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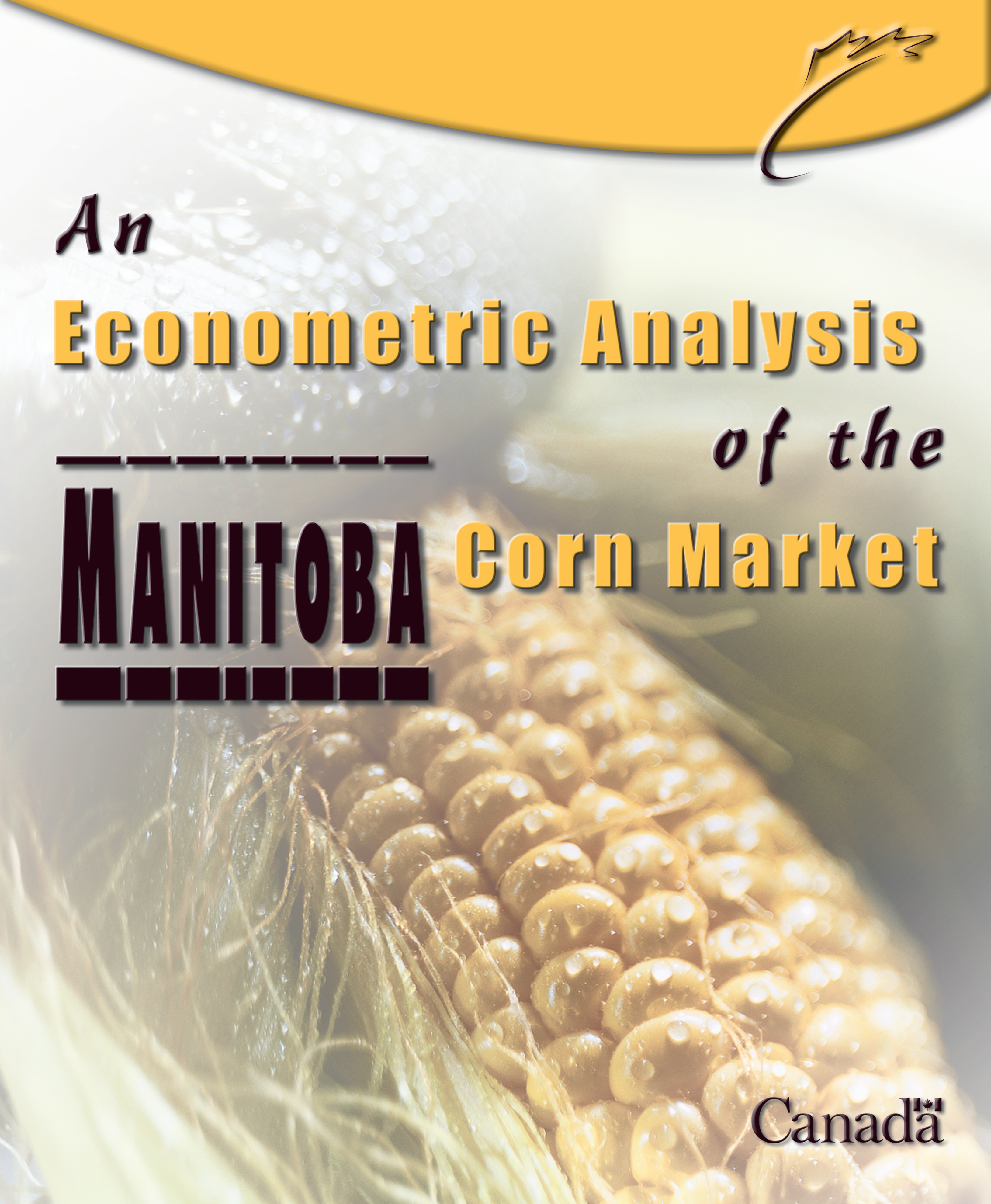
# An Econometric Analysis of the Manitoba Corn Market



Canada

# *An* ECONOMETRIC ANALYSIS *of the* MANITOBA CORN MARKET

by

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and

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Research and Analysis Directorate
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Agriculture and Agri-Food Canada

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# *Foreword*

*Historically, the western Prairie Provinces produced a surplus of feed grains, which made feed grain imports a relatively rare occurrence. However, the corn market now plays an increasing role in the future growth of the livestock industry in Western Canada. Corn is predominantly an Eastern Canadian crop, however, it has gained increasing importance as a feed ingredient in the Western Canadian feed grain market. Four factors, among others, have contributed to this situation:*

- *expansion of the Western Canadian livestock industry following the removal of grain transportation subsidies*
- *rising demand for malt barley in the domestic processing industry and the export market*
- *the incidence of fusarium in Manitoba cereal crops which made some production unfit for feeding*
- *reduced barley production because of low international prices*

*The recent prairie droughts of 2001 and 2002 are factors that exacerbated the Western Canadian feed supply situation.*

***In this environment, corn imports from the United States can act as a "safety valve" for the Western Canadian livestock industry due to the surplus available in the United States. Accordingly, a proper understanding of the evolution of prairie livestock production must include the element of corn imports. In the absence of corn imports from the United States, the value added of the Western Canadian livestock industry would be negatively affected. Livestock feeders would be less able to compete with their American counterparts for feeder cattle and feeder pigs. Furthermore, exports of slaughter animals and meat would fall while exports of feeder animals would increase. This increased integration of the North American feed and livestock market needs to be taken into account when domestic policy decisions are made.***

# *Executive Summary*

*The objective of this work was to develop a model of the Western Canadian corn market that could potentially be incorporated into the Agriculture and Agri-Food Canada, Food and Agriculture Regional Model (FARM) in order to better analyse the interaction between the livestock and feed grain markets in Western Canada.*

*A number of assumptions had to be made to construct the new corn model due to the relatively limited presence of corn in the Western Canadian grain complex. We assumed that local and imported corn can be considered to be homogenous products. Based on this assumption, and given the relatively small size of the Manitoba corn market (when compared to the North American corn market), we adopted a small open economy price taker spatial market structure.*

*In constructing the model, we estimated three key behavioural equations (price transmission, corn supply and feed demand). All the estimated parameters were significant and the direction of the signs on the parameters adhered to economic theory. Depending on the equation, the explanatory power of the estimated relationship ranged from acceptable to relatively strong. To determine how well the model could reproduce the historical situation, we performed an inter-sample simulation over a period in the recent past. Given the relatively limited size of the Manitoba/Western Canada corn market, the results of this simulation were considered to be acceptable.*

*We also performed simulation analysis to test the validity of the model. We found that a 1% increase in feed wheat and barley prices in Western Canada holding all other crops price constant would have a 0.34% impact on the Manitoba corn price in the medium term. A 1% increase in the U.S. corn price – holding all other prices constant – results in a 0.54% increase in the Manitoba corn price. Finally, the model predicted that the corn price in Western Canada would increase by 1% when all other feed prices were increased by 1%. For these reasons, we believe this model will be a useful addition to FARM.*

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# Introduction

The objective of this project is to develop a Western Canadian corn market model to be included in the Agriculture and Agri-Food Canada (AAFC), Food and Agriculture Regional Model (FARM). Corn has gained importance recently in the feed grain market in Western Canada. The substantial increase in livestock production, rise in malting barley exports, increased incidence of fusarium in Manitoba and the recent drought conditions have significantly contributed to the rapid reduction of the feed grain surplus in this region of Canada. As a result, corn imports from the United States have become the safety valve of this market in Western Canada. For these reasons, a detailed analysis of the Western Canadian feed grain and livestock markets cannot be undertaken without incorporating a corn component.

This report is divided into five sections. Following the brief introduction and background sections (sections one and two respectively) the theoretical considerations and empirical results are presented in section three. In section four the results of the multiplier analysis that was undertaken using the corn market model are presented. The final section of the paper concludes by identifying some of the limitations of the analysis.

2

# Background

The Manitoba corn market is one element of a much larger world feed grain market (e.g. feed wheat, barley, sorghum and corn) and there is a high level of substitutability between feed grains at the world level (on both the demand and the supply side), and for that reason prices of these products generally exhibit a high level of correlation. Thus, it is difficult to discuss changes in Western Canadian market conditions (e.g. a change in barley and feed wheat prices) without discussing the change in world market conditions for feed grains (which includes the U.S. price of corn).[1] For this reason the general structure of the

1. *In Canada the elimination of the WGTA grain transportation subsidy in 1995/96 may be one of the few examples were a change in domestic policy directly influenced Canadian prices.*

corn model follows the traditional supply and disposition balance sheet (see Table 1) of a small open economy price taker. Total corn supplies available over the crop year are the sum of beginning inventories plus any production and imports[2], which occur over the crop year. Disposition consists of the exports and domestic disappearance (food and industrial use; seed use; and feed, waste and dockage) which take place over the crop year plus the final end of crop year stocks. As with any balance sheet total supply must equal total disposition.

**Table 1: Supply and disposition balance sheet**

| Supply | Disposition |
|---|---|
| **Beginning Stocks**<br>**Production**<br>**Imports** | Exports<br>Food and industrial use<br>Seed use<br>Feed, waste and dockage<br>Ending stocks |
| **Supply = Disposition** | |

# 3 Theoretical Considerations and Empirical Results

This section elaborates on the theory, data and empirical results underlying the key equations that were included in the corn model. In developing a Western Canadian corn market model it was determined that three key equations needed to be estimated. They were:

- a price transmission equation linking the Manitoba and U.S. corn price,
- a Manitoba corn supply (area harvested) equation,
- a Western Canadian corn feed demand equation.

