Dynamics of Price Adjustment in Qualitatively Differentiated Markets in the U.S.: The Case of Organic and Conventional Apples

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Abstract

Production and consumption of conventional and organic apples in the U.S. have changed dramatically over the past two decades. Despite a drop in the conventional apple production, production of organic apples shows a double-digit growth. Demand for organic apples also continues to outpace growth in overall organic fruit sales. In this research, we investigate whether these changes have an impact on price adjustment dynamics between these two qualitatively differentiated products. We use a Markov-Switching Assymetric Vector Error Ccorrection model (MS-AVECM) and weekly U.S. national retail prices for the 2010-2015 period for three varieties of apples: Gala, Fuji, and Red Delicious. The MS-AVECM results indicate three Markov-Switching regimes can be defined for the three varieties during the study period. The results show there are different short-run price adjustment daynamics in each of these regimes and asymmetric price transmission behavior between organic and conventional apples. Result indicates that apple varity plays important role in the price relationship between organic and conventional apple. These findings have implications for farmers, wholesalers, retailers, policy makers, as well as consumers.

Keywords: Apple, Quality differentiation, Market integration, Markov Switching, Vector Error Ccorrection Model

JEL Codes: D4, Q11, Q13

Introduction

Organic products are growing in terms of production and consumption. Based on the FiBL and IFOAM (2014)[1] report; agricultural land under organic production in the world increased from 11 million hectares in 1999 to 37.5 million hectares in 2012. In terms of consumption, world organic market size was more than $60 billion in 2014. The U.S. is the third largest country in the world, after Australia and Argentina, in terms of land area under organic food cultivation. The number of farmers in organic food production has increased by 361% from 1992 to 2008 (USDA 2008 Census of Agriculture). This large increase happened in response to the rise in demand for organic products.

The total sale of organic products in the U.S. in 2012 was 31.5 billion dollars. The Organic Trade Association (OTA) report of organic industry survey in 2013 shows that comparing with 2012, organic food sales in the U.S. increased by 10.2%, while conventional food sale increased by 3.7%. Factors such as increase in consumers' awareness about organic products and its effects on health, and increase in availability and variety of these products from fresh fruits and beverages to frozen foods in mainstream supermarkets caused the rise in demand for organic products (Dmitri and Oberholtzer ,2009).

Organic and conventional products are differentiated in quality, and might have different price dynamics. Organic and conventional products have low substitutability in various stages of supply chain such as processing, marketing and trade, but the prices of these products may be related to some extent (Würriehausen et.al 2015). The law prohibits labeling conventional

[1] The port is available online at: https://www.fibl.org/fileadmin/documents/shop/1636-organic-world-2014.pdf

products as organic, but organic products can be labeled as conventional (Hamm and Gronefeld, 2004). Asymmetric price adjustment between organic and conventional products could happen due to the asymmetric substitutability between these products. Furthermore, changes in demand and supply of conventional and organic products could also lead to changes in dynamics of their price relations.

In this article, we investigate whether there is a short-run price adjustment daynamics and a long-run relation between organic and conventional apple prices. We also examine the possibility of asymmetric price transmission between these quality differentiated products. The objective is to expalin whether conventional apple prices affect organic apple prices and vise versa. We will test for asymmetric price impact of positive and negative deviations from the long-run equilibrium, and investigate whether the fundamental changes in the organic and conventional apple markets have had an impact on the relation between these markets. These findings could be critical to farmers' decisions regarding production, and wholesalers, retailers and other market decision makers, policy makers, as well as consumers.

Background and Literature Review

Organic and Conventional Apples in the U.S.

Different categories of organic food are fruit and vegetables, dairy, beverages, bread, and grains. According to the USDA report (2014), in the organic food market, fruits and vegetables have historically had the highest share of sales comparing to other categories of organic foods. In 2005, the total sales of organic fruits and vegetables was 5.36 billion dollars, increasing to 15.06 billion dollars in 2014. Fruits and vegetables had 40.3 percent share of the organic market in

2005 and 43 percent estimated share for 2014, indicating an increase in the market share of fruits and vegetables. Figure 1 shows different organic product market shares from 2005 to 2014.

Organic apples are one of the main products in the organic fruit and vegetable category. Organic apples are among the top 10 organic fruits with a share of about 22% of the total organic fruit production (USDA 2014). Based on the 2010 organic production survey of the USDA, the value of organic apples sold in the U.S. was $136.8 million, total production was 488.2 million pounds, and more than 20,000 acres of agricultural lands were under organic apple cultivation.

Organic apple market has experienced fast growth in the recent years. On the production side, certified organic apple farming acreage doubled from 1997 to 2008 and experienced even more growth in later years (USDA, ERS, 2010). Organic apple production accounts for five percent of the total apple production and growing rapidly. Furthermore, Conventional apples are one of the most important fruits in the U.S. in terms of production and consumption. The sales value of this product in 2012 was $3.1 billion (NASS 2013). In 2012, annual per capita fresh apple consumption in the U.S. was 16 pounds (ERS 2013). According to the USDA report, the number of farmers that are producing apples has declined over time. The number of apple farmers in the late 1990s was 34000, which dropped to 25600 in 2007. The U.S. apple association statistics shows that the number of apple farmers fell to 7500 in 2013.

