An Analysis of Price Determination in the Sweet Cherry Markets of British Columbia, Washington, Oregon and California

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1. Introduction

Sweet cherries have garnered increased popularity over the last decade in part attributed to their relatively high price premiums and reported health benefits (Kahlke et al., 2009). Europe, which has been producing sweet cherries for centuries and, later the U.S., have recently been joined by new producing areas in New Zealand, Chile and Argentina. The U.S. is the world's second largest cherry producer accounting for over 10% of world production and 19% of world exports, with Canada the largest importer of U.S. sweet cherries averaging 12,894 metric tonnes (mt) at a value of $60 million between 2004 and 2006 (USDA, 2007). While British Columbia (BC) is the major sweet cherry producer in Canada, Washington, Oregon and California are the principal sweet cherry producing regions in the U.S. (Boriss, Brunke, and Kreith, 2010). Approximately 92% of the U.S. sweet cherry crop is produced in Washington, Oregon and California (Pollack and Perez, 2006).

Sweet cherry is a high-valued fruit that commands some of the highest premiums in the world (Flaming, Marsh, and Wahl, 2007) with fresh U.S. consumption growing at a faster rate than that of frozen cherries. The U.S. per capita consumption of fresh sweet cherries increased from 0.23kg in 1980 to 0.54kg in 2007 (Pollack and Perez, 2008), whereas the Canadian per capita cherry (sweet and sour) consumption increased from 0.25 kg in 1981 to 0.52 kg in 2007 (Statistics Canada, 2007). The large sweet cherry consumption increase in the U.S. may have been influenced by the increasing percentage of sweet cherries diverted to the fresh market, price and quality of competing fruit, and the publicity about the health benefits associated with sweet cherry consumption (Word Sweet Cherry Review, 2008).

This study generates knowledge relevant to producer investment and marketing decisions. Sweet cherry trees require replacement in a commercial orchard after 20-25 years. The decision whether to replant cherry trees or what variety to plant commits grower's resources for an extended period of time. Growers also need information to select and formulate a marketing strategy related to variety and its perishability. This study estimates an inverse demand system to quantify the effects of demand and supply factors relevant to decisions of growers in three U.S. states and one Canadian province. Moreover, the estimation of the second phase provides insights for BC growers about factors influencing the sweet cherry imports. Understanding own consumer demand for imported sweet cherries expands insights that have relevance in making own marketing and merchandising decisions.

2. Variety Preferences, Marketing Practices and Prices

Productivity growth has been the principal driver responsible for the expansion of sweet cherry production in the Pacific Northwest and California. Since the early 1970s, there have been significant increases in fresh sweet cherry production in B.C, Washington, and California. Washington and California fresh sweet cherry production increased, respectively, from an average of about 23,950mt and 18,567mt in the period 1971-1973 to about 119,749mt and 59,814mt in the period 2007-2009, while the BC fresh sweet cherry production increased from 4,546mt in years 1971-1973 to 8,961mt in the period 2007-2009. Production expansion in BC has been driven by a combination of demand increases in both domestic and global markets, adoption of late season cultivars, and technology developments in crop management and packaging (Kappel, 2006).

In California, most of the varieties mature early in the season. The cultivar, ‘Bing’, accounts for 60-70% of the sweet cherry varieties packed by domestic shippers with the bulk of it exported to Japan, its most important lucrative overseas market (Grant, 2009). Besides ‘Bing’, other important cultivars packed by California shippers included ‘Tulare’, ‘Brooks’ and ‘Sequoia’. Unlike their northern counterparts, California producers are not interested in extending their cherry season with late season varieties because varieties ripening after ‘Bing’ would increase the harvest season overlap with the Northwest cherry producing states (Hansen, 2010). Overlapping in harvest seasons as a result of adverse weather conditions is likely to exert downward pressure on prices. Sweet cherries have a relatively short marketing season, with California’s cherry shipments beginning in early May and ending in the late June, while Washington’s and Oregon’s marketing season is from June through mid-July (Perez and Pollack, 2007) For late maturing varieties, the harvest season continues around the middle to late August. BC growers, in general, tend to grow late maturing varieties to minimize the overlap between Washington and BC’s harvest seasons. In Washington, ‘Bing’, ‘Sweetheart’ ‘Rainier’, and ‘Lapins’ were the top four varieties grown in 2009 (Galinato, Gallardo and Taylor, 2009), while ‘Lapins’, ‘Sweetheart’, ‘Staccato’, and ‘Santina’ were the principal varieties accounting for 85% of new variety re-plantings in BC (Okanagan Tree Fruit Authority, 2010). ‘Sweetheart’ has become popular over the years in BC, Washington and Oregon because it is a later-maturing cultivar that allows growers to extend the marketing season.