The remaining components of the standard supply and disposition (inventories, exports, food and industrial demand, and seed demand) are considered to be exogenous and the system of equations clears on the level of imports.[3]

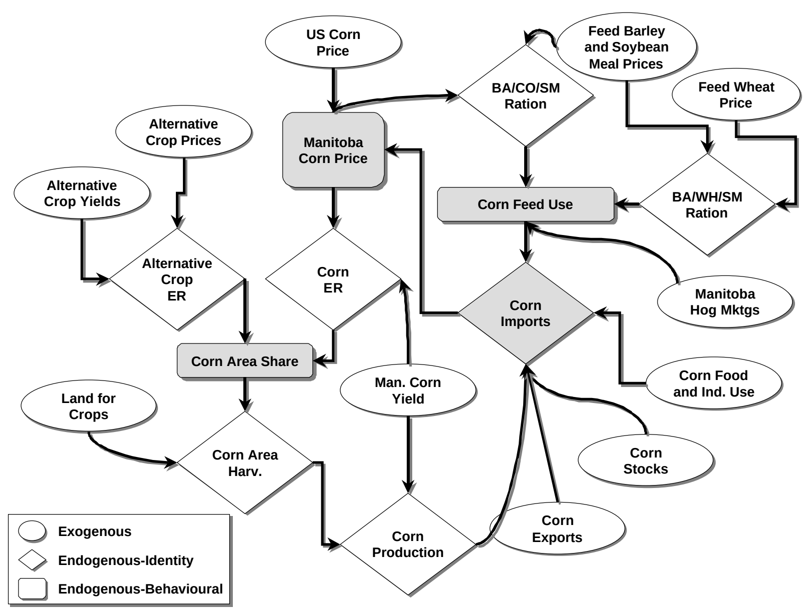
A schematic representation of the Manitoba/Western Canada

2. *This structure implies that local and imported corn are homogenous products. In reality, they are not likely perfect substitutes for all end users. However, the degree of substitutability is likely quite high and consequently an Armington type of model structure would not likely improve significantly the performance of the model.*

corn model is developed in Figure 1. The diagram identifies those variables that are exogenous or computed from either endogenous identities or endogenous behavioural equations. The three endogenous behavioural variables correspond to the estimated equations discussed above. The corn import variable is calculated residually in the market clearing identity (grey diamond). Each of the circles represents an exogenous variable(s).

From Figure 1, it is apparent that the U.S. corn price, alternative crop prices and alternative feed ingredient prices enter the model exogenously. The Manitoba corn price is determined endogenously by the U.S. corn price and the level of corn imports (a proxy for average transportation costs from the U.S. to Western Canada) into Western Canada. The Manitoba corn price then goes into the expected return calculation and the feed ration price index barley–corn–soybean meal (BA/CO/SM) calculation. Once the corn expected return variable is calculated, the corn area share is endogenously determined by the relative expected returns obtained from corn or alternative crops. The corn area share is multiplied by the total area available for crops and the yield to determine production. On the feed side, corn feed use is endogenously determined by the relative prices of the BA/CO/SM ration to the barley–wheat–soybean meal (BA/WH/SM) ration and the level of Manitoba hog marketings. The other corn supply and disposition variables that are exogenous include: stocks, exports and corn food and industrial use. As with all small open market economies, the trade variable (imports in this case) is the market clearing variable in the closing identity.

***Figure 1: Manitoba/Western Canada corn model***




3. *In terms of exogenous assumptions, since 1995/96 the level of corn inventories (both at the farm and commercial level) and exports have been negligible. Food and industrial use has averaged approximately 117 thousand tonnes while seed requirement has averaged 1.7 thousand tonnes (Statistics Canada – special request).*

## Price Transmission

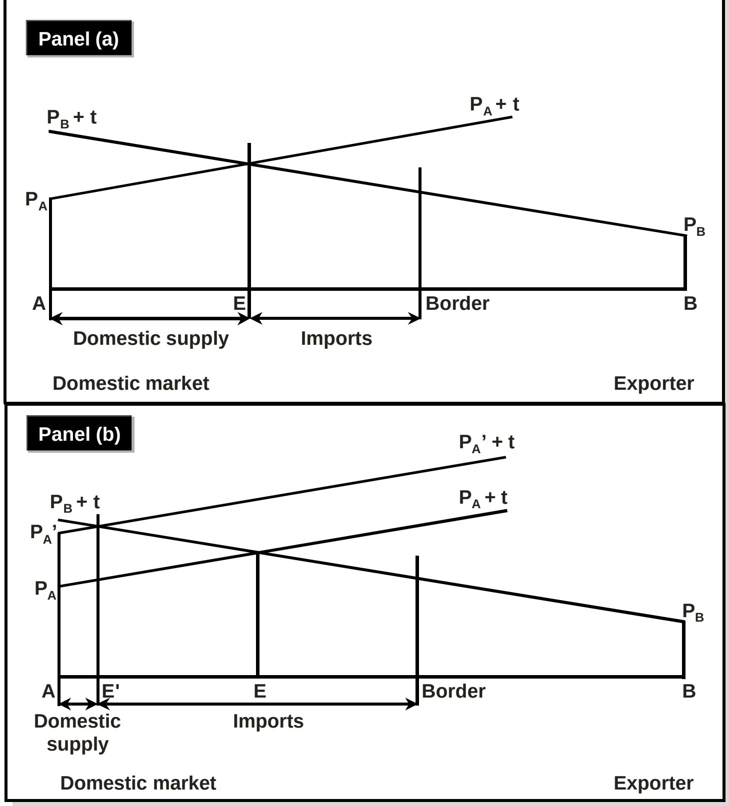
### *Theoretical Considerations*

The price of Manitoba grain corn is generally considered to be directly related to the U.S. grain corn price. In specifying a price transmission equation for the Manitoba corn price, we incorporated both the exchange rate adjusted U.S. corn price as well as the total level of imports undertaken by Western Canada. Although the specification of the U.S. corn price in the price transmission equation is apparent, inclusion of the level of imports requires further explanation.

The level of corn imports was included in the price linkage function as a replacement for the average cost of transporting corn from the U.S. to Western Canada. To demonstrate the relationship between prices, imports and the average transportation cost, Figure 2 theoretically illustrates a simplified spatial pricing relationship which includes the presence of imports and transportation costs.

In Figure 2, panel (a), there are two spatially separated suppliers (A and B). Domestic consumers are evenly distributed between the local supplier (A) and the border. Consumers pay transportation cost t, which is assumed to increase at a linear rate as the distance from the supply point increases. In the example, supplier A is the higher cost producer (product supplied at price $P_A$) while supplier B is the lower cost producer (imports supplied at price $P_B$ expressed in Canadian dollars). The respective market areas for A and B are uniquely determined by the location of the consumer that is indifferent to purchasing from either supplier. The location of this consumer is represented by point E in panel (a). Assuming that producer A is in the domestic market, consumers located between A and E will purchase from the domestic supplier and consumers lying between point E and the border will import the good. Thus, the average price paid in the domestic market is determined by a weighting of prices paid by consumers purchasing at the domestically supplied price ($P_A$+t) and consumers that pay the import price ($P_B$+t).

*Figure 2: Spatial model*



Although this theoretical model is simplified, the general results indicate an important relationship between the average local price, the import price, and the level of imports. If the complexity of the model was increased to make it more representative of the real world (e.g. producers were distributed between points A and B) the distance between point E and the border would no longer explicitly determine the level of imports as local production would occur in this space. However, the general pricing relationship between the two markets would continue to hold and to the extent that local supply was not able to meet demand (distance between point E and the border) imports would fill the gap. Thus, the inclusion of imports as a proxy for average transportation costs from the U.S. to Western Canada in the price transmission equation is still supported. It is important to acknowledge that this theory would be inappropriate if the price used in Manitoba was at a specific geographic point since the distance from Minneapolis would always be the same.

***Empirical Results***

In obtaining data to estimate the price linkage function there were some limitations. Although a number of time series data were available for U.S. cash corn prices at particular locations, an equivalent time series for grain corn prices in Manitoba was not available. Therefore, Manitoba provincial average prices had to be used in the estimation. The source of the provincial average Manitoba price is the Statistics Canada Farm Product Price Book and the source of the U.S. corn price (#2 Yellow Corn, Minneapolis, Minnesota) was the USDA Feed Yearbook.[4] Both of these data series were on a monthly basis and had to be converted to a crop year basis (See Appendix A).[5] The level of total grain corn imported by Western Canada was obtained from Statistics Canada and used as an independent variable in the specification (see Appendix B).[6]

The ordinary least squares (OLS) econometric technique was

4. *The Minneapolis corn price was chosen due to its proximity to the Manitoba market and the relative size of Minnesota corn production. For Manitoba and major producing regions contiguous to Manitoba (Ontario, North Dakota, and Minnesota) the respective average 1995/96 - 1999/00 shares of corn production were 0.56%, 17.95%, 5.60% and 75.89% respectively (Statistics Canada, USDA-AMS).*

5. *The Canadian corn price was available on a monthly $CDN/tonne basis. The monthly U.S. corn price was available on a $US/bushel basis. The U.S. price was converted to $CDN using Statistics Canada's monthly spot exchange rate and to a per tonne basis using the 39.368 bushels/tonne conversion factor. The Canadian crop year for corn up to 1992 was August/July, from 1993 forward the crop year definition was changed to September/August. These adjustments were taken into account in constructing simple average Manitoba and U.S. crop year corn prices (Statistics Canada).*

used to estimate the price linkage function[7]. A linear relationship was specified between the Manitoba provincial average corn price and the two independent variables (Minneapolis #2 Yellow corn and Western Canadian corn imports). The Canadian corn countervail duty – against U.S. corn imports – that was in place during certain years of the historical time period was incorporated.[8]

The regression results (see Table 2) indicate a reasonably good fit with an $R^2$ value of 0.88 ($R^2$ adjusted=0.86). The average error of the regression (i.e. standard error of the regression (SER) divided by the mean of the dependent variable (M)) is 8%. The signs on the coefficients are in the direction theoretically expected. This indicates that U.S. corn price is positively related to the magnitude of the Manitoba corn price and that imports (i.e. proxy for average transportation costs from the U.S. to Western Canada) are positively related to the difference between the Manitoba and Minneapolis corn prices. The t-statistics are significant and indicate that the estimated parameters are statistically different from zero (i.e. the probability of $\beta$ or (equalling zero is 0 and 0.4%). The Durbin-Watson statistic does not indicate the presence of first order serial-correlation, which suggests that none of the important variables were omitted from the specification.

