

# **The Impact of Post-Farmgate Value-Adding on Western Canadian Agriculture**

**K. K. Quagraine<sup>1</sup>, J. Unterschultz, and S. Jeffery**

Paper presented at the Western Agricultural Economics Association Annual Meetings, Vancouver, British Columbia, June 29-July 1, 2000.

Copyright 2000 by K. Quagraine, Jim Unterschultz and Scott Jeffrey. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

---

<sup>1</sup> Authors are respectively, graduate student and associate professors at the Department of Rural Economy, University of Alberta, Edmonton, Alberta, Canada T6G 2H1. Email addresses are respectively, kquagrai@ualberta.ca, jim.unterschultz@ualberta.ca, and scott.jeffrey@ualberta.ca. The financial assistance of the Alberta Agricultural Research Institute is acknowledged.

## **The Impact of Post-Farmgate Value-Adding on Western Canadian Agriculture**

### **Introduction**

Most of Canada's grain/oilseed and livestock is produced in the Prairie provinces with much of the grain destined for the export market. Domestic demand for agricultural and food products is relatively stable. Thus, apart from influences from the weather and technological factors, variations in farm prices and farm incomes are predominantly determined by situations in the international market. Such situations have caused a renewed interest in the concept of "post-harvest value adding" by the federal and provincial governments and the agriculture industry. Consequently, substantial investment has been made in value-added initiatives in the post-harvest sector.

Agricultural economists have expended much effort toward evaluating the economic benefits from cost-reducing research in agriculture. Much of the work has been carried out using a multi-stage production system in a partial-equilibrium framework. Studies have focused on the distribution of economic benefits from government policy such as investment in research and development (Dryburgh and Doyle 1995; Holloway 1991; Huang and Sexton 1996; Mullen et. al 1989; Voon and Edwards 1991;). Other studies have examined the benefits from investments in commodity promotion and advertising (Cranfield et. al 1995; Kinnucan et. al 1996; Wohlgenant 1993). The literature provides important insights into the effects of different types of exogenous factors on commodity prices and quantities as well as the welfare of particular groups in the food production system. The effects of promotion and/or advertising are evaluated under the assumption that promotion and/or advertising shift the retail demand curve and for research, the effects are evaluated under the assumption that research shifts the farm input supply curves. While this multi-stage approach is equally applicable to estimating the effects of value adding investment, no attention has been given to it. This study extends the literature on distribution of gains in a multi-stage production system to include gains/losses from investment in value adding in the post-farm-gate sector.

This study is similar to the work of Martin and Alston (1994) who measure the impact of a technological change that shifts the supply curve of farm commodities. This study is concerned with the impact of investment in value adding that shifts the derived demand curve for farm commodities. Five commodities are examined namely wheat, feed barley, canola, slaughter cattle

and slaughter hogs. Functional equations representing the supply and demand for the commodities are used to conduct simulation experiments involving increased demand for the commodities. Results from the experiments provide insights into the effects of investment in value adding on prices, quantities and farmers' welfare.

## The Model

The modelling procedure employed in the study lends itself directly to applications of full general equilibrium models but attention focuses on only a few commodity sub-sectors. Functional relationships are specified for the farm and processing sectors and are put together in a partial equilibrium framework and used for simulating the effects of changes in domestic demand for commodities.

The production functions for the farm commodities were derived from a Generalised Leontief profit function. The supply functions are represented as:

$$q_i(w) = \frac{a_i}{w_i^{0.5}} + a_{ii} + \sum_{j=2}^5 a_{ij} \frac{w_j^{0.5}}{w_i^{0.5}} \quad i \neq j \quad \& \quad i, j = 1, \dots, 5 \quad (1)$$

where  $q_i$  is the quantity of commodity  $i$  supplied; and  $w_i$  is the price. The subscripts  $i, j$  are indexed 1=wheat, 2=canola, 3=slaughter cattle, 4=slaughter hogs and 5= feed barley. In equation (1), the constant term  $\alpha_{ii}$ , subsumes the effects of the fixed and quasi-fixed factors. Similarly, the demand functions for the farm commodities were derived from a Translog profit function. The demand functions are represented as:

$$s_i = \frac{w_i q_i^d}{\Pi} = -(b_i + b_{i^*} \ln p_k + b_{ii} \ln w_i) \quad i = 1, \dots, 4 \quad (2)$$