Farm-level sweet cherry prices have exhibited an upward tendency since 1985 driven by the availability of newer cultivars and the relative profitability of sweet cherry production relative to substitute fruit (World Sweet Cherry Review, 2010). Sweet cherry market prices in Washington can be quite volatile, with price quotes in the early part of the season often twice larger than mid-season prices, and influenced by the variety grown and the timing of shipments (O’Rourke and Casavant, 1974; O’Rourke and Asante 1984; World Sweet Cherry Review, 2010). The average 2007-2009 price of BC sweet cherries was 139% higher than the average 1971-1973 prices. For Washington, Oregon and California, the average sweet cherry price increase over the same time period were 124%, 111% and 101%, respectively.

3. Conceptual Framework

Several studies examined sweet cherry demand focusing on the U.S. sweet cherry sector. The studies applied the inverse demand framework and employed log-linear single equations (McCracken, Casavant and Miller, 1989; Schotzko, Wilson and Swanson, 1989). A recent study by Flaming, Marsh and Wahl (2007) analyzed price-quantity relations of the Pacific Northwest (Washington, Idaho, Oregon and Utah) and California sweet cherry industries by employing a distance function in the specification of an estimable inverse demand model. From the normalized quadratic distance function, the study considered fresh farm-level cherry quantities as inputs and packaged cherry quantities targeted to the export and domestic market as outputs. Not all previous studies considered BC, a major producer and importer of sweet cherry in the Pacific Northwest in their analysis. Furthermore, the study by Flaming, Marsh and Wahl (2007) did not consider relevant factors that influence demand such as population and income changes. The review that follows provides some of the highlights of the previous studies.

Schotzko, Wilson and Swanson (1989) employed annual data for the period 1948-1966 to estimate inverse demand price functions for the Northwest (Washington, Oregon) and California cherry industries. They used seemingly unrelated regression modeling technique and concluded that Northwest quantities had a larger impact on Northwest prices than California quantities. Further, they stated that while the relationship between the per capita income and grower returns was statistically significant, the limited growth in per capita income was expected not to have a strengthening effect on prices. McCracken, Casavant and Miller (1989) found the American cherry price was slightly less responsive to own-volume marketed than the Japanese cherry price. Flaming, Marsh and Wahl (2007) expanded the analysis by Schotzko, Wilson and Swanson (1989) by including Utah and Idaho cherry sectors and using annual cherry price-quantities, U.S. national cherry consumption and export data for the period 1986-2004. The authors found that state-level cherry volumes, coupled with the quantities supplied to domestic and export markets, explained most of the variation in fresh sweet cherry farm-level prices for Washington, Oregon, Utah and California.

The current study addresses some of the limitations of previous studies. The aim is to investigate how differences in demand (e.g., income, population) and supply-side factors influence price formation in the Pacific Northwest and California; both regions differ in climate, geography, varieties grown, production scale, and marketing arrangements. The investigation involves the estimation of the seemingly unrelated regression models to estimate flexibilities between domestic cherries and substitute product while employing the state-level, or province-level in case of BC, price-quantity fresh sweet cherry data. Although sweet cherry demand studies have been undertaken in the Pacific Northwest (Washington, Oregon, Idaho, Utah) and California as a whole, little empirical research has been undertaken in BC; a region that imports a significant amount of fresh sweet cherries from the U.S., especially from Washington. According to O'Rourke and Casavant (1974), the sweet cherry industry in the Pacific Northwest is so interrelated that it is not statistically or economically sound to regard Washington sweet cherry demand as independent of cherry demand in other regions of the Pacific Northwest. Therefore, cherry markets in BC are likely to be interrelated with cherry markets in Washington, Oregon and California.