**Table 2: OLS Estimation results – price linkage equation**

| | |
|---|---|
| **PPCOMAN** | average crop year Manitoba corn price ($CDN/tonne) |
| **PPCOMIN** | average crop year Minneapolis #2 yellow corn cash price ($CDN/tonne) |
| **IMPORTS** | crop year Western Canadian imports of grain corn (million tonnes) |
| **CANCOCVD** | specific Canadian countervail duty against U.S. corn imports ($CDN/tonne) |

$$PPCOMAN = \alpha + \beta \times (PPCMIN + CANCOCVD) + \gamma \times (IMPORTS)$$

| Variable | Coefficient | Std. Error | T-Stat | Significance |
|---|---|---|---|---|
| $\alpha$ | -29.2186 | -16.5572 | -1.76471 | 0.103 |
| $\beta$ | 0.857022 | 0.100692 | 8.51128 | 0.000 |
| $\gamma$ | 140.864 | 39.7642 | 3.54247 | 0.004 |

| | | | |
|---|---|---|---|
| Number of observations | =15 | Sum of squared residuals | =1031.36 |
| R-Squared | =0,88234 | Std. error of regression (SER) | =9.27072 |
| R-Bar-Squared (ADJ) | =0,86273 | Sum of residuals | =0.00000 |
| Durbin-Watson (0 gaps) | =1,962844 | Mean of dep. variable (M) | =119.467 |

6. *Total imports of grain corn into Western Canada versus net trade was specified in the price linkage function as exports from this region are relatively non-existent. This includes imports from Ontario as well as the United States. Over the 1985/86 to 1995/96 period, imports of corn from Ontario to Western Canada generally averaged 20 to 30%of the total. From 1997/98 to current there have not been any corn imports from Ontario (Statistics Canada-special request).*

7. *Since there are 27 predetermined variables in the complete model and only 15 observations were available from the data, more suitable regression techniques, like two stage least squares, could not be pursued.*

8. *The relevant historical time period for this CVD was 1986 through 1991.*

## Corn Supply

### *Theoretical Considerations*

The second key behavioural equation that had to be developed for the corn model was a supply response equation. In terms of corn supply the two key determinants are the amount of corn area harvested and the yield (i.e. production=area harvested × yield). Because yield is very unpredictable, attention was focussed on developing a behavioural equation that would explain movements in corn area harvested while yields were assumed to be exogenous.

A relatively straightforward approach was adopted in developing a behavioural equation for corn area harvested. We assumed that a producer makes the decision to grow corn or an alternative major crop on the basis of the relative expected return. The producers expected return (ER) is defined as the dollar return per hectare that would be attained if the producer received the previous year price and a crop yield equal to the previous three year average.[9] Based on the relative expected returns for the alternative crops the producer then makes the decision regarding the allocation of available land. The expected return variables were transformed to a "real terms" basis by deflating the prices using the Western Canadian farm input price index for crops. Finally, it was assumed that the adjustment made by the producer would be a partial one due to a level of dedicated knowledge and equipment involved in corn production. This was captured in the equation by the lagged endogenous variable.

Based on this relationship it is anticipated that corn's share of the available crop land will be positively related to its own expected return and negatively related to the expected returns of alternative crops.

### *Empirical Results*

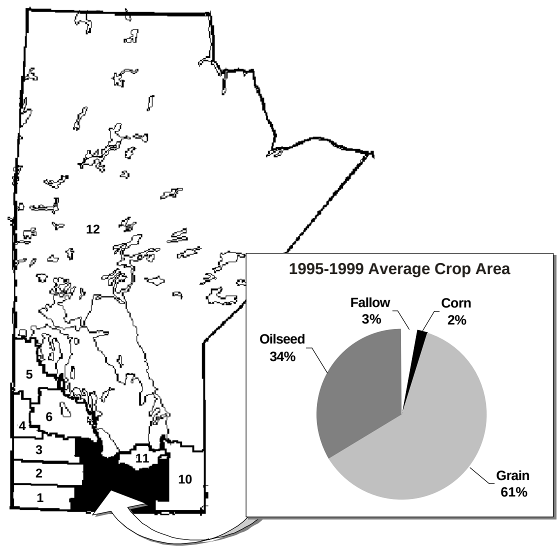
The underlying data required for the estimation of the area equation includes: area, yields and prices for corn and major competing crops. While most of this data was available for the major competing crops on a Western Canadian basis, it was necessary to limit the focus to a much smaller region in Manitoba due to the relatively small size of the western Canadian corn crop and the relatively concentrated production of corn in Manitoba.[10]

---

9. *The prices are measured in \$CDN/tonne and yields are measured in tonnes/hectare, thus the appropriate units for $ER$ is \$CDN/hectare. The mathematical representation for the $ER$ variable is: $ER_i = P_{i-1} \times (Y_{i-1} + Y_{i-2} + Y_{i-3})/3$ where $i$ indicates the particular crop (corn, wheat, barley, oats, canola, or flaxseed).*

Since corn production in Manitoba is largely concentrated in the Red River Valley, the focus of data collection was placed on Manitoba Census Agriculture Regions (CAR) 7, 8 and 9 (see darkened region in Figure 3). It was not possible to get actual corn data in each of these three regions so provincial level area, yield and production data is assumed to be a proxy for CAR's 7, 8 and 9. Statistics Canada was able to provide area harvested, yield and production for major competing crops in these three regions going back to the early 1980's. It was from these data that expected returns could be calculated for each of the crops and corn's share of major crop area could be determined (see Appendix C).[11]

***Figure 3: CAR's 7, 8 and 9 (black shade)***




The specification of the corn area share equation took a linear form. The corn share was specified as a function of its own expected return and the weighted average return from major competing crops (see Table 3). Problems with multicolinearity due to the correlation between expected returns of competing crops resulted in the construction of a weighted average competing crop expected return.[12] The 1992/1993 observation was dropped as the crop was very poor and harvested area was only 27% of seeded area. In most years harvested area is a reasonable proxy of seeded area which is the economic variable that reflects actual producer planting decisions.

The basic regression results in Table 3 indicate that although the fit of this equation is not as good as the one obtained for the price linkage function, the direction of the parameters adhere to economic logic and they are statistically significant. The corn

10. *Average western Canadian corn area harvested over the 1995/96 through 1999/00 period represented .0015% of the total grains and oilseed area harvested. Over that same period, Manitoba accounted for 93% of total Western Canadian production (Statistics Canada, AAFC-FARM databank).*

11. *The major crops competing with corn in CAR 7, 8 and 9 area are: wheat, barley, oats, canola and flaxseed. Expected returns where calculated for each of these crops from 1985/86 through 1999/00. Corn's share of the total available area in CAR's 7, 8 and 9 was determined by dividing provincial corn area harvested by the sum of: provincial corn area harvested plus all wheat, barley, oats, rye, canola, and flaxseed area harvested and summer fallow area in CAR's 7, 8 and 9. With the exception of corn, which used the same Manitoba price series identified in the price linkage equation above, prices for the alternative crops were proxied using the weighted average Western Canada producer prices available in the FARM model. Correlations of these prices with the producer prices available in the Manitoba Agriculture Yearbook are very high supporting their use as proxies.*

12. *The weighted average expected return was computed on the basis of each crops respective share of area harvested.*

area share is positively related to its own expected return and negatively related to the expected return obtained from major competing crops. The lagged endogenous variable is significant and has a positive sign. This suggests that the adjustment to changing crop returns is a partial one and that the corn share in the previous year has a positive influence on the following year. The t-statistics indicate that each of the estimated parameters is significantly different from zero with the probability of being equal to zero ranging from a low of 0.8% to a high of 1.1%. The "h" statistic, which is used when a lagged endogenous variable is specified, did not suggest that first order auto-correlation was present.[13]

**Table 3: OLS Estimation results – corn area share equation**

| | |
|---|---|
| **SHRCOMAN** | corn's proxied share of seeded area in CAR's 7, 8 and 9 |
| **ERCOMAN** | expected return from corn production in CAR's 7, 8 and 9 ($CDN/hectare) |
| **ERGOMAN** | weight average expected return from major grains and oilseeds production in CAR's 7, 8 and 9 ($CDN hectare) |
| **PJIGRI1** | deflator, farm input price index for Western Canadian crops |

$$SHRCOMAN = \alpha + \beta \times (ERCOMAN/PJIGRI1) + \gamma \times (ERGOMAN/PJIGRI1) + \tau \times (SHRCOMAN(-1))$$

| Variable | Coefficient | Std. Error | T-Stat | Significance |
|---|---|---|---|---|
| $\alpha$ | 0.218790 E-01 | 0.865984 E-02 | 2.52649 | 0.030 |
| $\beta$ | 0.433253 E-04 | 0.130759 E-04 | 3.31338 | 0.008 |
| $\gamma$ | -0.946002 E-04 | 0.334121 E-04 | -2.83132 | 0.018 |
| $\tau$ | 0.368308 | 0.119171 | 3.09057 | 0.011 |

| | | | |
|---|---|---|---|
| Number of observations | =14 | Sum of squared residuals | =0.182449 E-03 |
| R-Squared | =0.67824 | Std. error of regression (SER) | =0.427140 E-02 |
| R-Bar-Squared (ADJ) | =0.58172 | Sum of residuals | =0.242861 E-16 |
| Durbin-Watson (0 gaps) | =1.762601 | Mean of dep. variable (M) | =0.193871 |