According to the U.S. International Trade Commission report (2010), the U.S. apple industry experienced a financial crisis during the late 1990s and early 2000s due to the low apple prices and as a result, many small and less efficient producers left the industry between 1996 and 2001. Nationally, the average farm size did not change due to this recession, but the national acreage declined to 350100 in 2008 (USDA, NASS 2009). To sum up, on the production side, the total acreage under apple production in the U.S. declined during the last two decades by 25 percent. However, according to the USDA report, the per capita consumption of fresh fruits has relatively remained flat over the last two decades.

Due to the increase in variety of fresh fruits, conventional apples compete for market share with other fresh fruits. The growers of conventional apples switched to organic apple farming mainly to increase their income (USDA, ARMS, 2007). According to the same report, farmers have other reasons such as protecting family and community health, and adopting more environmentally friendly practices for switching to organic apple production. The consuming organic apples could have different reasons, but the primary reason is health (Organic Trade Association, 2009). Because of its importance in the U.S. agricultural markets, this study focuses on organic and conventional apples.

Previous Literature

There are only a few studies of organic and conventional price interrelations. Singerman, *et al.* (2010) used cointegration methods to test price relations of organic and conventional corn and soybeans in several locations in the U.S. They found no relationship between those organic and conventional products, and prices were independent in the long-run. Kleemann and Effenberger (2010) investigated price transmission in the European conventional and organic pineapple markets, and found causality between conventional and organic prices. Their results indicated that the organic market price was dependent on the conventional market price, but the conventional price was independent of the organic market. Würriehausen, *et al.* (2015) used German conventional and organic market wheat prices to investigate the relationship between these two quality differentiated products. They found that the organic wheat prices were related to the conventional wheat market, but they did not find price transmission from the organic market to the conventional wheat in Germany.

This study contributes to the literature in various ways. This research is the first study about dynamic price relations between organic and conventional apples in the U.S. We use retail-level data for different varieties of apple, which help compare and contrast the impact of variety on dynamics of price adjustment between organic and conventional apples.

Model Development

Most of price transmission studies use some version of a vector error correction model (VECM) to investigate the long-run relations between prices (Würriehausen et al. 2015). Prices are usually integrated order one, I(1), and deviate from the long-run equilibrium in the short run because of random shocks. These short-run deviations are corrected with speeds of adjustment over time toward the long run equilibrium. One of the main assumptions of these models is having a constant parameter for structural stability for the cointegration relationship in the period of the study. With the fundamental changes in the organic and conventional apple production and consumption, potential structural changes cast doubt on this assumption. To avoid this problem, different models can be estimated for different periods, which makes the time of the study shorter, and also it is difficult to determine the time of the structural breaks. The other option is to use dummy variables to reflect structural changes, but again the time of structural changes is unknown and difficult to determine.

A third option is using Markov Switching Vector Error Correction Model. The basic idea of this model is that the cointegration relationship varies over time (different regimes of cointegration relationships), as suggested by Goldfeld and Quandt (1973) and extended by Hamilton (1989). Several researchers have used this method to analyze price transmission of agricultural products. For example, Brümmer et al. (2009) used this model to analyze vertical price transmission between wheat and flour prices in Ukraine. They found four switching regimes whose timing coincided with the political and economic events in Ukraine.

Because substitutability between organic and conventional apples may be asymmetric, the MS-AVECM is a proper method to study the two quality differentiated apple price relations. Würriehausen et al. (2015) also used this model to study price relations between organic and conventional wheat in Germany. They found three switching regimes for the period of the study. They concluded that the organic wheat prices were related to the conventional wheat market, but they did not find any price transmission from the organic market to the conventional wheat in Germany.

In general, MS-AVECM can be written as the following:

$$\Delta p_t = v(S_t) + \alpha^-(S_t)ect_{t-1}^- + \alpha^+(S_t)ect_{t-1}^+ + \sum_{i=1}^{k} \Gamma_i(S_t)\Delta p_{t-i} + \varepsilon_t \quad (1)$$

where $\mathrm{p}_t = \left(p_t^{org}, p_t^{conv}\right)'$ is the vector of market prices for organic apples (superscript org) and conventional apples (superscript conv), v is the vector of intercept terms, and the ect_{t-1} is the co-integrating (long-run equilibrium) vector. To test for asymmetry, the co-integrating vector, ect_{t-1}, is divided into two negative and positive parts: $(ect_{t-1}^-, ect_{t-1}^+)$. The (α^-, α^+) is the vector of negative and positive adjustment coefficients, respectively, and measures the intensity of price responses to negative and positive deviations from the long-run equilibrium. The term $\sum_{i=1}^{k} \Gamma_i(s_t)\Delta p_{t-i}$ shows the short-run dynamics. Specifically, Γ_i is the matrix of short-run coefficients, Δ is the indicator of the first difference operator, and ε_t is a vector of Gaussian residuals.

