Price Behavior in Corn Market with Identity Preserved Types

Aziz Elbehri and Philip Paarlberg*

Abstract: This study examines the price behavior for identity preserved and generic corn under different demand and competition conditions. Simulation results suggest that generic corn has a greater market impact on specialty corn than the reverse, and that increased competition within processing may improve price premia received by corn growers.

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Introduction

Corn is the number one crop in the U.S. in terms of acreage and overall value (USDA). Given the wide range of possible uses for corn products and because of tremendous technological advances, corn is at the heart of the increasing industrialization of the U.S. grain system. US corn growers are faced with an increasingly differentiated market where identity preserved (IP) and segregated corn types (henceforth "specialty") coexist with the generic standard commodity (henceforth "generic") corn. The specialty corn market increased from 3.3% of total US corn in 1996 to 10.9% in 2000 (US Grains Council) and these trends are expected to continue, driven by several forces including biotechnology, technological innovations in processing and more differentiated consumer demand.

The economic implications for corn growers and processors are expected to be considerably different under a differentiated corn market compared to the homogenous corn system. IP production focuses on providing the customer with a higher valued product that commands premiums. Identity preservation involves additional costs, as IP crops require segregated marketing channels and additional transaction costs in the form of testing, monitoring and product certification (Bullock, Desquilbet and Nitsi, 2001; Maltsbarger and Kalaitzandonakes, 2001; Lin, Chambers and Harwood, 2000). However, the development of these specialty crops depends on the extent to which a price premium relative to generic corn is above IP costs.

Several economic factors influence the dynamics of price premium formation and variability. Under conditions of excess supply, price premia may be eroded substantially from one year to another. This is the case of non-GM corn, which experienced a sharp decline in the price premium from 2000 to 2001 due to excess supply of non-GM corn and ease of testing for GM presence (Moss et al., 2002).

Price premia of specialty corn types relative to generic corn also vary from year to year depending on factors such as crop quality, and the presence and type of production contracts. The quality of the corn crop has a significant impact on price premia, particularly if specialty corn types are produced without contracts. Under production contracts, price premia depend on the contract type. The most common contract type is “market price plus a premium”, which leaves the producer with all price and yield risks and keeps specialty corn tied to market conditions for generic corn. The variability of price premiums from year to year and the reliance on production contracting are also reflected in higher variability in supply and demand for IP corn compared to generic corn. This is evidenced by findings of the U.S. Grains Council survey that show the high degree of entry and exit of farms in and out of specialty crop production. The key factor drawing farmers in and out of specialty corn is the price premium and the relative returns compared to generic corn. This close price linkage plays a critical role in market developments in specialty versus generic corn markets.

For specialty corn types used primarily in corn processing another key factor affecting price premium received by growers is the impact of market coordination and the degree of market power along the supply chain. Technological innovations are enabling corn processing to expand the range of products with unique attributes, and this has facilitated the emergence of specialty corn types (waxy, high amylose) tailored to optimize processing options. These specialty corn types command high premiums and are often produced and marketed through an IP system under direct contracts between processors and growers that bypass intermediate handlers. Within this vertically coordinated structure one of the factors affecting price determination and returns to growers is the oligopsonistic buying behavior of processors, owing to a high degree of industrial concentration.

The objective of this study is to explore the price and market behavior of a corn market under product differentiation and identity preservation. Almost all of the existing studies on differentiated crops have focused on the GM and non-GM crop split (Moschini et al., 2000; Moss et al., 2002; Giannakas and Fulton, 2001; Lence and Hayes, 2001; Desquilbet and Bullock, 2002; Maltsbarger and Kalaitzandonakes, 2001). Also, except for Nadolnyak and Sheldon (2001), all studies have approached crop markets under a perfect competition assumption. This study differs from existing literature in that it considers a more general specification of a differentiated corn market with several specialty corn types coexisting with generic corn, recognizing that a variety of forces are shaping product differentiation for corn and biotechnology is only one factor. In addition to horizontal product differentiation, this study also accounts for imperfect competition for specialty corn types, incorporating corn processors as oligopsonistic buyers of IP corn from growers who behave as price takers. Specific objectives are to: (1) measure the price effects of different corn types, (2) assess the relative movement of price premiums, and (3) determine how changing the competitive environment of corn processing influences market effects and net benefits, given alternative demand shifts for different corn market segments.