where  $s_i$  is the cost of the commodity to total profit;  $\Pi$  is the processor profit;  $q_i^d$  is the quantity of the commodity demanded domestically; and  $p_k$  is the price of the output  $k$  produced from commodity  $i$ . It is assumed that feed barley is used mainly as livestock feed. Consequently, the demand function for barley ( $i=5$ ) is specified as a linear function of the price of slaughter cattle, slaughter hogs and barley:

$$q_5^d = s_0 + \sum_j s_{ij} w_j \quad j = 3, \dots, 5 \quad (3)$$

where  $q_5^d$  is the quantity of barley demanded and the  $s$ s are parameters.

To complete the model some market closing identities (market equilibrium conditions) and other price linkages need to be established. The commodity market closing identities are represented as:

$$q_i \equiv q_i^d + q_i^x \quad i = 1, \dots, 5 \quad (4)$$

where  $q_i^x$  is export of commodity  $i$ . For feed barley,  $q_i^x$  is denoted by a parameter that accounts for stocks. For wheat, canola, slaughter cattle and slaughter hogs, export supply functions are specified as functions of own price, that is,

$$q_i^x = f_0 + f_1 w_i \quad i = 1, \dots, 4 \quad (5)$$

where the  $f$ s are parameters.

Other price linkage equations involve relationships between processor output price and farm commodity price. These are specified as:

$$p_k = d_0 + d_1 w_i \quad i, k = 1, \dots, 4 \quad (6)$$

where the  $d$ s are parameters.

## Simulation

The complete model consisted of 22 variables and 22 equations and the solution method followed to solve the model was to treat the model as a collection of linear and non-linear algebraic equations. The system of equations was then solved using GAMS (General Algebraic Modelling System) and the CONOPT solver (Brooke et. al 1996). The process involved first, solving the system of equations to obtain optimal solutions for the variables (base case). Then shock experiments are conducted by increasing domestic demand of each commodity by 20%. With each shock, the system is resolved to obtain new solutions for prices and quantities besides the fixed levels. The changes in quantity, price and farmers' welfare are calculated for each solution. Data used are 1996 values obtained from Statistics Canada.

With the model specification as above, the values of the model parameters are determined using elasticity estimates from Quagraine (2000). Econometric estimates are used to calibrate the export and price linkage relationships. One implication of this mode of calibration is that the model cannot be statistically tested since the parameters are chosen in a deterministic way. In addition, a fundamental assumption is that the market is in equilibrium in the base period.

The system of equations derived and used in the present study involves more than one commodity and for that matter, changes in more than one price. Consequently, producer welfare is evaluated in this study using changes in producer profit. Producer profit ( $\Pi^f$ ) is calculated as:

$$\Pi^f = 2 \sum_{i=1}^5 \mathbf{a}_i w_i^{0.5} + \sum_{i=1}^5 \sum_{j=1}^5 \mathbf{a}_{ij} w_i^{0.5} w_j^{0.5} \quad i, j = 1, \dots, 5 \quad (7)$$

All variables are defined as previously. The  $\mathbf{a}$ s identified in equation (1) are used to parameterise equation (7).

### **Preliminary Results**

The analyses of the effects of value-adding investment follow the nature of the set up of the model. The base solution represents the initial market equilibrium conditions. Exogenous shocks to the system affect the initial equilibrium causing imbalances in the market. The variables then adjust to establish a new market equilibrium. From economic theory, it is assumed that changes in the price variables trigger changes in quantity variables and/or vice versa. Thus the model solution illustrates price and quantity response and cross-commodity substitutions (Table 1). The changes that occur in the variables contain both direct and indirect effects of the introduced shocks but it is difficult to distinguish between the two effects. However, it may be assumed that the direct effects are relatively larger than the indirect effects. This ensures the stability of the system.

#### Effects of a 20% Increase in Domestic Demand for Wheat

With an increase in domestic wheat demand, the price of wheat declined by 9.04% and barley by 2.81% (Table 1). There is however an increase in canola price. With the decline in prices, wheat and barley production experienced some decline in production. Canola production declined as well. The decline in barley price did not result in an increase in domestic demand but for canola, the increase in the price caused the domestic demand to fall by 4.19%. Canola export increased by 60%, which probably explains the increase in canola price. Wheat exports also increased by 10.78%. The changes in wheat and canola exports appear to be more pronounced than the changes in production of the commodities. The effects on barley were quite minimal. In terms of welfare, producer profits declined by 5.77%, which may be attributed to the unrealised increase in farm prices particularly, the grains.