The state variable $S_t = s \in \{1,2, \ldots, M\}$ is an unobserved variable and indicates which of the *M* possibel switching regiems directs the MS-AVECM at time *t*. All parameters in the model (except for $(ect_{t-1}^{-}, ect_{t-1}^{+})$) are allowed to switch between the regimes, and based on the value of S_t at time *t*, each regime-dependent variable takes certain values. The ν is an example of the regime dependent variable, and this adjustment coefficient vector is regime dependent. Specifically, $\alpha^+(S_t)$ =$\alpha^+(s)$ if S_t=*s*, which means we can write $\alpha^+(S_t)$ as the following:

$$\alpha^+(S_t) = \begin{cases} \alpha(1)^+ \ \ if\ S_t = 1 \\ \ . \\ \ . \\ \ . \\ \alpha(m)^+ \ if\ S_t = M \end{cases} \qquad (2)$$

The regime dependent parameters are constant in each state, but they are different across the M regimes. Markova chain determines the switching between the regimes. The probability of switching from regime *i* at time *t* to regime *j* at time *t+1* is called transition probability and can be modeled by the $\psi = \ (M\ X\ M)$ transition matrix. In the transition matrix *(ψ)* each element (λ_{ij}) indicates transition probability of regime *i* to regime *j*.

$$\psi = \begin{bmatrix} \lambda_{11} & \cdots & \lambda_{1M} \\ \vdots & \ddots & \vdots \\ \lambda_{M1} & \cdots & \lambda_{MM} \end{bmatrix} \qquad (3)$$

where $\lambda_{ij} \ = Pr(S_{t+1} = j|S_t = i)$. The adding-up assumption holds here, which means rows sum up to one *($\sum_{j=1}^{M} \lambda_{ij} = 1$)*. Furthermore, the transition probabilities are assumed to be time-invariant, which comes from the Markov chain homogeneity assumption. The estimation procedure is available in the MSVAR package (Krolzig, 2006) for the matrix programming language Ox (Doornik, 2002).

Data Description

In this article, we used the organic and conventional apples weekly retail price data from November 12, 2010, to February 27, 2015. For both organic and conventional apples, the retail prices come from the Market News, USDA database. More than 7500 varieties of apples are produced in the world and around 2500 of these varieties are produced in the U.S. (USDA, AgMRC, 2013). In this study, we used the national retail prices of the U.S. for three varieties of apples: Gala, Fuji, and Red Delicious. These varieties are among the 15 popular varieties of apples produced and consumed in the U.S. Red Delicious has the highest production share by U.S. farmers, followed by Gala and Fuji. Figure 2 shows the production shares of the three popular varieties for 2006-2011 periods.

There are totally 225 weeks (observations) for the study period for each variety. Table 1 shows the summary statistics of the data variables. There are some missing observations, especially for organic apples. Following Würriehausen et al. (2015), these missing values were estimated using a structural time-series model based on a state-space algorithm (Harvey, 1990). As can be seen from Table 1, price premium is paid for organic apples for all the three varieties, with the highest price paid for Gala apples. For conventional apples, Gala has the highest price and Red Delicious has the lowest.

Empirical Results

Long-run Price Relations

We used the Elliott-Rothenberg-Stock DF-GLS test to check for the unit roots. At the 5% significance level, the null of a unit root in the price series were not rejected. Hence, all the variables were integrated of order one, I(1). This allowed us to go to the next step for finding a long-run relationship between the price variables. The cointegration test proposed by Johansen (1995) was used to examine the existence of long-run relations between the price series. The optimal number of lags for price series was determined by using the Bayesian information criterion (BIC). Trace statistics indicated that there was one cointegration relationship between each pair of prices (i.e., between conventional and organic apple prices for each variety).

To study the long-term equilibria among the price variables, we used the VECM model. The long-run relations between organic and conventional apples for the three varieties are presented in Table 2. After estimating the long-run equilibrium and the VECM model, we constructed the Chow (1960) breakpoint test to check for structural stability. The stability parameter was rejected at the 5% significance level for all the observations. This indicates that structural changes happened in both conventional and organic apple markets. In other words, Chow breakpoint test result indicates the instability of the error correction model parameters. As explained in the model section, MS-AVECM takes these changes into account and the non-constant parameters can be estimated.

Markov Switching Asymmetric Vector Error Correction Model (MS-AVECM)

The model specification results show that the MS-AVECM model in equation 1 with three switching regimes (m=3) in the Markov Chain and two autoregressive lags (k=2) can be estimated for each apple variety. Table 3 shows the results of the Gala variety. We can see each switching regime characteristics in Table 3. In switching regime 1, only conventional Gala apple prices response to the negative price deviation from the long-run equilibrium, which is the simplest error correction interdependency in comparison to regimes 2 and 3.   In the switching regime 2, both conventional and organic Gala apple prices response to the negative deviation from the long-run equilibrium.   In the switching regime 3, conventional and organic Gala apple prices respond to the positive and negative deviations from the long-run equilibrium. This regime can be considered as having the most complex error correction interdependency between the three switching regimes.

