standard deviations of E_{ki} are estimated using equation (99) and (100). The results of the estimated mean sensitivity elasticities for the long run and short run are presented in Table 4.8. The results provide a measure of the sensitivity of economic welfare measures to a particular parameter, comparison of the relative importance of different parameters, and suggest the direction of the relationship between the economic welfare change and the parameters.

Because the R^2s for two components are very low, only the sensitivity elasticities for changes in Colorado total producer surplus are analyzed. As expected, the sensitivity elasticities are larger in the long run than in short run. A point to note is that this result is different from the analysis of producer surplus distributions. The producer surplus distribution analysis is based on the changes of all parameters, while only one parameter is changed each time for these estimates.

Overall, the changes in Colorado total producer surplus are sensitive to all parameters and the intervals show that the influences of most parameters are statistically different from zero because the confidence intervals do not include zero. The changes are most sensitive to the cross price demand elasticity between local apples and domestic apples (ε_A^{ld}, ε_A^{dl}), the aggregate own price supply elasticity (β), the elasticity of transformation between marketing through direct markets and through shipping points (τ), and the price differences between direct markets and shipping points (t_F). The result suggests that factors connected with the substitution between local apples and domestic apples dominate with respect to the magnitude of changes in producer surplus (on the demand side, ε_A^{ld} and ε_A^{dl}, on the supply side, τ).

In the short run, the changes in Colorado total producer surplus increase if the cross price demand elasticity of local apples with respect to domestic price increases, while they decrease if the aggregate supply elasticity increases. The changes in Colorado total producer surplus have a positive relationship with the cross price demand elasticity of local apples with respect to domestic price, aggregate supply elasticity, the premium (WTP) for local apples with respect to domestic apples, and the price difference between the supply offered in direct markets and shipping points. The changes have a negative relationship with all other factors. In the long run, the changes in Colorado total producer surplus have a negative relationship with all parameters except the cross price demand elasticity between local apples and domestic apples, aggregate own price supply elasticity, elasticity of transformation between marketing through direct markets and through shipping points, and the price difference between supply prices in direct markets and shipping points. As stated above, these are the parameters that the changes are also most sensitive to.

4.5 Conclusions and Discussion

This chapter employed an equilibrium displacement model (EDM) to explore the structural and performance dynamics of a market as a result of new labeling efforts and promotional campaigns highlighting the availability of locally grown products (both in direct markets and within more conventional marketing channels). In particular, the changes in market performance are derived as a result of changes in prices and demanded quantities of Colorado labeled apples relative to domestically produced apples, as well as changes in prices and supplied quantities of directly marketed apples relative to more conventionally marketed apples through major shipping points.

The results showed that, in the long run, consumers would shift their demand toward local apples due to increased promotion and markets that implement local labeling. Increases in Colorado's production of apples would be marketed more directly relative to the volume marketed through shipping points due to those demand shocks. The implications for Colorado producers are mixed depending on their market orientations. Although suppliers for shipping points would lose in short run, all Colorado suppliers would gain in the long run. The results are sensitive to all parameters used in this study and most sensitive to the parameters relating with the substitution between local and domestic apples and the transformation between different marketing channels.

These results are interesting for several reasons. As a complement to work done by Carpio and Isengildina-Massa, it shows there may be long term gains to producers as they strategically position some of their produce to more localized markets, thereby justifying local promotion programs.

One limitation of the study is the overly simple assumption that global markets do not matter. To derive an EDM that could be solved with available data, this was necessary at this point, but it is our intention to address that limitation in future research. Also, we only consider apples, even though most state marketing programs for local foods cover the full array of food products. The welfare changes are expected to be much lower than the estimation for aggregate food products. However, the cross price demand elasticities estimated based on Onozaka et al. 2008 survey data are much larger than the estimation by Carpio and Isengildina-Massa (2010) which indicates larger demand response to other apple segments' price changes. This explains why these welfare changes are not much different from those reported by Carpio and Isengildina-Massa, but we chose apples as a specific market to advance their efforts. Their work had to use parameter estimates that were more simplified in terms of market channels (not allowing directly marketed produce to vary from products offered in more conventional markets), which is a limitation given Onozaka et al. results that WTP does vary by where consumers shop.

Nonetheless, this paper contributes to the literature by providing insights on how strong consumer responses to local produce offerings (albeit among a relatively small set of buyers) may affect market dynamics. By allowing for segregated markets, akin to what occurs more formally with organic produce, this conceptual framework provides a method analyze welfare in an increasingly differentiated food system.

Table 4.8 Sensitivity Elasticities of Colorado Producer Surplus to Individual Parameters