## Corn Feed Demand

### *Theoretical Considerations*

A key element in constructing a Manitoba/Western Canada corn model is the aspect of corn feed demand. The major domestic usage of corn in Canada is for livestock feed.[14] Approximately 80% of domestic corn disappearance is attributed to feed usage. In Western Canada this average has been approximately 75% over the last five years. Given the surplus of feed grains in Western Canada and the substitutability between feed grains in livestock rations, a change in relative feed ingredient prices should have an impact on corn feed demand.[15]

13. *To have confidence in the "h" statistic a larger sample size is required. For this reason the error terms were plotted and examined and we concluded that the presence of first order auto-correlation was unlikely.*

14. *Feed usage actually includes feed, waste and dockage of which feed is the key element. Since the data for this variable are not generally observed it is determined residually from the supply and disposition balance sheet.*

Theoretically changes in corn feed demand should be directly linked to two key variables. The first variable captures the relative substitutability of feed ingredients through relative prices while the second, a scale effect captures the impact that increased/reduced livestock production has on all feed grain consumption. To capture the scale effect we assume that Western Canadian corn feed usage is directly related to the level of hog marketings in Manitoba.[16] To capture the substitution effect we assume that Western Canadian corn feed usage is directly related to the relative prices of two representative feed rations. Over a certain range, the effect of a change in relative ration prices on corn feed use is limited, but once ration prices begin to diverge substantially, the shift between feed rations is likely much more responsive. This behaviour is captured by increasing the exponent on the ration price ratio variable. Finally, the relative prices of the barley–corn–soybean meal and barley–wheat–soybean meal ration were specified using the current period and previous period to capture some of the rigidity livestock producers potentially face in switching between feed rations when ration prices diverge marginally and forward contracting is involved.

***Empirical Results***

To undertake this part of the analysis we had to use corn feed usage at the Western Canadian level due to data confidentiality restrictions (see Appendix B).[17] While it is not possible to determine exactly what quantity of the corn fed in Western Canada occurs in Manitoba, it is reasonable to assume that it is the majority. In terms of the consumption of corn in feed rations, it was assumed that most of the consumption is driven by the hog industry. Given the data limitations regarding both the corn usage in Manitoba and the distribution of that corn consumption across livestock groups we focussed on constructing a corn feed demand equation on the basis of Western Canadian corn disappearance and Manitoba hog production (see footnote 9).

The actual price of feed used in calculating the ration index prices include the Manitoba corn price previously mentioned

15. *Over the 1995/96 through 1999/00 period corn feed use in Western Canada accounted for approximately 2.5 to 3.5% of the feed grain usage (feed grains: corn, barley, wheat, oats)*

16. *We assume that most of the corn feeding that occurs in Western Canada takes place in Manitoba. Since the correlation coefficient between hog marketings and poultry production in Manitoba is 0.98 (over the 1979 to 1999 period), changes in Manitoba hog marketings should proxy changes in non-ruminant production (i.e. the major consumer of Manitoba corn).*

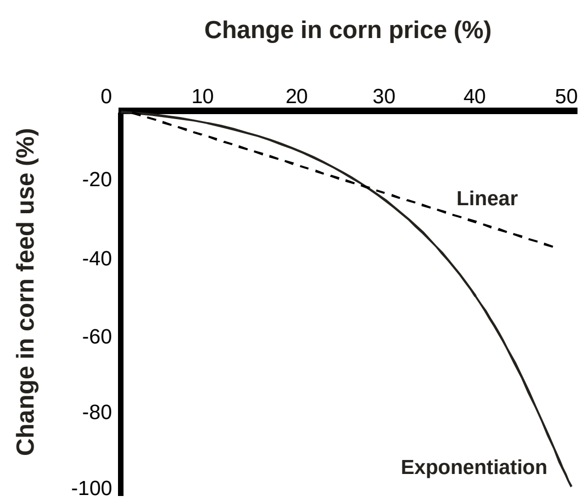
17. *Due to data confidentiality restrictions pertaining to corn food and industrial use at the Manitoba provincial level it is not possible to break out feed use.*

and Winnipeg feed wheat, feed barley and soybean meal prices (see Appendix A).[18] The weighting of feed ingredients in the representative rations (see Appendix D) indicates that the switch from a barley–corn–soybean meal to a barley–wheat–soybean meal ration actually leads to a small decline in the barley share as a greater proportion of wheat is required to replace corn.[19]

To capture the non-linearity in the corn feed demand reaction discussed earlier we have used exponentiation (a semi-log function was attempted with less success).

With the exponentiation, feed demand is much more responsive when ration prices begin to diverge substantially (due to higher corn prices for example) as can be seen in Figure 4. Using the initial linear specification a 40% increase in the corn price resulted in a 29% reduction in corn feed usage while under the final specification a 40% increase in the corn price results in a 56% reduction (see Figure 4).

*Figure 4: Corn feed demand*




The results of the OLS estimation are provided in Table 4. The parameter estimates have the appropriate signs, are consistent with economic logic, and are significant at the 95% confidence level. A negative ($\beta$) beta value indicates that Western Canadian corn feed demand is negatively related to an increase in the own price of corn (i.e. an increase in the barley–corn–soybean meal ration price) and positively related to an increase in the price of the substitute ration (barley–wheat–soybean meal). In terms of Manitoba hog marketings, the positive value of the parameter indicates that feed usage is positively related to hog marketings (crop year basis proxy). The R2 adjusted

18. *The source for the 3CW feed wheat and 1CW feed barley off board prices was Manitoba Agriculture and the source for the soybean meal price was the AAFC, Livestock Feed Group.*

19. *Due to the high level of fibre found in barley, hog rations that incorporate barley require corn in the ration to dilute the effect of fibre thereby supporting a complimentary pricing relationship between these two feed grains. This same situation does not exist in the case of ruminants and therefore a complimentary relationship would not be expected if ruminant consumption dominated feed corn usage in Western Canada.*

value of .725 indicates that approximately 73% of the variation in Western Canadian corn feed usage can be explained by the movement in the two independent variables. The average error of the regression (SER/M) is 16% and the Durbin-Watson statistic does not indicate the presence of first-order serial correlation.

**Table 4: OLS Estimation results – corn feed demand equation**

| | |
|---|---|
| **CORN_FEED** | corn feed, waste and dockage, Western Canada (million tonnes) |
| **MANBACO** | index price of barley-corn-soybean meal ration ($CDN/tonne) |
| **MANBAWH** | index price of barley-corn-wheat-soybean meal ration ($CDN/tonne) |
| **HOGMKT** | Manitoba hog marketings adjusted to a crop year basis (‘000 head) |

$$CORN\_FEED = \alpha + \beta \times (MANBACO + MANBACO(-1))/(MANBAWH + MANBAWH(-1)) \times 25 + \gamma \times (HOGMKT(1)*7/12 + HOGMKT*5/12)$$

| Variable | Coefficient | Std. Error | T-Stat | Significance |
|---|---|---|---|---|
| $\alpha$ | 0.189950 | 0.566076 E-01 | 3.35556 | 0.006 |
| $\beta$ | -1.135109 E-02 | 0.283652 E-03 | -4.76320 | 0.000 |
| $\gamma$ | -0.721343 E-04 | 0.219727 E-04 | 3.28290 | 0.007 |

| | | | |
|---|---|---|---|
| Number of observations | =15 | Sum of squared residuals | =0.300057 E-01 |
| R-Squared | =0.76398 | Std. error of regression (SER) | =0.500048 E-01 |
| R-Bar-Squared (ADJ) | =0.72465 | Sum of residuals | =0.138778 E-15 |
| Durbin-Watson (0 gaps) | =1.597902 | Mean of dep. variable (M) | =0.315423 |

## Simulated Elasticities

Since the equations were not specified on a log-log basis, elasticities can not be directly interpreted from the parameter estimates. Table 5 provides an overview of the simulated first year, second year and long term elasticities for both the corn feed usage and the corn supply equations. It should be noted that the feed elasticities presented in table 5 are relevant for small changes in relative prices. They would be larger (more elastic) for large shocks (see Figure 4).