Figure 3 shows the autoregressive dynamics of these switching regimes for Gala apple prices. The switching regime 1 has the highest number of partial interactions, having five interactions, compared to switching regime 2 having three and regime 3 having four reactions. The uncertainty of the switching regimes, which indicates price vitality in each regime, is measured by standard errors assosiated with each switching regime. The organic apple switching regime 1 has the lowest standard error; it increases in switching regime 2, and switching regime 3 has the highest uncertainty, indicting signifivcant amount of turbulence in the market. The conventional apple switching regime 2 has the lowest standard error and follows switching regimes 1 and 3.

The estimation results in Table 3 indicate the asymmetric price transmission assumption holds in all of the three switching regimes. In the first regime, when there is a positive deviation for conventional apples, the disequilibrium temporarily increases. In the second switching regime, the negative deviations from the long-run equilibrium for organic apples temporarily increase, and positive price shocks die out over time. For conventional apples only a negative disequilibrium dies out over time. In the third switching regime for organic apples, the negative deviations temporarily increase, similar to the second regime, and positive deviations die out quickly (takes less than two weeks). However, for conventional apple prices in this regime both positive and negative deviations from long-run equilibrium die out over time. Hence, these results indicate asymmetric price transmission for all the switching regimes.

Table 4 presents the transition probabilities between different switching regimes for Gala apples, showing the probability of switching from one regime to another. Comparing the three switching regimes, one can infer that the switching regime 1 is most likely followed by the switching regime 3 in the next period, while the switching regime 2 is most likely followed by itself in the next period. The switching regime 3 is less likely followed by itself, and also by the switching regime 1 in the next period. Table 5 shows the switching regime properties for Gala apples. The switching regime 2has the largest number of observations (145). We can observe that the switching regime 2 has the highest probability to occur and it last longer than the other two regimes conditional on its occurrence. Table 5 shows all three regimes properties including number of observations in each regime, probability of each regime and duration of each regime.

We also estimated the MS-AVECM for the other two major verities Fuji and Red Delicious. Table 6 shows the results for Fuji apples. The results indicate that only the negative deviations from the long-run equilibrium are corrected for conventional apples in the first switching regime. In the second regime, only the negative disequilibria for conventional apples are corrected; however, the positive deviations increase temporarily. Finally in the third switching regime, the negative deviations increase temporarily for organic apples. On the other hand, in this regime, the positive deviations are corrected for organic and conventional apples over time, but the correction speed for organic apples is faster. The estimation of responses to disequilibrium from the long-run equilibrium indicates that asymmetric price transmission holds in all six switching regimes, which means there are different responses to the positive and negative deviations from equilibrium.

The autoregressive dynamics between past and current price changes indicate that in the first switching regime only the first lag of conventional apple prices has an effect on conventional apples, and in this regard, this regime is the simplest among the three regimes. The second regime has more complex autoregressive dynamics structure than the first one. In this regime, both first and second lags of organic apple prices affect current prices. Finally, the third switching regime has the most complex autoregressive dynamics structure. The autoregressive dynamics between past and current price changes indicate that the first and second lags of organic apple prices have effects on the current organic apple prices. Also, the second lag of conventional apple prices affects current organic apple prices. On the other hand, the current conventional apple prices are affected only by the second lag of conventional apple prices. In other worlds, conventional apple past prices affect organic apple prices, but the opposite does not hold.

Table 7 presents probabilities of the transition from one switching regime to another for Fuji apples in the next period. The switching regime 1 is most likely followed itself or by the switching regime 3 in the next period. Regime 2 has equal probability to switch to itself or regime 3. Regime three is most likely followed by regime 2. The regime properties show that regime 2 has the highest number of observations and the probability of occurrence. In terms of regime duration, all the three switching regimes do not last long. Table 8 shows all three regimes properties including number of observations in each regime, probability of each regime and duration of each regime.

Table 9 shows the MS-AVECM model results for Red Delicious variety. In the first regime, only positive deviations are corrected for organic apples over time. For the conventional apples only negative deviations are corrected over time. In the second regime, similar to the switching regime 1, only positive deviations are corrected for the organic apples, but the speed of adjustment is higher than regime 1. For conventional apples, both positive and negative deviations are corrected over time, but the speed of negative disequilibrium's correction is higher. Finally, in the switching regime 3, both positive and negative deviations are corrected for organic and conventional apples over time. Regime 3 has the most complex autoregressive dynamics structure between all the regimes. That is, there are more ways for price relations between past and current prices and also between organic and conventional apple prices, compared to the other regimes for this specific variety. However, in this regime, the speed of adjustment for both negative and positive deviations is higher for organic apples than conventional apples. Similar to the other two varieties, we can see that asymmetric price adjustment assumption holds here as well.