Changes	ε_A^{ll}	ε_A^{ld}	ε_A^{dl}	β	ρ	τ	ΔWTP	t_d	t_s	t_l	t_f	ε_A^{dd}
Short Run												
ΔPS_A^F	-148.71* (-155.02,- 142.40), -301.19)	-7.89e+4* (-8.13,-7.65) e+4	3.77e+6* (3.66,3.89) e+6	3.85e+5* (3.73,3.96) e+5	-664.65* (-677.73, -651.57)	3.61e+4* (3.37,3.85) e+4	-8.79e+3* (-9.06,-8.53) e+3	-975.35* (-1.00,-0.95) e+3	6.78e+3* (6.61,6.96) e+3	-2.53e+4* (-2.61,-2.45) e+4	151.68* (148.46, 154.91)	9.68* (9.49,9.88)
ΔPS_A^S	109.07* (8.81,209.33)	-9.33e+3* (-8.55,6.69) e+4	4.56e+5* (-3.20,4.11) e+6	4.78e+4* (-3.26,4.22) e+5	-212.90* (-968.05, 542.26)	-4.82e+4* (-1.04,0.08) e+5	-1.06e+3* (-9.57,7.45) e+3	-130.73* (-1.09,0.83) e+3	1.08e+3* (-5.65,7.81) e+3	-3.15e+3* (-2.78,2.15) e+4	31.87* (-124.56, 188.31)	-0.41* (-6.54,5.71)
ΔPS_A	-17.78* (-26.51, -9.05)	270.60* (-0.76,1.31) e+3	-4.57e+4* (-2.30,1.38) e+5	1.46e+3* (-3.77,6.69) e+3	-95.33* (-361.08, 170.41)	-2.17e+3* (-3.07,-1.28) e+3	60.85* (-174.62, 296.31)	-8.50* (-48.92, 31.91)	30.73* (-53.93, 115.39)	-237.76* (-1.19,0.71) e+3	-325.02* (-1.59,0.94) e+3	-1.66* (-2.05,-1.27)
Long Run												
ΔPS_A^F	3.12e+7* (1.58,4.66) e+7	5.42e+9* (4.48,6.37) e+9	-2.68e+11* (-3.04,-2.33) e+11	9.13e+10* (0.77,1.06) e+11	-2.71e+9* (-4.42,-0.99) e+9	-6.54e+10* (-1.35,0.04) e+11	-1.77e+9* (-2.05,-1.49) e+9	4.27e+7* (3.65,4.90) e+7	1.41e+8* (1.23,1.60) e+8	2.15e+9* (1.81,2.49) e+9	-5.45e+9* (-6.31,-4.59) e+9	1.52e+7* (-0.39,3.42) e+7
ΔPS_A^S	6.28e+8* (-0.49,1.74) e+9	3.50e+10* (-0.34,1.04) e+11	-1.73e+12* (-5.15,1.69) e+12	5.90e+11* (-0.57,1.75) e+12	-2.01e+10* (-5.79,1.78) e+10	-3.50e+11* (-1.06,0.36) e+12	-1.15e+10* (-3.41,1.12) e+10	2.74e+8* (-2.68,8.17) e+8	8.54e+8* (-0.88,2.59) e+9	1.39e+10* (-1.35,4.12) e+10	-3.51e+10* (-1.04,0.34) e+11	6.02e+7* (-0.71,1.91) e+8
ΔPS_A	-1.70e+7* (-1.17,0.83) e+8	3.49e+10* (3.45,3.54) e+10	5.91e+11* (5.86,5.96) e+11	1.08e+11* (1.06,1.09) e+11	-1.90e+9* (-2.35,-1.46) e+9	2.12e+11* (1.67,2.58) e+11	-6.44e+9* (-6.53,-6.36) e+9	-1.61e+8* (-1.66,-1.56) e+8	-1.31e+8* (-1.58,-1.04) e+8	-7.28e+9* (-7.39,-7.18) e+9	3.96e+10* (3.90,4.02) e+10	-1.76e+8* (-2.35,-1.18) e+8

Note：

a. The first row of each change is the mean of the elasticities.

b. The values in the parenthesis are 95% confidence intervals.

c. * denotes significant at 5% level.

d. The results are based on 100,000 simulated observations.

CHAPTER 5 CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH

5.1 Introduction

The main objective of this study is to explore the structural and performance dynamics of a market as a result of new labeling efforts and promotional campaigns highlighting the availability of locally grown products. This goal was reached through the development of three complementary phases.

First, a descriptive analysis of current fresh apple production, consumption and supply chain structure was presented. Second, spatial market integration models were developed to examine the market structure and price relationships at different supply chain levels for the fresh apple market. In addition to providing parameters necessary for the welfare analysis to follow, the examination of market structure and spatial price relationships at each level allow me to infer the effect of various market factors and dynamics, such as truck rate and seasonality, on prices.

Finally, an equilibrium displacement model was developed based on the market statistics, supply chain considerations and cost/price relationships estimated in the earlier chapters to explore the impacts of local labeling by segmenting markets using regional-origin labeling as a criterion. The market was segmented in this model assuming perceived quality differences on the demand side and segmenting markets by marketing channels which were allowed to have varying transaction/marketing costs on the supply side. Using the equilibrium displacement model, we could analyze how consumer perceptions and marketing channel structure influence market performance, which was the overarching goal of this study.

5.2 Conclusions and Marketing Implications

The market linkages among spatially separate apple markets at retail and shipping point levels were examined through price relationship modeling as a means to understand drivers of the national market, and what may differ in the supply and demand dynamics of U.S. regions. Cointegration analysis and Granger causality tests were conducted to examine spatial price relationships. The results showed that the Southwest and Northeast retail markets dominated national markets and the Northwest retail market dominated western markets in terms of its influence on retail prices. Not surprisingly the Yakima Valley and Wenatchee District in Washington (the production region for the great majority of U.S. apples) significantly affected the price formation process of all other shipping points. This is a common first step in price analysis that considers spatial markets as important to behavior, but in this case, since regional and local apple marketing will vary significantly by the area considered, a more thorough analysis of what may vary in the cost structure across regional markets was deemed necessary.

A Threshold Autoregressive Regression (TAR) model was used to estimate the price relationship and the transaction costs from one location to another. A constant and a symmetric variable TAR model were estimated to show the sensitivity of results to the methods used to analyze the price behavior. The constant TAR model only utilized price data, while the symmetric variable TAR model applied both prices and transportation costs data (assuming that is one variable that would vary greatly across U.S. regions). Thus, the symmetric variable TAR model made it possible to examine how prices at different market levels were affected by market forces such as truck rates and seasonality.

The symmetric variable TAR model was revealed as a better representation of the price behavior in this market given the added variables were found to be significant. Truck rates and seasonality are confirmed to have a significant impact on the threshold band of each market pair. Specifically, higher transportation costs (on-highway diesel prices or truck rates) implied a wider neutral band between markets. This is as expected because higher transportation costs usually lead to an increase in costs and prices, but more importantly, more uncertainty about the returns from cross-region shipments of high volume, low- value goods.

Overall, the threshold bands estimated for the shipping points are larger than the estimates for retail markets. But, there would be more supply adjustments between markets if the threshold band is allowed to vary with transportation costs and seasonality, as the symmetric TAR allows. This means that if the unknown transaction cost band is allowed to vary according to transportation costs and seasonality, it may more closely mimic suppliers who view more opportunities to adjust their supply between regional markets in search of potential profits. One would assume this varies with market conditions as well (ie, number of active shipping points with apple supplies).