**Table 5: Elasticities**

| | 1st year | 2nd year | Long term (6 years) |
|---|---|---|---|
| **Percentage change in corn feed use given a 1% increase in the Manitoba price of:** | | | |
| Corn | -0.14 | -0.28 | -0.28 |
| Barley | -0.03 | -0.07 | -0.07 |
| Wheat | 0.22 | 0.44 | 0.44 |
| Soybean meal | -0.05 | -0.09 | -0.09 |
| **Percentage change in corn production given a 1% increase in the Manitoba price of:** | | | |
| Corn | 0 | 0.92 | 1.46 |
| Substitute crops | 0 | -1.2 | -1.91 |

In terms of corn feed usage, the own price elasticity indicates that livestock producers in the first year react to a 1% increase in the Manitoba corn price by reducing corn feed usage by 0.14%. Since the specification of the corn feed demand equation explicitly assumes that livestock producers partially adjust to changing feed ingredient prices, it is not until the second year that the full impact on corn feed demand is observed. The second year and long term elasticities are identical with the full impact of the 1% increase in corn prices resulting in a 0.28% decline in corn feed usage.[20]

In terms of the cross price effects on corn feed demand, it is necessary to quickly review the assumptions underlying the feed equation. In particular, the key assumption is that movements in corn feed usage in Western Canada are largely related to changes in Manitoba hog industry feed demand. Since Manitoba hogs are assumed to be the key corn user, it is the relative price of corn in a hog feed ration versus the relative price of wheat in the ration that will influence corn feed demand. Based on information we have received from Manitoba Agriculture (see Appendix D), a typical hog ration including corn contains more barley and soybean meal than in a typical barley–wheat–soybean meal ration. Therefore, by construction, corn, barley and soybean meal have complementary relationships (i.e. an increase in barley or soybean meal prices will reduce corn feed demand).[21] Wheat, the key ingredient in the alternative feed ration acts as a substitute for corn.

In terms of cross price elasticities, the wheat price has a very positive effect on corn feed demand. In the first year, a 1% increase in the wheat price results in a 0.22% increase in corn feed demand. By the second year, the full impact of a rise in wheat prices is observed as the 1% rise in the wheat price results in a 0.44% increase in corn feed demand. For barley and soybean meal, the individual first year effects of a 1% increase in their relative prices is a 0.03 and 0.05% drop in corn feed demand. In the second year (or long term) a 1% increase in barley or soybean meal ingredient prices result in a 0.07 or

20. *To give some indication of the impact that exponentiation in the corn feed demand equation has on elasticities, corn price impacts of 10, 20, 30 and 40% were simulated and the respective long term corn feed demand elasticities were calculated to be: -.40, -.60, -.90, and -1.40. For example, a 40% increase in the corn price results in a 56% (40*1.4) decline in corn feed use.*

21. *This result seems somewhat counter-intuitive as one might expect that corn and barley would be substitutes. We attempted to capture this by using a different configuration of the barley-wheat-soybean meal ration where barley was the only major feed ingredient in the finisher stage of production. Even under this specification barley continued to be a complement. Therefore we maintained the original specification which assumes wheat is used in all three stages.*

0.09% reduction in corn feed demand.

The second set of elasticities identified in Table 5 pertain to supply response. Given the producer's inability to react in the production year, first year own and cross price elasticities are zero. In the second year, the influence of a price change in the previous year affects the producers expected return and results in a re-allocation of crop area. For a 1% increase in the corn price, the short term effect (second year) is a 0.92% increase in corn production. The cross effect given a 1% increase in alternative crop prices is a 1.20% reduction in corn area. Over the longer term, supply adjustments to own and cross prices are even more elastic with a 1% increase in the corn price resulting in a 1.46% increase in corn production and a 1% increase in competing crop prices resulting in a 1.91% reduction in corn production.[22]

# 4 Model Performance

To give some indication of how well the model performs as a whole, an inter-sample simulation was undertaken over the 1996 through 1999 period.[23] This period was chosen as it directly follows the removal of the Western Grain Transportation Act (WGTA) which had subsidized export movements of Western Canadian grain and implicitly distorted local market prices. On a percentage basis, the average absolute errors on four of the key variables: price, production, feed and imports were 5.9, 13.9, 10.3 and 11.4% respectively. Given the relatively limited size of the Manitoba/ Western Canada corn market, there are many factors outside of the specified equations, which may contribute to the size of these errors. Therefore, given the reasonable parameters achieved through estimation, this size of errors was considered acceptable and the model judged useful in answering policy and/or market related questions. In addition to the inter-sample simulation a multiplier analysis was undertaken to help validate the model.

22. *In this case the equation is not homogenous of degree zero (i.e. the own price elasticity is not equal to (-1)×(the weighted average of the cross price elasticities) as some of the data required to completely specify the equation were not available (i.e. special crops, pasture, etc.)*

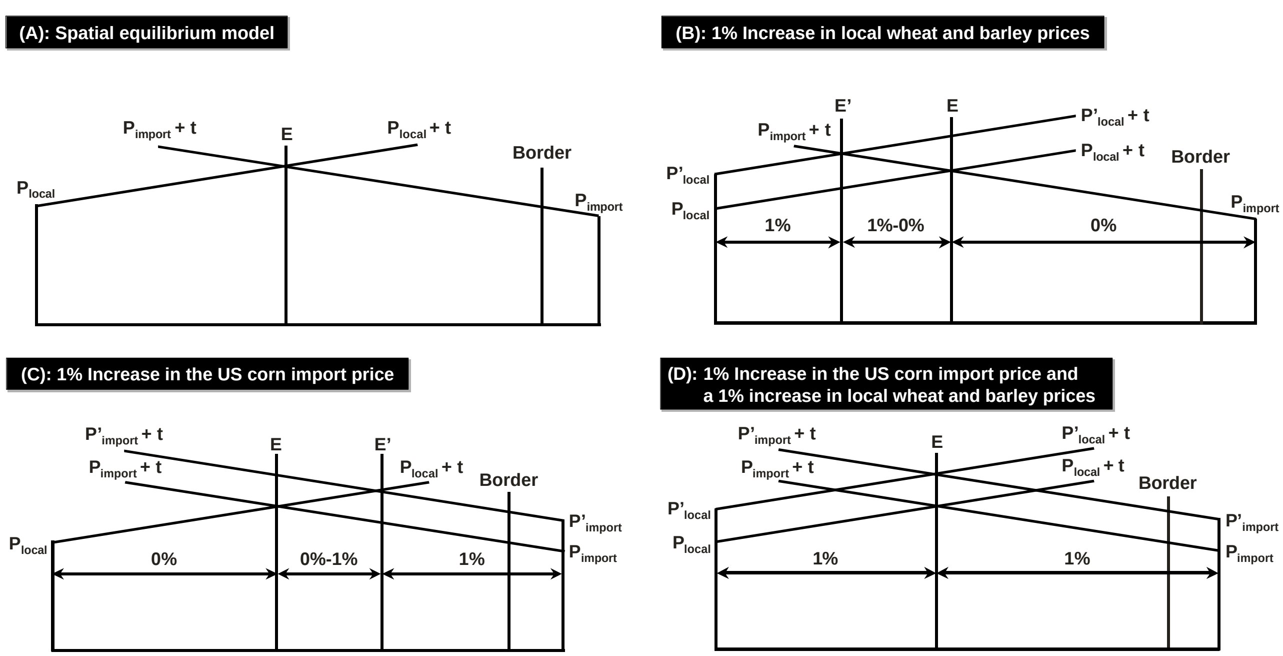
23. *The models stability was also tested by setting all of the exogenous variables equal to a certain period value and simulating the model over a twenty year period. Since the corn import variable is the market clearing variable in the model, the observed stability of this variable suggests the whole model is stable.*

## Multiplier Analysis

### *Theoretical Considerations*

Figure 5, panel (a) represents the base equilibrium situation where domestic market consumers receive a price either determined by the local market or by the import price.[24] The consumer located at point E is indifferent between importing the good or paying the local market price. If a shock (for instance in competing local market wheat and barley feed grain prices – panel (b)) is introduced, which results in a shift up in the local market price (corn price) line by 1% to (P'local+t) for example then the location of the indifferent consumer is at E'. In terms of the average domestic market price paid by consumers, those consumer located between the local market pricing point and E' will see a full 1% increase in their respective purchase price. Those consumers located between E' and E will see a price increase ranging from 0 to 1%. Finally consumers lying between E and the border will continue to face the same import price as they previously did. Since the average market price is determined across all consumers in the domestic market it is apparent that the average will be less than 1%. It is also apparent that imports will be greater.

*Figure 5: Theoretical representation of shocks introduced*




24. *For simplicity of explanation the discussion above has been limited spatially to consumers. However, including producers in the explanation would not change the result.*

In Figure 5, panel (c) demonstrates why an increase in the import price (U.S. corn price) is not perfectly transmitted back to the domestic market average corn price. In this case the import price line shifts up to P′import+t and the location of the indifferent consumer is closer to the border at E′. Now consumers that are more closely located to the border (between E′ and the border) will experience a full 1% increase in prices, consumer between E′ and E will face a price increase ranging between 0 and 1%, and consumers to the left of E will continue to pay the original local market price. Once again from a weighted average perspective, the price transmission to the average domestic market price has to be less than 1%.

Panel (d) identifies the important theoretical property of homogeneity in prices. From the diagram it is apparent that if both (all) prices increase by the same proportion there should be no change in the respective market areas of the suppliers (i.e. no distributional affect). Although this property was not imposed on the model the following simulated results will show that the estimated model is essentially homogenous of degree zero in prices.

***Empirical Results***

Table 6 provides a summary of the important estimated multipliers of this model. To capture the evolution of the impact of the shock the 1$^{st}$ year, 2$^{nd}$ year, and longer term (6 year) multipliers were calculated. The first shock measures the impact of a 1% increase in Western Canadian wheat and barley prices on the average Manitoba corn price while holding the U.S. corn price constant. In the first year, there is a 0.12% increase in the average corn price and in the longer term the price increases by 0.34%. The price response is driven by the livestock sector in the first year as corn is fed more intensively due to the higher alternative feed ingredient prices. This increase in demand translates into a local price line, which results in a higher average Manitoba corn price and higher imports of corn. In the second year, the livestock sector has fully adjusted and crop producers also respond by shifting some land out of corn production and into wheat and barley production which further reduces Western Canadian corn supplies and results in a higher average price and increased imports. In the longer term, the market reaches a new equilibrium resulting in reduced local production and increased feed usage balanced off by increased imports.