The current study differs from the previous studies. First, none of the previous U.S. studies included BC as part of the Pacific Northwest cherry markets. The BC cherry sector is major part of the Northwest cherry industry because it is both an importer of fresh fruit from the U.S. and a developer of late season varieties for cherry industries around the world. Second, none of the previous studies have analyzed the effects of sweet cherry imports on domestic prices. BC sweet cherry imports from the U.S. have increased substantively since the enactment of the Canada-U.S. Free Trade Agreement on 1 January 1989. Imports from the U.S. account for roughly 96% of BC's fresh cherry imports (Statistics Canada, 2010b). Unlike Canada that reports cherry trade by provinces, the U.S. does report neither cherry exports nor imports by state (Perez, 2010). Flaming, Marsh and Wahl (2007) included national domestic consumption and exports in their state-inverse demand functions, but failed to include factors influencing demand such as per capita income and population. It is suggested that shifts in sweet cherry demand that have taken place in the U.S. over the last decade may be attributed to growing affluence of consumers, increased promotion of cherries by suppliers and improvement in the size, quality and availability of fresh sweet cherries (World Sweet Cherry Review, 2010).

4. The Empirical Model Specification

Price determination for perishable goods, such as sweet cherries, is an integral part of commodity market analysis with price adjustments providing the market clearing mechanism (Barten and Bettendorf, 1989). Inverse demand models are an empirically valid tool for studying the price-quantity relationships in sweet cherry markets, where quantities are predetermined and cannot adjust in the short run compelling producers to be price takers. The inverse demand framework is a plausible approach for modeling products that are perishable and, despite some progress in assuring postharvest quality (Cavalheiro et al., 2004; Schena et al., 2004; Vangdal, Nordbo and Flatland, 2004), cannot store for long periods of time.

Price dependent sweet cherry demand models have been employed in previous studies (e.g., Flaming, Marsh and Wahl, 2007; McCracken, Casavant, and Miller, 1989) that used annual data. Flexible functional forms that have been previously used require higher frequency and detailed data on budget shares (Grant, Lambert, and Foster, 2010). Single equation demand functions are useful for analyzing production management decisions and their effects on growers' revenues and prices. The model described below (equation 1) hypothesizes sweet cherry prices to be a function of quantities sold, income and prices of substitute fruit (Price and Mittelhammer, 1979). Such model specification is preferred because fresh fruit quantities purchased by consumers are directly influenced by the prices of substitutes because price variation is the primary vehicle for market clearing. The modeling framework adopted in this study includes first estimating a system of four price-dependent equations for sweet cherry producing regions (BC, Washington, Oregon, California) over the period 1971-2009 and, second, estimating four price-dependent and one import supply equation for the 1988-2009 period. The price-dependent demand model is specified as follows:

$$(1)\ \ln P_{i,t} = \alpha_{i,t} + \beta \ln Q_{i,t} + \gamma \ln P_{-1,i,t} + \phi \ln Y_{i,t} + \Gamma \ln MQ_{i,t} + \varepsilon_i ; i = 1,2,3,\ldots,4$$

$$(2)\ \ln MQ_{i,t} = \alpha_{i,t} + \delta \ln IP_{i,t} + \chi \ln Y_{i,t} + \mu_{i,t}$$

where $P_{i,t}$ is the logarithm of fresh sweet cherry farm-level prices in state or province i (Washington, Oregon, California, BC) in year t, $Q_{i,t}$ is the logarithm of per capita fresh sweet cherry farm-level quantities in state or province i (Washington, Oregon, California and BC), $P_{-1,i,t}$ is the logarithm of substitute fresh fruit prices (raspberry, strawberry, blueberry and peaches), $Y_{i,t}$ is the logarithm of per capita personal disposable income, $MQ_{i,t}$ is the logarithm of per capita sweet cherry imports and ε_i is a random error term. We assume that sweet cherry imported supply is endogenous and is specified as a function of imported price and income. Because the variables in equation (1) are expressed in logarithms, the estimated coefficients are interpreted as price flexibilities defined as the percentage change in sweet cherry prices due to a one percent change in its quantity demanded or that of other relevant variables.