The results suggested a narrower band in the off season (when most local harvests would have been fully consumed) between retail markets. In contrast, a wider band was estimated for the harvest season between shipping points. This is consistent with the idea that, when local markets are still active, there are more potential trade partners affecting the dynamics of the markets, and thus, the range of shipping-retail market pairs, prices received and transaction costs will vary especially if more localized markets continue to emerge and grow. To delve further into the economic implications of emerging market innovations, the market dynamic and welfare effects of local labeling were estimated using an equilibrium displacement model, with sensitivity analysis of the parameters that may influence those results. The model was customized to better represent local food market innovations by segmenting markets with particular attention to the share of consumers with increased stated values due to regional-origin labeling (based on perceived quality differences) on the demand side while segmenting markets by realizing differential costs and prices in marketing channels on the supply side.

In this customized EDM, the whole economy is necessarily separated into two regions: Colorado and the rest of the United States, which has otherwise competitive supply and demand relationships with the Colorado apple sector. There are two differentiated categories of apples on the demand side: Colorado local apples and domestic apples that were produced in other regions of the U.S. In addition, two marketing channels were examined on the supply side, direct markets, where farmers handle and market directly to consumers at localized market sites, and more traditional shipping points that are the entry point into the national supply chain.

One of the contributions of this study was the care that was taken to understand the relevant market structure and estimate product- and market-specific parameters to input into the EDM using recent consumer research and available secondary data from the USDA Agricultural Marketing Service. The selection of representative markets and the construction of price relationship equations were based on the price relationship analysis and the transaction costs estimates in chapter 3. Then, the model was simulated separately based on two groups of market buyers, median market buyers (MMB) and current market buyers (CMB). This choice to "shock" the model at two points serves as a type of sensitivity analysis of how the market shock would affect the market overall, versus how it would impact the market given the current share of consumers who actively participate in direct markets (given the increasing demand for regional foods by some was one of the guiding motivations for this project and the growth of direct markets themselves. The main results obtained in the simulation of this model are summarized as follows.

Overall, local labeling was found to increase consumers' willingness to pay for local apples relative to domestic apples in Colorado, and subsequently, this model found that demand will shift toward local apples and the supply will shift toward direct markets in Colorado. In terms of producer surplus, Colorado suppliers for direct markets gain while Colorado suppliers for shipping points lose in short run. In the long run, both suppliers will gain but the suppliers for direct markets will gain more than the suppliers for shipping points. Overall, the Colorado producers lose in the short run while they gain in the long run. Most of the changes based on the CMB scenario were similar to the changes based on the MMB scenario except for the magnitude of the changes in Colorado demand for domestic apples. This coincides with the fact that, at current market shares, CMB consumers are more loyal to local apples, and thus, their effect on the market yields a larger shock to the demand for local apples and results in a smaller increase in demand for domestic apples in Colorado. We feel this is a more realistic scenario, and also yields more realistic estimates of changes to the broader apple market.

Sensitivity analysis was conducted to investigate the distribution of changes in producer surplus and the sensitivity of the results to individual parameters. The results suggested that suppliers for direct markets would always gain with the local labeling efforts, while suppliers for shipping points would always lose due to the shift in demand toward local apples, and subsequently, supply toward direct markets. Whether the gain by suppliers for direct markets could offset the loss by suppliers for shipping points depends on the market conditions.

The changes in Colorado total producer surplus are sensitive to all parameters and the influence of most parameters is statistically different from zero. The changes are most sensitive to the cross price demand elasticity between local apples and domestic apples, the aggregate own price supply elasticity, the elasticity of transformation between marketing through direct markets and through shipping points, and the price differences between direct markets and shipping points.

5.3 Applications to Other Markets

While this study examines only the apple industry, the results and modeling efforts in this study can be applied to other markets. Most clearly, the approach used in this study can be applied to other foods that are marketed locally but the results are expected to vary based on the characteristics of the food and dynamics of the market (level of imports, number of areas that have the climate, lands and facilities to produce the food, level of processing needed).

Taking lettuce, a perishable product with shorter production response time as an example, it cannot be stored for as long of a period as apples, and hence, the demand for lettuce is less elastic to prices than apples. Following what was found here, the demand shock from promotions would be expected to be lower for lettuce than the shock for apples, thus, smaller changes in prices and quantities and lower changes in producer surplus are expected. Moreover, the production planning period of lettuce is much shorter than apples, thus, the supply of lettuce is less "fixed" so the long run scenario may be arrived at more quickly. In our model, that would allow all shippers to achieve a "gain" position more quickly, but only if other constraints did not exist. In actuality, the perishability and climatic needs for lettuce are such that local and regional markets may achieve gains in seasons of the year, but the dynamics of the more conventional system may be relevant for over half of the year, since consumers seek lettuce year-round in areas that cannot produce except for a 4-6 month window (because of extremes in cold and/or heat).

How close the agricultural raw product is to final form also matters to the analysis of local marketing. The closer the raw product is to the final form, such as fresh fruits and vegetables, eggs, and milk, research suggests there is more concern about the local attributes (e.g. Hu et al. (2010) found that consumers rated the local attribute highest for fresh and perishable products and lowest for processed products), which brings larger demand shocks that induce larger changes in prices, quantities, and economic welfare. On the other hand, the supply chains of these products are shorter than other products with more processors in the chain, such as apple juice and soybean oil. Thus, the transaction costs with marketing products that could be consumed immediately post-harvest are relatively lower than products that require some processing (meats and grains). Since regional supply chains for products that need to be processed will may or may not have appropriate scale facilities for segregating and handling local suppliers (who may be smaller scale), the economics would be more complex in estimating post-harvest handling (and processing) costs for segmented markets. But, such analysis is worth pursuing, given emerging examples of mobile meat processing units and renewed interests in value-added production (see USDA's Rural Development Value Added Grant program and the many projects it has put in place across the U.S.)