**Table 6: Multipliers (% impact)**

| Question | 1st year | 2nd year | Long term (6 years) |
|---|---|---|---|
| First | 0.12 | 0.36 | 0.34 |
| Second | 0.79 | 0.55 | 0.54 |
| Combination | 0.91 | 0.91 | 0.88 |
| Other prices | -0.02 | 0.12 | 0.14 |
| All prices | 0.89 | 1.03 | 1.02 |

The second shock measures the impact of a 1% increase in the U.S. corn price on the average Manitoba corn price holding domestic barley and feed wheat prices constant. The price transmission is significantly less than 100% due to the relatively small share grain corn represents in the overall Western Canadian feed grain complex. In the first year, there is 0.79% increase in the Manitoba price and the impact dampens to 0.54% (i.e. equivalent to the longer term effect). Hog producers partially adjust to higher corn prices in the first year by reducing corn feed usage, which reduces import. In the second year, the livestock sector further reduces corn feed usage, local corn production increases due to higher expected returns and the level of imports decline even more. At the new equilibrium imports are smaller, average transportation from the U.S. to Western Canada cost is smaller and therefore the average Manitoba corn price has not increased by 1%.

World commodity markets generally exhibit a high level of correlation so it is unlikely that a shock would only affect a particular commodity (e.g. grain corn) and not the whole complex of commodities. Therefore, we have undertaken three other shocks to more fully demonstrate the properties of the model. The third simulation is a combination of the first two. This simulation is probably more representative of the impact a 1% increase in the U.S. corn price has on the Manitoba corn price. The fourth simulation shocks all of the other grains and oilseeds prices in the model (canola, flaxseed, oats and soybean meal) while holding U.S. corn and Canadian wheat and barley prices constant. In the final simulation we shock all prices by 1% to see if we get a 1% increase in the Manitoba corn price which would effectively demonstrate that the system is homogenous.

As identified in Table 6 the combination shock resulted in an additive effect which indicates that a 1% increase in domestic wheat and barley prices combined with a 1% increase in the U.S. corn price results in a long term Manitoba corn price multiplier of 0.88. Other prices included in the model when shocked resulted in a long term corn price multiplier of 0.14. The net addition of these two is essentially 1% suggesting that in the long term a 1% increase in all of the exogenous prices result in a 1% increase in the Manitoba corn price (i.e. homogenous in prices).

The impact of a 1% increase in the U.S. grain corn price on some of the key economic variables are outlined in Table 7. The first number indicates the percentage impact while the second one represents the kilo-tonne impact. With respect to area harvested and production, the long term impact of a 1% increase in the U.S. corn price is a 0.68% increase in both corn area harvested and production, since yields are exogenous. From a production standpoint, in the long term this is approximately equivalent to an increase of 1.4 thousand tonnes of corn production in Manitoba. In terms of corn feed usage and imports, the long-term impact of a 1% increase in the U.S. price are declines in feed usage of 0.15% and imports of 0.66% or approximately 0.62 and 2.14 thousand tonnes of corn respectively.

**Table 7: Impact on key variables (% impact/kilo-tonne impact)**

| Corn variable | 1st year | 2nd year | Long Term (6 years) |
|---|---|---|---|
| Area | 0.00/– | 0.68/– | 0.75/– |
| Production | 0.00/0.00 | 0.68/1.51 | 0.75/1.66 |
| Feed | -0.09/-0.38 | -0.15/-0.62 | -0.12/-0.49 |
| Imports | -0.12/-0.38 | -0.66/-2.14 | -0.66/-2.14 |

# 5 Analytical Limitations

In undertaking this econometric analysis there were a number of limitations:

- Since the model was estimated over a period characterized by the absence of major shocks, it should provide reasonable estimates when a modest shock is imposed on the model. In situations where a major shock is introduced the model structure would have to change. For instance, this type of shock would include a drought in Western Canada, which results in a very large increase of corn imports above historical levels and a change in the price relationship between corn and barley in the feed ration. The model structure would also have to change if Western Canadian access to U.S. corn was restricted. This situation would result in a change in the specification of the price linkage equation with the Manitoba corn price having to be determined on a competitive basis with other Western Canadian feed grains (versus U.S. corn).

- Given the relatively small size of the Western Canadian corn market the availability of detailed data was limited and some strong assumptions were required (discussed in Section 3). In addition, more sophisticated specifications and/or methods of estimations were excluded because of the limited number of degrees of freedom available from the data. It should be noted though that the estimation undertaken did result in relatively reasonable elasticity estimates that adhered to economic logic. It is unlikely that a further effort dedicated to data collection would result in improvements.
- Although behavioural equations were estimated for three key variables in the Western Canadian corn market it is apparent from the schematic representation (see Figure 4) of the model that a number of important economic variable remain exogenous. The extent to which leaving these variable exogenous enhances or restricts the model's ability to react to a price shock will be better known when this new component is included in FARM.

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# Appendix A

## Table A1: Prices (crop year basis)

| | (1) Corn Manitoba | (2) Corn Minneapolis | (3) Feed Wheat Winnipeg | (4) Feed Barley Winnipeg | (5) Soybean Meal Winnipeg |
|---|---|---|---|---|---|
| | | | ($CDN/tonne) | | |
| **1984** | 144 | 145 | 139 | 114 | 238 |
| **1985** | 125 | 126 | 100 | 86 | 272 |
| **1986** | 94 | 81 | 70 | 66 | 273 |
| **1987** | 95 | 94 | 86 | 57 | 337 |
| **1988** | 133 | 122 | 139 | 108 | 358 |
| **1989** | 122 | 111 | 122 | 89 | 264 |
| **1990** | 109 | 106 | 81 | 68 | 244 |
| **1991** | 91 | 110 | 74 | 65 | 257 |
| **1992** | 93 | 104 | 68 | 69 | 282 |
| **1993** | 113 | 134 | 77 | 66 | 312 |
| **1994** | 129 | 123 | 118 | 90 | 257 |
| **1995** | 182 | 201 | 173 | 138 | 337 |
| **1996** | 153 | 143 | 137 | 102 | 409 |
| **1997** | 135 | 135 | 120 | 91 | 330 |
| **1998** | 114 | 111 | 92 | 78 | 238 |
| **1999** | 104 | 103 | 88 | 72 | 263 |

*Note: (1) Manitoba provincial average corn price. Simple average of monthly average prices obtained from Statistics Canada. Underlying monthly data: Statistics Canada, Agriculture Division, Farm Income and Prices Section, Farm Product Price Book, unpublished data.*

*(2) Minneapolis #2 Yellow corn cash price. Simple average of monthly average prices obtained from the United States Department of Agriculture (USDA), 2000 Feed Yearbook. Conversion from bushels to metric tonnes using a conversion factor of 39.368 bu/tonne. Conversion to Canadian dollars using a crop year exchange rate constructed from the average U.S. dollar noon spot rate in Canadian dollars (CANSIM D4300).*

*(3) Feed wheat price (Canada Feed) basis Winnipeg, Manitoba (Source: Manitoba Agriculture and Food).*

*(4) Feed barley price (1 CW) basis Winnipeg, Manitoba (Source: Manitoba Agriculture and Food).*

*(5) Soybean meal feed ingredient selling price basis Winnipeg, Aggregation of monthly data obtained from AAFC, Economic and Industry Analysis Division, Market Research and Analysis Section.*

# Appendix B

## Table B1: Western Canada: corn supply and disposition

| | 1985-86 | 1986-87 | 1987-88 | 1988-89 | 1989-90 | 1990-91 | 1991-92 | 1992-93 | 1993-94 | 1994-95 | 1995-96 | 1996-97 | 1997-98 | 1998-99 | 1999-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | August 1 – July 31 | | | | | | | | | | | | | | |
| **Beginnig Stocks:** | | | | | | | | | | | | | | | |
| On farms | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Commercial Positions | 0.0 | 1.1 | 8.4 | 5.3 | 3.4 | 2.6 | 4.0 | 3.0 | 2.0 | 11.0 | 2.0 | 1.0 | 1.0 | 1.0 | 0.0 |
| **Total** | **0.0** | **1.1** | **8.4** | **5.3** | **3.4** | **2.6** | **4.0** | **9.0** | **3.0** | **11.0** | **2.0** | **1.0** | **1.0** | **1.0** | **0.0** |
| **Production** | **106.5** | **78.3** | **127.0** | **139.7** | **128.3** | **181.6** | **226.0** | **41.2** | **49.5** | **129.5** | **106.7** | **148.6** | **162.6** | **227.3** | **259.1** |
| **Imports:** | | | | | | | | | | | | | | | |
| Ontario | 68.1 | 71.7 | 75.0 | 69.1 | 70.5 | 69.4 | 63.7 | 69.6 | 54.0 | 100.0 | 82.5 | 25.0 | 0.0 | 0.0 | 0.0 |
| U.S. | 289.0 | 175.1 | 85.5 | 185.6 | 257.1 | 231.2 | 150.6 | 181.4 | 134.6 | 259.1 | 242.7 | 251.8 | 284.4 | 337.4 | 352.0 |
| **Total Imports** | **357.1** | **246.8** | **160.5** | **254.7** | **327.6** | **300.6** | **214.3** | **251.0** | **188.6** | **359.1** | **325.2** | **276.8** | **284.4** | **337.4** | **352.0** |
| **Total Suppliers** | **463.6** | **326.2** | **295.9** | **399.7** | **459.3** | **484.8** | **444.3** | **301.2** | **241.1** | **499.6** | **433.9** | **426.4** | **448.0** | **565.7** | **611.1** |
| **Exports** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** |
| **Domestic Disappearance:** | | | | | | | | | | | | | | | |
| Human Food and Industrial Use | – | – | 83.2 | 85.6 | 115.0 | 114.8 | 114.6 | 114.6 | 105.0 | 119.0 | 125.0 | 100.0 | 110.0 | 120.0 | 130.0 |
| Seed Requirements | 1.1 | 1.1 | 1.5 | 1.5 | 1.3 | 0.8 | 1.8 | 1.1 | 1.2 | 1.0 | 1.3 | 1.4 | 1.7 | 1.8 | 2.3 |
| Feed, Water and Dockage | 380.1 | 239.1 | 205.9 | 305.9 | 340.4 | 365.2 | 318.8 | 182.6 | 123.6 | 377.6 | 306.6 | 324.0 | 335.3 | 444.0 | 478.9 |
| **Total** | **462.5** | **317.8** | **290.6** | **393.0** | **456.7** | **480.8** | **435.2** | **298.3** | **229.8** | **497.6** | **432.9** | **425.4** | **447.0** | **565.8** | **611.2** |
| **Ending Stocks:** | | | | | | | | | | | | | | | |
| On farms | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Commercial Positions | 1.1 | 8.4 | 5.3 | 3.4 | 2.6 | 4.0 | 4.0 | 2.0 | 11.0 | 2.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 |
| **Total** | **1.1** | **8.4** | **5.3** | **3.4** | **2.6** | **4.0** | **9.0** | **3.0** | **11.0** | **2.0** | **1.0** | **1.0** | **1.0** | **0.0** | **0.0** |
| **Total Disposition** | **463.6** | **326.2** | **295.9** | **399.7** | **459.3** | **484.8** | **444.3** | **301.2** | **241.1** | **499.6** | **433.9** | **426.4** | **448.0** | **565.7** | **611.1** |