According to economic theory, state-level or province-level fresh sweet cherry farm prices are likely to be influenced by the sweet cherry quantity produced, the imported volume of sweet cherries, consumer income, and substitute fresh fruit prices. Consequently, U.S. states (Washington, Oregon, California) and BC farm-level production are expected to have a negative effect on farm-level cherry prices. BC sweet cherry imports from the U.S. have increased since 1988 and are hypothesized to be impacted positively by own-imported price. Fresh fruit considered as substitutes were fruit with similar marketing seasons, quantities marketed fresh and taste characteristics. Fresh raspberry and strawberry are hypothesized to be substitutes for fresh sweet cherry production in BC, Washington and Oregon and, therefore, their quantities are expected to have a negative effect on state or province-level sweet cherry prices at the farm-level. Due to climate differences and natural resource characteristics, the substitute fruit in California are strawberries and peaches, which are hypothesized to have a negative effect on California fresh sweet cherry farm-level prices.

Apart from state and province-level marketed production and imports, per capita personal disposable income is included in the inverse demand function to account for changes in demand. The study includes the income variable in equation (1) to capture the relationship between income and prices. In equation (2), the income variable is included in the BC imported volume equation and it is expected to affect positively the imported quality. The variables accounting for income and population were included in inverse demand studies by McCracken, Casavant and Miller (1989) and Schotzko, Wilson and Swanson (1989), but excluded in the recent study by Flaming, Marsh and Wahl (2007).

5. Data Description and Sources

The study applies annual data for the period 1971-2009. For the purposes of this study, the sweet cherry production regions considered included BC, Washington, Oregon and California. Data included farm-level cherry prices and quantities, substitute fruit quantities and per capita personal disposable income. The data were compiled from several sources.

Farm-level sweet prices and quantities for Washington, Oregon and California were obtained (USDA, 2010a; 2010b). Substitute fresh fruit prices (e.g., raspberry, strawberry) in Washington, Oregon and California were also obtained (USDA, 2010c). British Columbia farm-level sweet cherry prices and quantities and substitute fresh fruit volumes were obtained from Statistics Canada (Morin, 2010) and augmented with data from the BC provincial government (British Columbia Ministry of Agriculture, Fisheries and Food, 2010). Farm-level quantities were expressed on a per capita basis, while farm-level cherry prices were deflated by the U.S. producer price index (1982=100) for fresh fruit and melons (U.S. Department of Labor, 2010). BC sweet cherry import quantities and prices from the U.S. for the period from 1988 to 2009 were obtained from Statistics Canada (2010b).

Per capita personal disposable income and population for Washington, Oregon and California were obtained from the U.S. Department of Commerce (2010a), while BC personal disposable income and population were obtained from Statistics Canada (2010c). Per capita personal disposable income was deflated by the U.S. Implicit Price Deflator (2005=100) (U.S. Department of Commerce, 2010b).

6. Results

The estimation procedure consists of two phases. In the first phase, a system of four equations was estimated by the seemingly unrelated regression (SUR) procedure using data for the period from 1971 to 2009. The SUR procedure provides improved efficiency relative to OLS if there is contemporaneous correlation in the error terms across the equations. In the second phase, the three-stage least squares (3SLS) procedure is applied to estimate five equations using data for the period starting in 1988 through 2009. According to Greene (1997), the 3SLS is more efficient than OLS when the exogenous variables from each equation are different and there is contemporaneous correlation among the error terms in the equations.

Table 1 shows results from the estimation of the first phase. The estimated equations have substantial explanatory power given the R^2 ranging from 0.73 to 0.85. The DW values are marginally significant and suggest the presence of serial correlation cannot be excluded. The estimated coefficients, apart from the coefficients associated with the BC's and Oregon's income, have the expected signs. The BC farm-level price of sweet cherry is influenced by the price of substitute fresh fruit (raspberry and strawberry prices), while the Washington farm-level price of sweet cherry is influenced by own-quantity, substitute fresh fruit (raspberry) prices and income. The effect of sweet cherry quantities and income on Washington fresh sweet cherry prices is consistent with results reported by Price and Mittelhammer (1979). The Oregon farm-level sweet cherry price is influenced mainly by the price of substitute fresh fruits (raspberry and strawberry prices), while the California farm-level price of sweet cherries is influenced by own-quantities and the prices of substitute (peach and strawberry prices) fresh fruit.