Moreover, this study gives suggestions on the key factors that matter most to those who seek to analyze local food markets, or more generally, any other relocalized sectors using an equilibrium displacement model. If a market is consumer driven, such as the local food market, then the premia that consumers are willing to pay for a local produce with respect to a non-local produce, the cross price demand elasticities, and where people choose to shop (if local products are not available everywhere) matter most to the impact of a policy or program aiming to support the local product. On the other hand, if a market is supply driven, such as the interest in relocalizing the biofuel industry, the key factors that determine the performance of a policy or program are the difference in the production costs between local firms and domestic or international competitors, gains from scale economies, the expense of marketing through less developed or efficient channels, and again, the transformation variables of redirecting inputs or semi-processed products into a product bundle that is characterized as local to the relevant buyers.

From a more general view, the market behavior and structure examined in this study inform the broader economic field. When markets start to fragment, welfare analysis should be decomposed by those who are buying or selling through different channels in order to assess the winners and losers; information pertinent to the political debates underlying most economic decisions. An interesting example to consider is creative industries where products influence quality of life. In the past, if you want to buy music through CDs for a specific band, to the buyer would be required to drive to music stores and search. So, transaction costs were higher for those bands that were more local, obscure and popular with the average national consumer. More currently, anyone can choose to buy from either a conventional music store or download from Internet sources (such as the ITunes music store). So, in the past, those with more unique tastes in music, may have had to pay higher prices (directly and through increased search costs). But, the transformation variable has evolved with online options, so these markets may be converging. And, this modeling effort shows the general framework to consider and estimate how those "niche" markets could be evaluated more carefully. In short, when doing welfare analysis that is driven by a economic question related to new market behavior that is an exception to the norm, this analysis shows the market should be decomposed by different channels both on the demand side and on the supply side to provide insights to who gains and loses.

The analysis of the distribution of welfare effects suggests that, in the long run, it is more likely that all marketing strategies may gain in welfare, because consumers may shift to the market they feel suits them best, and suppliers will move toward more perfect price discrimination which can be Pareto optimal. Suppliers will make pricing strategy with regard to different consumer groups, and redevelop marketing channels to achieve a new efficiency level (although segmented markets may persistently lose some scale efficiencies).

5.4 Limitations

The empirical results from this study are interesting for several reasons. It shows there may be long term gains to producers as they strategically position some of their produce to more localized markets, thereby justifying local promotion programs. However, there may be a short-run downside, even with support from consumers, because of the efficiencies lost in high volume supply chains being fragmented to marketing channels that deliver more localized goods. Moreover, this conceptual framework does not consider the broader picture: is this a zero-sum game for U.S. fresh produce suppliers? Or does it grow consumer confidence and overall buying power dedicated to fresh produce (or other relevant food categories)? These questions lead us to a discussion of the limitations of this study.

One limitation of the study is the overly simple assumption that global markets do not matter, domestic apples could not enter direct markets, and the market shares of direct sales are the same throughout the U.S. To derive an EDM that could be solved with the available data, employing these assumptions was necessary at this point, but it is our intention to address these limitations in future research.

Also, the changes in consumer surplus are not examined in this study. The willingness to pay and market share data in Colorado (2008 survey data) showed that the demand for fresh local apples in Colorado exhibits a kinked demand curve due to the segmentation of the market where there are some consumers with more inelastic demand for locally labeled apples. In short, it seems that the demand curve will not only shift but also rotate due to the local promotion. The specific demand curve (equation) is not available, thus it is difficult and inaccurate to estimate the changes of consumer surplus along any segment of the estimated demand relationship. Thus, only the producer surplus is examined in this study.

Moreover, supply shocks are not included in the EDM at this stage. Local labeling would not only increase consumers' valuation, but also induce differential costs and prices in marketing channels on the supply side which will shock the supply for different marketing channels. Due to the inavailability of more localized production, distribution and labeling costs, the supply shock is not examined in this study.

Finally, we only consider apples, even though most state marketing programs for local foods cover the full array of food products. This explains why these welfare changes are much smaller than those reported by Carpio and Isengildina-Massa, but we chose apples as a specific market to advance their efforts. Their work had to use parameter estimates that were more simplified in terms of market channels (not allowing directly marketed produce to vary from products offered in more conventional markets), which is a limitation given Onozaka et al.'s results that WTP does vary by where consumers shop and by product type (they examined both tomatoes and apples).

5.5 Future Research

Although limitations exist in this study, some of these limitations can be addressed with more data and effort. For example, the world apple market can be integrated into a larger model system. This extension will be completed in a future study which examines the welfare effects of origin and carbon information labeling on a more seasonally segmented U.S. apple market.

The approximate changes in consumer surplus can be estimated if one can estimates the exact demand curve or demand elasticity before and after promotion so that the rotation of demand can be estimated. Moreover, if the marketing costs associated with local labeling efforts are available, then the supply shocks can be estimated and the model can be developed including both demand shocks and supply shocks. The changes in producer surplus are expected to be higher than the results in this study. Overall, most of the limitations of this study can be addressed if one obtains the necessary data, but this study serves as a starting point for such further developments.

For the market relationship analysis, since transaction costs, such as energy and labor costs, are expected to be the main driving factors for the spatial price difference based on previous apple industry reports, the prices are only deflated by U.S. consumer price index (CPI) rather than using real prices across regions. It may be more relevant to deflate prices by regional producer price indices (PPIs) to compare with the results in this study, even if it makes it more difficult to tease out whether energy/transport costs are part of the reason regions are differentially competitive.

In addition, an analysis of vertical market relationship across supply chain levels is important to thoroughly understand the market structure. For example, the shipping point prices are expected to dominate retail prices in explaining price innovations. Moreover, based on the comparison of market relationship models in chapter 3, although some methods are built upon the limitation of prior approaches, they still have their own limitations. The comparison of the results of the TAR model with results derived from other switching regime models may provide important insights into the market structure and contribute to the literature of methodology.