# Appendix C

**Table C1: Harvested area major crops and summerfallow – Manitoba, Census Agriculture Regions 7, 8 and 9**

| | All Wheat | Barley | Oats | Rye | Canola | Flax | Summerfallow |
|---|---|---|---|---|---|---|---|
| | | | | hectares (ha) | | | |
| **1982** | 628,113 | 279,233 | 58,275 | 29,056 | 126,545 | 193,035 | 90,650 |
| **1983** | 732,481 | 246,858 | 60,298 | 25,212 | 124,319 | 175,876 | 73,653 |
| **1984** | 676,108 | 258,999 | 67,178 | 30,230 | 147,386 | 217,640 | 48,967 |
| **1985** | 715,606 | 265,878 | 59,084 | 22,217 | 143,663 | 245,078 | 53,823 |
| **1986** | 756,357 | 215,293 | 57,465 | 5,747 | 151,555 | 248,922 | 85,955 |
| **1987** | 743,084 | 255,761 | 67,178 | 6,758 | 154,023 | 182,270 | 103,195 |
| **1988** | 755,143 | 200,724 | 58,720 | 15,945 | 245,239 | 150,138 | 77,295 |
| **1989** | 844,984 | 239,169 | 70,699 | 42,087 | 146,092 | 146,901 | 59,489 |
| **1990** | 861,748 | 223,629 | 43,706 | 30,918 | 124,847 | 149,736 | 43,707 |
| **1991** | 827,682 | 181,299 | 31,242 | 7,081 | 181,287 | 141,839 | 39,619 |
| **1992** | 806,498 | 163,898 | 85,793 | 7,284 | 227,676 | 87,938 | 34,398 |
| **1993** | 723,537 | 161,672 | 82,758 | 5,180 | 274,337 | 134,153 | 35,774 |
| **1994** | 634,400 | 155,300 | 116,700 | 3,100 | 394,600 | 149,800 | 42,000 |
| **1995** | 590,163 | 179,633 | 117,937 | 7,278 | 393,932 | 180,496 | 60,136 |
| **1996** | 604,914 | 249,339 | 190,956 | 4,922 | 248,544 | 124,148 | 54,529 |
| **1997** | 565,612 | 222,928 | 131,800 | 7,310 | 388,701 | 153,072 | 50,759 |
| **1998** | 452,215 | 195,785 | 198,933 | 11,838 | 429,077 | 144,141 | 27,842 |
| **1999** | 506,764 | 140,728 | 164,846 | 10,012 | 423,556 | 111,077 | 50,710 |

***Source: Statistics Canada, Agriculture Division, Crops Section, Crops Small Area Data, Annual***

*Note: Aggregation of Statistics Canada Source Data.*

## Table C2: Yield – Manitoba, Census Agriculture Regions 7, 8 and 9

| | All Wheat | Barley | Oats | Rye | Canola | Flax |
|---|---|---|---|---|---|---|
| | tonnes/ha | | | | | |
| **1982** | 2.46 | 3.23 | 2.55 | 2.48 | 1.18 | 1.31 |
| **1983** | 1.94 | 2.44 | 1.92 | 2.11 | 1.09 | 1.02 |
| **1984** | 2.30 | 3.10 | 2.19 | 2.48 | 1.28 | 1.19 |
| **1985** | 2.89 | 3.79 | 2.83 | 2.41 | 1.68 | 1.39 |
| **1986** | 2.28 | 3.01 | 4.84 | 2.01 | 1.40 | 1.30 |
| **1987** | 2.24 | 3.03 | 2.49 | 1.98 | 1.47 | 1.31 |
| **1988** | 1.06 | 1.66 | 1.26 | 1.41 | 0.83 | 0.59 |
| **1989** | 2.27 | 2.89 | 1.98 | 2.28 | 0.97 | 0.84 |
| **1990** | 2.79 | 3.21 | 2.38 | 2.22 | 1.32 | 1.32 |
| **1991** | 2.29 | 2.50 | 1.97 | 1.42 | 1.50 | 1.30 |
| **1992** | 3.25 | 3.93 | 3.25 | 2.06 | 1.79 | 1.70 |
| **1993** | 1.86 | 2.68 | 2.48 | 1.55 | 1.19 | 1.07 |
| **1994** | 2.35 | 3.30 | 2.83 | 2.48 | 1.70 | 1.44 |
| **1995** | 2.19 | 3.12 | 2.75 | 2.20 | 1.47 | 1.34 |
| **1996** | 2.75 | 3.71 | 2.93 | 2.85 | 1.82 | 1.60 |
| **1997** | 2.21 | 3.19 | 2.98 | 2.37 | 1.63 | 1.31 |
| **1998** | 2.68 | 3.41 | 3.08 | 2.63 | 1.83 | 1.37 |
| **1999** | 2.85 | 3.47 | 3.34 | 2.70 | 1.89 | 1.45 |

***Source: Statistics Canada, Agriculture Division, Crops Section, Crops Small Area Data, Annual***

*Note: Aggregation of Statistics Canada Source Data.*

## Table C3: Production – Manitoba, Census Agriculture Regions 7, 8 and 9

| | All Wheat | Barley | Oats | Rye | Canola | Flax |
|---|---|---|---|---|---|---|
| | | | (tonnes) | | | |
| **1982** | 1,548,211 | 900,922 | 148,546 | 71,982 | 149,896 | 252,599 |
| **1983** | 1,420,831 | 603,053 | 115,604 | 53,132 | 135,309 | 178,657 |
| **1984** | 1,558,392 | 803,229 | 146,803 | 75,182 | 188,073 | 259,915 |
| **1985** | 2,070,539 | 1,006,474 | 167,130 | 53,548 | 241,391 | 340,835 |
| **1986** | 1,724,935 | 648,274 | 278,333 | 11,565 | 212,703 | 323,611 |
| **1987** | 1,666,244 | 774,794 | 167,546 | 13,381 | 227,057 | 237,897 |
| **1988** | 799,266 | 334,011 | 74,103 | 22,505 | 202,438 | 89,234 |
| **1989** | 1,917,906 | 690,970 | 140,079 | 96,042 | 141,929 | 122,916 |
| **1990** | 2,400,672 | 718,074 | 104,015 | 68,741 | 164,377 | 197,375 |
| **1991** | 1,895,175 | 452,936 | 61,442 | 10,072 | 271,182 | 184,448 |
| **1992** | 2,622,095 | 644,464 | 279,141 | 14,974 | 407,154 | 149,750 |
| **1993** | 1,348,573 | 433,531 | 205,449 | 8,029 | 326,403 | 143,964 |
| **1994** | 1,493,200 | 511,900 | 329,700 | 7,700 | 671,100 | 215,200 |
| **1995** | 1,293,673 | 559,686 | 324,631 | 15,977 | 580,201 | 242,557 |
| **1996** | 1,662,656 | 925,355 | 559,402 | 14,040 | 452,443 | 198,782 |
| **1997** | 1,250,336 | 710,830 | 392,374 | 17,348 | 633,161 | 200,168 |
| **1998** | 1,213,119 | 668,355 | 611,941 | 31,122 | 783,817 | 196,811 |
| **1999** | 1,444,555 | 487,882 | 550,451 | 27,009 | 802,182 | 161,062 |