The autoregressive dynamics between past and present price changes indicate that organic Red Delicious apple prices have an effect on conventional Red Delicious apple prices in the first regime, and this effect gets more intensive in the second regime. The third regime has the most complex autoregressive dynamics structure among all the switching regimes. Table 10 shows the switching probabilities from one regime to another. Regime 1 is more likely to follow regimes 1 and 3. Regime 2 is more likely followed by Regime 3. Finally, regime 3 is also more likely followed by itself in the next period. The regime properties in Table 11 show that regime 3 has the highest number of observations and also the highest probability of happening.

Summary and Conclusions

In this article, we used the MS-AVECM method to estimate the relations between prices of organic and conventional apples for three popular varieties of apple: Gala, Fuji, and Red Delicious in the U.S. This model has the capability to take into account both asymmetric price transmission as well as structural changes in the market. Model selection showed that MS-AVECM with two lags and three Markov-switching regimes was the best specification for the three varieties. We tested four hypotheses in this article, and the results showed that there was a long-run relationship between organic and conventional apple prices for all the varieties. Also, we found asymmetric price transmission behavior in both conventional and organic apple markets. The results indicate that each Markov-switching regime has two different responses to positive and negative deviations from the equilibrium. The findings confirmed asymmetric price transmission behavior for all the three varieties.

We also tested for the existence of different switching regimes in retail price formation. The results indicated there were three different switching regimes between the prices of the two types of quality differentiated apples for the three varieties. We also investigated the existence of different phases of price interaction between organic and conventional apples because of the fundamental production and consumption changes in the organic and conventional apple markets over time in the U.S. The results confirmed that the price relations between conventional and organic apples have changed over time. We also found significant asymmetric price dynamics for all the three varieties, which differ across the varieties and also across the regimes. Positive (negative) deviations from the long-run equilibrium between organic and conventional prices for specific variety imply that organic prices are higher (lower) than the 1.41 in the Gala apple case (and 1.43 in the Fuji and 1.46 in the Red-Delicious apple cases, respectively) (Table 2) compared to conventional prices, which means that price margins between conventional and organic apples increased (decreased). For example, for the Gala apple variety, the results indicate that in the regime 1 only negative deviation affect conventional Gala apple price movements in the subsequent week. In contrast, in the second regime for Gala apples, only the negative deviations affect both conventional and organic Gala apple price movements in the subsequent week. This indicates that both prices decrease if organic Gala apple prices are too low in comparison to the conventional Gala apples. In the regime 3 for Gala apples, both positive and negative price deviations affect organic and conventional Gala apple prices in the subsequent week. This means both prices increase (decrease) if organic Gala apple price is too low (high) comparing with conventional Gala apple prices.

Finally, the autoregressive price dynamics between past and current prices differ depending on the apple variety and also the regime. Past Gala conventional apple prices effect on the current organic apple prices and vice versa, depending on the regime. However for Fuji apples, there is no effect from past conventional (organic) prices to the current organic (conventional) Fuji apple prices in any of the regimes, and for Red Delicious, this effect is only one way: past organic apple prices affecting current conventional apple prices in all the regimes. The difference in autoregressive price dynamics among the three varieties can be due to factors such as difference in production, prices, farmland under cultivation for each variety, or production location, which needs further investigation

To sum up, the empirical results indicate that there is a long-run price relationship between organic and conventional apple prices, and the intensity of this relationship depends on the type of apple variety. Negative and positive deviations from the long-run equilibrium are treated differently, and short-run price dynamics between conventional and organic apples change over time among the different apple varieties. These findings have important agribusiness implications. The long-run relationships between these two markets indicate that policies that affect conventional (organic) apple prices will also affect organic (conventional) apple prices