Nonetheless, this paper contributes to the literature by providing a thorough analysis of U.S. fresh apple market structure and price relationships with an estimation of unobservable transaction costs at different market levels. It provides insights on how strong consumer responses to local produce offerings (albeit among a relatively small set of buyers) may affect market dynamics. By allowing for segregated markets, akin to what occurs more formally with organic produce, this conceptual framework provides a method to analyze welfare in an increasingly differentiated food system, allowing for the flexibility of varying demand, supply, transaction cost and other variables across segments of the market that would be expected to behave differently.

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APPENDIX A DATA RESOURCE

Table A.1 Data Resource…

Variable	Unit	Data Source
Price and Quantity second hand Data		
Retail Price (P_A^l, P_A^d, P_B^d) (for price relationship estimation)	\$/lb	AMS, USDA
Consumers' WTP for local apples (P_A^l) (for elasticity and demand shock estimation)	\$/lb	Experiment
Consumers' WTP for domestic apples (P_A^d, P_B^d)	\$/lb	Experiment
Farmers' market price (P_A^F)	\$/lb	CSU Extension
Shipping point price	\$/lb	AMS, USDA
Truck rate	\$/lb(apple)/mile	AMS, USDA
On-highway diesel price	\$/mile	Energy Information Administration
Aggregated quantity demanded in Colorado(Q_A^d)	pounds	USDA, ERS, U.S. Census Bureau
Aggregated quantity demanded in U.S.(Q_B^d)	pounds	USDA, ERS, U.S. Census Bureau
Aggregated quantity produced in Colorado(Q_A^S)	pounds	Colorado Agricultural Statistics 2008
Aggregated quantity produced in U.S. (Q_B^S)	pounds	Agricultural Census 2007
Value of directly marketed agricultural products	\$1000	Colorado Agricultural Census 2007
Total sales of agricultural products	\$1000	Colorado Agricultural Census 2007
4 counties fruits sales	\$1000	Colorado Agricultural Census 2007
Colorado fruits sales	\$1000	Colorado Agricultural Census 2007
4 counties directly marketed agricultural products	\$1000	Colorado Agricultural Census 2007
4 counties sales of agricultural products	\$1000	Colorado Agricultural Census 2007
U.S. local food sales through all channels	\$ billion	Local Food System
U.S. all food sales	\$1000	Agricultural Census 2007

Table A.1 Data Resource…, Continued

Variable	Unit	Data Source
Obtained Parameters		
Expenditure Elasticity (α)		Lin, Yen, Huang, and Smith (2009)
Expansion Elasticity (ρ)		Carpio
Elasticity of substitution (ϑ)		Carpio
Elasticity of transformation(τ)		Carpio
Aggregate Own Price Elasticities of Demand(ε)		Lin, Yen, Huang, and Smith (2009)
Aggregate own price elasticities of supply(β)		Chavas and Cox
Calculated Parameters		
Market Shares:		
w_{AT}^{Dd}		Q_A^d, Q (consumption)
w_{BT}^{Dd}		Q_B^d,Q (consumption)
w_{AA}^{Dl}		Q_A^l, Q_A(consumption)
w_{AA}^{Dd}		Q_A^d, Q_A(consumption)
w_{BB}^{Ds}		Q_B^S, Q_B(consumption)
w_{AA}^{DS}		Q_A^S, Q_A(consumption)
w_{AA}^{DF}		Q_A^F,Q_A (consumption)
w_{AA}^{SF}		Q_A^F,Q_A (production)
w_{AA}^{SSA}		Q_A^{SSA},Q_A (production)
w_{AT}^{Ss}		Q_A^S, Q(production)
w_{AT}^{SF}		Q_A^F, Q(production)
w_{BT}^{Ss}		Q_B^S, Q(production)
w_{AA}^{DSA}		Q_A^{SA}, Q_A (consumption)
w_{AT}^{Dl}		Q_A^l, Q (consumption)

Table A.1 Data Resource…, Continued

Variable	Unit	Data Source
Elasticities:		
Expenditure Elasticity(α_l)		w_{AA}^{Dl}, w_{AA}^{Dd}
Expenditure Elasticity (α_d)		Lin, Yen, Huang, and Smith (2009)
Expansion Elasticity(ρ_F)		Carpio
Expansion Elasticity(ρ_S)		w_{AA}^{Dl}, w_{AA}^{Dd}
(ε_A^{ll})		w_{AA}^{Dl}, α_l, ε, ϑ
(ε_A^{ld})		w_{AA}^{Dl}, α_l, ε, ϑ
(ε_A^{dd})		w_{AA}^{Dd}, α_d, ε, ϑ
(ε_A^{dl})		w_{AA}^{Dd}, α_d, ε, ϑ
(ε_B^{dd})		w_{BB}^{Dd}, α_d, ε, ϑ
(β_A^{FF})		w_{AA}^{DF}, ρ_F, β, τ
(β_A^{FS})		w_{AA}^{DF}, ρ_F, β, τ
(β_A^{SS})		w_{AA}^{Ds}, ρ_S, β, τ
(β_A^{SF})		w_{AA}^{Ds}, ρ_S, β, τ
(β_A^{SAF})		w_{AA}^{DSA}, ρ_{SA}, β, τ
(β_A^{SAS})		w_{AA}^{DSA}, ρ_{SA}, β, τ
(β_A^{SAl})		w_{AA}^{DSA}, ρ_{SA}, β, τ
(β_A^{SAd})		w_{AA}^{DSA}, ρ_{SA}, β, τ
(β_B^{SS})		w_{BB}^{Ds}, ρ_S, β, τ
Demand shock (γ)		w_{AA}^{Dl}, w_{AA}^{Dd}, ε_A^{ll}
t_A^l		P_A^l, P_A^d
t_A^d		P_A^d, P_B^d
t_A^F		P_A^F, P_A^S
t_A^S		P_A^S, P_B^S