The Model

This section presents a model of the corn market characterized by the presence of several specialty or identity preserved corn types in addition to generic corn. The generic corn market is characterized by perfect competition, and markets for specialty corns are characterized by imperfect competition. Such a model is used to understand the interactions among markets for different types of corn. The model also provides insight into what happens when new processing firms enter specialty corn markets. The presentation begins with a two-commodity example to clearly demonstrate the model structure. The discussion begins with the farm supply component. It then proceeds to the demand side for the generic corn market. Next imperfect competition is introduced in the specialty corn market.

Farm Sector

The farm supply component assumes that profit-maximizing farms produce two types of corn under constant returns to scale technology. Generic corn is subscripted by *g*, while corn subscripted by *p* is a specialty (identity preserved) corn. Interactions with other crops, like soybeans, are ignored to keep the model and analysis tractable. Production agriculture is assumed to be characterized by perfect competition with free entry and exit and price taking behavior. Each type of corn production uses two factors of production. One factor, L, is mobile with price of w. The other factor, K, is corn-specific with prices of r_g and r_p for generic and specialty corns, respectively. The factors are in fixed supply.

Using complementarity from the farm profit maximization problem, the above assumptions give rise to the following model where unit cost given by the left-hand side equals unit revenue (price) on the right-hand side:

(1) $a_{Lg}(w, r_g, r_P)w + a_{Kg}(w, r_g, r_p)r_g \quad = PF_g$

if $P_g \geq LR$, then $PF_g = P_g$

if $P_g < LR$, then $PF_g = LR$

(2) $a_{Lp}(w, r_g, r_p)w + a_{Kp}(w, r_g, r_p)r_p \quad = P_p$

(3) $a_{Lg}(w, r_g, r_p)Q_g + a_{Lp}(w, r_g, r_p)Q_p \quad = L$

(4) $a_{Kg}(w, r_g, r_p)Q_g \quad = K_g$

(5) $a_{Kp}(w, r_g, r_p)Q_p \quad = K_{p,}$

where:

Q_g = Output of generic corn by the farm sector; $Q_g > 0$;

Q_p = Output of specialty corn by the farm sector, $Q_p > 0$;

PF_g = Price of generic corn to farmer, $PF_g > 0$;

P_g = Price of generic corn on market, $P_g > 0$;

P_p = Price of specialty corn, $P_p > 0$;

a_{Li} = Use of mobile factors per unit of good i, $a_{Li} > 0$;

a_{Ki} = Use of specific inputs per unit of good i, $a_{Ki} > 0$;

LR = Loan rate for corn, $LR > 0$.

An example of this type of supply side modeling can be found in Jones (1981). Solution to equations (1) through (5) using the implicit function theorem gives the supply functions for each type of corn:

(6) $Q_g = Q_g(PF_g, P_p, L, K_g, K_p);\ \partial Q_g/\partial PF_g \geq 0$;

(7) $Q_p = Q_p(PF_g, P_p, L, K_g, K_p);\ \partial Q_p/\partial P_P \geq 0$.

Demand behavior consists of two components. One component applies to generic corn and assumes this market is perfectly competitive. That allows it to be described by demand equations as found in traditional commodity models, and the market clears in a standard fashion.

(8) feed: $F_g = F_g(P_g);\ \partial F_g/\partial P_g \leq 0;$

(9) food: $C_g = C_g(P_g);\ \partial C_g/\partial P_g \leq 0;$

(10) Industrial: $I_g = I_g(P_g);\ \partial I_g/\partial P_g \leq 0;$

(11) Ending Stocks: $E_g = E_g(P_g);\ \partial E_g/\partial P_g \leq 0;$

(12) Exports: $X_g = X_g(P_g^*);\ \partial X_g/\partial P_g \leq 0;$

Trade policy, denoted s_g, links the world price of generic corn, P_g^*, to the U.S. price:

(13) $P_g = P_g^* + s_g$

Market clearing determines the U.S. price for generic corn (assuming seed is purchased not saved):

(14) $X_g(P_g - s_g) = E_{g(-1)} + Q_g(PF_g, P_p, L, K_g, K_p) – F_g(P_g) - C_g(P_g) - I_g(P_g) – E_g(P_g)$