Table 1 Effects of 20% Increase in Domestic Demand for Commodities

Variable	<u>Percentage change (%) from base solution</u>			
	Increase in domestic demand for wheat	increase in domestic demand for canola	increase in domestic demand for cattle	increase in domestic demand for hogs
Wheat production	-4.09	-3.12	0.68	-1.80
Barley production	-0.06	-0.02	-0.19	0.01
Canola production	-3.59	21.06	-1.89	-1.04
Cattle production	0.00	-0.32	16.90	-0.11
Hog production	-0.69	-11.11	4.86	2.78
Wheat price	-9.04	-6.21	2.26	1.13
Barley price	-2.81	-1.40	0.00	0.28
Canola price	2.73	5.45	1.36	0.91
Cattle price	0.00	-0.19	-1.14	0.09
Hog price	0.09	0.36	-0.18	0.18
Flour price	-5.40	-3.71	1.18	0.51
Oil price	2.88	6.12	1.44	0.72
Meat price	0.00	0.00	-0.84	0.00
Wheat demand	19.99	21.69	-6.34	-2.61
Barley demand	-0.12	-0.04	-0.40	0.01
Canola demand	-4.19	20.11	-2.19	-1.24
Cattle demand	0.00	-0.11	20.00	-0.22
Hogs demand	-9.52	-95.24	42.86	19.05
Wheat export	10.78	49.61	49.70	0.01
Cattle export	0.00	-5.88	-64.71	2.94
Hogs export	0.81	3.25	-1.63	0.00
Canola export	60.00	50.00	30.00	20.00
Producer profit	-5.77	-1.42	5.09	4.72

Effects of a 20% Increase in Domestic Demand for Canola

From Table 1, a 20% increase in the domestic demand for canola caused an increase in the price of canola by 5.45% but a decline in the price of wheat and barley. With an increase in price, canola production increased by 21.06%. The production of wheat and barley declined which may be attributed to the decline in price and to substitution effects in production with canola. Exports of canola increased by 50%. The decline in wheat price however, caused an increase in domestic demand for wheat by 21.69%. An increase in the domestic demand for canola resulted in an increase in hog price but a decrease in cattle price. Nonetheless, the production of both cattle and hogs decreased by 0.32 and 11.11 respectively. The domestic

demand for the two commodities also declined and for exports, hogs exported increased by 3.25% while export of cattle decreased by 5.88%.

#### Effects of a 20% Increase in Domestic Demand for Cattle

Table 1 also reports the effects of a 20% increase in domestic demand for slaughter cattle and hogs. With a 20% increase in domestic cattle demand, the price of cattle declines by 1.14% instead of increasing. The price decline appears contrary to expectation nevertheless, there is an increase in cattle production by 16.9% suggesting a positive net effect for the cattle industry. Export of cattle decreased by 64.71%. The price of hogs fell by 0.18% but hog production increased by 4.86%. However, the decrease in hog price resulted in an increase in the domestic demand for hogs by 42.86%. Export of hogs decreased by 1.63%. Generally, changes in the prices and production of the crops were modest but significant in the quantities exported. In terms of producer welfare, total profits increased by 5.09%.

#### Effects of a 20% Increase in Domestic Demand for Hogs

Generally, a 20% increase in domestic demand for slaughter hogs resulted in price increase for all the five commodities ranging from 0.09% to 1.13% (Table 1). The price rise did not cause much change in commodity supply except in hog production. The production of hogs increased by 2.78%. There was no change in hog exports. With a price increase, the domestic demand for wheat, canola and cattle decreased. The quantity of canola and cattle exported increased by 20 and 2.94% respectively. The effects on barley were minimal. In terms of producer welfare, total profits increased by 4.72%, which may be attributed to the resulting increases in commodity prices.