APPENDIX B SUMMARY OF MARKET RELATIONSHIP MODELS

Table B.1 Summary of Static Models for Market Relationship Analysis…

Static Model		Data	Results	Advantages & Weakness
Static model advantages: Easy to estimate and understand Assumption of stationary price behavior Assumption of fixed transaction costs	**Bivariate Correlation**	price	Degree of linear association Price co-movement Direction of the effect	Easy to calculate and understand Data are available Neglect the time series properties of price Neglect the existence of transaction costs Can only test linear relationship Inter-seasonal trade flow reversals make results unreliable Bias due to common exogenous trends, common periodicity, auto-correlation Fail to incorporate the effects of synchronous factors Overestimate segmentation due to lags in information or delivery Fail to recognize the heteroscedasticity in prices Consider the price co-movement as an indicator of market integration Doesn't take lags into consideration Can only be applied to two variables at a time Provide little reliable information on market condition

Table B.1 Summary of Static Models for Market Relationship Analysis…, Continued

Static Model		Data	Results	Advantages & Weakness
	Bivariate Regression	price	Same as above	Easy to calculate and understand Provide information to calculate transmission elasticity Can test relationships statistically Can take into account lagged effects, inflation, and seasonality Can analyze the relationship between more than two variables at a time Misleading results with non-stationary variables Static model Only consider linear relationships Assumption of fixed transaction costs

Table B.1 Summary of Dynamic Models for Market Relationship Analysis…

Dynamic Model		Data	Results	Advantages & Weakness
Dynamic model advantages: Recognize and specify dynamic price relationship and arbitrage process Assumption of stationary spatial market margin, stationary transaction costs Assume constant trade patterns	**Granger Causality**	price	Evidence of price transmission, price comovement The direction of price transmission	Allow for lagged or leading effects in price interrelationship Does not take seasonality and other non-stationary factors into account Results can be spurious Solely depend on the statistic difference of coefficients of the lagged exogenous variables to infer relationship Sensitive to omitted variables

Table B.1 Summary of Dynamic Models for Market Relationship Analysis…, Continued

Dynamic Model		Data	Results	Advantages & Weakness
	Ravillion's Model	price	Market inter-relationship Price co-movement Short run and long run dynamics Autocorrelation and spurious correlation Differentiate between three market relationships	Take inflation and seasonality into consideration Improvement over static and Granger causality test Short run and long run dynamics Give some suggestions to address the effect of non-stationarity Allow for autocorrelation Provide other variables that affect prices The assumption of the existence of a central market The assumption that central market price is exogenous All market shocks originate from a central market Inter-seasonal flow reversals and direct trade between regional markets violate the radial market assumption Assumption of constant transaction costs Assumption of linear relationship between prices Doesn't distinguish market integration due to noncompetitive behavior Directly exclude inter-market transfer costs

Table B.1 Summary of Dynamic Models for Market Relationship Analysis…, Continued

Dynamic Model		Data	Results	Advantages & Weakness
	Cointegration	price	Insight into dynamic market relationship Long run market relationship Price co-movement	Series don't need to be stationary Don't need assumptions Don't need restriction on market structure Admit short run instability in marketing margin Cointegration implies Granger causality Fail to account for non-stationary transaction costs Assume a linear relationship between price series Reversal of trade flows leads to misleading results Assumption of a unique equilibrium between prices Neither necessary or sufficient condition for market integration
	Error correction	price	Short run market integration	Test for short run market relationships Assumption of exogenous markets Assumption of continuous and unidirectional trade flow Unable to identify irregular breaks in trade, thus reject short run integration

Table B.1 Summary of Regime Switching Models for Market Relationship Analysis…

Regime Switching Model		Data	Results	Advantages & Weakness
Regime switching model advantages: Recognize and handle nonlinear price relationship Distinct spatial arbitrage regimes instead of strict classified to integrated or segmented cases	**Threshold Auto-regression**	price transaction costs	Characterize market dynamic Dynamic of price adjustment Infer process of integration	Allows for non-linearity and discontinuity in the equilibrium dynamics Recognize and account for the effect of transaction costs Doesn't require observations on transaction costs Measure the degree of violating the spatial arbitrage condition Measures the speed of eliminating the violations Tests for the existence of a central market Require identification and measurement of the factors inducing the regime switches Maintains the hypothesis of unique equilibrium relationships Highly parameterized Spurious correlation due to non-stationary prices Degree of spatial integration is studied in a one-way directional perceptive Constant transaction cost assumption (solved in extended models)

Table B.1 Summary of Regime Switching Models for Market Relationship Analysis…, Continued

Switching Regime Model		Data	Results	Advantages & Weakness
				Difficulty in identifying the threshold variable and estimating the associated threshold values Problems in inference on the threshold parameters

Table B.1 Summary of Regime Switching Models for Market Relationship Analysis…, Continued

Switching Regime Model		Data	Results	Advantages & Weakness
	Parity Bound Model	price	Test of market integration	allows for trade discontinuity and complex and time-varying transaction costs
		transaction costs	Other results including the frequency of profitable trade opportunities	Accounts for non-linear and discontinuous in long run relationship
		trade flow	Distinct between market efficiency and market integration	Differentiates between different types of breaks in trade
			Differentiate between six market conditions	Allows for a continuum of inter-market price relationships within the range of perfect integration and segmentation Offers more informative results Identifies efficiency of the markets If price, transaction costs, and trade flow data are available, allows for a clear distinction between spatial market integration and efficiency

Table B.1 Summary of Regime Switching Models for Market Relationship Analysis…, Continued

Switching Regime Model		Data	Results	Advantages & Weakness
				Combined market data with inter-market relationship Does not take the time series nature of data into consideration (static in nature) Requires identification and measurement of the factors inducing the regime switches Assumes transaction costs to be symmetric Offers few insights into dynamic of price response Sensitive to distribution assumptions Unobservable transaction costs are assumed to be constant (solved in extended models) Transaction costs are difficult to obtain or estimate Trade flow data are difficult to obtain Relies on competitive market and certainty assumptions Tradability might imply information flow between markets without observed trade Market integration can hold without price transmission when threshold effect persists Considers short run deviation from equilibrium as inefficiency Can only handle a limited number of markets