The specialty corn market is assumed to be characterized by imperfect competition where firms in the market recognize the effect their actions have on rivals. This component is described by a two stage game. Stage I is the entry and exit decision -- the number of firms, n, is endogenous. In Stage II firms determine output -- n is given. Since this research focuses on the specialty corn premiums at a point in time, only Stage II is modeled. The model could be solved via backward induction to find n. Entry and entry deterrence behavior are examined once the Stage II model is working by exogenously changing the number of firms. Specific assumptions for Stage II are:

1. n symmetric firms produce an output of corn products $q_R > 0$;
2. Output of corn product (for each corn type) is homogeneous;
3. Domestic and international markets are not segmented;
4. Output is freely traded;
5. Firms set the quantity of corn products produced to maximize profit; that is, corn products are strategic substitutes;
6. Lower case letters denote firm variables. Upper case letters denote market variables.

Let demand for a processed product from corn, like starch, be the aggregate of domestic and export demand. That is, the output is homogeneous and markets are not segmented so the firm cannot price discriminate. Demand is given by $C_R = C_R(P_R)$; $\partial C_R/\partial P_R \leq 0$, $\partial^2 C_R/\partial P_R^2$ \$ 0. With quantity competition the inverse demand is:

$$(15) \quad P_R = P_R(C_R);\ \partial P_R/\partial C_R \leq 0;\ \partial^2 P_R/\partial C_R^2 \leq 0.$$

With n symmetric firms $C_R = nq_R$

Each firm has a production function that converts corn purchased, q_p, into the processed product (starch) sold, q_R:

$$(16) \quad q_R = q_R(q_p);\ \partial q_R/\partial q_p > 0.$$

Costs are assumed to consist of a fixed cost, φ, plus variable costs of specialty corn. This means there are returns to scale as average fixed cost falls as output increases. Other variable costs are ignored in the formulation to keep the presentation simple.

To construct the firm's profit maximization problem, invert the supply function (expression (7)) for specialty corn:

$$(17) \quad P_p = P_p(PF_g, Q_p, L, K_g, K_p);\ \partial P_p/\partial Q_p\ \$0,$$

where total market output of specialty corn is Q_p which equals per firm purchases times the number of firms, or $Q_p = nq_p$.

Thus, the firm wants to maximize profit (π) subject to the production function:

$$(18)\quad \text{MAX}\ \pi = P_R(nq_R)q_R - \varphi - P_p(PF_g, nq_p, L, K_g, K_p)q_p$$

$$\text{Subject to: } q_R = q_R(q_p)$$

$$\text{where } \partial^2\pi/\partial q_p^2 < 0.$$

First-order conditions for an interior solution ($q_R > 0$; $q_p > 0$) are:

$$(19)\quad \partial L/\partial q_R = P_R(nq_R) + n.q_R\,(\partial P_R/\partial C_R) + \lambda = 0,$$

$$(20)\quad \partial L/\partial q_p = -P_p(PF_g\,, nq_p, L, K_g, K_p) - nq_p\,(\partial P_p/\partial Q_p) - \lambda[\partial q_R/\partial q_p] = 0,$$

$$(21)\quad \partial L/\partial \lambda = q_R - q_R(q_p) = 0.$$

Substitute expression (20) and expression (21) into expression (19) to determine the firm's purchases of specialty corn:

$$(22)\quad (\partial q_R/\partial q_p)\{P_R(nq_R(q_p))+nq_R(q_p)[\,\partial P_R/\partial C_R]\} =$$

$$P_p(PF_g,nq_p,L,K_g,K_p)+nq_p[\partial P_p/\partial Q_p].$$

Solving expressions (14) and (22) simultaneously gives q_p and P_g. The farm price for generic corn is determined by whether P_g is above or below the loan rate. If the farm price exceeds the loan rate the market price is used in the farm supply. But if the market price is below the loan rate, the loan rate is used as loan deficiency payments equal to the difference are assumed paid to farmers. When per firm specialty corn purchase is determined, multiplication by n gives Q_p. Once total purchases of specialty corn are known, the price, P_p, is found using the inverse supply expression (17). The difference between P_p and PF_g or P_g is the premium paid for specialty corn. Per firm specialty corn purchases can be used to find per firm corn product output, q_R, via the production function, expression (16). Multiplication by the number of firms gives the total output which determines the price, P_R, using the inverse demand equation, expression (15).