### **Summary**

Research investment in value adding is assumed to enhance demand for primary commodities through improvement in product quality and production of new and alternative products causing an outward shift in the demand curve for farm commodities. The resulting effects would include price and quantity responses as well as cross-commodity substitution in production. Overall, the various simulation results indicate that increases in commodity prices cannot be realised in the short term from increased domestic demand for commodities. Currently,

commodity prices appear to be exogenously determined. Nonetheless, results suggest that, to smaller extent, increased domestic demand for cattle and hogs may increase farmers' welfare. Value-added investment in the livestock and canola processing industries appears to provide some short-term returns.



## References

- Benirschka, M., W. W. Koo, J. Lou. "World Sugar Policy Simulation Model: Description and Computer Program Documentation." Agricultural Economics Report #356, Department of Agricultural Economics, North Dakota State University, Fargo (1996).
- Brooke, A., D. Kendrick, and A. Meeraus. GAMS Release 2.25. A User's Guide. GAMS Development Corporation, D.C., 1996.
- Cranfield, J., J. Weerahewa, D. Sellen, and E. Goddard. "Welfare Effects of Generic Advertising on US and Canadian Beef and Cattle Markets." Selected Paper at the Canadian Agricultural Economics and Farm Management Society annual meeting, July 9-12, 1995, Ottawa.
- Dryburgh, C. R., and C. J. Doyle. "Distribution of Research Gains under Different Market Structures: The Impact of Technological Change within the UK Dairy Industry." *Journal of Agricultural Economics*, 46(January 1995): 80-96.
- Holloway, G. J. "The Farm-Retail Price-spread in an Imperfectly Competitive Food Industry." *American Journal of Agricultural Economics*, 73(December 1991): 979-989.
- Huang, Shu-Yu and R. J. Sexton. "Measuring Returns to an Innovation in an Imperfectly Competitive Market: Application to Mechanical Harvesting of Processing Tomatoes in Taiwan." *American Journal of Agricultural Economics*, 78(August 1996): 558-571.
- Just, R. E., D. L. Hueth, and A. Schmitz. *Applied Welfare Economics and Public Policy*. Englewood Cliffs, NJ: Prentice-Hall, 1982.
- Kinnucan, H. W., H. Xiao and C. J. Hsia. "Welfare Implications of Increased US Beef Promotion." *Applied Economics*, 28(1996): 1235-1243.
- Klein, K. K. B. Freeze and A. M. Walburger. "Economic Returns to Yield-increasing Research on Wheat in Western Canada." *Canadian Journal of Agricultural Economics*, 44(November 1996): 207-218.
- Martin, W. J. and J. M. Alston. "A Dual Approach to Evaluating Research Benefits in the Presence of Trade Distortions." *American Journal of Agricultural Economics*, 76 (February 1994): 26-35.
- McCarl, B. A., and T. H Spreen. "Model Validation: An Overview with Some Emphasis on Risk Models." *Review of Marketing and Agricultural Economics*, 52 (1984): 153-173.
- Mullen, J. D., J. M. Alston, and M. K Wohlgenant. "The Impact of Farm and Processing Research on the Australian Wool Industry." *Australian Journal of Agricultural Economics*, 33 (April 1989): 32-47.

Quagraine, K. K. "The Impact of Post-Farm-Gate Value-Added Activities on Western Canadian Agriculture." Ph.D. dissertation, Department of Rural Economy, University of Alberta. 2000.

Rodriguez, G. and D. Kunkel. "Estimation of Flexibility Coefficients for Recursive Programming Models: Alternative Approaches." *American Journal of Agricultural Economics*, 56 (May 1974): 344-50.

Voon, J. P., and G. W Edwards. "Research Payoff from Quality Improvement: The Case of Backfat Depth in Pigs." *Journal of Agricultural Economics*, 42 (1991): 66-76.

Wahl, T. I., D. J. Hayes, and S. R. Johnson. "Impacts of Liberalizing the Japanese Pork Market." *Journal of Agricultural and Resource Economics*, 17 (July 1992): 121-137.

Weerahewa, J. "Return from Investments under Imperfect Competition: Sri Lankan Tea Research, Promotion and Advertising." Ph.D. dissertation, Department of Agricultural Economics and Business, University of Guelph, 1996.

Wohlgenant, M. K. "Demand for Farm Output in a Complete System of Demand Function." *American Journal of Agricultural Economics*, 71 (May 1989): 241-52.

Wohlgenant, M. K. "Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: The Case of the US Beef and Pork Industries." *American Journal of Agricultural Economics*, 75 (August 1993): 642-651.