***Source: Statistics Canada, Agriculture Division, Crops Section, Crops Small Area Data, Annual***

*Note: Aggregation of Statistics Canada Source Data.*

## Table C4: Manitoba grain corn production (provincial total)

| | Area Harvested (ha) | Yield (tonnes/ha) | Production (tonnes) |
|---|---|---|---|
| **1982** | 80,900 | 3.14 | 254,026 |
| **1983** | 77,000 | 2.83 | 217,910 |
| **1984** | 73,000 | 3.23 | 235,790 |
| **1985** | 40,500 | 1.88 | 76,140 |
| **1986** | 13,800 | 4.42 | 60,996 |
| **1987** | 20,200 | 5.41 | 109,201 |
| **1988** | 34,400 | 3.32 | 114,311 |
| **1989** | 36,400 | 3.14 | 114,296 |
| **1990** | 34,400 | 4.80 | 165,086 |
| **1991** | 40,500 | 5.08 | 205,740 |
| **1992** | 12,100 | 2.93 | 35,453 |
| **1993** | 14,200 | 2.60 | 36,920 |
| **1994** | 22,300 | 5.25 | 117,075 |
| **1995** | 18,200 | 5.16 | 93,912 |
| **1996** | 28,300 | 5.02 | 142,066 |
| **1997** | 30,400 | 5.01 | 152,304 |
| **1998** | 36,400 | 5.93 | 215,852 |
| **1999** | 40,500 | 5.90 | 238,950 |

***Source: Statistics Canada, CANSIM***

## Table C5: Western Canadian weighted average producer prices (Aug/July crop year)

| | Wheat | Barley | Oats | Flax | Canola |
|---|---|---|---|---|---|
| | | | ($CDN/tonne) | | |
| **1984** | 169 | 117 | 101 | 315 | 352 |
| **1985** | 141 | 95 | 85 | 264 | 267 |
| **1986** | 111 | 65 | 72 | 174 | 204 |
| **1987** | 114 | 61 | 99 | 199 | 260 |
| **1988** | 175 | 107 | 139 | 356 | 298 |
| **1989** | 150 | 100 | 82 | 343 | 266 |
| **1990** | 109 | 70 | 66 | 202 | 255 |
| **1991** | 106 | 79 | 83 | 153 | 236 |
| **1992** | 128 | 78 | 95 | 210 | 279 |
| **1993** | 134 | 76 | 92 | 226 | 314 |
| **1994** | 168 | 94 | 93 | 270 | 352 |
| **1995** | 209 | 144 | 148 | 295 | 372 |
| **1996** | 165 | 112 | 126 | 328 | 388 |
| **1997** | 147 | 110 | 118 | 349 | 380 |
| **1998** | 141 | 96 | 107 | 297 | 346 |
| **1999** | 123 | 83 | 79 | 201 | 240 |

***Source: AAFC FARM model databank***

*Underlying data: Statistics Canada, Agriculture Division, Farm Income and Prices Section, Farm Product Price Book, unpublished data.*

## Table C6: Constructed variables used in the corn area share equation

| | (1) Corn Area | (2) Corn Expected Return | (3) Grains and Oilseeds Expected Return | (4) Farm Input Price Index |
|---|---|---|---|---|
| | Share | ($CDN/tonne) | ($CDN/tonne) | (1986=100) |
| **1985** | 0.030 | 442 | 364 | 1.029 |
| **1986** | 0.010 | 331 | 315 | 1.000 |
| **1987** | 0.010 | 299 | 256 | 0.978 |
| **1988** | 0.020 | 371 | 281 | 0.993 |
| **1989** | 0.020 | 583 | 322 | 1.021 |
| **1990** | 0.020 | 483 | 272 | 1.049 |
| **1991** | 0.030 | 409 | 215 | 1.072 |
| **1992** | 0.010 | 395 | 250 | 1.066 |
| **1993** | 0.010 | 397 | 334 | 1.088 |
| **1994** | 0.010 | 400 | 332 | 1.141 |
| **1995** | 0.010 | 464 | 404 | 1.236 |
| **1996** | 0.020 | 789 | 446 | 1.285 |
| **1997** | 0.020 | 787 | 444 | 1.286 |
| **1998** | 0.020 | 684 | 422 | 1.268 |
| **1999** | 0.030 | 606 | 410 | 1.266 |

*Note: (1) It is assumed that Manitoba provincial grain corn area harvested is a reasonable proxy of the corn area harvested in Census Agriculture Regions (CAR) 7, 8 and 9. Thus, the corn area share is a proxy for that proportion of the land in CAR's 7, 8 and 9 that was dedicated to corn production versus land that went into the production of major gains and oilseeds or was left as summerfallow.*

*(2) The corn expected return is equal to the average Manitoba corn yield for the previous three years multipied by the previous year provincial average corn price.*

*(3) Expected returns were calculated for each of the major grain and oilseed crops (wheat, barley, oats, canola and flaxseed) and then a weighted average G&O expected return was constructed on the basis of annual production. Weighted average Western Canadian producer prices were used in this calculation due to their availability and the high level of correlation between grain prices across the Prairies.*

*(4) Farm input price index for Western Canadian grains - Source AAFC FARM Model.*

# Appendix D

## Table D1: Generic swine grower/finisher rations

| Ingredients | Grower 1 | | Grower 2 | | Finisher | | |
|---|---|---|---|---|---|---|---|
| | Bar-Corn | Bar-Wheat | Bar-Corn | Bar-Wheat | Bar | Bar-Corn | Bar-Wheat |
| **Barley** | 489.2 | 223.5 | 388.4 | 351.1 | 861.8 | 622.7 | 466.6 |
| **Corn** | 264.3 | 0.0 | 409.2 | 0.0 | 0.0 | 224.8 | 0.0 |
| **Feed Wheat** | 0.0 | 588.0 | 0.0 | 510.7 | 0.0 | 0.0 | 426.2 |
| **Soymeal (47%)** | 213.1 | 152.7 | 168.1 | 102.8 | 112.9 | 127.0 | 80.0 |
| **Salt** | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| **Min/Vit Premix** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| **Limestone** | 10.3 | 10.7 | 10.4 | 10.7 | 8.9 | 8.9 | 9.5 |
| **Dical (16-21)** | 5.9 | 6.2 | 6.9 | 6.8 | 3.8 | 4.3 | 4.5 |
| **Lysine – HC1** | 0.6 | 2.0 | 0.5 | 1.5 | 0.9 | 0.8 | 1.5 |
| **L-Threonine** | 0.1 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 |
| **Veg Oil** | 10.0 | 10.0 | 10.0 | 10.0 | 5.0 | 5.0 | 5.0 |
| **Total** | 1,000.0 | 1,000.0 | 1,000.0 | 1,000.0 | 1,000.0 | 1,000.0 | 1,000.0 |

***Source: Manitoba Agriculture, Animal Industry Branch***

*Notes: Grower 1 – feed to pigs 20-50 kg*
*Grower 2 – feed to pigs 50-80 kg*
*Finisher – feed to pigs 80 kg to market weight.*

**Table D2: Weighted average ration index prices (based on Winnipeg feed wheat, feed barley and soybean meal prices)**

| | Grower 1 | | Grower 2 | | Finisher | | All Three Stages | |
|---|---|---|---|---|---|---|---|---|
| | Bar-Corn | Bar-Wheat | Bar-Corn | Bar-Wheat | Bar-Corn | Bar-Wheat | Bar-Corn | Bar-Wheat |
| **1985** | 133 | 120 | 130 | 109 | 116 | 104 | 126 | 110 |
| **1986** | 115 | 98 | 110 | 87 | 97 | 83 | 107 | 88 |
| **1987** | 125 | 115 | 118 | 98 | 100 | 90 | 113 | 100 |
| **1988** | 164 | 161 | 156 | 145 | 142 | 138 | 153 | 147 |
| **1989** | 132 | 132 | 129 | 120 | 116 | 115 | 125 | 121 |
| **1990** | 114 | 100 | 112 | 90 | 98 | 86 | 107 | 91 |
| **1991** | 111 | 98 | 106 | 87 | 94 | 83 | 103 | 88 |
| **1992** | 118 | 99 | 112 | 88 | 100 | 84 | 109 | 89 |
| **1993** | 129 | 108 | 125 | 95 | 107 | 89 | 119 | 96 |
| **1994** | 133 | 129 | 131 | 118 | 117 | 113 | 126 | 119 |
| **1995** | 187 | 184 | 185 | 171 | 170 | 165 | 180 | 172 |
| **1996** | 178 | 166 | 171 | 148 | 150 | 139 | 165 | 149 |
| **1997** | 150 | 141 | 146 | 127 | 129 | 120 | 141 | 128 |
| **1998** | 119 | 108 | 117 | 99 | 105 | 95 | 113 | 100 |
| **1999** | 119 | 108 | 115 | 97 | 102 | 92 | 111 | 98 |

*Note: Based on the weighting derived from the generic swine grower/finisher rations and the three key feed ingredient prices (corn, wheat, soybean meal), index ration prices were calculated for each stage of swine production using either a barley-corn or a barley-wheat feed ration. A weighted average ration price was constructed for all three stage using the weights of 27, 36.5 and 36.5% for grower 1, grower 2 and finisher. The lowest weighting is given to grower 1 as feeding efficiency is highest at this stage.*

# Appendix E

## Table E-1: Grain shipments by rail from Thunder Bay terminal elevators

| | Million tonnes |
|---|---|
| **1984** | 0.295 |
| **1985** | 1.065 |
| **1986** | 1.251 |
| **1987** | 0.741 |
| **1988** | 0.726 |
| **1989** | 0.976 |
| **1990** | 0.700 |
| **1991** | 1.210 |
| **1992** | 0.304 |
| **1993** | 0.430 |
| **1994** | 0.210 |
| **1995** | 0.149 |
| **1996** | 0.318 |
| **1997** | 0.071 |
| **1998** | 0.066 |

***Source: Canadian Grains Council Statistical Handbook (Various Issues)***