Numerical Model

In the numerical model a variety of types of corn are considered, including high-oil corn, nutritionally dense, waxy corn, amylose corn, and white corn. Corn types where imperfect competition prevails (waxy, high amylose) each have expressions like expression (23). Corn types characterized by perfect competition (generic, high oil, nutritionally dense, white) have market clearing identities like expression (14).

Data used in the model include supply, use, and price data and are derived from a variety of sources, including Jefferson, Traxler, and Wilson; *Agriculture Census for United States* (USDA/NASS); USDA/NASS farm survey data (see table 1). Generic area and production are calculated by subtracting specialty crops (except sweet corn) and seed from total U.S. corn for grain reported in *Agricultural Outlook* (USDA/ERS). Import and export data are derived from the USITC *Trade Database*. That dataset does not report specialty yellow corn trade, except trade in seed which is excluded from the model. A variety of industry sources were used to derive a rough indication of trade volumes for specialty corn types.

Most usage data comes from the *Feed Situation and Outlook Yearbook* (USDA/ERS). That source identifies feed, seed, HFCS, glucose and dextrose, starch, fuel, brewing, and cereal use. Glucose and dextrose use is separated based on product supply and use. Food use is determined from food consumption survey data (Blisard, 2001). Once total use of corn by activity is identified individual corn types are allocated based on the major use classification in Jefferson, Traxler, and Wilson. High oil corn is assumed exported for feed. Most waxy corn goes into U.S. starch production. White corn is treated as a food corn. Nutritionally dense corn is assumed to be fed while high amylose corn is assumed milled for starch production. Use of generic corn by activity is found by removing the specialty corns from the total.

Parametrization of the numerical model required both calibration and indirect estimation when data were unavailable. Supply elasticities are derived based on Cobb-Douglas technology using unit cost shares from USDA data on cost production, and shocking the model to arrive at a matrix of elasticities. Feed demand elasticities for generic, nutritionally dense and high oil corn are derived using an LP feed ration model for five livestock types taking feed rations as cost functions. By varying price and solving the LPs a set of price and quantity pseudo-data is created from which a feed elasticity matrix and hence feed demand equations are derived. For the imperfect competition sectors, the firm level demand elasticity is calibrated by fixing the number of firms and market conduct. From this, market level demand elasticity is generated.

Simulations and results

We present simulation results of three "what if" scenarios to explore the price and quantity linkages under alternative demand and market structure scenarios affecting specialty and generic corn differentially. In scenario 1, we implement an exogenous demand shift of 10% for specialty corn types with domestic use—waxy, high amylose and nutritionally dense. High oil corn, which is totally exported and white corn exclusively for food use are not shocked. This scenario can be thought of as representing favorable domestic market conditions for specialty corn, reflected in stronger demand and expanded specialty corn utilization leading to a higher price premium relative to generic corn. In scenario 2, the exogenous demand shock of 10% is extended to include generic corn in addition to the three specialty corn types. This scenario can be thought of as the "ethanol effect" that pushes up demand for all corn types.

In scenario 3, we consider an alternative market structure scenario by allowing firm entry into the corn processing. This would be a case, for example, when a farm cooperative enters corn processing in order to internalize value added. In all 3 scenarios we assume a loan rate for corn is in effect for all corn types. That is, when market price falls below loan rates, growers receive the loan rate. This implies that growers of specialty corn continue to hold ownership of the crop when they enter into a production contract with processors.

Simulation results are shown in table 2. The exogenous increase in specialty corn demand simulated in scenario 1 results in higher prices for all specialty corn types. Specialty corn prices increase about 2% and the generic corn price increases 0.5% due to the slight reduction in output (-0.1%) that results from substitution away from generic to specialty corn production. The price of white corn, which does not benefit from the demand shock, is unchanged. The percentage premia changes are greater. Specialty corn premia increases—nutritionally dense (+17.7%--from $7.9 to $9.3), waxy (+14.9%), and high amylose (+4.4%)—while the white corn premium declines (-3.3%). Given the significant shares of feed and industrial uses for generic corn, there are stronger substitution effects between generic corn on hand and feed type corn (N. dense, HO) and industrial (waxy, h. amylose) than with food corn types (white).