Table B.1 Summary of Regime Switching Models for Market Relationship Analysis…, Continued

Switching Regime Model		Data	Results	Advantages & Weakness
	Markov Switching Models	price	The nonlinear behaviors associated with abrupt changes Forecast turning points and identify in-sample structural changes	Best alternatives to linear models Flexibility in modeling regime-dependent time series behavior Allows for multiple relationships between prices Can be applied to markets with changes even if there are several regimes of price transmission in the market Provides insight into the dynamic of price response Can model the switching mechanism without the specification of switching variables Relaxes the restrictive assumption that all observations are drawn from a Gaussian distribution with constant mean and variance Forecasts turning points and identifies trend break Helps to explain non-linearity in data Provides price adjustment process Doesn't require an explicit transition variable Doesn't require trade data or other data beyond price data

Table B.1 Summary of Regime Switching Models for Market Relationship Analysis…, Continued

Switching Regime Model		Data	Results	Advantages & Weakness
				Doesn't account directly for transaction cost effect on the price adjustment Doesn't impose equilibrium conditions Allows for changes between regimes to depend on unobservable state variables Danger of over-fitting in modeling price behavior because no general valid model selection procedure has been established Restricted to just two regimes (solved in extended models) Assumption of constant transition probabilities (solved in extended models)
	MS-VECM	price	The relationship between multiple time series variables Short run relationship	Accounts for periods of temporary divergence from the long run equilibrium relationship Allows for an easy analytical access to the properties of the optimal multi-step predictor Same advantages with Markov switching models

APPENDIX C ESTIMATION OF SUPPLY ELASTICITIES

On the supply side, we assume there is no direct substitution between domestic and local apples because these two classes of apples that are grown in different regions (local apples are grown in Colorado and domestic apples are grown in other states). The calculation can be separated into two steps. First, aggregate supply elasticities for Colorado (β_A) and other states (β_B) together with the supply elasticity of apples produced and consumed in Colorado and marketed through shipping points (β_A^{SA}) are calculated based on Alston, Norton, and Parden's formula (1995) and following Wohlgenant (2005). Second, decomposed supply elasticities are calculated using the aggregate elasticities calculated in the last step. This step will be mainly based on Armington's formula (1969) and Alston, Norton, and Parden's formula (1995).

The aggregate supply elasticity (β) for U.S. is obtained from previous literature. Aggregate supply elasticities for Colorado production is obtained by dividing the U.S. elasticity by the quantity of Colorado production as a share of the U.S. average production, and then multiplying this quantity by the price ratio comparing Colorado apple prices (Seattle terminal market apple price) to U.S. apple prices (Washington shipping point price). This relationship can be represented in the following formula:

(101) $$\beta_A = \frac{\beta}{\left(\frac{S_A^F + S_A^S}{S_A^F + S_A^S + S_B^S}\right)} * \frac{P_F}{P_S}$$

where, S_A^F is Colorado supply for directly (locally) marketed apples, S_A^S is Colorado supply for shipping point marketed apples, S_B^S is the rest of the country's supply for shipping point marketed apple, P_F is Colorado apple supply price (average supply price for direct markets and for shipping points) (we use the Seattle terminal market apple price as a proxy), and P_S is U.S. apple supply price for shipping points (we use the Washington shipping point price as a proxy).

The U.S. aggregate supply elasticity is a share weighted sum of the supply elasticity for Colorado and supply elasticity for other states. Given the supply elasticity for Colorado, the aggregate supply elasticity for other states is derived using the following formula (assuming shipping point prices are the same throughout the whole country):

(102) $$\beta_B = \left[\beta - \frac{S_A^F+S_A^S}{S_A^F+S_A^S+S_B^S} * \frac{P_F}{P_S} * \beta_A\right] / \frac{S_B^S}{S_A^F+S_A^S+S_B^S}$$

The supply elasticity of apples produced and consumed in Colorado and marketed through shipping points (β_A^{SA}) is estimated by dividing the aggregate supply elasticity for Colorado (β_A) by the share of locally consumed local apples through shipping points (S_A^{SA}) to Colorado total production ($S_A^F + S_A^S$). Prices of locally consumed local apples through shipping points are assumed to be the same as price of apple marketed through other channels in Colorado. The following formula is derived based on the formula in Wohlgenant (2005):

(103) $$\beta_A^{SA} = \frac{\beta_A}{S_A^{SA}/(S_A^F+S_A^S)}$$

By now, we have obtained all aggregate supply elasticities (β_A, β_B , and β_A^{SA}) that we need to calculate decomposed supply elasticities.

Next, we need to estimate own and cross supply elasticities for directly marketed and shipping point marketed apples. To get elasticities at different separable levels, we need use two models: two-market channel model and three-market channel model following James and Alston's two-quality level model and three-quality level model (2002).

Assume directly marketed apples and shipping point marketed apples are weakly separable and the price index used for these two groups of apples are invariant to income. Own and cross supply elasticities for two differently marketed apple groups are given by the following formula based on Armington's formula (1969), Alston, Norton, and Parden's formula (1995), and Johnson, Lin, and Vocke (2005):

(104) $\beta_A^{FF} = s_F \rho_F \beta_A - s_S \tau$

(105) $\beta_A^{FS} = s_S(\rho_F \beta_A + \tau)$

(106) $\beta_A^{SF} = s_F(\rho_S \beta_A + \tau)$

(107) $\beta_A^{SS} = s_S \rho_S \beta_A - s_F \tau.$

where β_A^{FF} is the own price elasticity of supply for directly marketed apples in Colorado, β_A^{SS} is the own price elasticity for shipping point marketed apples in Colorado, β_A^{FS} is the elasticity of supply for directly marketed apples with respect to shipping point prices, and β_A^{FS} is the elasticity of supply for shipping point marketed apples with respect to the direct market price in Colorado. s_i is the budget share of channel *i* marketed apple in Colorado production ($s_i = \frac{P_i Q_i}{P * Q}$). τ is the elasticity of transformation in production between direct marketed apples and shipping point marketed apples. The elasticity of transformation ($\tau = -1.80$) was chosen to ensure directly marketed and shipping point marketed apples are substitutions in supply based on Carpio and Isengildina-Massa (2010). ρ_i is expansion elasticity. Expansion elasticities of directly marketed apples are assumed to be equal to 1 (ρ_F =1) based on Carpio and Isengildina-Massa (2010). The shipping point marketed apple expansion elasticities are recovered from equation:

(108) $\rho_S = (1 - \rho_F * s_F)/(1 - s_F)$=1.00

Own and cross supply elasticities of apples marketed through different channels can be estimated using equations (1)-(8).