Figures and Tables

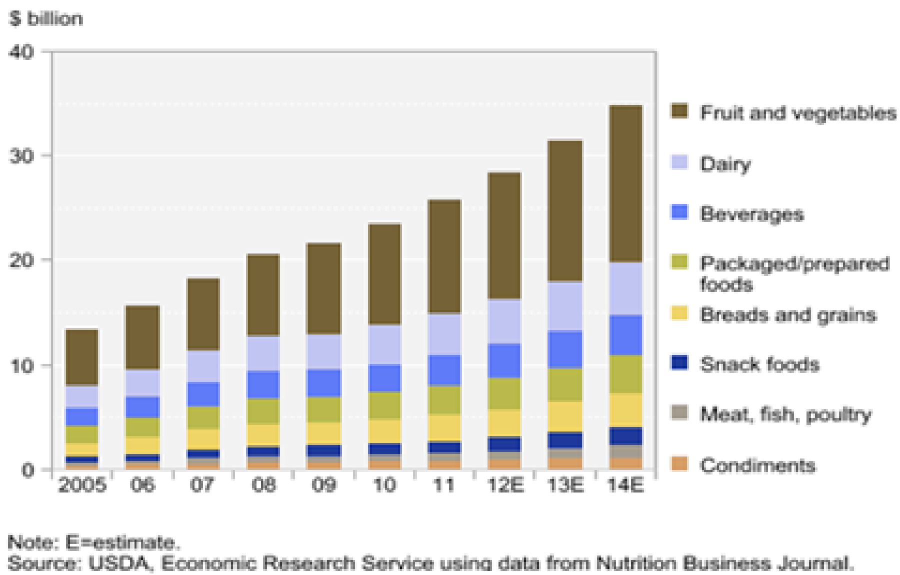


Figure 1: The U.S. Organic Food Sales by Category

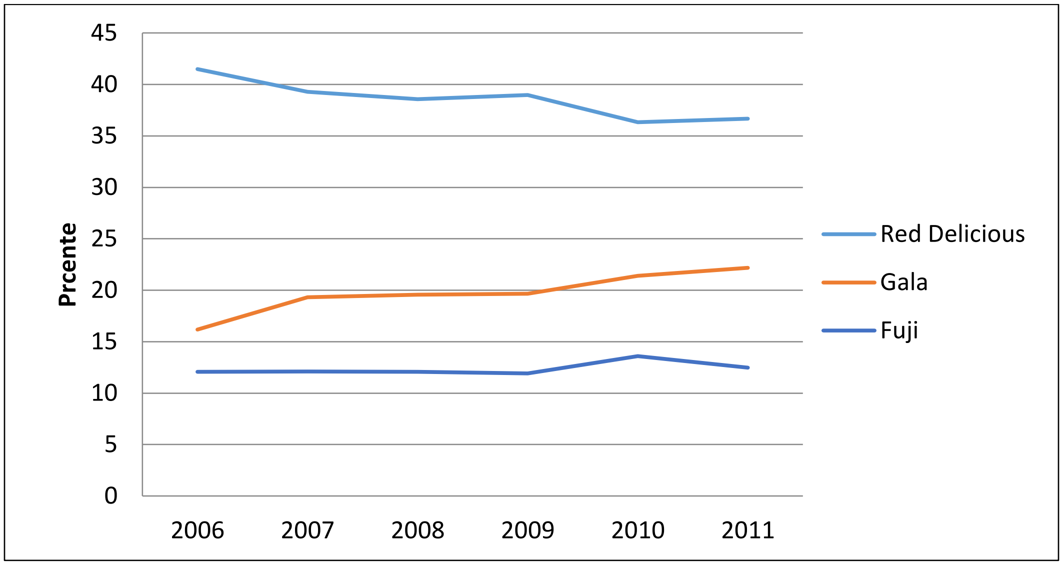
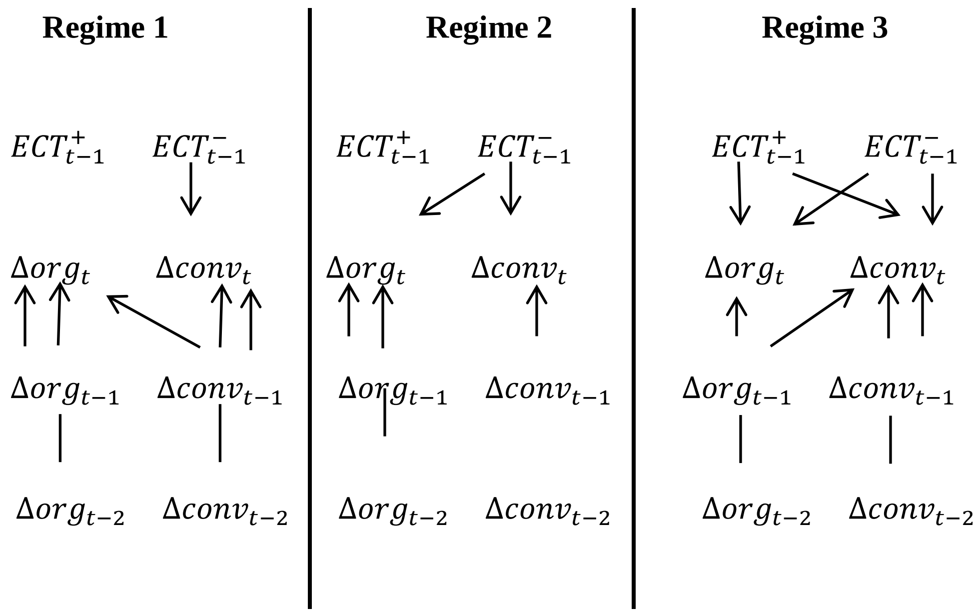
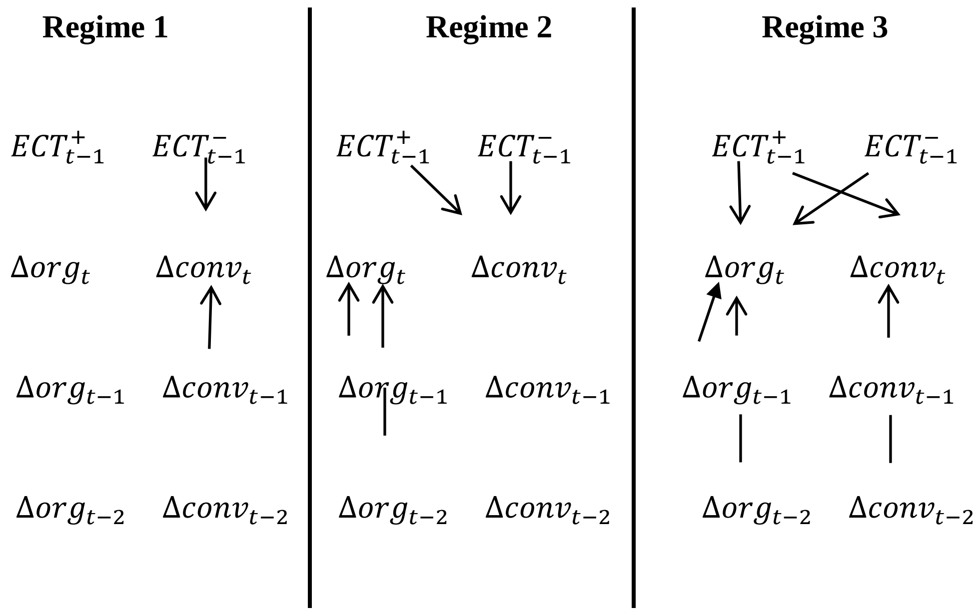