The Pacific Northwest and California sweet cherry price equations were re-estimated using the data for the period from 1988 to 2009, but included the import supply equation (Table 2). In the import supply equation all the coefficients have the expected directional effects and are statistically significant. Results imply that BC sweet cherry import supplies are influenced partly by BC sweet cherry import prices and per capita real personal disposable income.

Estimating equation (1) in a log linear functional form allows price flexibilities to be calculated directly. The price flexibility parameters for BC and Oregon supplied sweet cherry quantity have the expected sign, but are insignificant. However, the price flexibility for Washington and California equations is negative and significant at the 10% level. For example, the Washington quantity supplied of sweet cherry was 0.62, while in case of California it was 0.22. The results imply that a one percent decrease in Washington and California's sweet cherry quantity increases sweet cherry prices by 0.62% and 0.22%, respectively (Table 1). Washington and California are the two largest producers of sweet cherries in the U.S. and, therefore, their quantity supplied will have a larger effect on farm-level prices than BC or Oregon. It is important to note that own-price flexibility parameter value is less than one, implying farm-level sweet cherry prices are inflexible in terms of their own quantities. The cross-price flexibilities for fresh fruit substitutes (e.g., raspberry) varied from 0.53 for the BC farm-price equation to 0.25 and 0.57 for the Washington and Oregon farm-price equations, respectively. A one percent increase in the price of fresh raspberries increases BC, Washington and Oregon sweet cherry prices by 0.53, 0.25 and 0.57%, respectively. Cross-price flexibilities for other substitute fresh fruit, such as fresh strawberries, varied from 0.52 for the Oregon farm-level equation to 1.08 for the California farm-level price equation. It is important to note that within the inverse demand framework, positive cross-price flexibilities can be considered complements. In this analysis, only Washington farm-level sweet cherry prices respond positively to income changes and may be considered normal goods. For example, Washington income flexibilities were 1.43 which implies that a one percent increase in Washington's per capita disposable income increases sweet cherry prices in Washington by 1.43%. This result is consistent with U.S. studies suggesting that there has been a positive shift in the demand for sweet cherry attributed to the growing affluence of consumers and the desire to diversify and upgrade their fruit experiences (World Sweet Cherry Review, 2010). Since sweet cherry is a high-priced fruit, consumers with higher incomes would be expected to purchase more cherries in response to an increase in their incomes. With stable incomes and the availability of greater variety of fresh fruit alternatives, consumers are likely to buy less expensive fruit which may explain the negative income flexibilities in BC and Oregon. For the smaller sample, income flexibilities tended to be larger for Washington and California (Table 2). It is important to note that for the period 1988-2009 Oregon own-price flexibilities were significant, while cross-price flexibilities were insignificant, with the exception of fresh strawberries in California, and fresh raspberries in Oregon and British Columbia, respectively.

7. Implications

The review of descriptive data favors the sweet cherry production in BC. The real sweet cherry prices in BC have been showing a tendency to increase in the recent two decades. Such tendency, given the life span of a sweet cherry tree, suggests that growers give a serious consideration to replant their sweet cherry orchards if they chose to rotate the trees. The increasing volume of imported sweet cherries to BC from the U.S. also supports the continuation of sweet cherry production in BC because there evidently is a strong demand in the province.

The results of estimation must be treated with caution in terms of their accuracy given the results of tests on robustness of the specified relationships. However, the estimation results confirm important relationships consistent with expectations based on demand theory. From the grower standpoint, an interesting effect is that of substitution of other considered fruit. In BC, sweet cherry growers can expect a particularly strong effect (almost one-to-one) on cherry prices if the raspberry crop is short and raspberry prices increase. The effect of changes in strawberry prices is much weaker, but nevertheless positive and significant. The strawberry price effect on sweet cherry prices was much stronger in California, while in Oregon it was the raspberry price change, although the latter was about a half of the similar influence on BC sweet cherry prices.

Changes in real per capita disposable income indicated that the income flexibility with regard to sweet cherry prices was particularly high. In Washington the income flexibility suggested that sweet cherry prices could be expected to increase by nearly two percent for every one percent increase in real per capita disposable income. The income flexibility in case of California was also substantial and suggested 1.37 % increase in sweet cherry prices in response to a one percent increase in the income measure. In BC, the increase in income led to more than proportionate increase in the sweet cherry volume imported from the U.S. Although the imports concentrate on the early maturing varieties, once a consumer develops preference for a product, they likely purchase it whenever it is available. Indeed, BC growers may want to continue their efforts in extending the sweet cherry growing season by developing and testing new varieties.