Under scenario 2, with a demand boost for domestic uses for specialty and generic corn (at 10% of base quantities), market prices rise more sharply than in scenario 1 (when only specialty corn demand is raised). Increased feed and industrial demand for generic corn results in a substitution away from demand for food, exports, and stocks with a net output increase of 0.5%. The price increase ranged from 12.1% for high oil to 16.4% for generic corn. However, despite significant price increases for specialty corn induced by the demand boost, price premiums relative to generic corn fell for all specialty corn types. The exception is high amylose for which the premium increased (+9.8%) despite a lower price increase (13.9%) compared to generic corn (+16.4%). The much larger absolute price premium for high amylose ($42 in benchmark compared to $9.1 for waxy) accounts for the price premium boost. For the other specialty corn not shocked with a demand increase, such as high oil (used for exports) and white (food), relative prices or price premiums vis-a-vis generic corn deteriorate even more than specialty corn for feed or industrial use. The price linkages between generic and specialty corn show that favorable demand conditions for generic corn can have a negative impact on price premia for specialty corn types. Also the magnitude of the price effects in scenario 2 compared to scenario 1, show that initial market shares play a significant role in market outcomes for various specific corn types.

We also checked for the sensitivity of these results due to the presence of the loan rate and the initial market prices relative to loan rates. The extent of supply response from exogenous demand boost may be affected by the relative position of market price vis a vis the loan rate. As a sensitivity analysis, we repeated scenario 2 (scenario 2b) using as a starting point a market price for generic corn just above the loan rate, derived via a preliminary simulation. Numerical results from scenario 2b show that quantities and price responses are somewhat larger in magnitude but in the same direction comparing to scenario 2 (where initial market price is somewhat below the loan rate). The implication here is that the demand boost needs to be larger when market price is below the loan rate to induce a full supply response.

In scenario 3, we examine increased firm competition at the starch processing level by simulating an exogenous increase in firm number in waxy and high amylose processing. Simulation results show that increased firm competition boosts demand and output for waxy and high amylose corn. Mark-ups also shrink, reducing starch prices as additional firms now supply the market. This translates into higher corn prices with market prices rising by 1.8% for waxy and by 2.2% for h. amylose. Since the generic corn price is not significantly affected, there is an increase in price premia for both waxy corn (15.1%) and high amylose (5.66%).

Conclusions

This study offers an empirical analysis of dynamics of price premia for several identity preserved (or specialty) corn types when they co-exist with generic corn in a differentiated market. The study examines the price and market impacts when these specialty corn types are subject to different demand conditions and changing competition structure beyond the farm gate.

Simulation results suggest that given its dominant market share, changes in generic corn have greater impact on specialty corns than changes in specialty corns have on the generic market. Thus specialty corn markets must expand greatly before they will generate large positive spillover effects on commodity corn. The study demonstrates that price and market incentives for growing specialty corn depend significantly on the generic corn market. While specialty crops can mean high-value for an individual grower who receives price premiums, at the market level these premia are the result of supply and demand factors linking several sub-markets with generic corn serving as the default system. The interplay of these factors determines relative prices and hence growers' decisions between planting generic and specialty corn types.

The study also shows that the competitive structure affects prices and price premia for growers and processors and that through increased competition within processing, corn growers may receive improved price premia. This outcome is particularly important when production and delivery is handled via direct contracts between growers and processors.

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Table 1: Calculated Supply and Use of Corn by Type, 1999[1]