To derive decomposed supply elasticities for apples produced and consumed in Colorado and marketed through shipping points ($\beta_A^{SA,F}, \beta_A^{SA,S}, \beta_A^{SA,l}, \beta_A^{SA,d}$), a three-market channel model is constructed. Directly marketed apples (S_A^F) and shipping point marketed apples are assumed to be weakly separable and within the shipping point marketed group, apples produced in Colorado but shipped to other states (S_A^{SB}) and apples produced in Colorado and shipped back to Colorado (S_A^{SA}) are also assumed to be weakly separable. Thus, we have three weakly separable classes of apples distinguished by marketing channels: S_A^F, S_A^{SA}, and S_A^{SB}. The supply elasticities for differently marketed groups of apples with respect to individual price changes are estimated using the following formulas based on Armington (1969) and James and Alston (2002):

(109) $\beta_A^{F,SA} = s_{SA}(\rho_F \beta_A + \tau)$

(110) $\beta_A^{F,SB} = s_{SB}(\rho_F \beta_A + \tau)$

(111) $\beta_A^{SA,F} = s_F \rho_{SA}(\rho_s \beta_A + \tau)$

(112) $\beta_A^{SB,F} = s_F \rho_{SB}(\rho_s \beta_A + \tau)$

(113) $\beta_A^{SA,SB} = s_{SA}[\rho_{SA}(s_s \rho_s \beta_A - s_F \tau) + \tau_{SA,SB}]$

(114) $\beta_A^{SB,SA} = s_{SB}[\rho_{SB}(s_s \rho_s \beta_A - s_F \tau) + \tau_{SA,SB}]$

(115) $\beta_A^{SA,SA} = s_{SA} \rho_{SA}(s_s \rho_s \beta_A - s_F \tau) - (1 - s_{SA})\tau_{SA,SB}$

(116) $\beta_A^{SB,SB} = s_{SB} \rho_{SB}(s_s \rho_s \beta_A - s_F \tau) - (1 - s_{SB})\tau_{SA,SB}$

where ρ_{sA} and ρ_{sB} are expansion elasticities for Colorado apples produced but shipped to other states segmented from the Colorado apples produced and shipped back to Colorado. $\tau_{SA,SB}$ is the elasticity of transformation in production between apples produced in Colorado but shipped to other states and apples produced in Colorado and shipped back to Colorado. The value of $\tau_{SA,SB}$

($\tau_{SA,SB}$ =-2) is chosen based on values from the literature, intuition and economic theory. s_{sA} is the budget share of Colorado apples produced and shipped back to Colorado. s_{sB} is the budget share of Colorado apples produced and shipped to other states. Expansion elasticities of Colorado apples produced and shipped back to Colorado are assumed to be equal to 1 (ρ_{sA} =1). Colorado apples produced and shipped to other states' expansion elasticities are recovered from equation:

(117) $\rho_{sB} = (1 - \rho_{sA} * s_{sA})/(1 - s_{sA})$=1.00

Following the logic in Wohlgenant (2005) and Lemieux and Wohlgenant (1989), the supply elasticity for Colorado apples marketed through shipping points but consumed locally with respect to aggregate shipping point prices ($\beta_A^{SA,S}$)is taken as a weighted sum of supply elasticities for Colorado locally consumed apples marketed through shipping points with respect to Colorado apples produced and shipped to other states prices ($\beta_A^{SA,SB}$), and supply elasticities for Colorado apples marketed through shipping points and shipped back to Colorado prices ($\beta_A^{SA,SA}$). This relationship is represented in the following equation:

(118) $\beta_A^{SA,S} = \frac{S_A^{sA}}{S_A^s+S_B^s} * \beta_A^{SA,SA} + \left(1 - \frac{S_A^{sA}}{S_A^s+S_B^s}\right) * \beta_A^{SA,SB}$

where $S_A^{sA}$is supply for Colorado consumption of local apples through shipping points, S_A^s is Colorado supply for shipping point marketed apples, and S_B^s is the rest of the country's supply for shipping point marketed apples.

Supply elasticities for Colorado apples consumed locally but marketed through shipping points with respect to the domestic price ($\beta_A^{SA,d}$)and supply elasticities for Colorado local apples marketed through shipping points with respect to local price ($\beta_A^{SA,l}$) are derived based on formulas in Alston, Norton, and Pardey (1995) and Wohlgenant (2005) using the idea of excess supply. Basically, we assume domestic apple prices are the same throughout the U.S. The Colorado shipping point marketed local apple supply elasticity with respect to domestic price ($\beta_A^{SA,d}$) is derived by dividing the supply elasticity for Colorado consumed apples marketed through shipping points (β_A^{SA}) by the share of Colorado consumption of domestic apples relative to the whole U.S.' consumption of domestic apples. The Colorado shipping point marketed local apple supply elasticity with respect to local price ($\beta_A^{SA,l}$) is obtained by dividing the supply elasticity for Colorado consumed local apples marketed through shipping points (β_A^{SA}) by the share of Colorado consumption of local apples in U.S. consumption of Colorado apples.

(119) $\beta_A^{SA,d} = \frac{\beta_A^{SA}}{D_A^d/(D_A^d+D_B^d)}$

(120) $\beta_A^{SA,l} = \frac{\beta_A^{SA}}{D_A^l/(S_A^F+S_A^S)}$

By now, all decomposed supply elasticities needed in the EDM can be estimated using equations (101)-(120).