Figure 2: Production Shares of Red Delicious, Gala, and Fuji apples



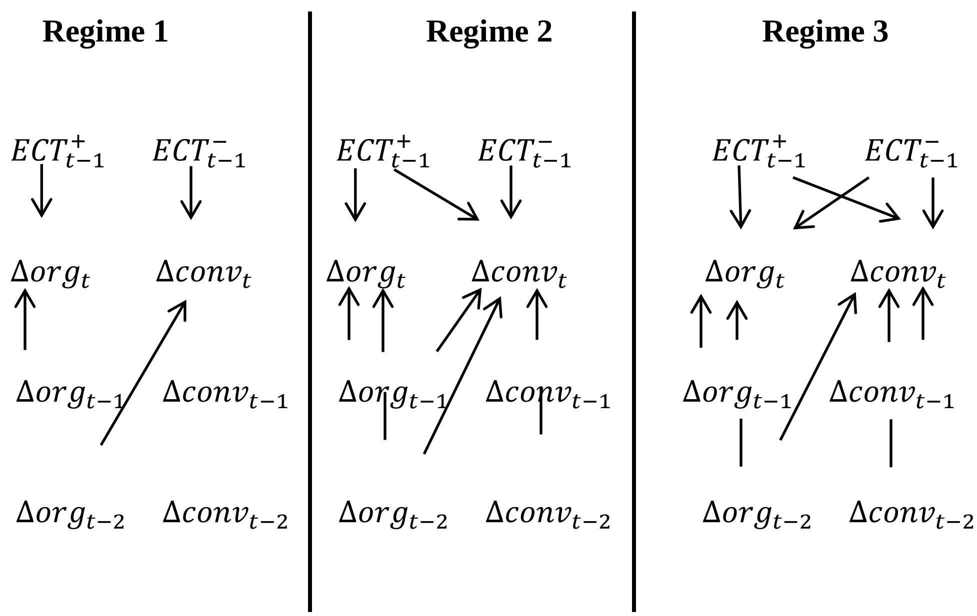
Note: Only 5% and higher significance level are considered.

Figure 3- Regime-Dependent Partial Influences for Gala



Note: Only 5% and higher significance level are considered.

Figure 4- Regime-Dependent Partial Influences for Fuji



Note: Only 5% and higher significance level are considered.

Figure 5- Regime-Dependent Partial Influences for Red Delicious

Table 1- Summary Statistics of Different Varieties

variety	Organic			Conventional		
	price mean ($/LB)	**# of obs.**	**# of missing/ % missing**	**price mean ($/LB)**	**# of obs.**	**# of missing/ % missing**
GALA	1.91	194	31 (13%)	1.40	219	6 (3%)
FUJI	1.82	176	49 (21%)	1.35	218	7 (3%)
RED DELECIOUS	1.82	182	43 (19%)	1.26	221	4 (2%)

Table 2- Long-Run Equilibrium between Price Pairs

variety	
GALA	$Org_t = 1.41Conv_t$
FUJI	$Org_t = 1.43Conv_t$
RED DELICIOUS	$Org_t = 1.46Conv_t$