	Generic	High Oil	High Dense	Waxy Amylose	White	Nutri.	High	Pop	Sweet

	Generic Oil	High Dense	Waxy Amylose	White	Nutri.	High	Pop	Sweet
Area (thd. Ha.)	27,228.63	404.86	222.67	445.34	80.97	18.22	136.55	285.5
Yield (mt/ha)	8.36	9.22	9.72	9.22	9.29	5.83	3.31	14.43
	Quantities in thousand metric tons							
Beginning Stock[2]	45,392.36	0	0	0	0	0	0	0
Output	227,755.10	3,734.01	2,165.47	4,107.41	751.88	106.31	451.96	4,121.04
Imports	179.16	0	0	55.91	0	0	0.34	47.03
Exports	43,554.23	3,732.78	4	1,604.00	0	0	102.5	320.26
Feed	143,147.50	0	0	0	751.63	0	0	0
Wet Mill	37,816.43	0	2,160.76	0	0	106.27	0	0
HFCS	13,716.77	0	0	0	0	0	0	0
Glucose	4,546.86	0	0	0	0	0	0	0
Dextrose	1,092.26	0	0	0	0	0	0	0
Starch	4,108.73	0	2,160.76	0	0	106.27	0	0
Fuel	14,351.81	0	0	0	0	0	0	0
Brewing	3,302.19	0	0	0	0	0	0	0
Food	1,791.94	0	0	2,557.97	0	0	349.8	3,657.60
Ending Stock[2]	43,639.66	0	0	0	0	0	0	0
Loss[3]	75.65	1.23	0.71	1.35	0.25	0.03	0	0
Prices in dollars per ton:								
Market	71.65	79.52	80.7	80.7	79.52	114.95	220.46	478.4
Loan[4]	74.41							

[1] Supply and use of seed corn is exlcuded

[2] Due to lack of data stocks for specialty corns are assumed zero althrough processors might carry over working stocks.

[3] Calculated as a percent of production using the aggregate forn for grain share.

[4] Speciality corns assumed under contract and not available for LDPs

Sources: Specialty corn area, output, and price (except pop and sweet)- Jefferson, Traxler and Wislon

Popcorn area and yield- USDA/NASS

Sweet corn - Lucier and Lin; Lucier and Plummer

Total corn - USDA/ERS

Trade- USITC and industry sources

Table 2. Model simulation results: price and market effects (percent change from base)

Corn types	Units	Benchmark or base	Increased demand use for: Specialty corn	Specialty & generic corn	Firm entry into corn processing
			Scenario 1	Scenario 2	Scneario 3
Generic					
Output	mt	227842.8	-0.1	0.5	-0.1
Feed use	mt	143167.6	0.2	9.3	0.0
Industrial use	mt	41157.7	-0.1	8.8	0.0
Food use	mt	1791.8	-0.1	-4.9	0.0
Exports	mt	43555.0	-0.6	-19.6	-0.2
End. Stocks	mt	43667.0	-0.5	-16.4	-0.1
Market price	$/mt	71.6	0.5	16.4	0.1
Producer price	$/mt	74.4	0.0	12.0	0.0
High oil					
Output	mt	3733.5	-99.7	-99.7	
Exports	mt	3732.3	-99.9	-99.6	
Market price	$/mt	79.5	-97.2	-82.3	
Producer price	$/mt	79.5	-77.7	-108.7	
Price premium	$/mt	7.9	-100.0	-100.0	
Nutri. Dense					
Output	mt	751.8	9.9	9.9	
Feed use	mt	751.5	9.9	9.9	
Market price	$/mt	79.5	2.2	14.1	
Producer price	$/mt	79.5	2.2	14.1	
Price premium	$/mt	7.9	17.7	-7.0	
Waxy					
Output	mt	2189.5	10.2	10.2	9.0
Industrial use	mt	2158.7	10.4	10.4	9.1
Exports	mt	30.0	-0.2	-1.4	-0.2
Market price	$/mt	80.7	2.1	14.0	1.8
Producer price	$/mt	80.7	2.1	14.0	1.8
Price premium	$/mt	9.1	14.9	-5.2	15.1
WAXY PROCESSING					
starchcons	mt	1321.2	-1.1	-3.9	9.1
starchprice	$/mt	442.0	0.7	2.5	-5.8
High Amylose					
Output	mt	106.4	9.3	9.2	10.5
Industrial use	mt	100.4	9.9	9.9	11.1
Exports	mt	6.0	-0.2	-1.5	-0.3
Market price	$/mt	113.6	2.0	13.9	2.2
Producer price	$/mt	113.6	2.0	13.9	2.2
Price premium	$/mt	42.0	4.4	9.8	5.7
HIGH AMYLOSE PROC					
starchcons	mt	55.8	-0.6	-2.0	11.1
starchprice	$/mt	1101.0	0.5	1.6	-8.6
White					
Output	mt	4107.4	0.0	-3.4	
Food use	mt	2558.0	0.0	-3.4	
Exports	mt	1604.0	0.0	-3.4	
Market price	$/mt	80.7	0.0	11.2	
Producer price	$/mt	80.7	0.0	11.2	
Price premium	$/mt	9.1	-3.5	-29.4	