In terms of own price flexibility, all states or province can expect a price decline in response to the increased volume produced in own orchards, but the effects vary widely. In BC the price-quantity relationship is statistically insignificant, but in all three regions of the U.S. it has been confirmed. The highest negative effect was expected in Washington, the largest sweet cherry producing area. The decrease in price due to quantity increase in California was considerably smaller and that in Oregon was the smallest, likely because most of the crop was destined for processing. Prices of fruit used in processing tend to change less in response to changes in supply.

California and the Pacific Northwest created a sweet cherry producing area that is isolated from sweet cherry producing regions of Europe and independent, due to the timing of harvest, of the sweet cherry production in the Southern Hemisphere (e.g., New Zealand, Chile). Indeed, the two regions in the Northern Hemisphere are so isolated that require separate studies to quantify the effect of income and other relevant factors on demand. The European, North American and the Southern Hemisphere sweet cherry industries do not compete on the same markets or during the same season and may benefit from cooperation in the development of new varieties, short term storage improvement, and the research on how to increase consumer demand.

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Table 1: Summary Results of the Pacific Northwest (BC, Washington, Oregon) and California Cherry Model, 1971-2009

Variables	BC farm price of sweet cherry	Washington farm price of sweet cherry	Oregon farm price of sweet cherry	California farm price of sweet cherry
Intercept	1.2865 (1.48)	-3.1875* (4.42)	0.3420 (0.34)	-0.5741 (0.46)
Q_{bc}	-0.1201 (1.61)			
Q_{wa}		-0.6223* (6.41)		
Q_{or}			-0.1791 (1.59)	
Q_{ca}				-0.2234* (2.44)
RP_{bc}	0.5364* (1.96)			
SP_{bc}	0.9371* (3.13)			
RP_{wa}		0.2598* (2.06)		
BP_{wa}		0.1802 (1.12)		
RP_{or}			0.5753* (3.56)	
SP_{or}			0.5246* (2.54)	
PP_{ca}				0.6068* (2.62)
SP_{ca}				1.0881* (4.02)
Y_{bc}	-0.6540* (2.06)			
Y_{wa}		1.4389* (5.51)		
Y_{or}			-0.2287 (0.64)	
Y_{ca}				0.4136 (1.25)
R-squared	0.8006	0.8538	0.7432	0.7288
DW	1.72	1.64	1.72	1.35

Notes: * indicated significance at the 0.10 level; values in parentheses are t-ratios

Table 2: Summary Results of the Pacific Northwest (BC, Washington, Oregon) and California Cherry Model, 1988-2009

Variables	BC farm price of sweet cherry	BC import supply from the U.S.	Washington farm price of sweet cherry	Oregon farm price of sweet cherry	California farm price of sweet cherry
Intercept	-0.4006 (1.43)	-4.6814* (3.54)	-4.7467* (2.54)	-0.2489 (0.08)	-3.8867 (1.29)
Q_{bc}	-0.0461 (0.40)				
Q_{wa}			-0.6253* (3.54)		
Q_{or}				-0.2840* (1.91)	
Q_{ca}					-0.3305* (1.93)
RP_{bc}	0.9223* (2.52)				
SP_{bc}	0.2574 (0.59)				
IP_{bc}		0.7859* (3.48)			
M_{bc}	-0.5116 (0.31)				
RP_{wa}			0.2109 (1.39)		
BP_{wa}			-0.0133 (0.05)		
RP_{or}				0.4794* (2.09)	
SP_{or}				0.5276 (1.24)	
PP_{ca}					0.4852 (1.41)
SP_{ca}					0.9656* (2.87)
Y_{bc}		1.2165* (2.60)			
Y_{wa}			1.9676* (3.04)		
Y_{or}				-0.0325 (0.03)	
Y_{ca}					1.3720* (1.66)
R-squared	0.6853	0.4968	0.5810	0.6129	0.6429
DW	1.66	2.09	1.45	1.53	1.27

Notes: *indicates significance at the 0.10 level; values in parentheses are t-ratio values