Table 3- Estimation Result of MSA-VECM for Gala Variety

variable	Regime 1		Regime 2		Regime 3	
	ΔOrg_t	$\Delta Conv_t$	ΔOrg_t	$\Delta Conv_t$	ΔOrg_t	$\Delta Conv_t$
Constant	0.005*	0.024*	0.005*	0.024*	0.005*	0.024*
$\alpha^-(ECT^-)$	0.003	0.083	-0.161**	0.219***	-0.773***	0.476***
$\alpha^+(ECT^+)$	-0.008	0.136**	-0.137*	0.039	-0.928**	-0.447**
ΔOrg_{t-1}	-0.016**	-0.094	-0.752***	-0.071	-0.006	0.253**
ΔOrg_{t-2}	0.025**	0.051	-0.310***	-0.097*	-0.621**	0.205*
$\Delta Conv_{t-1}$	-0.027**	-0.685***	-0.037	-0.261***	-0.423	-0.581***
$\Delta Conv_{t-2}$	-0.012	-0.225**	-0.089	-0.081	-0.016	-0.615***
Std. error	0.010	0.133	0.140	0.109	0.31	0.15

Note: *, **, and *** respectively indicate significance at the 10%, 5% and 1% level.

Table 4- Estimated Result of Transition Probabilities for GALA Variety

	To regime 1	To regime 2	To regime 3
From regime 1	0.62	0.17	0.21
From regime 2	0.03	0.94	0.02
From regime 3	0.35	0.05	0.59

Table 5- Estimated Result of Regime Properties for GALA Variety

	Number of obs.	probability	Duration
From regime 1	44.1	0.19	2.63
From regime 2	145.4	0.67	17.01
From regime 3	32.5	0.14	2.44

Table 6- Estimation Result of MSA-VECM for Fuji Variety

variable	Regime 1		Regime 2		Regime 3	
	ΔOrg_t	$\Delta Conv_t$	ΔOrg_t	$\Delta Conv_t$	ΔOrg_t	$\Delta Conv_t$
Constant	0.0005***	0.017	0.0005***	0.017	0.0005***	0.017
$\alpha^{-}(ECT^{-})$	-0.00016	0.39***	-0.019	0.25***	-0.73***	0.03
$\alpha^{+}(ECT^{+})$	0.00008	0.16	0.005	0.21***	-0.54***	-0.13**
ΔOrg_{t-1}	-0.0004	0.10	-0.59***	-0.06	-0.41**	-0.036
ΔOrg_{t-2}	-.00025	-0.03	-0.15**	0.07	-0.37**	-0.105
$\Delta Conv_{t-1}$	0.00003	-0.29**	-0.037	0.12	-0.43	-1.03
$\Delta Conv_{t-2}$	0.00033	-0.015	0.19	0.17	0.64	-0.43**
Std. error	0.00048	0.24	0.19	0.12	0.30	0.10

Note: *, **, and *** respectively indicate significance at the 10%, 5% and 1% level.

Table 7- Estimated Result of Transition Probabilities for Fuji Variety

	To regime 1	To regime 2	To regime 3
From regime 1	0.69	0.08	0.21
From regime 2	0.08	0.42	0.49
From regime 3	0.11	0.81	0.06

Table 8- Estimated Result of Regime Properties for Fuji Variety

	Number of obs.	probability	Duration
From regime 1	53	0.23	3.27
From regime 2	102	0.46	1.73
From regime 3	66	0.29	1.07

Table 9- Estimation Result of MSA-VECM for Red Delicious Variety

variable	Regime 1		Regime 2		Regime 3	
	ΔOrg_t	$\Delta Conv_t$	ΔOrg_t	$\Delta Conv_t$	ΔOrg_t	$\Delta Conv_t$
Constant	0.0007***	0.021***	0.0007***	0.021***	0.0007***	0.021***
$\alpha^-(ECT^-)$	-0.0001	0.17**	-0.087	0.22***	0.27***	0.075***
$\alpha^+(ECT^+)$	-0.0007***	0.005	-0.37***	-0.05***	-0.25***	-0.06**
ΔOrg_{t-1}	-0.00061***	0.008	-0.55***	0.10***	-0.53***	0.002
ΔOrg_{t-2}	-0.0003	0.005***	-0.21***	-0.08***	-0.18***	0.06***
$\Delta Conv_{t-1}$	-0.0004	-0.29	-0.12	-0.027	-0.11	-0.64***
$\Delta Conv_{t-2}$	-0.00008	-0.18	0.31	-0.99***	-0.14	-0.23***
Std. error	0.0004	0.13	0.09	0.02	0.27	0.09

Note: *, **, and *** respectively indicate significance at the 10%, 5% and 1% level. \

Table 10- Estimated Result of Transition Probabilities for Red Delicious Variety

	To regime 1	To regime 2	To regime 3
From regime 1	0.57	0.08	0.35
From regime 2	0.22	0.14	0.63
From regime 3	0.08	0.10	0.80

Table 11- Estimated Result of Regime Properties for Red Delicious Variety

	Number of obs.	probability	Duration
From regime 1	45	0.20	2.33
From regime 2	22	0.10	1.17
From regime 3	154	0.70	5.18

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